CAPACITY BUILDING TO ASSESS TECHNOLOGY NEEDS, MODALITIES TO ACQUIRE AND ABSORB THEM, EVALUATE AND HOST PROJECTS

II PHASE OF GEORGIA'S ENABLING ACTIVITIES

Report is prepared under the
UNDP/GEF –Government of Georgia
Project GEO/96/G31 (Phase II)
by the National Agency on Climate Change
at the Ministry of Environment and
Natural Resources Protection

Tbilisi
2002

UNDP/GEF
Government of Georgia
Project GEO/96/G31 (Phase II)

Project Manager T. Gzirishvili
M. Shvangiradze

Performers of the Report

G. Arabidze, N. Bakanidze, M. Basilashvili, B. Beritashvili, G. Dadiani,
D. Dvali, T. Gochitashvili, L. Inasaridze, M. Inashvili, P. Janelidze, J. Karchava, I. Khundadze,
M. Kipshidze, I. Shekriladze, K. Skhirtladze, T. Veliani.

Editor B. Beritashvili
Design & Computer Graphic N. Neparidze

Additional information is available
at the following address:
150[A], David Agmashenebeli Ave., 380012, Tbilisi, Georgia
National Agency on Climate Change
Tel.: (995 32) 941580
959254
Fax: (995 32) 941536
E-mail: mshvangiradze@ gol. ge

PREFACE

Since 1996 Georgia is actively engaged in the international processes under the UN Framework Convention on Climate Change and through the National Agency on Climate Change at the Ministry of Environment and Natural Resources Protection is trying at most to adopt the principles of Convention in Georgia and to apply the Convention financial mechanisms for the promotion of sustainable development of Georgian economy.

A lot of things have been done already in this field. Among them especially noteworthy are pilot projects and project proposals, prepared in energy and industry sectors the implementation of which would raise the energy efficiency of these sub-sectors, would facilitate the maximum use of renewable energy and will restrict the emission of greenhouse gases, allowing Georgia to contribute to the mitigation of global warming process.

In the framework of present project which is the continuation of the project GEO/96/G31, aimed at enabling Georgia to prepare its initial national communication under the UNFCCC, the energy efficiency problems in energy and industry sectors have been studied and a number of project proposals have been designed, intended to reduce the GHG emissions. The highly qualified invited experts from the Georgian Technical University, Ministry of Economics, Industry and Trade, Sectoral Economy Committee of the Georgian Parliament actively participated in this work.

The Ministry of Environment and Natural Resources Protection is greatly thankful both to the invited experts and the leaders and technologist of those industrial enterprises as well, which agreed to collaborate with the National Agency on Climate Change in the solution of above mentioned problems and thus made an important contribution to the rise of practical value of obtained project results.

The Ministry and its National Agency on Climate Change are grateful to the authorities of Global Environment Facility which provided timely assistance to the non-Annex I countries for the implementation of projects, aimed at the capacity building to adopt technologies so necessary for their development. The Ministry also notes with pleasure great contribution, made by the UNDP Country Office in Georgia to the specification of the project objectives and for the constant support given to the Ministry in the process of preparing for the execution of second national communication.

N. Chkhobadze

Minister of Environment and Natural
Resources Protection

ABBREVIATIONS

BS	-	Pipeline “Blue Stream”
C	-	Carbon
CDM	-	Clean Development Mechanism
CH_4	-	Methane
CO	-	Carbon monoxide
CO_2	-	Carbon dioxide
CPC	-	Caspian Pipeline Company
G /A	-	Georgian -American
G /B	-	Georgian -British
GBN	-	“Georgian Business News” newspaper
GDP	-	Gross Domestic Product
GEF	-	Global Environment Facility
Gg	-	Gigagram (thousand ton)
GHG	-	Greenhouse gas
GIOC	-	Georgian International Oil Corporation
GPC	-	Georgian Pipeline Company
G /S	-	Georgian -Swiss
IGCC	-	Integrated Gasification Combined Cicle
IRR	-	Internal Rate of Return
JSC	-	Joint Stock Company
KfW	-	German Reconstruction Credit Bank
MWe	-	Megawatt (electric)
N.A.	-	Data not available
NMVOC	-	Non-Methane Volatile Organic Compound
NO_X	-	Nitrogen oxides
N_2O	-	Nitrous oxide
NOC	-	National Oil Company
NPV	-	Net Present Value
NSC	-	North-South Caucasus main gas pipeline
OKIOC	-	Offshore Kazakhstan International Oil Company
RMP	-	Rustavi Mettalurgical Plant
SEMEK	-	Georgian Energy Regulating National Commission
SO_2	-	Sulphur dioxide
SOCA	-	State Oil Company of Azerbaijan
TACIS	-	Technical Assistance for Commenwealth of Independent States
Tg	-	Teragram (million ton)
Toe	-	Ton of oil equivalent
UNFCCC	-	United Nations Framework Convention on Climate Change
USAID	-	United States Agency for International Development
USD	-	United States dollar
WB	-	World Bank

CONTENTS

PART I

1. Executive Summary 7

2. Main Objectives of the Project 13

3. Georgian Energy Recourses 15

3.1. Energy Recourses all over the World and in Georgia 15
3.2. Coal Industry 19
3.3. Oil and Natural Gas Estimated Reserves in Georgia, Current Activities and Technologies 24
3.4. Renewable Energy Resources of Georgia 26
3.5. Transportation of Energy Carriers 27
3.6 Export, Import and Transit of Energy Recourses 36
3.7. CO_2 Emissions Resulting from Non-efficient Technologies Operating in Energy Resources Extraction and Transportation Sector 44

4. Inventory of Technologies Applied in the Energy Sector and Current State of their Efficiency 46

4.1 Generation Sector 47
4.1.1 Electricity Generation 47
4.1.2 Heat Generation 54
4.1.3. CO_2 Emission Reduction Potential in the Electricity and Heat Power Generation Sectors 58
4.2. Transmission and Distribution 61
4.2.1. Electricity Transmission and Distribution 62
4.2.2. Thermal Power Transmission and Distribution 67
4.2.3. GHG Emission Reduction Potential in Transmission and Distribution Systems 68
4.3. Consumption 72
4.3.1. Electricity Consumption 74
4.3.2. Heat Consumption 82
4.3.3. GHG Emission Reduction Potential in the Heat and Electricity Consumption Sectors 83
4.4. Structure of Computer Database for Energy and Industry Sectors (1990 and 2000) 86
4.5. Scenarios of Electricity Demand and Development of Electric-Power Industry till 2015-2020 87
4.5.1. Projection of Energy Demand in Georgia for the Period of 1999-2020 87
4.5.2. Assessment of Electricity Demand in Georgia for the Period up to 2020 105

5. Industry Sector 111

5.1 State of Georgian Industry Sector in 1990 and 2000 111
5.1.1. Industry Sector by the state of 1990 111
5.1.2 Industry Sector by the state of 2000 112
5.1.3. Examples of the Revival of Individual Sub-sectors of Industry 116
5.1.4. Regional Features of the Industry Sector Functioning 119
5.2. Assessment of Current State in Some Sectors of the Industry 124
5.2.1. Metallurgy 124
5.2.2. Cement Production 131
5.2.3. Timber, Wood-processing, and Cellulose and Paper Industry 136
5.3. GHG Emission Reduction Potential in the Energy and Industry Sectors 138
5.4. Barriers to the Technology Transfer in the Industry Sector and the Ways to Remove them 140
6. GHG Emissions Abatement Technologies and Measures 144
7 Raising of Public Awareness 153
8 Conclusions 156

PART II

ENERGY SECTOR

1 Proposal on GHG Emissions Reduction in Power Generation Sector (Tbilisi CHP Reconstruction and Modernization Applying Advanced Energy Efficient Technologies) 157

2 Proposal on GHG Emissions Reduction in Electricity Transmission Sector (Adoption of Advanced Commutation Technologies for High Voltage (500 kV, 220 kV) Transmission Lines) . 166

3 Proposal on GHG Emissions Reduction for Electricity Consumption Sector (Adoption of Energy Efficient Technologies for Street and Indoor Lighting) …………………… 172

INDUSTRY SECTOR

4 Rustavi JSC "Azoti" ……………………………………………………………………………. 184

5 Rustavi Metallurgical Plant ………………………………………………………………….. 189

6 Braed Industry ……………………………………………………………………………… 195

7 Rustavi Cement Plant ……………………………………………………………………….. 202

REFERENCE
ANNEX

PART I

1. EXECUTIVE SUMMARY

1.1. Main Objectives of the Project

In 1997-1999 under the financial support of GEF Georgia has prepared its Initial National Communication under the United Nations Framework Convention on Climate Change. Before the starting of the work on the second national communication, to avoid the possible break and for the preservation of local potential, the country has been provided with additional financing of the climate change enabling activity. After the consultations between the team which has implemented the Initial National Communication, the Ministry of Environment and GEF Operational Focal Point it has been decided to use this financial assistance for the assessment of current state of energy efficiency and for the determination of technology needs to abate the GHG emissions. Prospects for the adoption of these technologies were to be assessed as well.

The project started in October 2000 and ended in March 2002. In the framework of the project the status of energy and industry sectors has been examined for the years 1990 and 1999-2000. These sectors were chosen in view of their major share in the emission of GHGs from the territory of Georgia. According to the internationally accepted practices the transportation module-one of the principal emitters of GHGs has been omitted from the energy sector, as its assessment is related to the additional complications. Carrying out GHGs inventory from this module on the regional level is planned in the near future under the assistance of UNDP National Communications Support Programme.

In the energy sector all rings have been reviewed: energy resources, their extraction and transportation, generation of electricity and power, transmission, distribution and consumption of both kinds of energy by the state of 1990 and 1999. The same depth could not been achieved for the industry sector which, after the collapse of the Soviet Union, still remains in a grave condition. In the framework of the present project it was managed to undertake an inventory of applied technologies in the energy sector and assess their energy efficiency, to create the relevant computer database, to estimate the GHG emissions reduction potential in two ways–in case of bringing the currently applied technologies in correspondence with the design values and in case of introducing modern, more energy efficient technologies. The same estimation in the industry sector was possible to carry out only for some large enterprises, but even these assessments have shown that there is a sufficiently great potential for the reduction of GHG emissions in this sector. At the same time it becomes possible to get contemporary energy efficient technologies in this sector on the basis of preferential loans, that is possible under the UNFCCC mechanisms.

In the framework of the project the opportunity has been provided to raise the awareness of managers of large industrial enterprises on the emerging new possibilities in the technology transfer area, and to establish adequate links. This creates a precondition to examine this sector more deeply in future, to prepare more project proposals for it and to fill up the database, the structure of which has been prepared while implementing this project.

According to the objectives of the project, four project proposals have been prepared for the energy sector in generation, distribution and consumption sub-sectors, and a number of measures have been identified in the industry sector, the adoption of which could significantly reduce the GHG emissions at the major enterprises of iron and steel, cement, chemical and food industry. Separately were prepared data for the elaboration of project proposal aimed at the reduction of technical losses from the Tbilisi natural gas distributing network. Information has been obtained on the GHG emissions reducing technologies, available at the international market, their review has been undertaken and the possibility of their application in the conditions of Georgia has been assessed. The results of this review will be used to supplement the database on GHGs reduction technologies, created for the developing and transitional countries. Obtaining this data base remains high on the agenda at the National Agency on Climate Change.

1.2. Energy Resources of Georgia

After a brief review of the world fuel and energy resources the structure of fuel resources consumption in Georgia is discussed. Tables are presented which describe the extraction, import, export, processing and consumption of primary energy resources in the country for the period of 1990-2000.

The Georgian coal industry is examined in some detail. Relevant tables are used to describe the coal reserve and projected resource, among them coal reserve of the Tkibuli-Shaori deposit. Information is given on the applied technologies at the Tkibuli-Shaori and the Tkvarcheli deposits as well. Corresponding technical and economic features are presented, the coal quality is evaluated along with the prime cost of its recovery. It is shown that in case of the restoration in the near future of the Georgian coal industry the prime cost of the extraction of 1 ton of coal could make US$ 30 that confirms the economic advisability of the development of that sub-sector of industry.

Information is given on the probable reserves of oil and natural gas in Georgia, on the companies working in this sector and technologies applied by them. Briefly are discussed the potential of Georgia's renewable energy resources, including hydro, wind and solar energy, geothermal waters and forest resources potential.

The transportation of energy carriers on the territory of Georgia is discussed in detail. On the background of energy resources` international trade and, especially, considering the prospects for the development of Caspian deposits, present systems of oil transportation in Georgia are described. The technical and technological features of the Western route of Baku-Supsa Azerbaijan crude oil pipeline and the Khashuri-Batumi oil product pipeline are given, suggesting the necessity for the restoration of the last one. The main gas pipelines crossing the territory of Georgia are described and the prospects for their reconstruction and development are reviewed. According to different sources the Caspian oil and gas reserves are estimated along with their export potential. The export-import potential of the Black Sea ports is determined and their role on the international energy carriers market is analyzed. The short, medium and long range prospects for the transportation of Caspian oil and export of natural gas are examined along with the assessment of revenues which should be got as a result of taxation for their transit through the territory of Georgia. Finally, the estimates are made of CO_2 emissions resulting from the non-efficient technologies operating in energy resources extraction and transportation sector, according to which it would be possible to save annually about 3.2 thousand tons of CO_2 emission only in the coal mining sector.

1.3. Inventory of Technologies Applied in the Energy Sector and Assessment of their Efficiency

In the energy generation sub-sector the electricity and power generation modules are discussed separately by the state of 1990 and 1999. It is shown that in the electricity generation module as far back as in 1990 the volume of electricity generated at the thermal stations made 61.24 % of the design value, while at the large and medium-size hydro power plants it made 74.15 % of design value. At the Tbilsresi specific rate of conventional fuel consumption exceeded by 28 % the design value that was caused by the termination of amortization period of the main units. Similar to this, in 1990, due to the technical state of HPPs, the combined design value of installed capacity utilization coefficient for them, equal to 43.36 % was actually reduced to 32.15 %. By this year 20% of totally generated electricity was supplied to the population, while 80% was used by the industry and other consumers.

For 1999 the situation has worsened significantly. At the thermal electric stations electricity generation made only 15.85 % of the design value while at the large and medium HPPs this figure fell down to 65.51 %. The installed capacity utilization coefficient for the thermal stations was reduced this year from the design value of 68.49 % to 10.85 %, and for the HPPs-from 43.60 % to 28.60 %. The structure of electricity consumption underwent basic changes as well-electricity supplied to the population made 42.9 % of total generation, while the industry and other consumers used 57.1 %.

The comparative energy efficiency analysis has been carried out for the objects, operating during the mentioned years in the electricity generation module. As a result of this analysis it is established that the major condition to overcome the energy crisis in Georgia is the increase of basic capacities and corresponding generation. For this reason in the first place it is necessary to reconstruct Tbilsresi and the Tbilisi CHP Plant, as well as to construct on the basis of modern gas-turbine units some new thermal electric stations of 200-250 MW capacity, operating on the combined cycle. The optimal version of their disposition must be based upon the minimization of electricity flow between the energy generation and consuming regions.

The thermal energy generation module is reviewed mainly by the state of 1990, as after the collapse of the USSR the heat supply system in Georgia ceased functioning in 1993. The scale and capacity of heat supply system operating in Georgia in 1990 is described, its low energy efficiency is demonstrated ensuing from the low prices on fuel and the backwardness of applied technical means and technologies. It is mentioned that since 1995 the process of autonomous boilers introduction has begun, though it is entirely insufficient yet for the heat supply of population. By 1999 the absolute majority of population used stoves operating on different fuel for heating the safety of which is remarkably low.

The assessment of CO_2 emissions reduction potential in electricity and power generation modules has shown that in the electricity generation module only by restoration of design efficiency in 1990 it was possible to save more than 1 mln tons of CO_2, and in 1999-more than 929 thousand tons. The same estimation for the thermal energy generation module gives more than 400 thousand tons of excessive emission of CO_2 in 1990.

In the energy transmission and distribution module the 1990 and 1999 states are described separately for the electricity and power. In the electricity sub-module the main parameters of high voltage (500-35 kV) transmission lines and substations are given, the comparative energy efficiency analysis for the objects operating in the transmission and distribution system is undertaken and the necessity for the modernization and reconstruction of system is demonstrated. By the same way, in the thermal energy sub-module the low efficiency of technologies being applied by 1990 is revealed, that caused excessive consumption of fuel. Comparing actual losses with the design values the potential for the reduction of CO_2 emissions in both sub-modules is estimated, which resulted to be equal for electricity 64.6 thousand tons in 1990 and 21.0 thousand tons in 1999. For the thermal energy the relevant value in 1990 made 422.6 thousand tons.

In the energy consumption module the drastic changes are described, that took place in the use of both kinds of energy since 1991, after the disintegration of the USSR. In the electricity sub-module the analysis is given of energy losses in municipal and residential sectors by the state of 1990 and 1999, and the low energy efficiency of most part of applied devices is demonstrated. The energy losses are analyzed separately for the city above-ground and underground transport, as well as for the railway network. In the thermal energy sub-module the state of 1990 is described, notable for squandering of energy and unjustified excessive spending of fuel. By comparing the actual and design values of losses it is derived that in 1990 due to the inefficient use of electricity the CO_2 extra emission in the residential and municipal sectors made 583.5 thousand tons, and in 1999–452.2 thousand tons. Respectively, in 1990, due to excess losses of energy, the CO_2 extra emission equaled to 389.1 thousand tons.

To foresee the future demands of energy and industry sectors the scenarios on electricity demand in Georgia till 2020 have been developed using two different approaches. In the first case estimations were carried out in the assumption of linear growth of country's economy with two distinct rates, and in the second case-considering the non-linear processes taking place in the country's economy. In the firs approach for the various options of the national economy development the value of anticipated integral consumption by the year 2020 has been obtained in the range of 16.5-20.1 billion KWh, while in the second approach-17.4 billion KWh (including technical losses). By the way, in the first approach, aiming the regional projection of electricity demand, Georgia has been divided into 5 power industry regions for which, taking into account their specific character, the projection of consumption has been carried out separately. In relation with this problem the features of existing and prospective hydro and thermal power plants, as well as high voltage electric transmission lines have been discussed along with their links with energy systems of neighboring states.

1.4. Industry Sector

The description of industry sector begins with the general review of the sector and its resource base by the state of 1990. Information is given on its sectoral structure and mineral recourses potential. The change in sectoral structure of industry by the year 2000 is revealed. The features of GHG emissions from the industrial processes according to different sub-sectors are given for 1990 and 2000, as well as the data on energy consumption by them and on the associated GHG emissions. It is shown that since the beginning of economic crisis in 1991 the GHGs total emission from the industry sector has dropped in 2000 by the order of magnitude compared with 1990. A brief analysis is given of the causes of industry sector rapid decline and of the reasons for its slow recovery in recent years. The examples of the revival of individual sub-sectors of industry are reviewed, which indicate the possibility of successful performance under the foreign investments of enterprises and sub-sectors using local row materials and applying modern technologies. The regional features of industry sector functioning is analyzed and a number of measures are proposed to pull out the sector from the crisis.

Relatively in more detail is discussed the existing state in some sub-sectors of industry, which make the greatest contribution to the total emission of GHGs from the sector.

In the module of iron and steel industry the Rustavi Integrated Steel Plant and the Zestaponi Plant of Ferroalloys are examined. For the Rustavi Plant the main rings of the cast steel production by the state of 1990 and 2000 are presented along with major features of plant’s functioning and GHGs emissions from it. It is shown that due to the application of outdated technology the CO_2 emission intensity, related to the production of 1 ton of cast steel, in 1990 exceeded by 80-90% the CO_2-intensity of similar enterprises in other countries, using the same process routes. Recommendations are given for the raising of energy efficiency in case of restoration of the enterprise as Integrated Steel Plant. For the Zestaponi Plant a brief description of technological steps are presented by the state of 1990 and 2000 along with data on main features of plant’s functioning and GHGs emissions from it.

In the cement industry module after a brief overview of modern world practices in this field the data are given on the operation and efficiency in 1990 of two existing cement plants (Kaspi and Rustavi) in Georgia. The necessity for significant increase of energy efficiency and, in particular, of dust-catching efficiency at these enterprises in demonstrated.

The main features of the functioning in 1990 and 2000 of timber, wood processing, cellulose and paper industry are presented. By comparing with international standards it is shown that in view of the use of outdated machinery and inefficient technologies the actual overall energy consumption in 1990 in this sub-sector of industry exceeded the recommended values by 24.8% on the average, while in 2000 this factor increased up to 41.0%.

As a result of comparison between actual and design values of energy losses in the energy and industry sectors the data has been obtained which was used to estimate the GHGs emissions reduction potential in different modules of energy sector and in leading sub-sectors and enterprises of the industry sector. It has been derived that by the state of 1990 the extra emission in the industry sector made 2.373 mln tons, while in 2000 it exceeded 1.354 mln tons. In the selected enterprises of industry sector representing chemical industry, metallurgy, cement production, food industry and wood-processing, the potential of CO_2 emissions reduction by the state of 2000 made 655.2 tons. In the energy sector for the increase of energy efficiency 4 project proposals are discussed in the current project, the adoption of which could make it possible to save annually 237.4 thousand tons of CO_2. Separately has been assessed the possibility of the reduction of technical losses from the Tbilisi gas distributing network. This led to the conclusion that from this source it would be possible to save additionally GHGs emissions equivalent to 253 thousand tons of CO_2 annually.

Finally, the barriers existing to the process of transfer and adoption of energy efficient technologies in the Georgian energy sector are reviewed and recommendations on the activities to remove them are proposed.

1.5. GHG Emissions Abatement Technologies and Measures

Along with the provision of compliance with the design parameters the second effective way of GHG emissions reduction is the introduction of modern environmentally friendly technologies. Using different sources in the framework of the present project new technologies have been identified suitable for Georgia's conditions, the adoption of which in the energy and industry sectors would significantly contribute to the reduction of GHG emissions from the territory of the country.

In the energy sector most contemporary technologies are related with the transportation and processing of energy carriers. In particular, the technologies of pre-mining degasification and Gob Well recovery in coal beds are discussed, which could be successfully applied at the Tkibuli and Tkvarcheli deposits after the restoration of full-scale operations there. The technologies for the rehabilitation and efficiency increase of oil and natural gas pipelines are considered along with the up-to-date technologies for reducing emissions from them. In the energy generation module the modern co-generation units are reviewed, the application of which at the Tbilisi CHP Plant is examined in a separate project proposal. New technology of biomass-fired power generation is mentioned as well.

In the industry sector new energy efficient technologies in the iron and steel production are discussed and the introduction of some of them at the Rustavi Metallurgical Plant is proposed. This problem in more detail is considered in the second part of Project Report, in the frames of relevant project proposal. In the module of cement production the information on energy efficient technologies is given as well and the possibility of their use in Georgia's conditions is discussed in general terms. To this subject is also devoted a project proposal included in the second part of the Report. In the end a list of reviewed technologies and their main features is given.

1.6. Raising of Public Awareness

In the framework of the current project the activities were continued on the raising of public awareness on the Climate Change problem that began during the implementation of the initial phase of the project. The Project Management Team established close contacts with the managers of different state bodies and organizations related to the energy efficiency problem in the energy and industry sectors. In the implementation of the project experts have been involved representing the Department of Science and Technologies, the Georgian Technical University, Georgian Parliament, Ministry of Environment, Ministry of Economy, Industry and Trade, National Agency on Climate Change, various design institutions and some large industrial enterprises. In all, about 20 national experts have been trained in identifying the compliance of currently applied technologies to the principles of the UNFCCC and the benefits of the introduction of advanced technologies in the energy and industry sectors.

Through the implementation of the project the Project Management Team and leading experts frequently met with managers of Rustavi Metallurgical Plant, Zestafoni Plant of Ferroalloys, Rustavi and Kaspi cement plants, Rustavi Chemical Enterprise "Azoti", separate enterprises of energy sector, Tkibuli mines, companies engaged in the transportation of oil and gas, important enterprises of food industry and Tbilisi gas distributing company. As a result of these meetings valuable material has been obtained which was used in the compilation of Project Report and, in particular, for the preparation of project proposals.

One of the major events in raising public awareness on the problems of energy efficiency and technology transfer was the project concluding workshop, held in December of 2001 at the UN Georgian Office in Tbilisi. The subject of the workshop was Energy efficiency in Georgia, barriers to energy efficient technology transfer and ways to remove them. Representatives of more than 15 governmental bodies, academic institutions, NGOs and large industrial enterprises took part in this two-day meeting, which enabled them to discuss a number of urgent problems and coordinate their activities in the mentioned field.

Separate items of activity, carried out under the project programme were periodically reviewed in press, and in TV and radio interviews of project managers. They were discussed also in the No10 issue of Bulletin of the National Agency on Climate Change, published in Georgian and English and widely distributed among the concerned organizations both is Georgia and abroad.

1.7. Conclusions

In the concluding part of the report the special importance of implemented project is stressed for such country with economy in transition as Georgia is, where for many decades all sub-sectors of economy were functioning using outdated and inefficient technologies on the background of squandering energy policy. Offering of modern energy efficient technologies to sub-sectors and enterprises of energy and industry sectors, which are experiencing the rehabilitation and restructuring processes, is an urgent condition for the sustainable development of the country.

It is mentioned that from the two sectors being examined in the project, particularly interesting results have been obtained for the energy sector-1345 objects, operating in the generation and transmission modules have been described in detail and their energy efficiency has been estimated by the state of 1990 and 1999. The database has been created using the collected materials. In the consumption module completely has been described railway transport, subway, trams and trolleybuses, and in general terms-the residential consumption. Along with the energy efficiency, the quantity of greenhouse gases has been estimated which could be saved even in case of the restoration of design efficiency of applied technologies. It has been derived that in this circumstances it would be possible to save annually at least 1.46 mln tons of CO_2 in the energy sector.

On the basis of obtained results those inefficient objects have been assessed, in which the raising of energy efficiency by the adoption of modern technologies could bring significant economic and environmental effect–the Tbilisi CHP Plant from the generation objects, modern electric gas switches in the energy transmission module and energy efficient lamps for street and indoor lighting in the consumption module. These results have gained much interest from the side of those organizations in Georgia which is directly related with the energy and efficiency problems.

As to the industry sector, the work being done in this direction represents a first serious step to assess this sector and to offer the recommendations in the light of the UNFCCC. For a number of important enterprises the energy efficiency of separate technological steps has been assessed and some proposals have been prepared to increase this efficiency. Accordingly the quantity of GHGs has been estimated which it would be possible to save in case of the adoption of proposed measures or the introduction of offered technologies.

As a result of the implementation of the project it became obvious that without the execution of such type of activities it is actually impossible to carry out effectively the Convention principles in the country. Major barriers on the way to solve this problem are the still low awareness of society on the environmental principles and the difficulties concerning the coordination of actions between different entities for the practical realization of these principles.

1.8 Project Proposals on the Abatement of GHG Emissions in the Energy and Industry Sectors

In the second part of the Project Report project proposals are given aimed at the adoption of new energy efficient technologies in the energy and industry sectors, and corresponding abatement of greenhouse gas emissions.

? *Modernization of Tbilisi CHP using new energy efficient technologies*

The current state of Tbilisi CHP is reviewed. The inefficient and outdated technologies, currently applied at the CHP are described, and the necessity of their modernization is argued. For this purpose, after the relevant selection, the “FT8-30” type energy efficient gas turbines produced by the company “MAN GHH Borsig” are offered along with “Heat Recovery Generator” type steam boiler utilizers as a base units. It is suggested that following the reconstruction, the efficiency of CHP would increase from the present value of 23.4 % up to 60%, while the specific consumption of fuel would decrease by 61-53%. This will result in the reduction of current CO_2 emission by 98 thousand tons annually.

? *Adoption of new commutation technologies for the high voltage transmission lines*

The high voltage (500 and 220 kV) switches, currently operating in the high voltage sector of Georgian energy system are described. The necessity for the replacement of old-fashioned gas and oil switches by the contemporary electric-gas switches is argued. By the corresponding calculations it is shown that the introduction of selected electric-gas switches produced by Siemens and Alsthom would provide substantial economic and environmental efficiency. In particular, the replacement of 40 gas switches operating in the Georgian energy system by the mentioned electric-gas switches will ensure the saving of more than 1 thousand tons of CO_2 equivalent emissions annually.

? *Introduction of energy saving technologies for street and indoor lighting*

For the perfection of street lighting systems currently operating in Georgia the import and adoption of energy efficient starting devices for the energy saving lamps of street lighting is offered as well as the introduction of autonomous solar lighters for the same purpose. It is shown that as a result of these measures it would be possible to save annually GHG emissions, equivalent to about 1 thousand tons of CO_2.

Instead of currently applied incandescent lamps for indoor lighting the perfection of modern energy saving lamps is proposed on the basis of authors` original know-how, the arrangement of their production in Tbilisi using the existing base and wide-scale introduction in Georgia and in neighbouring countries. After the review of features of the energy saving lamps of different production, the Chinese made "Topstar Jia-Mei" type lamps are chosen for the adoption in Georgia. According to performed estimations, the replacement all over the country of 1 million of 100W lamps by 20W lamps of a new type would provide saving of 146 mln kWh of electricity, that is equivalent to the abatement of about 38 thousand tons of CO_2 emission.

? *For the Rustavi JSC "Azoti"*, which is the largest enterprise of the Georgian chemical industry, main operational features are reviewed by the state of 1990 and 2000. The analysis of energy consumption by the major units of the enterprise with the associated GHG emissions, as well as of technological emissions from these units made it possible to reveal those rings, which are making predominant contribution to the emissions in the atmosphere. The efforts aimed at the modernization of JSC "Azoti" are discussed and the high efficiency of proposed measures is demonstrated. In particular, as a result of their implementation it would be possible to reduce annually the CO_2 emission by 31 thousand tons, as well as the emissions of other GHGs on a significant level.

? *For the Rustavi Metallurgical Plant* a project proposal is discussed on the reconstruction of open hearth furnace, which envisages the installation of electric arc furnace, continuous casting and new rolling units at the steel making mill, as well as the modernization of other auxilliary operations. On the basis of relevant calculations it is derived that the introduction of these measures, which foresee the application of modern energy efficient technologies, could result in the annual saving of about 308 thousand tons of CO_2 comparing with current technologies.

? *In the sector of bread industry*, after a brief review of fundamental changes, which took place in this sub-sector of industry for the last decade, the energy efficiency features and the prospects of the introduction of new technologies are discussed for 3 selected enterprises. As a result of relevant assessments it is derived that the adoption of proposed measures at the Tbilisi N4 bread-baking plant would provide the annual saving of CO_2 emissions by 413 tons, at the JSC "Temkis Puri" –by 310 tons, and at the JSC "Spaghetti-94"- by 1870 tons.

? *For the Rustavi Cement Plant*, along with the Kaspi Cement Plant, the main features of cement production, energy consumption, emissions of GHGs and the cement dust are discussed by the state of 1990. For the Rustavi Plant the inverse correlation between specific energy consumption and dust-catching efficiency is shown. The assessment of necessary expences and the resulting economic effectiveness is carried out for the case of 99% efficiency of dust-catching system at both plants. It is demonstrated that even in case of adoption of only this measure it would be possible to save about 90 thousand tons of CO_2 at each plant annually. Finally, a number of proposals are given on the introduction of new technologies at the mentioned plants, among them list of measures worked out by the JSC "Rustavcementi". Along with the corresponding economic estimations these measures foresee the transfer of the plant from the "wet" to the "dry" process, the installation of modern dust-catching filters and other activities which would significantly raise the energy efficiency of the enterprise and reduce ints loading on the environment.

2. MAIN OBJECTIVES OF THE PROJECT

Georgia had prepared its initial national communication to the UNFCCC (to which the country was joined in 1994) under the financial assistance of the Global Environment Facility (GEF) in 1997-1999. During this period, the technical, economic and staff potential of the National Climate Research Center – executing body of the convention principles in the country was continuously increased under the support of the above-mentioned program and the country government. This organization was formed in 1996 under the Decree of the President of Georgia and its objective was the examination of scientific, economic and political issues and problems related to the climate change and the submission of the corresponding recommendations to the Georgian government. The results of the initial national communication were submitted at the COP-5 in autumn 1999 in Bonn, Germany. Periodicity of preparation of the national communication by the non-Annex I countries and the relevant financial mechanisms are not identified according to the principal document of the Convention, that causes danger for the preservation of local potential created within the preparation of the initial national communication in the developing and transitional countries. The decision on application of GEF financial mechanism for the elaboration of the second national communication of non-Annex I countries was made at the Conference of Parties in accordance with the insistent demand of the mentioned countries in 1998 at the COP-4 in Buenos Aires, Argentina. Despite this decision, the Guidelines and the document submission exact procedure are not elaborated by the GEF, yet. To avoid the anticipated break between the national communications and to preserve the local potential, the countries were granted the interim support with more simplified procedure in the framework of which the country should select one issue out of the following three ones to be implemented: examination of demand for the modern technologies in the country, working out of the programs related to the climate change (among them is the specification of GHG emissions factors) and perfection of systematic observations network.

After the consultations between the executive group of the initial national communication, the Ministry of Environment and the GEF Operational Focal Point in 2000, it has been decided to use these project for the examination and assessment of the current status of the country from the energy efficiency standpoint and for capacity building to assess the needs in the GHG emissions reduction technologies, because full involvement in the technology transfer process, at this stage, is one of the crucial tasks for Georgia.

The project was started in October 2000 and was terminated in March 2002. The state of energy and industry sectors in 1990 and 1999-2000 were reviewed in the framework of the project. 1990 was examined, because the UNFCCC regards this year as the baseline and as compared to it, GHG annual emission should be 5% less all over the world by the year 2012. This is important for the stabilization of GHG concentration in the atmosphere and for ceasing its growing. The state of 1999-2000 corresponds to the current condition. Trends for some rings of the energy sector were assessed within this interval.

It has to be underlined that the depth and quality of examination of these two sectors is very different that has its objective and subjective reasons. In particular, all rings discussed in the energy sector: resources, their extraction and transportation, thermal and electricity generation, transmission and distribution of thermal and electricity and consumers were carefully examined by the state of 1990 and 1999-2000 as well. The situation is different in the industry sector that is still in a grave condition. Related to this fact it should be noted that such results were anticipated, as the energy sector was the first one out of the sectors of economy that had raised the interest of the National Agency on Climate Change. In 1980-1990, this very sector was the major GHG emitter in Georgia and it has the greatest potential of GHG limitation and reduction due to the vast amount of the renewable energy resources available in Georgia and to the enormous low energy efficiency at present. After establishing the close contacts with the representatives of this sector, examination of problems in the sector and working out of the specific project proposals since 1997, inventory of the technologies operating in this sector and their assessment from the energy efficiency standpoint was performed within the current project. The relevant computer database has been created and GHG abatement potential was assessed for two directions – in terms of raising of the existing technologies energy efficiency up to the design value and in case of introduction of the contemporary GHG emission saving technologies.

As to the industry sector, the obtained data are not sufficient, but at this stage the obtained database could be regarded as satisfactory. This sector was not thoroughly examined in the initial national communication, as in the 1980-1990 GHG emissions from this sector were relatively low as compared to emission from the energy and transportation sectors. Share of this sector in the total GHG emission could be relatively small, but the reduction potential is rather high and what is most important, it makes possible to introduce the latest energy efficient technologies in this sector under the preferential loans according to the convention mechanisms. This fact is the most important for the revival and sustainable development of the sector. Within this project, the awareness of managers of the large enterprises functioning in the industry sector concerning the existing possibilities was raised and the appropriate relations were established. It gives hope for thorough examination of the mentioned sector at the following stages, working out of more project proposals and filling up of the database, the structure of which was elaborated in the framework of the current project, though it is filled only for some large enterprises, and incompletely as well.

Another main goal of the project was working out of economically effective project proposals on GHG emission abatement as a result of introduction of energy efficient technologies, or by the implementation of measures that should promote the energy efficiency raising. In this regard, four project proposals were elaborated for the energy sector: modernization plan for Tbilisi CHP was discussed in the generation ring, adoption of high voltage modern switches – in the distribution ring, production and application of energy efficient lamps for indoor and street lighting – in the consumer ring. Material for the elaboration of the project proposals concerning the reduction of technical losses from the Tbilisi natural gas distribution network was prepared separately. Project proposal, on replacement of steam boilers existing in the Bakery Plant N4 in Tbilisi by more energy efficient modern steam boilers, was worked out in the electricity, numerous of measures that would significantly reduce GHG emission were identified at the JSC "Azoti" in Rustavi, project proposal on the improvement of process energy efficiency and saving of the consumed energy resources was worked out for the Rustavi Metallurgical Plant.

One more crucial aim of the project was searching for the GHG emissions abating technologies existing at the international market, their evaluation from the standpoint of expediency of their application in the Georgian condition and creation of the computer database of these technologies. Numerous technologies were revealed and reviewed during the project implementation. Creation of database, at this stage, is not expedient, as the technical base of GHG emission abatement created for the developing and transitional countries has been revealed. In fact, this database is more comprehensive than would be ours. Therefore, getting of the existing software under the technologies transfer program and making its Georgian version will be more effective for the Georgian manufacturers. Despite the already started co-operation with the international organizations, the earlier-mentioned base on technologies inventory is not still obtained, but the National Agency on Climate Change continues the appropriate activity in this direction and hopes to get it in the nearest future.

3. GEORGIAN ENERGY RESOURCES

INTRODUCTION

By the beginning of XXI century one of the main global problems is the sustainable development of humanity based upon the harmonic combination of environmental protection and economic progress.

Georgia, like other independent countries formed after the disintegration of the Soviet Union, is intensively involved in this process. These countries, along with the other economic difficulties characteristic for the transition period, are facing the urgent necessity to substitute the inherited energy-wasting technologies.

According to the principles of Kyoto Protocol, the integration process strategy of Georgia and other transitional countries into the world economy should be closely linked to the replacement of old technologies by energy-efficient, environmentally friendly technologies and intensive substitution of environment polluting fossil fuel, rich in carbon, by fuel containing rather less amount of carbon and by the renewable sources of energy.

Projection of local fuel resources and/or possibility of their import are necessary to solve that problem of strategic importance. It provides the reasonable planning of their effective application and speedy adaptation of environmentally sound technologies in the industry and energy sectors.

The main attention in the presented report on fuel and energy resources and transportation of energy carriers is attached to the statistical data on extraction, import and consumption of fuel and energy resources of Georgia, to the technologies applied in these processes and problems of their possible improvement.

3.1. ENERGY RESOURCES ALL OVER THE WORLD AND IN GEORGIA

3.1.1. World Energy Resources

The increase of energy resources consumption intensity was actually going on by the traditional rate during the last quarter of the XX century as well as during the whole human development history.

Nevertheless, the structure of world fuel resources consumption undergoes the considerable changes. Since the 70's traditionally dominated solid fuel has been gradually substituted by oil products. In the last period oil is being replaced by natural gas, which is characterized by high technological and ecological features and also by renewable energy sources (Fig. 3.1.1).

About 60% of world fossil fuel resources are represented by coal. Its reserves are relatively unevenly distributed over the territories of about 90 countries, while the liquid and gaseous hydrocarbon fuel resources are mainly located only in some regions of the world. That is dominant stimulator for intensive international trading by oil and natural gas. Traditional demand for energy resources and delivery possibilities were unbalanced between the different regions of the world – industrial countries had lacked enough resources, but the developing countries were able to produce rather more resources than their demand. Gradually, owing to the international trading by energy resources, this problem became regulable and mutually beneficial. Developing countries obtained the leading technologies and plenty of additional subsidies for the economic development in return for the hydrocarbons export. The export rate for the coverage of oil demand in different regions of the world has increased by 16% in the last decade. This process would become more intensive in future, e.g. by 2010 about 70% of consumed solid energy resources and natural gas and more than 90% of crude oil demand would be covered by imports in Europe.

The prospecting of crude oil and natural gas new resources are successfully going on during the last period. From the end of 80s the world reserve of explored crude oil was increased by 25%. During the last twenty years natural gas world reserve was doubled. It's anticipated, that filling up of oil and especially natural gas resources will be continued, the Caspian deposits were playing the significant role in this process.

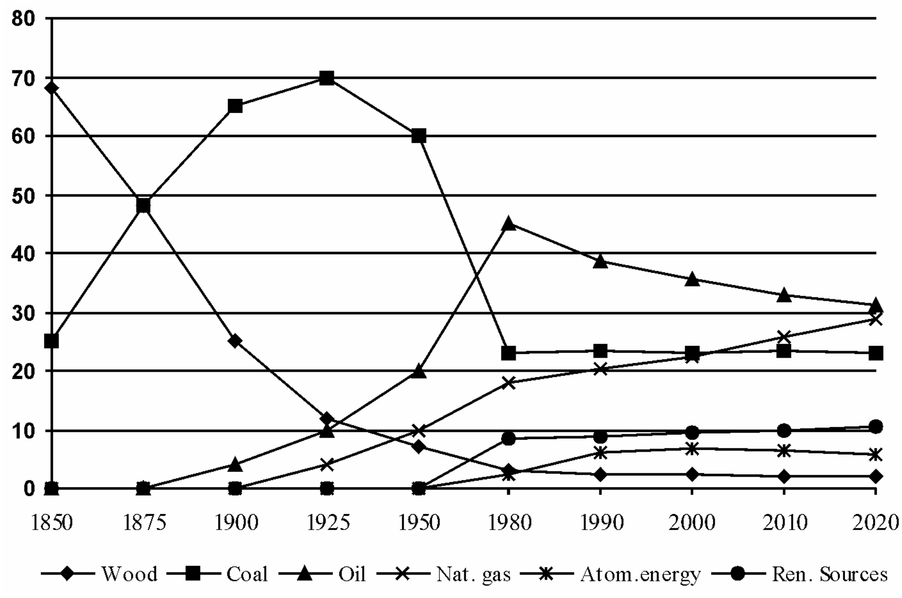


Fig. 3.1.1. Variation of energy carriers consumption in the world, %
(historic and projected)

3.1.2. Fuel Resources Consumed in Georgia

Conditionally, two periods should be examined while analyzing the structure of fuel resources consumption in Georgia. The first one includes the period till 1991, when the economy of the country was more or less stable within the entire centralized state. The changes in fuel resources consumption structure, familiar for this period, reflect the current world tendencies – utilization of oil products and solid fuel is reduced and becomes stable, while consumption of natural gas and hydro energy is significantly increased.

The primary energy resources consumption per capita in the former Soviet Union was equal to Europe and significantly exceeded to world average indices. Primary energy resources consumption per capita in Georgia was lagged behind the average Soviet features, but was nearly equal to the rate of European countries located in the same climatic conditions.

In the second period, which began after the disintegration of Soviet Union, the rate of primary energy resources consumption is considerably reduced in Georgia, though during last years it is about equal to the world average indices. According to the experts' estimation the level of per capita consumption may reach 2.0-2.9 toe in Georgia by 2005-2010 (Tab. 3.1.1, 3.1.2, 3.1.3, 3.1.4 and 3.1.5. historic and projected data on extraction, import, export and consumption of energy resources).

Table 3.1.1. Extraction of primary energy resources, equivalent to 1000 t of oil (toe)

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Oil	180	190	135	42	51	52	128	134	120	91	110
Natural gas	51	50	40	40	8	8	0	0	0	20	75
Coal	410	300	35	36	19	18	10	2	6	5	3
Renewable resources in total	903	993	1101	1388	1677	1070	1442	1322	1112	1121	10.04
Among them firewood	230	336	525	803	1217	525	910	750	547	550	500
Among them hydro resources	673	657	576	585	460	545	532	572	548	571	504
Total	1550	1533	1311	1506	1755	1148	1570	1458	1238	1237	1192

Table 3.1.2. Import of primary energy resources, equivalent to 1000 t of oil (toe)

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Oil	2132	1729	315	280	0	0	0	27	0	0	40
Natural gas	4400	3845	3833	3069	2003	935	1775	1896	684	690	879
Coal	385	280	220	53	35	2	5	5	2	3	5
Electricity	284	220	104	74	60	60	20	56	60	38	38
Coke	87	84	87	42	33	4	0	0	10	0	0
Oil products	4653	2953	3020	2482	2284	1291 (3688)	978 (2575)	1034 (2955)	1229 (3560)	1260 (3600)	1240 (3540)
Total	12150	9111	7579	6000	4415	2292 (4689)	2758 (4538)	3018 (4939)	1989 (4316)	1991 (4331)	2202 (4502)

Table 3.1.3. Export of primary energy resources, equivalent to 1000 t of oil (toe)

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Oil	0	0	0	0	0	0	113	131	54	40	35
Coal	308	175	70	11	7	7	1	1	1	0	0
Oil products	980	403	295	148	0	0	110	86	81	20	8
Electricity	0	0	0	0	0	0	11	40	69	33	17
Natural gas	0	0	0	0	0	0	928	1163	NA*	NA	NA
Total	1288	578	365	159	7	7	1163	1421	205	93	60

*NA – data not available

Table 3.1.4. Processing of primary energy resources, equivalent to 1000 t of oil (toe)

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Oil processing	2318	1920	447	321	50	50	0	27	50	65	118
Coke industry	401	140	0	28	0	0	0	0	0	0	0
Total	2719	2060	447	349	50	50	0	27	50	65	118

Table 3.1.5. Consumption of energy resources, equivalent to 1000 t of oil (toe)

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Natural gas	4451	3895	3873	3109	2011	943	612	733	684	690	934
Oil products	5991	4470	3172	2655	2334	1341 (3738)	874 (2480)	975 (2785)	1223 (3563)	1260 (3600)	1254 (3580)
Coal and coke	574	489	272	120	80	17	14	6	17	12	12
Imported electricity	284	220	104	74	60	60	20	56	60	38	38
Fuel wood	230	336	525	803	1217	525	910	61 (744)	547	70 (500)	78 (500)
Hydro resources	673	657	576	585	460	545	532	572	548	554	(504)
Resources in total	12203	11060	8522	7346	6162	3431 (5828)	2962 (4568)	2403 (4902)	3079 (5419)	2656 (5426)	2927 (5530)
Among them power engineering	2730	2365	2045	1658	1508	1580	1220	939	1000	1033	984
Boiler houses	2617	1223	1322	853	325	323	94	0	0	155	0
Industry	1440	2225	1302	986	955	273	386	381	327	342	347
Construction	127	92	123	120	86	-	38	57	56	NA	NA
Transport	1341	1151	953	799	748	343 (1000)	296 (1000)	552 (1250)	258 (1250)	543 (1500)	603 (1500)
Residential sector	1447	1428	1756	2099	1830	601 (750)	412 (1000)	436 (1250)	1406	925	1055
Agriculture	536	350	242	199	189	95	76	78	114	36	142
Other consumer	392	407	321	324	303	35 (200)	54 (200)	202	338	267	291
Total for consumption	10630	9241	8064	7038	5944	3215 (4186)	2576 (4014)	2640 (4151)	3172 (4441)	3361 (4318)	3422 (4319)

While analyzing the data presented in the Tables, we should consider that the formal statistics doesn't include import and export operations carried out by the private sector when old, centralized system of calculation and stock-taking was paralyzed (beginning and middle of the 90's). In addition, according to the international experts' estimation, only 20-40% of imported oil products are included in customs registration. Correspondingly, approximate figures are given in the columns of oil products import and consumption. Expediency of such assumption is also proved by the analysis of the primary energy resources' consumption dynamics. Oil products consumption in transportation sector could not be reduced so sharply as it is reflected in the official statistics (see data on oil products import and consumption by transport in 1995-1999) considering the fact that during last years the traffic of special cars (microbuses, transit transports for international freightage) has significantly increased as well as the number of passenger cars in the country. Sizeable reduction of internal transportation (especially for industrial and agricultural needs) also could not significantly influence such tendency, as at present the trucks engaged in this sector mainly serve internal trading and distant transportation. In our estimations it is assumed that not more than 35% of oil products actual import is revealed in official statistics (data after 1995 presented in the Table), while the evaluation of consumed oil products is considered with one more additional term according to which the reduction of oil products consumption during the economy revival period (since 1995) is excluded.

As a result of analysis it is evident that the official statistics on fire wood production and consumption is also insufficient. Owing to this fact, the data is corrected considering the results of examinations especially dedicated to this issue. The examination was carried out in the frames of TACOS program (Project GEE/95/92 "Technical Assistance on the Production and Consumption Level"). On the basis of examination undertaken in the above-mentioned project framework it was determined that per family average wood consumption is 6 m^3 (9-10 m^3 in piles). Consequently, the total consumption of rural families for which wood is accessible, makes about 2430000 m^3 annually (450 thous. toe). Here also should be added fire wood (equivalent to about 100 thous. toe) utilized for heating of rural educational and administrative institutions. Thus, it eventually leads to about 550 thous. toe (approximately 3 000 tous. m^3) of wood annual consumption by 2000.

The projected fire wood consumption in the rural areas of Georgia, where this fuel is available (economically reasonable and without impact on environment if wood resources utilization rules are protected) may constitute 350 thous. toe for families and educational institutions heat supply.

The structure of consumed fuel resources undergoes the sizeable changes in the last period. In the conditions of economic crisis the consumption of expensive imported fuel resources (crude oil, natural gas, coke) was restricted along with the increase of local hydro resources and wood consumption. Contrary to the early assumptions, local coal consumption was sharply reduced. It is mainly connected with the technological and ecological problems of its utilization and also with the high prime cost of its extraction in case of small enterprises.

As it was expected, the complete substitution of imported fuel appeared impossible. This circumstance fostered the drastic deficit of energy resources in the country and it became one of the stimulators to disintegrate the economy of the country.

Retrospective analysis of fuel resources consumption in the different sub-sectors of Georgian economy before the crisis indicates that for a long time one of the largest and permanent consumers of fuel resources was energy sector. Approximately 20% of total amount of resources are consumed by this sector. The situation has changed after the crisis began. Share of energy generated at the thermal electric stations was gradually reduced that was linked to the decline of imported fuel supply due to low solvency of the country. During last years, fuel consumption for electricity generation was 10 times less than in the 80's.

More impressive is the reduction of fuel resources consumption in the other sectors of industry and economy that is mainly explained by high energy capacity of products generated in these sectors and correspondingly their low competitiveness on the international market and also by the delayed structural reorganizations in the market economy terms. It should be supposed that in the nearest future the broad utilization of local hydro-, other renewable resources and partially of coal would be necessary to cover the deficit in electricity sector, production of building materials, food industry and agriculture, residential sector, etc. In the predictable future (till 2010-2015) hydrocarbon fuels will retain the leading position that undoubtedly would be facilitated by the status of Georgia as Caspian oil and natural gas resources main transit country.

Correspondingly, the main attention in the report is paid to the possibilities of local coal (country possess the great reserve of it) and oil extraction, and natural gas and oil products import on energy resources market of Georgia and to the examination of transportation technologies to meet the needs of country's energy and industry sectors at present and for the predictable period in the future.

3.2. COAL INDUSTRY

3.2.1. Coal Deposit

Different criteria for the calculation of coal reserves were used in Georgia. For instance, 332.5 mln. tons of coal is registered on the state balance for Tkibuli-Shaori deposit, while only 218.3 mln. tons of coal was approved by the State Commission of the former Soviet Union. According to data of "Saknakhshiri" Department, the balanced reserve of operating mines of the deposit (named after Dzidziguri, Mindeli and "Dasavleti 2" under construction) is 90.7 mln. t (that is not doubtful, because of high reliability of exploration works), and Shaori coal field equals to 186.1 mln. t (that requires updating). Coal commercial reserves of operating and under construction mines of deposit are about 75 mln. t. Coefficient of extraction of the balance reserves varies within 75-84% that can be considered as unrealistic. As it is shown from the practical experience, during the extraction using the present technologies the losses are equal to about 40-50%.

According to the recommendation of foreign experts of TACIS, coal commercial reserve of functioning mines of deposit is limited (1200m of depth) and the extraction coefficient is taken within 0.5-0.7 for the different terms of stratum location. Economically beneficial reserve, after the calculation using such criteria, equals to only 50 mln. t. Data on Georgian coal reserves and projected resources are given in the Table 3.2.1.

Table 3.2.1. Coal reserves and projected resources of Georgia, mln. t (1990)

Deposit	Reserve t/toe	Projected resourse, t/toe	Total t/toe
Tkibuli-Shaori	388.3/163.1	373/152.9	761.3/316
Tkvarcheli	21.7/9	12.0/3	33.7/12
Akhaltsikhe	75.7/20	-	75.7/20
Other	7.1/3	-	7.1/3
Prospective fields	-	360/not known	360/not known
Total	492.8/195.1	745	1237.8

The coal reserve of Tkibuli-Shaori deposit is evaluated in Table 3.2.2 according to 1999 data (reserves of the other deposits were not updated during the last decade).

Table 3.2.2. Estimation of coal reserve of Tkibuli-Shaori deposit based upon the various sources, mln. t

<table>
<tr><th rowspan="2">Parameter</th><th rowspan="2">Registered on State balance</th><th rowspan="2">Approved by the State Commission</th><th colspan="2">Department of "Saknakhshiri"</th><th rowspan="2">Commercial reserve according to TACIS experts estimation</th></tr>
<tr><th>Total reserve</th><th>Commercial reserve</th></tr>
<tr><td>Total on the deposit</td><td>332.5</td><td>218.3</td><td>276.8</td><td>NA</td><td>NA</td></tr>
<tr><td>On operating and under construction mines of deposit</td><td>-</td><td>-</td><td>90.7</td><td>75</td><td>50</td></tr>
<tr><td>On the Shaori coal field</td><td>274.7</td><td>-</td><td>186.1</td><td>NA</td><td>NA</td></tr>
</table>

As it is evident from the analysis, the different sources of reserve's evaluation give the different results. At present it is more expedient to apply the criteria for estimation of reserves typical for the Western European countries, according to which the commercial reserve of Tkibuli-Shaori deposit equals to about 50-60 mln. t.

Determination of Tkibuli-Shaori actual reserve is complicated due the specific technical problems, e.g. low ratio according to data during the discussion of the new mine construction expediency, especially high category reserve with the total reserve.

Thus, it is necessary to refine actual geological and commercial reserves of Tkibuli-Shaori and other deposits considering the results of conducted detailed survey and exploration works, problem of opening and mining technology of the deposit, other technical and economic data in the context of local conditions.

3.2.2. Coal Mining Technologies Applied In Georgia

3.2.2.1. Tkibuli-Shaori Deposit

Exploitation of Tkibuli-Shaori deposit is performed by the JSC "Tkibulnakhshiri". The deposit is located in Tkibuli and Ambrolauri districts, 40-50 km north-west to Kutaisi. It is divided into two morphological units: Tkibuli hollow located in south between the altitudes 800-900m, and Shaori field located in north at the altitude 1100-1300m. They are divided by the Nakerala Ridge that surrounds the Tkibuli hollow like an arch and has maximum altitude of 1570m.

The Tkibuli part of the deposit is divided into western, eastern and south-eastern sections. Their exploitation is performed by "Dasavleti", "Imereti" and "Okriba" mines. Shaori field is divided into three sections – South or Mukhuri (north to Sabilasuri fault), Central or Kharistvali (between Sabilasuri fault and Mokhvarauli fault-slide) and North (north to Mokhvarauli). "Aghmosavleti" mine is located south to the central section; mine under construction "Dasavleti-2" and designed mine "Akhali Shaori" are located west and east to the section.

The Tkibuli-Shaori deposit belongs to complex and difficult for processing groups of deposits. It is characterized by the complex structure of coal strata represented by humic and liptobiolithic coal, coaly shale, clay, shale and sandstone layers with thickness up to 60m and variable inclination - up to 45-500C and redescent, deepness (down to 1400-1700m) and high tensity of rocks, gas content and tendency towards the manifestation of different dynamic phenomena (sudden emissions, mining shokes), spontaneous ignition and inflammability, seismic activity of the region, complex tectonics, etc. (coal marks Ã-gaseous and D-inflammable according to the Soviet statistics).

The deposit was put into operation in 1946. Four mines: "Dasavleti", "Imereti", "Aghmosavleti-2" and "Okriba" were operated on deposit in 1990. Their main technical features are presented in Table 3.2.3. As it is clear from the Table, total commercial capacity of the mines operated in Tkibuli by January 1, 1990 was equal to 9.20 thous. t. In 1990 664.6 tous. t of coal was mined on the deposit that equals to 55% of coal extracted in 1985. Among them was mined 438 thous. t of Ã mark coal and 226.6 thous. t of D mark coal. The mentioned mines are characterized by the different technical and economic features (per worker productivity, prime cost). Parameters of "Okriba" and "Imereti" mines are rather high and the indices of "Dasavleti" mine are worse.

Table 3.2.3. The main technical and economic features of Tkibuli mines (1990)

N	Mine	Date of putting into operat.	Commercial reserves till 01.I.1990 thous.t	Industrial capacities by 01.I.1990 thous.t	Extraction, thous.t		Productivity of miner labor t/month	Prime cost, roubl/t
					1985	1990		
1	"Imereti"	1941	390	-	593.4	223.2	26.6	36.52
2	"Dasavleti"	1941	110	-	125.4	70.5	15.0	62.69
3	"Aghmosavleti-2"	1973	250	-	152.8	144.3	25.9	36.64
4	"Okriba"	1948	300	-	306.1	222.6	46.6	21.70
	Total in Tkibuli		49 840	920	1205.5	660.6	-	-

"Dasavleti-2" mine is under construction in Tkibuli since 1962 and is not yet ready for operation. In 1985-86 the reserves of "Imereti" mine were reduced on the scope of transfer of the reserves located 300 m below the horizons to "Aghmosavleti-2" mine. Owing to this fact, the project concerning the reconstruction of the last one was designed. Its implementation began in 1987. Based upon this project, blind shafts of "Imereti" mine should be deepened from +350 m to +190m. Main crosscuts were constructed to +190m of main field drifts of "Dasvleti-2" mine. Reconstruction works were ceased, because of an accident in blind shaft happened in 1989.

In 1988 about 1 mln. t of coal was mined in Tkibuli. Hereafter, the coal extraction was sharply declined and it fell down to 664 and 42.65 thous. t in 1990 and 1995 correspondingly that equals to 66.3 and 4.26% of coal extracted in 1988. Only 12000 t (1.2%) was mined in 1999 and 7260 t - in 2000. Such sharp reduction of coal extraction resulted in steep increase of prime cost of extracted coal. It's enough to mention that prime cost of 1 t of coal was equal to 130 Lari in 1999, and according to the results obtained during 10 months of 2000 the prime cost was 203 Lari, while coal was sold even for 12 Lari/t.

Measures for reconstruction and development of Tkibuli mines are set in "The program for reconstruction and development of coal industry in Georgia" elaborated by former State Department "Saknakhshiri", accepted by the Ministry for Fuel and Energy and approved under the Order of the President of Georgia (August, 1997). Based upon the above-mentioned program, "Okriba" and "Dasavleti" mines due to the lack of coal reserves and high ash content have been conserved and at present their liquidation is under way.

Works on the "Dasavleti-2" mine being under construction are conserved for the indefinite time. At present only "Imereti" and "Aghmosavleti-2" mines are functioning. Reconstruction and development works for these mines planned under the Program were not implemented due to the absence of necessary investments.

The prospects for increasing the technical and economic parameters of Tkibuli mines is depended on effective mine processing technologies.

Due to mountainous relief, the mine fields are stripped by galleries. Vertical height of the floor equals to 100m. The field preparation of floor is used. Along the field drifts the floor is divided into double wing fields 120-150 m of wide. Protective layer is treated by means of entire long wall breaker with backward motion on the independent stratum drifts (on the side of goaf) or with direct motion on the group drifts (towards the massive). Extraction of protected strata all over the thickness was conducted using of blocks with horizontal columns following to the shortcut. Until 1974 progressive methods of treatment with the entire hydraulic filling up of goaf were successfully applied in Tkibuli mines. Afterwards, this method was rejected because of additional financial and labour expenditure on filling up.

Extraction method using entire long walls was commercially tested in Tkibuli, applying ÓÊÐ-1Ê, Óðàë-2Í types of combines with narrow tool and ÊÌ-87ÄÌ, 10ÊÏ, 20ÊÏ, ÊÍÊ-1 types of combines and mechanized complexes. Finally, the examination didn't reach the positive result due to several reasons. The most important appeared the difficulty concerning the delivery and stopping of filling substance back to working space (during the extraction by filling up) due to coal spontaneous ignition and underground endogenic fires (during treatment by sloughing).

Extraction was conducted in 1990 according to the version that was elaborated by the "Saknakhshiri" and Tkibuli sub-sector of A. Skochinski Mining Institute. The mentioned technology scheme as previously applied version in Tkibuli mines has the numerous shortcomings, among them are great specific length of tunnels, dangerousity of the industrial processes, especially during drilling and transportation of coal demolished from the chamber, unfavorable conditions of winnow of cleaning breaker and provision of dust and gas regime, high exploitation losses (up to 60%) and inflammability, dangerousity caused by the different dynamic processes, etc.

The above-mentioned technology entirely exhausted its potential on small and medium depths and its farther application on great depth is impossible. Thus, it is necessary to elaborate and test in the short run the alternative versions, which would facilitate the elimination of the above-mentioned shortcomings.

By the end of 80s the G. Tsulukidze Institute of Mining Mechanics of the Georgian Academy of Sciences in collaboration with "Sakhnakhshiri" and A. Skochinski Mining Institute designed the technology schemes using the means of complex mechanization for Tkibuli-Shaori mines for the treatment by inclined and horizontal strata of thick layers. It is expedient to test and apply the above-mentioned technologies in the mine fields for the treatment of inclined (up to 25-450) layers within the restoration and development process of Tkibuli mines. The special attention should be paid to the elaboration, testing and application of fire protection preventive measures over the experimental works.

Moreover, the technologies of treatment by hydraulic filling up should be applied again in Tkibuli mines. For the beginning it is appropriate to use the Tsintskila limestone quarry operating in Tkibuli region as a source of filling substance. Extracted substances should be transported by trucks and rope-way to the surface of expedient mines and be delivered to the exploitation sections by wells. After the determination of specific share of treatment technology by filling up, it would be necessary to elaborate and apply more radical measures to provide Tkibuli mines with the filling substance.

3.2.2.2. Tkvarcheli Deposit

The "Tkvarchelnakhshiri" Mines Department, which comprised No2, No3, No6 and No8 mines (by January 1, 1990) served the processing of Tkvarcheli coal deposit. The deposit is located in Abkhazia, 25-40 km north-west of Ochamchire.

Tkvarcheli deposit also belongs to integrated and difficult for processing group of deposits. Jurassic, Cretaceous, Tertiary and secondary sedimentary rocks are the components of the geological structure of the deposit. Coal bed is placed between the Jurassic sediment and is represented by sandstones, solid argillites, layers and strata of coals and high ash-content coals. Its total thickness equals to 115-250m. About 9 thin, medium and thick strata with working thickness are revealed. Coal beds' structure, thickness and angle of inclination are highly variable. Strata are often merging and branching. Quite complex tectonic structure is familiar for the deposit. Coal layer on some sections is washed and I, II …VI fields, so from each other are created in deposit contour. First field is worked out by Tkvarchely No4 mine, II-III fields were treated by NoNo1, 2, 3, 5 and 6 mines. Their main reserves are worked out. Protective pillars of tunnels and fields newly revealed on No6 mine were processed only in No2 and No3 fields. First geological section of IV field is actually worked out by No8 mine. Working of protective pillars of bind shaft and reserves located on low horizon of section was going on. Development of the work on No2 and No3 geological section of the mentioned field was planned for the future. V field with quite limited reserve is not yet worked out. Coal containing beds were not revealed on VI field and due to this fact it has no commercial importance. Marks of produced coal were Ã, Ê and Æ (gaseous, coking and fertile).

Intensive tectonic disruption mainly by faults is familiar for the deposit. Contained rocks are mostly represented by very steady rocks (sandstones). Besides the tectonic disruptions, mine fields are crossed by protective pillars located under the river that make some difficulties during the deposit's exploitation. Deposit is characterized by mountainous relief. Part of layers depth from the surface is varying within some tens to hundreds of meters and its maximum is 700-800m (on coal containing IV field). Considering the gas and dust contents, the Tkvarcheli mines belong to highest category. Layers in the IV field are characterized by spontaneous ignition and they are dangerous from the fugitive emissions standpoint.

Due to the mountainous terrain the mine fields are opened by galleries. The storey and panel-storey preparatory schemes are used. Main preparatory tunnels are placed in underlying or in lower coal beds. Upper layers are opened by winzes and crosscuts.

Thin and middle-sized layers were treated by long columns with entirely habitual breakers and caving. Treatment of sloping (up to 350m) bedss with enlarged thickness (>3.5m) was performed by caving from leading sections and treatment of inclined layers – by so called drifts method.

Coal demolishment in testing trenches was preferentially (97%) performed using drilling and explosion works. In some cases baffling hammers and combines with narrow tools were applied. The conveyers were used for coal transportation in district tunnels and wagons - in basic tunnels.

Exploitation of Tkvarcheli deposit began in 1935. Four mines were operated on the deposit in 1940, out of them: Noon 2, 3 and 6 - on II and III fields and No - on IV field. Their main technical and economic parameters according to 1989 data are presented in Table 3.2.4.

Table 3.2.4. Main technical and economic parameters of Tkvarcheli mines (1989)

No	Mines	Date of putting into operation	Commercial reserves by 01.I.1990 thrust	Industrial capacity by 01.I.1990 thrust	Extraction, thus. t		Productivity of labor t/month	Prime cost, ruble/t
					1985	1990		
1	No 2	1946	-	-	88,9	-	-	-
2	No 3	1952	-	-	136,0	-	-	-
3	No 6	1955	-	-	92,6	-	-	-
4	No 8	1966	-	-	148,0	-	-	-
	Total in Tkvarchelnakhshiri		22605	350	465,5	290,2	21,5	52,89

As it is seen from the Table, by 1/I 1990 total reserve of Tkvarcheli acting mines consisted of about 23 million ton and industrial capacities - 350 thous.t. 465.5 thous.t of coal was extracted in Tkvarcheli in 1985 and 290.2 thous.t of coal – in 1990. Æ and K types of coal were mined and after the concentration they were transported to Rustavi Metallurgical Plant to produce coke. Interim products were supplied to energy and residential sectors. Productivity of labor was low and prime cost of coal extraction in Tkvarcheli mines was high that is caused by rather complex mining and geological conditions, quite limited reserves and low industrial capacities. At the same time, the exploitation works were predominantly carried out on outlaying sections of mines for processing the pillars of different purposes. There are prospects of increasing the industrial reserves of mine fields. In particular, considerable reserves are conserved in lower strata of thick layers 2+3, 2+3+4, 3+4+5 on No2 and No3 mines. Reserve sections are revealed on No6 mine, where about 800 thous.t of coal is conserved. No2 and No3 geological sections on No8 mine need treatment. About 3.5 mln.t of reserves are in V field. As a result of detailed investigation a thin layers with significant reserves may be revealed in VI coal content field.

Exploitation works were ceased in Tkvarcheli after 1991-92 political events in Abkhazia. Technical buildings of mines surface complex were destroyed and ransacked, staff was dispersed. Restoration and development of mines on afore-mentioned deposit requires enormous investments, reassembling of employees and a lot of time.

3.2.3. Coal Quality and Extraction Prime Cost

According to the former Soviet Union standard (ÃÎÑÒ 25543-88) Tkibuli deposit coals belong to longflamable (Ä 0.5.0.40.01 – "Okriba" mine), long flammable - gaseous (Ã 06.0.38.7 – "Imereti" and "Agmosavleti" mines) and initial- gaseous (1 ÃB 07.0.36.11 – "Dasavleti" mine) coals.

Results of analysis of Tkibuli deposit coal are given below:

Humidity, %	8
Calorific value, Kcal/kg	4200
Ash content in dry mass, %	30
CO_2 in dry mass, %	1.2
Volatiles in dry mass, %	29
Fixed carbon in dry mass, %	41
Sulphur total in dry mass, %	1.5
Combustible sulphur in dry mass, %	1.2
Carbon in dry mass, %	53
Hydrogen in dry mass, %	4.1
Nitrogen in dry mass, %	1.0
Oxygen in dry mass, %	11

The results of this analysis show that according to the international scale of coal classification recommended by UNO and Economic Commission of EU, coal models from the bunkers of Tkibuli "Imereti" and "Agmosavleti" mines belong to subbitumous (SB) type of coals.

Coal is of quite low quality compared with other coals extracted underground in similar conditions. On the other hand, it indicates that its effective utilization, as other similar high ash content coals, is possible mainly for energy purposes. Consumption of Tkibuli coal to produce high quality products is less profitable due to the significant rise in price on output.

Economic indices of mines functioning in almost similar conditions may be used to forecast the coal extraction prime cost that has a decisive meaning to determine the prospects of deposit development in market economy terms. Comparison shows that the parameters of Silezian deposit (Poland), deep mines of Germany and other deposits of various countries (e.g. USA) operating by drilling and explosion technology, where labor productivity is rather low and about equal to Tkibuli deposit parameters may be considered as an analogue for the deposits of Georgia. Furthermore, as it was mentioned above, for the determination of coal extraction cost, from the produced output unit cost is subtracted the share of miner's real salary (analogue to the country) and added the share of anticipated salary in Georgia by the corresponding time. It is supposed that in the nearest 5 years the salary of miner in Georgia will be 6000$/y (500$ per month) (e.g. till 1992 the same amount of salary was fixed in transitional period in Poland). By 2005 the expenses on salary will reach 9000$ per person annually (9600$ in Poland by 1995) and by 2010 minimum 12000$ per person annually (by 1996 11700$ in Poland, 55400$ in Germany, 41400$ in USA, etc.).

Variation of extraction cost over low (0-3300t/y) productivity of labor in USA (1995-96) and in Georgia (forecast) and the same data for German and Polish coal industries are presented in Table 3.2.5. Progected prime cost obtained after the corresponding calculation of coal extracted from USA, German and Polish mines is recalculated for the conditions of Georgia (miner salary - 6000$ per person annually).

Original method proposed by the European experts of TACIS to calculate Tkibuli coal prime cost is based upon the analysis of a structure of economic parameter recognized in the international practice. Prime cost of coal extraction calculated according to such method for Tkibuli mines in case of 700 thous.t of annual productivity is estimated as 28.63$/t. Out of this 6.7$/t are additional expenses obtained after correction of calculation method. Mentioned expenses envisage the correcting index of capital expenses and salary fund according to international indices. Considering the above-mentioned, the prime cost of coal extraction for the different stages of mines' rehabilitation is presented in Table 3.2.6.

If the issue concerning the planned rehabilitation of the deposit (see the program of rehabilitation and development of coal industry approved by the Decree of the President of Georgia, Tbilisi, 1997) will be solved positively, the extraction volumes and costs will distribute according to the years as follows:

Year of rehabilitation	Extraction volume, thous. t	Prime cost, $/t
I year	60	45-52
II years	100	34-41
III-IV years	300	32
V-VII years	600-700	29-30
VIII-X years	700-800	31-34
Next period	700-1000	35-41

As the analysis shows, in the first approximation, in case of perfect rehabilitation of mines of Tkibuli deposit and in the nearest future keeping the miners` salary on low level, the cost of 1 t of coal recovery may be taken as Cm=29-30$. Coal price for the last consumer (free from expenses on grinding or other auxiliary technological processes necessary for utilization) is calculated according to the following formula:

$$C_{co} = k_{vat}*C_m + a*L + b + d,$$

where, Cco is coal cost for end-user, $/t; Kvat=1.2 – coefficient that includes the Value Added Taxes according to the Law of Georgia, a=0.05-0.055$/km; L – distance of transportation, km; b=0.30-0.15$/t – expenses on loading and lost time; d=0.03-0.04$/t –expenses on unloading.

If fuel preparation for combustion is considered by the technology, the last end-user's expenses are correspondingly increased (22-25% of coal cost in terms of TES conditions operation by a traditional technology) and are calculated by the following formula:

$$C_{co} = k_{vat}*k_{pr}*C_m + a*L + b + d,$$

here k_{pr}- envisages expenses on fuel preparation (about 4-5$/t may be taken on Tkibuli coal grinding).

Table 3.2.5. Coal extraction cost (C) and productivity of miner's labour (Pr)

Indices	Actual cost of extarction			Forecasting cost of extarction
	USA	Germany	Poland	Georgia
C, $/t	39.8	120	27-34	30
Pr,t/y	1650	560	520	450-500

Table 3.2.6. Progection the coal extraction prime cost for the different stages of Tkibuli mines rehabilitation

Productivity	Prime cost	Productivity	Prime cost
thous t/y	$/t	thous t/y	$/t
700	28.63	300	31.8
650	29.1	100	34.3-41.0
600	29.3	59	45.5-52.2

3.3. OIL AND NATURAL GAS RESERVES IN GEORGIA, CURRENT ACTIVITIES AND TECHNOLOGIES

Oil potential resource in Georgia is estimated at about 550 mln.t. Its extraction has a century long history, and the maximum (3.3 mln. t) was reached in 1983. Later, the extraction was sharply reduced due to the exhaustion of reserves of the revealed mines and the lack of investments necessary for new exploration works and development and it fell down to 180 thous. t in 1990. By the same period natural gas annual extraction was equal to about 60 mln. m^3.

Oil industry crisis was deepened by the beginning of the 90's, after the disintegration of the Soviet Union when the economy of independent Georgia appeared in a grave condition because of the destroyed old development plans and lack of investments from the center. Thus, only 40-50 thous. t of oil was extracted in 1993-95 (Tab. 3.1.1).

Oil and natural gas reserves and potential resources official data by 1990 and 2000 are presented in Table 3.1.1 Prospective license blocks of oil and gas available on the territory of Georgia and deposits located on the blocks are given on the map. For example, the National Oil Company "Saknavtobi" owns licenses of blocks which include: Teleti, Norio, Satskhenisi, Supsa, Shromisubani-Tskaltsminda and Western Chaladidi oil deposits. (Based upon the license agreement, Supsa, Shromisubani-Tskaltsminda and Eastern Chaladidi deposits were transferred to the joint Georgian-German oil company "Georgeoil" established in 2000).

Oil company "Ioris Veli" licensed blocks include the Samgori and Patardzeuli sections oil deposit of Samgori south arch, Krtsanisi section of Western Rustavi oil deposit and the Rustavi condensated gas deposit.

The Ninotsminda section of Samgori gas and oil deposit, central and the southern sections of western Rustavi oil deposit are located within the frames of licensed blocks of joint Georgian-British oil company (GBOC).

The US Company "Frontera Resources" and Georgian National Oil Company "Saknavtobi" established joint company "Frontera Eastern Georgia", which license block with Mirzaani, Patara Shiraki, Taribani, Nazarlebi, Mtsare Khevi and Baida deposits.

License block of oil company "Kakhetis Navtobi" is located in Lower Cretaceous settings of Vedzebi-Java-Phkhoveli possible oil-gas region that is not yet properly prospected to evaluate the reserve and to start the possible deposit's exploitation.

Oil and gas prospective resources projected as a result of modern, three-dimensional seismic survey under the international oil companies operating in Georgia are not included in data on reserves and potential resources. For instance, the results of preliminary explorations carried out by the company "Frontera Eastern Georgia" on the territory of Kakheti are not known. The optimistic results are obtained during the preliminary exploration and test drilling of gas deposits and other prospective oil deposits (including offshore deposits). Nevertheless, by this time, the data may be considered just as projection and therefore only the data officially proved by the National Company "Saknavtobi" are presented in Table 3.3.1.

Gradual development of oil industry was commenced after the entry of Western oil companies in the oil industry of Georgia, which have introduced expensive, modern exploration technologies. Data for the year 2000 on foreign companies involved in oil recovery industry in Georgia are given in Table 3.3.2 (Information on companies, projected indicative parameters of their development are taken from materials of the conference "Prospects of oil extraction and processing in Georgia" held in Krtsanisi State Residence on October 27, 2000).

Table 3.3.1. Oil and natural gas resources and potential reserves in Georgia by the state of 1990 and 200, million toe (natural gas in billion m^3)

Initial potential resource	Extracted	Rated reserve		Resource		Total remaining resources, %	Development of resources, %	Explored resources, %	Note
		$A+B+C_1$ category	C_2, category	C_3, category (prospected)	D_1+D_2 category (projected)				
582.6	26.8	11.5	20.7	59.6	464.0	556.8	4.6	6.6	Oil, 2000
582.6	25.8	12.5	20.7	59.6	464.0	556.8	4.4	6.6	Oil, 1990
130 (161.8)	0.27 (0.34)	2.0 (2.5)	4.8 (5.96)	102 (127)	20.8 (26.0)	129.7 (161.4)	0.2	1.8	Gas, 2000
130 (161.8)	0.27 (0.34)	2.0 (2.5)	4.8 (5.96)	102 (127)	20.8 (26.0)	129.7 (161.4)	0.2	1.8	Gas, 1999
			0.9 (11.3)	1.9 (2.37)					Accomp. gas, 2000

Table 3.3.2. Foreign companies acting in oil extraction sector of Georgia

Foreign company	Georgian partner	License block	Established operating company
JKX Oil & Gas (Great Britain)	NOC "Saknavtobi"	IX	G/G.B Oil Company, Ltd
Ninotsminda oil company (Canada)	NOC "Saknavtobi"	XI	G/G.B Oil Company –GBOC-N, Ltd
"Ramko Energy", (Great Britain)	NOC "Saknavtobi"	X	G/G.B "Oil Company – Kakhnavtobi" , Ltd
"Frontera Resources" (USA)	NOC "Saknavtobi"	XII	G/A Oil Company "Frontera Eastern Georgia", Ltd
Canargo-Nazvrebi (Canada)	NOC "Saknavtobi"	XIII	G/G.B Oil Company "Nazvrebi" , Ltd
"Anadarko", JSC	NOC "Saknavtobi"	II, III	"Nadarko-Georgia" , Ltd
"National Petroleum Limited", Switzerland	NOC "Saknavtobi"	XI	G/Sw Oil and gas company "Ioris Veli", Ltd
GWDF (Germany)	NOC "Saknavtobi"	V, VII	Association "Georgeoili"

According to the plan it is expected to increase the oil extraction up to 150 thous. t by 2000 and up to 1.2 mln. t by 2005 (see Fig. 3.3.1). In the projected period the increase of oil extraction is considered only for those companies, which have already open deposits or possess the reliable prognosis on available oil reserve. Other companies like Georgian-German "Georgeoil" are yet conducting only the exploration works on oil and gas.

By 2005 natural (free and oil accompanying) gas extraction would be increased by 0.5 billion m^3 annually.

After putting the relevant capacities of oil refining industry units into operation, which along with local oil will processes the oil delivered by transit on the territory of Georgia from the Caspian deposits, the considerable part of country's demand should be covered by local oil products (annual projected consumption is about 5 mln.t).

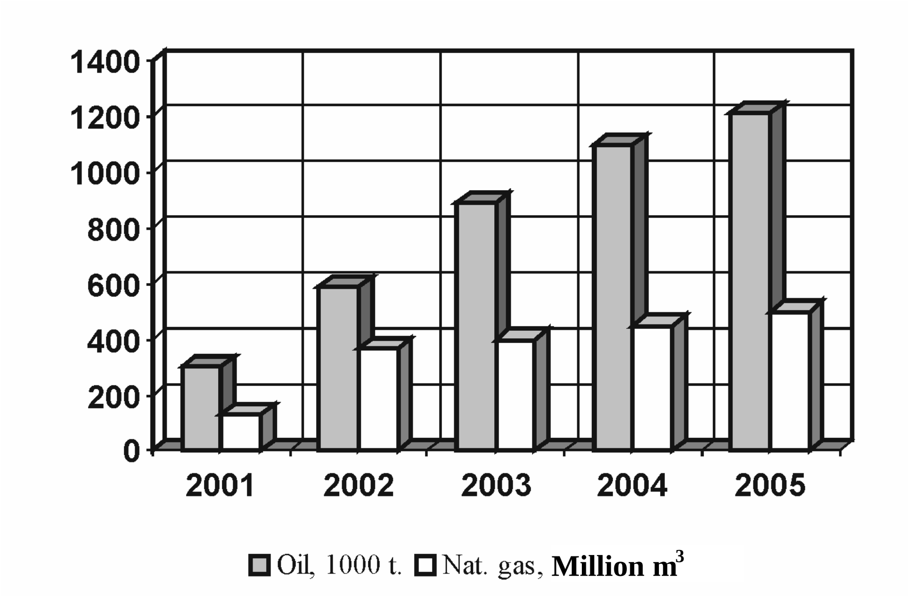


Fig. 3.3.1. Projected parameters of oil and natural gas extraction

3.4. RENEWABLE ENERGY RESOURCES OF GEORGIA

3.4.1. Hydro Resources

As it is known, in the last decade, the energy generation in Georgia was drastically decreased from 14.24 billion kWh (1990) down to 7.5 billion kWh (2000) due to the absence of finances necessary for fuel purchase, deficit of spare parts for uninterrupted operation of power plants and lack of funds for timely reconstruction works. In 1990, 53% of total energy production belonged to HPPs, but in last years this index exceeds 80%, while the electricity generated at the HPPs made only 60% of its full capacity.

It's evident that such decrease of electricity generation and correspondingly consumption level resulted in total degradation and crisis of the economy.

Moreover, Georgia is known as one of the richest countries in hydropower resources. On the average 56 billion m^3 of water is formed on the territory of country, 9 billion m^3 flows by transit that makes 65 billion m^3 of total annual river run-off. By the end of the 80's, 3-4 billion m^3 of this reserve was used for irrigation and water supply purposes (20-25% was returned to the rivers).

According to estimated specific technical potential of hydropower resources, Georgia takes one of the leading positions all over the world. Theoretical energy of total run-off in Georgia is 229 billion kWh and the capacity – 26.1 million kW. Potential power of the main part of the rivers is 137 billion kWh (13.6 mln. toe/y), capacity – 15600 MW. Total potential of rivers run-off with the potential of quite small rivers is 160 billion kWh, capacity – 18300 MW. Average annual technical hydropower potential of the main rivers equals to 80-85 billion kWh (6.9-7.4 mln. toe/y), economically usable potential makes about 32-50 billion kWh. In the nearest future a feasible economic potential may reach approximately 20 billion kWh (equivalent to about 1.7 mln. toe/y).

3.4.2. Wind Resources

Theoretical potential of wind energy on the whole territory of the country is estimated at 1 trillion kWh. According to the experts' assumption, getting of 2-3 billion kWh of electricity may be considered as economically sound even in the remote prospect. Based upon the examination carried out in Georgia some of regions have been selected (Sabueti Mountain, Poti, Kutaisi, Samgori, Batumi, Dedoplistskaro), where the construction of economically reasonable wind power stations is possible.

According to the current assessments, the share of wind energy may reach 1.5-2% in overall energy balance of the country by 2020.

3.4.3. Solar Energy Potential

Heat, equivalent to 1500 kWh of energy is accumulated on each 1m^2 territory of Georgia annually (it varies within 1250-1800 kWh according to zones). Out of them 300-500 kWh could be assimilated.

The successful development of solar energetics is available in Georgia as well as in other countries with the same geographic location and climatic conditions. According to experts' estimation in case of proper development of helio energetics the share of solar energy in total energy consumption could reach 0.5-1.0% by 2010-2020.

3.4.4. Geothermal Water Potential

Sufficient potential of geothermal water is available in Georgia. According to examination an annual projected debit of these waters equals to 220-250 mln. m^3 (water temperature - 50-1000C), among them 100 mln. m^3 is proved reserve.

Wide area of spreading and rather low mineralization (0.4-2.2 g/l) promotes the consumption of thermal waters in Georgia for energy generation, in particular for the hot water supply purposes.

Theoretically, the power potential of thermal waters in Georgia is estimated at 245-290 MW, technical potential – about 150 MW. Assimilation of this potential will save about 1.3 billion kWh of energy or 110 thous. toe annually.

3.4.5. Biopotential

Georgia is rich in forest resources. According to an official statistics total wood reserve of Georgian forests equals to about 434 mln. m^3. In recent years, wood consumption was significantly increased in terms of energy crisis and has reached dangerous level for the natural balance. This process was intensified by drought during the spring and summer of 2000 and may serve as a basis for potential ecological disaster.

Considering the wood average natural surplus (1.8 m^3/ha) it is defined that the ecologically permissible level of woodcutting in Georgia could be 3-6 mln.m^3 (equal to about 540 thous. toe) annually. At the same time, it should be considered that the main part of forests is located on the slopes and their involvement in total consumption balance is not expedient on the scope of anticipated ecological catastrophe.

Under the recommendation of the experts of TACIS energy project ("Technical assistance on industrial and consumption level", component 3, "Wood fuel management and distribution in the rural regions for effective energy supply", Tbilisi, 1998) the consumption of wood equivalent to 350 thous. toe is permissible for heat supply to rural population and educational institutions.

The possibility to apply biogas stations on the basis of utilization of agricultural wastes should be noted among the bio-resources as well. At present, some tens of biogas stations are already in action in Georgia. Their capacity is enough for family fuel supply during the whole year.

3.5. TRANSPORTATION OF ENERGY CARRIERS*

3.5.1. International Trading in Energy Resources and Prospects of Export and Import

Traditionally, the demands on energy resources for the different regions of the world and delivery possibility are unbalanced. Gradually, this problem became mutually beneficial owing to the international trading by energy resources. This process is illustrated in the Table 3.5.1.

Table 3.5.1. Forecast on changes in fossil resources import indices in Europe

Types of fuel	Year	The volume of imports in Europe	
		Equivalent of MW oil	% of total consumption
Solid fuel	1992	100	37
	2020	49	65-80
Oil	1992	484	56
	2020	550	90-94
Natural gas	1992	96	40
	2020	278	65-75

The world society fosters avoiding the deficit of energy resources supply or decreases it to the possible minimum by designing alternative delivery means (among them pipelines) and routes.

Expenses on hydrocarbons transportation varies within wide range in accordance with the possibilities of applying its types and means of transport. As it is known, oil transportation by tankers is more convenient than through pipelines. Therefore, the pipelines are used for oil transportation only from the place of extraction

* This part of the Report is intended predominantly for the Georgian specialists

to the seashore or to the oil refinery. Application of onshore pipelines for natural gas supply on the less than 3000 km distance is more profitable. Transportation of liquefied gas by tankers on about 14-15 thous. km or more distance is more efficient. Using of underwater (offshore) pipelines for gas transportation on less distance is more suitable.

In general, some tens of thousand km length of pipelines are put into operation annually in the world. Their total cost exceeds some tens of billion dollars.

In 2000, the projects concerning roughly 225 significant main pipelines of crude oil, oil and natural gas were under implementation (planning, designing, construction) in the world. Works were performed on the pipelines with 32880 miles (52600 km) of total length, 70% (22900 miles) out of them were gas pipelines. The pipelines were intensively developing in USA (about 18% of the world's total) and in Caspian region (about 17% - see Tab. 3.5.2).

The pipeline that supplies mid-western part of USA from Canada with natural gas and condensate costing $4.6 billion is the most significant international project of 2000. The construction of the oil-pipeline (costing $ 2.5 billion) from Kazakhstan's Tengiz deposit to Novorosiisk was continuing. It should be completed by 2001. The construction of oil-pipeline with 653 mile of length from Dobi deposit (Chad) to Cameroon under the support of consortium established by Exxon Mobil Corp., Petronas and Chevron would be accomplished by the same year. There is a plan related to the accomplishment of natural gas main pipelines' construction from the Gulf of Mexico to the Abbey of Florida Manatee (length - 774 miles, cost – $1.6 mln) and from Alabama to the Abbey of Pasco (length - 674 miles, cost – $1.5 billion). Elaboration of large-scale projects concerning the gas supply pipelines from Russia to Turkey ("Blue Stream"), from Turkmenistan to Europe (Tanscaspian) and from Azerbaijan to Turkey was under way. Significant progress has been achieved in the development of Baku-Tbilisi-Jeikhan main oil-pipeline project.

New energy policy "Energy strategy 2020" has been elaborated in Russia, the main goal of which is the substantial development of gas production in Siberia and in the Far East and construction of large-scale thoroughfares (including 1650 km gas pipeline from Kovitk deposit to Irkutsk and then to China, costing $1.6 billion in total). As a matter of fact, Russia plans the construction of 16800 miles (26880 km) of new pipeline and replacement of 14300 miles (22880 km) of existing corroded pipeline within 20 years.

Table 3.5.2. Planned and under construction projects of Caspian deposits, 2000

Company	Location	Type	Length of pipeline	Status	Date of accomplishment	Note
AIOC	Baku-Tbilisi-Jeikhan	Crude oil	1080	Design	2004	New, $2.7 billion
BP	Shah Deniz- Tbilisi-Ersrum	Natural gas	675	Design	2002	New, $125 billion
Kaztransoil	Aktiubinsk-Aturau	Crude oil		Plan	2002	New, $180 mln
CPC	Tengizi deposit-Novorasiisk	Crude oil	1340	Under construction	2001	New, $2.5 billion (I stage)
Gazprom	Jubga-Ankara (I stage)	Natural gas	572	Under construction		New, $1.7 billion
CentGas	Dovlatabad (Turkey)-Multan (Pakistan)	Natural gas	993	Plan		Via Afghanistan
Karachaganak Inter. Consortium	Big Changan-Aturau	Oil product	290	Plan	2002	$440 mln
	Transcaspian	Natural gas	1024			$2.4 billion

In general, the following main conclusion can be made on the basis of analysis of problems concerning the international market of energy resources and their transportation:

For the nearest decades, besides the main tendencies concerning the formation of energy resources international market that includes the final globalization of market relations and corresponding restructurization of the economy, on the one hand the dependence on the import of the main regions consuming these resources and on the other hand the necessity to improve the security level and to develop the economy of producing countries (which sometimes are environmentally or politically isolated) will be significantly raised. Diversification of energy resources supply sources and financial and political support to the alternative transport routes will be broadly applied to solve these problems that will facilitate the stability on international market of energy resources keeping comparatively low prices.

3.5.2. Oil Transportation Systems Existing in Georgia

The oil- and gas-pipelines are mainly used in Georgia for the transportation of energy carriers (railway is used for coal and also Kazakhstan oil transportation).

The main pipelines existing on the territory of Georgia are:

- ? Baku-Supsa Azerbaijan crude oil western route pipeline;
- ? Khashuri-Batumi oil products pipeline;
- ? Transcaucasian gas pipeline “Vladikavkaz-Gardabani-Yerevan”;
- ? Gas pipeline “Azerbaijan-Georgia” (from Karadag to Tbilisi).

Oil-pipelines in Georgia are mainly used for Caspian, in particular, Azerbaijan deposits’ oil transportation. In Azerbaijan, on Abhsheron peninsula oil was extracted from oil natural springs and wells with small depth in VIII B.C. Since the second half of XIX century oil was extracted on the large scale that was fostered by wide implementation of wells’ mechanic drilling. By the beginning of XX century, according to the amount of extracted oil, the Abhsheron deposits occupied the first place in the world (more than 11 mln t of oil was extracted in 1904).

Raising of oil extraction and demand level on the international market resulted in the necessity of searching for cheap and reliable means of its delivery. Construction of oil transport pipelines solved the problem. The first such kind of pipeline was constructed in the USA. The first pipeline on the territory of Russian Empire, which included the Caspian deposits, was constructed in Baku, in 1878. The Nobel Brothers Company constructed the main pipeline from Baku to Batumi in 1897-1907. By this time, the pipeline was considered as the longest one in the world. The pipeline has operated till 1981.

In 1976 when oil extraction was considerably increased in Georgia, “Samgori-Gachiani” oil-pipeline of 22 km and oil-casting railway platform of Gachiani, which supplied the oil to Batumi through the railway tanks were constructed. Afterwards, the construction of one more new main pipeline become necessary as a result of increasing of oil extraction volume. It was put into operation in 1980. This 400 km pipeline was used for pumping oil extracted on the deposits of Georgia and Azerbaijan to Batumi.

Political and social upheavals commencing from the second half of the 80’s stipulated step-by-step disintegration of the existing centralized economy, including damaging and putting out of order existing pipelines.

3.5.3. Western Route of Baku-Supsa Azerbaijan Crude Oil Pipeline

The total length of west route of Baku-Supsa Azerbaijan export oil pipeline equals to 830 km. Its designed operational duration is 330 days annually, maximum capacity 115000 barrels (about 762 m^3/h) per day. The pipeline’s average annual capacity is 5.1 mln t or 37.8 mln barrels (about 105000 barrels a day, or 700 m^3/h). Design maximum pressure on the territory of Azerbaijan and Eastern Georgia (thickness of pipe wall – 7.5 mm) is 60 bar (about 6 MPa), and on the territory of Western Georgia (thickness of pipe wall – 9 mm) is 72 bar (about 7.2 MPa).

Six interim pumping stations are serving the oil pipeline. 3 centrifugal, 5-stage “Sulzer” type pumps are installed on each station (Fig. 3.5.1). In normal conditions 2 pumps (the third one is in reserve) are simultaneously operated at each station that provides 750-800 m^3/h capacity and about 40 bar of pressure surplus. Each pump is equipped with diesel (or oil) autonomous engine with 920 kW capacity.

For the environmental protection and safety reasons the whole pipeline is burried in the ground. Pipeline’s sections on the ground are insulated by the melted epoxide and on the river crosses – by concrete. Cathode protection system is used against stray currents and corrosion.

Oil is supplied to Supsa terminal located to the South of Poti port and includes four reservoirs of 25000 barrel capacity (about 40000m^3 of active capacity and 7000 m^3 of inactive volume). Three autonomous engine pumps (Q=5780 m^3/h=4884t/h) and pipeline (5km of length, 914 mm of diameter) sink on the bottom are used for oil delivery to tankers up to charging and floating platform. Pumps are equipped by diesel engines with 1075 kW capacity.

Filling up of each reservoir takes about 60 hours and pumping up of oil from reservoir to tankers – 10-11 hours. Supsa terminal is able to receive 18600m^3 (approximately 115000 barrels) oil every day. Nominal operating pressure of pumps is 6 bar (0.6 MPa), maximum pressure – 10-12 bar (1-1.2 MPa).

Terminal is equipped with its autonomous power supply system that includes distributing network and diesel-generator of 850 kW capacity. Power supply and all technological systems at the Supsa terminal are duplicated that guarantees its reliable operation without any delay.

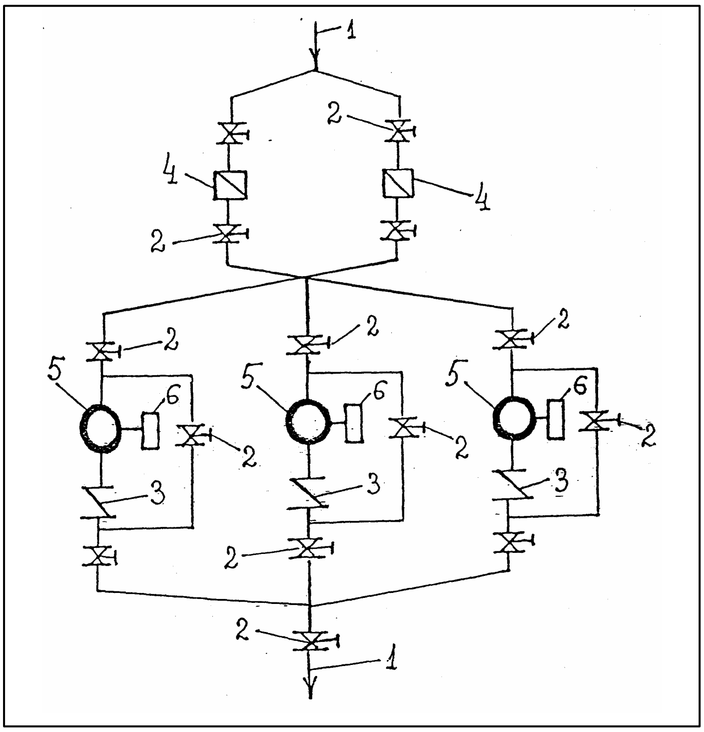


Fig. 3.5.1. Technological scheme of middle pumping station of Baku-Supsa main oil pipeline
1. Main pipeline; 2. Bars; 3. Feedback valves; 4. Filters; 5. Pumps; 6. Pump engines.

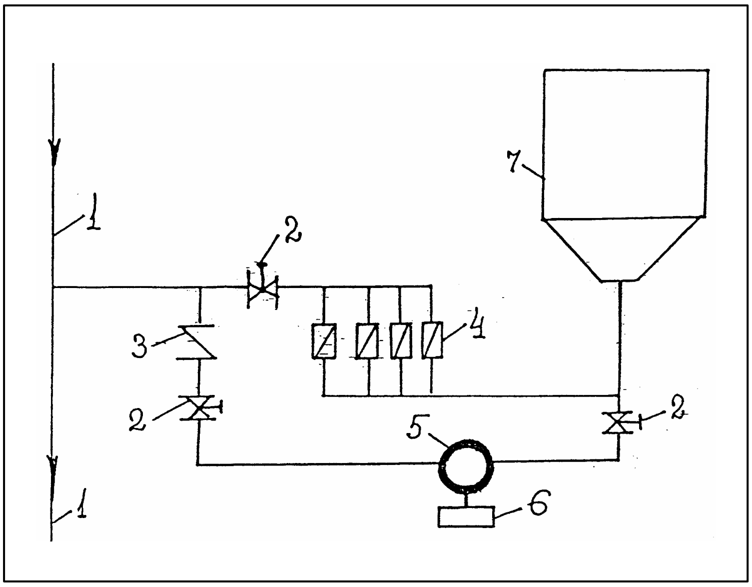


Fig.3.5.2. Technological scheme of pressure regulating (reduction) station
1.Main pipeline; 2. Bars; 3. Feedback valves; 4. Protecting valve- throttles;
5.High-pressure pump; 6. Pump engine; 7. Stock reservoir.

Oil that flows from pipeline should be filtered before keeping in reservoirs and representative test should be sent for laboratory analysis. The results of analysis are used for the selection of optimal management parameters (the best parameters of oil are: density - 850 kg/m^3, water content – 0.04-0.1%, viscosity – about 8% at 130C temperature).

Floating platform is placed in 50m-deep water 3 km away from the bank. It is able to receive and charge up to 150 000 deadweight ton tankers. Normally, it is designed for charging of 100 000 t displacement (118343 m^3) tankers during 20 hours including 6-8 hours required for connection and separation.

Communication and management modern systems are adopted on the Baku-Supsa oil pipeline system. They comprise radio communication system of ultra high frequency with 23 transmitting stations located along the route, sound connection of VSAT satellite system and mobile communication network to be used in state of emergency.

The increase of oil pipeline capacity up to 8-9 mln t annually (about 200 000 barrels per day) and application of 13 pumping stations for this purposes is envisaged by the project (the version concerning the increase of annual capacity up to 11 million t or 245000 barrel a day and correspondingly, application of 18 pumping stations is also considered).

Pipeline is operated under the "Georgian Pipeline Company" (GPC), which was established as a subsidiary of Azerbaijan International Operational Company (AIOC) in April 1996. At present, "British Petroleum" is a major shareholder of GPC stocks.

GPC managed the restoration and construction of Azerbaijan crude oil transportation system on the territory of Georgia. During the next 30 years after coming into exploitation it will serve as an operator (responsible for pipeline exploitation).

"Georgian International Oil Corporation" is the Georgian partner of GPC. GIOC was founded under the Decree No178 of the President of Georgia on February 20,1996. According to this Decree the Corporation has right on ownership and operation of oil pipelines existing on the territory of Georgia. So, in relation with the Consortium (and later with its representative – the GPC) Georgian side is represented by GIOC.

On October 10, 1996 GPC made an agreement with the tender winner - British company "Kwaerner John Brown" on design, purchase and project management of Baku-Supsa oil pipeline.

In April 1997 the company "McConnel Dowel" from New Zealand won the tender on permission to restore and construct the western route. From the beginning the project envisaged the restoration of existing "Samgori –Batumi" 341 km section of the oil pipeline and building of new 39 km oil pipeline on the territory of Azerbaijan to join with being under construction AIOC pipeline. But owing to the fact that the old oil pipeline had a great number of unforeseen defects, GPC made a decision to apply new pipes on the remaining 250 km section.

The construction was carried out step by step. By the beginning of December 1998 the first oil flow was charged in the pipeline from the Caspian Sea coastal Sangachali terminal. At this time the construction works were still performed on the territory of Georgia. Caspian crude oil crossed the boarder of Georgia in January 10, 1999. The first tanker was filled up by oil on the Supsa terminal in April 17, 1999. Till 1 February 2001, 8 907 111 t of oil was transported through the pipeline in total (3.4 million t – in 1999, 5.018 t – in 2000). Oil transportation tariff on the territory of Georgia is 18 cent/barrel.

Technological and ecological safety of the pipeline is provided on the international standard level. To achieve this goal and provide the effective control from the Georgian side, the integrated system was used during the pipeline's design and construction – the examination results of construction, technological and ecological safety were gathered in the Ministry of Urbanization and Construction of Georgia. All three conclusions were compared, environmental risks were assessed and especially dangerous sections were detected.

It was determined from the beginning that no sections of pipeline have to be placed on the surface of the ground that excluded the possibility of pollution of fertile layers of soil by oil in the event of an accident.

The special attention was paid to the intersection of rivers. To avoid the river pollution, the shutting valves were located in such a way that provides instant reaction in case of leakage in order to reduce the scale of pollution to the minimum. Pipeline (including the rehabilitated sections) was buried 2 m below the impellent mark of the bottom that actually excludes the risk related to the mechanical damage to the pipeline.

Control system of pipeline integrity is adopted through the exploitation period. This system is capable to define the areas where corrosion, leakage and holes are originated. Pipes along the total route are covered by principally new, anticorrosion, armored, epoxide oleoresin coat.

Pumping and pressure reduction stations as well as Sangachali initial and Supsa marine terminals are connected with each other by satellite communication that gives possibility to act immediately in case of pipeline damage and subsequent oil leakage. According to the GPC norms at most 7 hours are in reserve to detect this place and reach it. 19 hours is limit for rehabilitation works in case of oil leakage at the sea.

Special measures were carried out on 30 sections of higher vulnerability. For example, the direction of route was completely changed to pass by the landslip hazardous areas north to Tbilisi and the Narionali Lakes at the Kolkhida Lowland.

Construction of coast-protecting gabions and other protecting hydro engineering buildings, planting and terracing of landslip and geologically hazardous slopes are under way. During the passed exploitation period, bank flushing by floodwater resulted in critical situation. Consequently, as the first line support, the pipeline's operation was immediately ceased till the liquidation of potential risk. Afterwards, the flushed sections (where pipeline was uncovered) were redesigned and reliably reinforced anew.

Noise limitation standard requirements are kept on each technological unit. For this purpose, additional noise muffling equipment was installed on pumps, motors, switching devices, etc. This kind of equipment was installed at all pumping and pressure regulating stations as well as at the Supsa terminal.

3.5.4. Khashuri-Batumi Oil Pipeline

The Khashuri-Batumi oil product pipeline includes Khashuri oil-receiving (from the railway tanks) terminal and pumping station, pressure reduction stations in Argveta and Vani, Batumi oil-receiving (from the pipeline) terminal. The pipeline was designed to deliver light oil products (diesel fuel, kerosene, petrol) with 6 million t/y capacity.

The Khashuri oil receiving terminal is intended to accept simultaneously 60 tank-cars. The design capacity of terminal makes 1200 t in a day. The product received from the tanks after filtration was supplied through pumps (14 H ?cH type, Q=1100m^3/h, H=40 m, N=160kW, 4 units) to the reservoir park with total volume of 70 000 m^3 (59 000t). The park includes 14 basic reservoirs of 5000m^3 capacity each.

The product from the reservoirs is delivered by flooding pumps 14HDcH (=1100m^3/h, H=40 m, N=160 kW, n=980 revo/min) to the collector (Fig. 3.5.3), from which 2 main pumps 14H1222 (Q=1100m^3/h, H=370 m, N=1600 kW, n=2980 revo/min) are supplied. One pump functions in normal regime, the second one is kept in golden reserve.

The oil product pipeline was put into operation in 1974. The total length of the pipeline is 232 km, 224 km of which consists of 510 mm and 8 km 377 mm steel (10? -38 km and 14X ?C-194 km) pipes. The pipes are located underground and on the surface as well. Air-route of the pipes crosses several riverbeds, traffic and railway roads both under- and above the ground.

20 cathode corrosion-protecting stations of KCC-1200 and KCC-1500 types are installed along the route. 15 ???-300 type and 16 ? ? ? type drainage stations are constructed at the crossing points of high voltage electricity transmitting and railway lines. “HE???H?K” type system was used for communication purposes. The air emitting valves are installed at several points of pass (at 14, 47, 55, 132, 225, km). In order to decrease the pressure in case when it exceeds the norm, the pressure reduction stations are constructed at 71 and 113 km of route in Argveta and Vani equipped with 1000m^3 storage reservoirs, as well as with blocker regulator devices and high pressure pumps (of 56K-5 type), for sending the product back into the pipeline. The protecting valves of pressure decrease stations start the operation when pressure exceeds 73.5 bar (on the first section of pipeline) and 64.5 bar.

According to the design, oil products were taken in Batumi by central oil base recharging reservoirs of 10 000 m^3 capacity, from which they were transported to tankers.

The pipeline has never operated under a design capacity. The pipeline worked at maximum capacity (2mln t/y) in 1975, in other years its loading made on the average 15% of design capacity.

In terms of operation under small loading the hydraulic inclination is minimum and the impermissible growth of pressure is fixed on the descent at the section of self-flow motion, following the turning point. To protect the pipeline against the inadmissible high pressure a throttle unit is installed on the 22nd km, equipped by successively plugged 4 valves and 2 chimneys. The throttle unit fosters pressure decrease by about 35 bars. The same throttle unit is also installed on the 229th km of the route near the settlement of Makhinjauri.

Several accidents, caused by the floods and landslides, were fixed on the pipeline during the years of exploitation in 1974-91. The pipeline was also damaged by corrosion at three points on the territory of vil. Ajameti and town of Khashuri.

The pipeline passes over the mountainous terrain and mossy areas that causes the complexity of the route. The pipeline originates from Khashuri at the 735.7 m mark altitude by the horizontal section, then gradually begins to ascend, at the 14th km crosses the peak mark of 1005m in the vicinity of the Rikoti Pass and ends at 16 m mark in Batumi, on the 232nd km of the route.

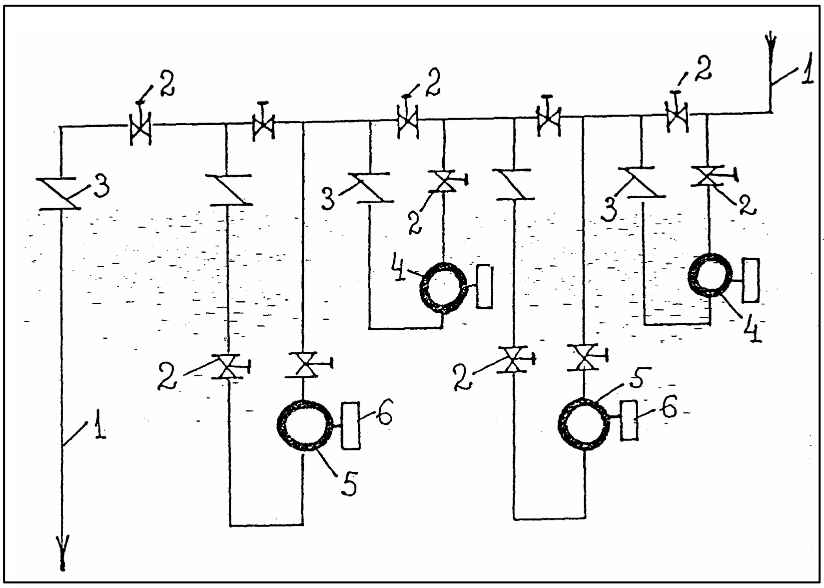


Fig.3.5.3. Technological scheme of head pumping station of the Khashuri-Batumi main pipeline
1. Main pipeline; 2. Valves; 3. Feedback valves; 4. Flooding pumps;
5. Main pumps; 6. Pump engines.

The current owner of the pipeline is the state-owned company "Saknavtobtransi" Ltd.

Under the request of "Shevron" Corporation the "Geoengineering" Ltd has elaborated the project on the rehabilitation and reconstruction of the pipeline. After the rehabilitation the pipeline is intended for the transportation of Kazakhstan's "Tengiz" deposit oil from Khashuri railway terminal to the Batumi marine terminal.

The characteristics of the "Tengiz" oil deposit (according to "Shevron" data) are:

Density - 870kg/m^3 (100C), 850kg/m^3 (32.20C), 830kg/m^3 (54.50C); Kinematic coefficient of viscosity: 13.2 centistokes (100C), 6.0 centistokes (32.20C), 3.6 centistokes (54.50C); Dynamic coefficient of viscosity: 11.46 centipoises (100C), 5.12 centipoises (32.20C), 3.0 centipoises (54.50C).

The pipeline development program includes step by step implementation of the following measures:

1. Restoration of the existing pipeline;
2. Substantial increase of the pipeline capacity;
3. Prolongation of pipeline to the Caspian Sea coast of Azerbaijan (up to Diubend Terminal).

The projects on rehabilitation and reconstruction of the system with various capacity: 6, 7, 8 or 10 mln t/y are examined. The approximate economic analysis of the mentioned projects demonstrates the expediency of increase of system's capacity up to 6 mln t/y. The final decision concerning the selection of other versions of system reconstruction will be made on the basis of an additional economic analysis.

The project on the reconstruction of oil-product pipeline for the transportation of 3 mln t/y diesel fuel is elaborated under the request of "Saknavtobtransi" Ltd. The demand for fuel supply from Azerbaijan, Turkmenistan and Uzbekistan is significantly growing at the international market.

Table 3.5.3. Demand for transportation of export diesel fuel

Year	2001	2002	2003	2004	2005	2001-2005
Quantity of exported diesel fuel, t	2 200 000	2 700 000	2 900 000	3 200 000	3 600 000	14 600 000

3.5.5 Existing Natural Gas Pipelines

Main pipelines with the total length of 1940 km and with 300-1200 mm diameter for natural gas supply are constructed in Georgia.

Construction of main pipelines in Georgia began in 1958 and through the first pipeline Karadag (Azerbaijan)-Tbilisi (its construction was completed by 1959) the country had begun to receive natural gas. The pipeline enters at the territory of Georgia near the "Red Bridge", crosses the gorges of the rivers Khrami, Algeti, Mtkvari and ends at Samgori distributing station, located in the suburban area of Tbilisi. This pipeline was replenished by 500 mm pipes (after the reconstruction works performed in 1975-1980 these pipes were replaced by 700 mm pipes, excluding the crossing areas of the River Mtkvari and the motorway directed to the Tbilisi airport). At present the pipeline is out of operation.

Henceforth, the demand for gas grew so rapidly that the construction of the second pipeline became necessary, which would supply gas from an alternative source. For this reason the Vladikavkaz-Tbilisi gas pipeline was constructed in 1963-1966 that provided Georgia with gas from the North Caucasian deposits.

Since 1970 gas was supplied from Iran, though this source was shut down in 1978 after the Islamic Revolution in this country.

Since 1992 Georgia, like other former Soviet South Caucasian republics, is supplied by natural gas from Turkmenistan. For this reason the existing pipeline (Vladikavkaz-Tbilisi) was rehabilitated and a new 1200 mm gas pipeline North Caucasus –South Caucasus has been installed.

The retrospective data of natural gas supply to Georgia are presented in the Table 3.5.4.

Table 3.5.4. Gas consumption in Georgia from 1960 to 2000

Year	1960	1965	1970	1975	1980	1985	1990	1995	2000
Gas supply, mln.m^3	453	1481	1912	3392	3012	4539	6046	910	1167

As it is seen from the Table, natural gas (as well as fuel resources in general) consumption is sharply reduced in Georgia compared with pre-crisis period. For example, by the beginning of 1990, 292 thousand families, 46 district heating boilers, 256 industrial enterprises and 585 municipal buildings were supplied with gas in Tbilisi. Natural gas annual consumption was equal to 2.1 billion m^3, 50% out of it was consumed by heating systems, 20-22% - by industrial enterprises and population.

At present, the following main gas pipelines are ready for operation: North Caucasus – South Caucasus and Kazakh – Red Bridge – Saguramo (Table 3.5.5). The design capacity of these pipelines equals to about 50 mln m^3 per day (about 20 billion m^3 annually). The main pipeline with its sub-sectors – Saguramo-Kutaisi-Sukhumi (to Kobuleti, Tskinvali, Bakuriani and Ambrolauri) in the direction of Khakheti and South Georgia is linked to almost all regions of the country.

Table 3.5.5. Main pipelines of Georgia

Route	D, mm	Length, km	Time of construction
North Caucasus – South Caucasus	1200	135	1988-1994
Khazakh – Red Bridge – Saguramo	1000	112	1980
Karadagh Tbilisi	800, 700, 500	110	1959-1968
Vladizavkaz – Tbilisi	700	266	1963-1966
Saguramo – Kutaisi	700, 500	370	1967-1975
Kutaisi – Sukhumi	700, 500	338	1986-1989
Rustavi – Telavi – Zhinvali	500, 300, 200	370	1969-1975
Red Bridge – Tsalka – Alastani	500, 300	180	1978-1990
Gomi – Khashuri – Bakuriani	500, 300	59	1972-1989

North Caucasus – South Caucasus natural gas main pipeline is assembled mainly by pipes with 1200 mm diameter and 16 mm wall thickness. The construction had not satisfied all design demands and at present on several sections old pipes of 700 mm, in some places pipes of 1000 mm diameter are used. This significantly limits the potential capacity of the system. Therefore, in case of demand for output increase, it will be necessary to replace the pipes of small diameter by 1200 mm pipes, or to parallel those using lupines.

Main gas pipeline Khazakh – Red Bridge – Saguramo connecting Azerbaijan with Georgia was built by the beginning of the 80’s and was mainly assembled by pipes of 1000 mm. For the time being, the system does not operate, though it is in potential readiness and after carrying out of some comparatively small-scale rehabilitation works, and also after the reconstruction of anticorrosion protection, dispatching and control systems it could be applied to supply natural gas from Azerbaijan for self-consumption or transit. In addition, it has to be mentioned that these pipelines are put on trial using limited testing pressure (35 Mpa at most).

Basic main pipelines are equipped by automatic compressor stations, which are located in Saguramo and Kvesheti. Saguramo compressor station was built in 1965 and was used for natural gas supply and distribution through the internal main pipelines of the country. Later, after the installation of 1200 mm pipelines, construction of a new, more powerful compressor station has started, which comprises six gas-turbine units (centrifugal compressor and gas turbine) with total capacity of 37,8 MW; the efficiency of this plant is about 27 % (capacity of each compressor is about 6 MW). Unfortunately, the technical equipment of new compressor station has not been completed. At present the station is temporarily closed down. According to the assessments made by the experts, required expenses for its rehabilitation and putting into operation make about US$ 39 million.

Kvesheti compressor station is equipped by three gas-turbine units. Their total capacity is 18.9 MW. At present, the compressor station is out of order.

Due to natural climatic and geographic conditions, a lot of objects of gas supply system, especially main pipelines laid in the high-mountainous regions, represent the complex of complicated engineering structures and cross more than 600 rivers, dry ravines, railways and motor roads, Great Caucasian Range (at the altitude of 2400 m above sea level). The complexity of the gas supply system facilitates the expensive rehabilitation works for its normal exploitation. Before the crisis began, works costing about US$ 20 million were carried out annually for this purpose. During last ten years, these works have been sharply limited due to disintegration of material and equipment supply existing systems and significant increase of gas purchasing price. Complicated criminal situation during the civil war in Georgia incurred losses to the system's technical conditions (sabotage explosions on gas pipes, plundering of fixed assets, etc.). And in addition disorder concerning the collection of consumed natural gas price has rolled the country to the actual financial bankruptcy.

At present, Russia supplies natural gas to Georgia and due to inactive compressor stations it is distributed under the low (not more than 35 bar) pressure over the territory of the country. In case of necessity to increase the capacity (e.g. by putting the compressor stations into operation), it will be essential to increase the pressure that requires pre-testing of all pipelines under the corresponding pressure.

At present, main pipelines of Georgia are loaded only by 10-15 % of capacity. Low level of loading and inoperation of anticorrosion system together with condensate sedimentation and inaccuracy of measurements cause the comparatively high (5-6 %) technological losses and self-consumption share in the network, despite the fact that during last five years such kind of losses have been substantially reduced on the main pipeline. At the same time, especially high losses in gas distribution networks foster inefficient exploitation of the whole system. For comparison, in 1987-1991, technological losses and self-consumption at the main pipelines of Georgia varied within 2.1-2.9%. Total losses from the gas supply point to the end user constitutes 2-4,5 % in the Western countries, while it reaches almost 50 % in Georgia.

International energy center ENECO has worked out business plan - "Rehabilitation of gas main pipelines system in Georgia (including compressor stations and infrastructure)". Approximately US$ 250 million investment is determined by the plan for the overall rehabilitation, though the volume of primary foreign investments does not exceed US$ 80-100 million during the first 4-5 years of project realization. Subsequently, the system will become profitable and it will allocate investments from its own income. According to the project, cost for the rehabilitation of linear part of pipelines (except the reconstruction of compressor stations, communication and remote control devices, auxiliary mechanisms and equipment) will constitute US$ 217,4 million.

Calculations made by the American consulting company "Hagler Bailly Consulting, Inc" have shown that required rehabilitation costs for gas pipelines based upon the replacement value (which is different from historical value, that could be significantly reduced due to the fluctuation of prices during the past exploitation period), depreciation value, net book value and other necessary data, constitutes US$ 204 million.

The exploitation of main gas pipelines of Georgia has been managed by the State Enterprise (hereinafter – The State Department) "Sakgazi" under the Ministry of Gas Industry of the former Soviet Union, established by the end of the 1950's.

Complying with the decision of the Georgia Government Session held on 2 October 1996, all gas enterprises under "Sakgazi" existing on the territory of Georgia were transferred to the local authorities and municipalities, while the exploitation of main gas pipelines was entrusted to the State Enterprise "Sakgaztransmretsvi".

The State owned "International Gas Corporation of Georgia" has been established according to the Decree No 206 of the President of Georgia dated 20 April 1997. All existing main gas pipelines (300 mm - 1200 mm) with total length of 1939,2 km, all compressor and distributing stations, cleaning devices and the land necessary to use for ownership, utilization, management, exploitation and reconstruction, are put in the equity capital of the corporation.

Above mentioned property was transferred to the corporation for specified time considering the possible prolongation of the agreement, or for 30 years.

Besides the ownership rights on the existing systems, corporation was authorized to represent Georgian side in negotiations on the natural gas transit through the territory of Georgia and enter into an agreement between Georgia and any other foreign partner.

In December 1999 the corporation established "Gas Transport Company" Ltd., which was authorized to manage the existing main gas pipelines on the territory of Georgia.

3.6. EXPORT, IMPORT AND TRANSIT OF ENERGY RESOURCES
3.6.1. Caspian Oil and Natural Gas Deposit and Export Potential

As it is known, particular geographical location and geopolitical priorities of Georgia determine its potential as the main transit country delivering Caspian hydrocarbon resources at the international market. Integration of Georgia, similar to the other transitional countries of South Caucasus and Central Asia, in global business systems and formation and strengthening of sustainable regional economic relations are priorities, which should determine their future political and economic independence level. Exact projection of export capacity of local hydrocarbon-bearing fuel resources and reasonable designing of their delivery at the international market should act as the favorable terms for the successful realization of these priorities.

In accordance with data obtained from the State Oil Company of Azerbaijan (SOCAR), the prospected oil reserve in the country equals to 17.5 billion barrel (3.4 billion t), though according to other data, reserve profitable for extraction is estimated only at 3-11 billion barrel (0.4-1.5 billion t), e.g. under the report elaborated for the USA Congress, Azerbaijan holds about 3.6 billion barrel (491 mln. t) of oil reserve advantageous for extraction and about 27 billion barrel (3.7 billion t) of additional reserve. More than 90% of oil reserves of Azerbaijan are accumulated in the offshore deposits.

Azerbaijan has also substantial amount of natural gas reserve. In accordance with an earlier estimation, natural gas reserve favorable for extraction stands at about 300 billion m^3 and estimated additional reserve – 1000 billion m^3. According to the published findings based upon the study of Shah Deniz deposit carried out BP – Amoco, it contains 700 billion m^3 of natural gas and correspondingly, total reserve of the country was estimated at 1000-1300 billion m^3. After SOCAR, prospected reserve of natural gas in Azerbaijan equals to about 800 billion m^3.

In accordance with various estimations, total oil reserve of Kazakhstan makes 95-117 billion barrel (12.8-15.8 billion t), including 8-22 billion barrel (1.1-3.0 billion t) of prospected reserve. According to the report prepared under the Government of USA, estimated oil reserve in this country is 95 billion barrel and prospected reserve consists of 10 billion barrel.

Main reserve of oil and natural gas of Kazakhstan is located in the Caspian Sea or in the neighboring territories in Mangustau and Aturau regions. At the present time, the geological exploration has been performed only about on the half of total oil-bearing area (17 mln. km^2).

The largest prospected reserve of oil – 6-9 billion barrel (0.81-1.23 billion t) is accumulated at the Tengiz deposit being already in operation. The first results of Kashagan offshore deposit are very promising. According to the information provided by the Offshore Kazakh International Operation Company (OKIOC), reserve of Kashagani deposit significantly exceeds the reserve of Tengiz deposit and it constitutes approximately 5 billion t (35 billion barrel). Confirmation of Kashagan deposit reserve can positively amend the estimation of Kazakhstan's oil reserve and prospects for the increase of its extraction.

Estimated reserve of natural gas in Kazakhstan equals to 4 trillion m^3, among them 1500-2350 billion m^3 is prospected reserve. More than 40 % of the reserve is situated at the Karachaganak deposit.

Different data on the prospected oil reserve of Turkmenistan are provided by two separate sources of information - BP Statistical Review and Petroconsultants (correspondingly - 1.4 and 0.89 billion barrel). According to the US Government report, the prospected reserve of Turkmenistan oil equals to 1.5 billion barrel and additional estimated reserve – 32 billion barrel.

Basic reserves of Turkmenistan gas are concentrated in the central and eastern part of the country in the Amu Daria reservoir. Under the estimation of foreign sources, Turkmenistan gas reserve constitutes 2.7–4.4 trillion m^3. In accordance with the assessment made by the Russian "Gazprom" consortium (1988), the overall 7.8 trillion m^3 of natural gas reserve of the country includes 2.7 trillion m^3 of prospected reserve.

According to the Turkmenistan Government assessment, that is recognized by the independent experts as quite optimistic, prospective oil reserve of the country equals to 47 billion barrel (that also includes 18 billion barrel offshore reserve), and natural gas reserve is 15-21 trillion m^3.

In accordance with the data obtained from the state corporation "Uzbekneptogas", oil reserve of Uzbekistan makes 3.9 billion barrel, gas prospective reserve – 2 trillion m^3, potential reserve - 5.44 trillion m^3, though, other independent sources give rather modest data. According to the report of the US Government, prospective reserve of Uzbekistan oil is 200 million barrel and estimated reserve equals to 990 million barrel. Prospected reserve of natural gas stands at 1.6-2.1 trillion m^3, and additional reserve – 1 trillion m^3. After "Petroconsultant", oil reserve of Uzbekistan constitutes 513 million t and reserve of condensate is 162-216 million t.

Intensive development of newly prospected reserves of Caspian hydrocarbon-bearing recourses has started by the end of last decade. Significant increase of produced oil volume from the Caspian deposits is planned within the nearest 20-30 years. Azerbaijan intends to increase oil extraction volume from 13-14 million t (in 2000) up to 40 million t by 2010. That is based upon the experts' assessment according to which actual production potential for the year 2010 is estimated at 40-45 million t, out of which about 30 million t is intended for exportation. By the year 2015 Azerbaijan oil export volume may increase up to 46-51 million t, and by 2020 - up to 65-68 million t (according to the Least Cost Panning scenario).

Maximum gas extraction in Azerbaijan – 14 billion m^3 was registered in 1985. Later, due to gradual exhaustion of deposits being in operation, gas extraction has began to decrease year by year and in 1989 it was less then 10 billion m^3. Gas extraction has decreased much more sharply after the breaking of the Soviet Union up. This course of action was supported also by the destruction of old economic relations and inability to renew technological processes in terms of strict investment deficit. This caused the decrease of gas extraction down to 5.6 billion m^3 (1998).

According to the earlier projection (SOCAR, 1999) it was supposed that by 2010 gas production in Azerbaijan would be increased up to 16.5 billion m^3, but the results obtained from Shah Deniz exploitation give a hope that the gas extraction from only this deposit could make 24 billion m^3 annually. Furthermore, the results of preliminary research on neighboring Apsheron structure under CHEVRON were found to be promising. Accordingly, in conformity with the SOCAR projection, gas extraction in Azerbaijan will reach 20 (pessimistic scenario) – 40 (optimistic projection) billion m^3 within 10-12 years after putting the Shah Deniz deposit into operation (by the beginning of 2003). For this period gas local consumption will be increased approximately up to 15 billion m^3 (for comparison: 15.8 billion m^3 was consumed in 1990, and about 5-6 billion m^3 - in the recent years). Correspondingly, maximum export potential of gas in Azerbaijan may reach 20-25 billion m^3 for the period of 2015-2017.

The increase of oil extraction volume is envisaged in Kazakhstan mainly from the deposits of Tengiz, Karachaganak and other operating fields, also from the OKIOS offshore (basically Kashagan) deposits, which have to be developed by 2005-2007. Estimated volume of 40 million t projected for 2001 could be increased up to about 100 million t by 2010; and in case of full-scale development of offshore deposits (2013-2015) under the Italian AGIP using $ 20 billion of investments it will reach 125-140 million t.

By the end of the 90's production of local natural gas in Kazakhstan constituted 6-7 billion m^3, with the increase perspective up to 12 billion m^3 by 2005, and at least up to 15 billion m^3 - by 2010.

In 2000 estimated gas consumption in Kazakhstan made approximately 12-13 billion m^3, which along with the local natural gas was balanced by the cost of gas transit from Turkmenistan (18 % of transported gas) and by gas exchanged with Uzbekistan. Increase of self-consumption of gas in Kazakhstan at least up to 16-17 billion m^3 is planned for the years 2005 and 2010. This fact indicates that Kazakhstan could not be recognized as a large gas exporter country (it has to be mentioned that according to earlier more optimistic projections, gas production could be increased up to 25 billion m^3 by 2010, though analysis of current rate of development illustrates that realization of this kind of scenario is less expectative).

By the end of the century the Government of Turkmenistan was planning to produce 10 million t of oil annually, though rather less amount of oil has been extracted in 2000. Under the conclusion of analysts, prospected reserve of Turkmenistan deposits could allow to extract 10 million t of oil by the year 2010 with consequent outlook of increasing (up to 20 million t). There is also more pessimistic projection according to which oil extraction in Turkmenistan may reach about 5.3 million t by 2010. Oil extracted in Turkmenistan is mainly provided for self-consumption.

Maximum level of natural gas extraction (85-90 billion m^3) in Turkmenistan was reached by the end of the 80's. In terms of the self-consumption of 7 billion m^3, great part of gas was exported to the Republics of the former Soviet Union and Europe.

By the end of the 90's gas extraction in the country was considerably (5 times and more) decreased, that was mainly caused by significant limitation of gas transportation from Turkmenistan through the pipelines of Russia and by the absence of other alternative routes.

According to the plan, the increase of Turkmenistan gas export potential up to 60-85 billion m^3 is considered correspondingly for the years 2010 and 2015, though in conformity with the experts' estimation, the achievement of such kind of results is quite complicated, primarily due to the absence of direct relations with actual consumer markets (Europe, South-east Asia).

About 15 billion m^3 of natural gas was extracted in Turkmenistan in the first quarter of 2001, out of which only one-third was used for self-consumption. Export of 30 billion m^3 of natural gas to the Ukraine, selling of 10 billion m^3 to the Russian company ITERA registered in the USA and sell of 6 billion m^3 to Iran is planned during the year.

According to the information published by the Government of Uzbekistan, the country plans to produce 12-15 million t of oil by 2010-2020. Western experts regarded this amount as quite realistic. For example, in correspondence with "Petrotoconsultant" projection, about 15.7 million t of oil could be produced in Uzbekistan by 2020. However, export capacity of the country is estimated very pessimistically, because high number of population (about 25 million residents) and anticipated economic progress will result in significant increase of existing level of specific energy consumption (2 t of oil equivalent per capita) and the use of produced oil, basically to meet self-demand. Furthermore, Uzbekistan is completely isolated from the international market, it does not have direct entrance to the Caspian Sea that makes oil transportation much more expensive and it limits export potential. Export of Uzbekistan oil to the neighboring regions of Turkmenistan and Kazakhstan is more profitable. In return, these regions, from their side, will export equivalent volume of released oil.

Natural gas production in Uzbekistan was increased up to about 50 billion m^3 within ten years (40.4 billion m^3 in 1990). Increase of gas extraction up to about 60 billion m^3 is foreseen. It provides 3-5 billion m^3 gas export potential by 2010. In addition, Uzbekistan is recognized as regional exporter country of about 5-7 billion m^3 gas annually (neighboring to Kazakhstan, Kirgizistan, Tajikistan and Turkmenistan) because of its distant location from the international market.

Prospects of oil industry development in Georgia and also the impact of powerful export potential of Russian oil and gas on the formation of general lanscape has to be taken into account during the determination of regional market and export capacity.

At present oil extraction in Russia exceeds 300 million t/y. The steep increase of oil extraction that would cause the overloading of traditional export routes to the Black Sea is less probable in the nearest future. This is also stipulated by the fact that export of extracted oil within the next decade from the different deposits (Timan-Pechora reservoir, the Pechora Sea, Sakhalin Island) to this direction is not expedient from the economic standpoint. At the same time, relatively growing delivery towards the Black Sea ports can be planned from the deposits of Russian sector of the Caspian Sea by “Lukoil”, where increase of annual extraction up to 30 million t is expected. Correspondingly, till 2005 the Russian oil flow via the routes of the Black Sea will be kept at about present level - 50 million t. Later, by 2010, when oil extraction may reach 340 million t/y, approximate volume of exported oil supplied in this direction will equal to 60-75 million t.

3.6.2 Export-Import Potential of the Black Sea Ports and Oil Terminals

At present, total annual volume of oil and oil products transported from Russia via the Black Sea ports constitutes about 55 million t (11 billion brl/day), that includes up to 3 mln t of mixture of oil from Kazakhstan, Azerbaijan and Turkmenistan as well.

Current capacity of the Port of Novorossiysk (in 2000) is 34 million t/y (680 kbrl/day). Increasing of port’s capacity up to 42 million t/y is planned. Annual export of additional 4 million t of oil and 6 million t of oil products from the terminals of Tuapse Port is possible. Increasing the capacity of Tuapse Port up to 15 million t/y is foreseen. New terminal of “Yuzhnaia Ozerovka” near Novorossiysk, which is under construction, is destined for taking oil from the pipeline of Caspian Pipeline Company (CPC) and for its further transportation via the Black Sea.

Part of oil exported from the territory of Russia is transported via Odessa (Ukraine) Port, current capacity of which makes 10 million t/y (200 kbrl/day). 50 % of terminal volume is intended for the transportation of oil products. Substantial share of oil transited from Kazakhstan through Russia is exported via the Odessa Port. Increasing of the Odessa Port capacity is planned up to 12 million t/y. Construction of a new oil terminal of Pivdeni near Odessa with 9 million t/y of capacity has been started.

Supply of oil (approximately 3.5 million t/y) transited from Russia and Kazakhstan via the Black Sea for further exportation is also possible using barges through the Volga-Don channel.

Thus, at present the maximum amount of exported oil supplied through the territory of Russia and via the Black Sea equals to 50 million t/y (together with oil products – 60 million t/y), and it will reach 100 million t/y (2 million brl/day) in the future.

Potential capacity of Supsa Terminal located at the Black Sea coast of Georgia equals to 10 million t/y (200 kbrl/day). At present, terminal exports about 5 million t/y (maximum 115 kbrl/day) of oil supplied from Azerbaijan through Baku-Supsa pipeline. Capacity of another operating Black Sea port of Georgia – Batumi is 3.5 million t/y (70 kbrl/day). Terminals of the Batumi Port are mainly used for the exportation of oil supplied from the Tengiz deposit in Kazakhstan through the Caspian Sea by barges and then – by Transcaucasus railway. Additional increase of capacity of this terminal by 3.3 million t/y (up to 135 kbrl/day) is envisaged.

Construction of one more new terminal in Supsa in order to serve the Kazakhstan oil is also planned. According to the preliminary calculation, construction of 200 000 m^3 marine charging equipment of railroad overpass and deadlock will cost US$ 50 million. Estimated annual operational expenses on terminal exploitation stands at US$ 2 million. Construction of a relatively low capacity terminal, which will basically serve the domestic export and import of oil products, has also started at the Black Sea coast of Georgia.

Correspondingly, the estimated maximum capacity of the ports of eastern and northern coasts of the Black Sea, which are connected to the Caspian and Russian deposits, does not exceed 75 million t/y, though it could be increased up to 120-125 million t/y in future.

The best conditions for accommodating and further delivering of Caspian oil are organized in the Port of Constantsa (Romania) at the western coast of the Black Sea. The port is equipped by terminals with 600 thousand t of oil capacity and 300 thousand t of oil products capacity, which are able to import and export 24 million t of oil and 10 million t of oil products annually. Increasing of capacity of the port in order to serve 36 million t/y of crude oil is foreseen.

The port of Constantsa (together with the ports of Petromidia and Tulenovo) is connected with ten Romanian oil-refineries through the pipelines and railway transport as well. Total capacity of these enterprises makes 34 million t/y, effective capacity – 26 million t/y, but their actual load does not exceed 50 % of this capacity.

The Port of Burgas (Bulgaria) is regarded as the receiver of Caspian oil (estimated capacity is 35-75 million t/y). The transit pipelines should be constructed from this port to Alexandropol (Greece) with estimated capacity of 15 million t/y at the first stage and 40 million t/y finally or to Vrole (Albania). In addition, development of the Vrole Port to serve supertankers is discussed for further transportation of oil towards the western markets. The removal of floating charger from low water port of Alexandropoulos away from the bank to the open sea is also under consideration.

3.6.3. Market Analysis

As it is known, oil is regarded as a universal fuel, because its transportation, storing and consumption is possible using a lot of alternative methods and means. Correspondingly oil, regardless the place of its production, may be considered as a potential product for any region of the world, if its supply by the technically available means is economically sound.

The initial consumer of Caspian oil is Caspian-Black Sea Region. Though, analysis shows that the countries of the Region are not able to adapt its overall potential and they are mostly recognized as the transit countries of the Caspian oil for the markets of Europe, North America and Southeast Asia.

Routes passing through Russia and Eastern European countries (pipelines, railway, water transport) and the Transcaucasian routes via the Black Sea ports and Turkish straits towards the ports of Mediterranean (Genoa, Trieste) could be used in order to supply Europe with Caspian oil. The ports on eastern and western coasts of the Black Sea through the main pipelines via the Balkans or Ukraine, Poland and the Baltic Sea are used for the Central and Western Europe supply. Only the tankers with not more than 150 000 tones of displacement can navigate because of small depth of fairway at the Black Sea ports and the small capacity of the Bosphorus Strait as well. Consequently, oil supplied through the Black Sea route is economically sound only if it is supplied at the European market, as oil transportation by such tankers towards the remote markets of North America and Asia turns unreasonably expensive.

Overland territory of Iran via the Persian Gulf should be less attractive for the Caspian oil transportation, because, traditionally, it is the major export route for the rather cheap oil from Iran and Arabian Peninsula. Correspondingly, the Caspian oil cost should be significantly decreased in order to maintain competitive ability of the Caspian oil within the application of this route.

Caspian oil exportation via the territories of Azerbaijan, Georgia and Turkey and through the deep-water port of Jeikhan facilitates its efficient delivery at the world market. First and foremost this is preconditioned by the unlimited charging capacity of tankers with 250 000 tones and more of displacement in the port of Jeikhan. Afterwards they could be transferred towards any part of the world, especially in the direction of the North American and South-east Asian markets with less expense. Correspondingly, the Caspian oil distribution markets through the Jeikhan port are limited neither in size nor in space. Nevertheless, to prove economic profitability and safety of oil transportation through this route is complicated. It has to be noted that the Baku-Tbilisi-Jeikhan route is safeguarded by the credible political support preferentially as the guarantee of economic independence of Central Asian and South Caucasian countries and their harmonic integration in the international economic space.

Natural gas is marketable product distinctly from oil. Its supply is available only in case of appropriate, special infrastructure intended for gas transportation and consumption that requires unreasonably high initial investments. It has to be mentioned that the development of natural gas deposit and construction of transportation pipelines could be executed only in case if the concrete consumer is determined and relevant contract is signed between the producer and the consumer. (For comparison: existence of commercial reserve and required investments are preconditions for adoption of oil deposit and the obtained oil is considered for market sale and not for use by any specific consumer). Consequently, the natural gas market is comparatively limited and in some context, unlike the oil, it represents regional fuel resource.

In spite of above mentioned, in the recent years the significant attention is drawn to the problems concerning the development of natural gas deposits and its delivery at the market, among them - from the Caspian region as well. According to the projections, natural gas will become one of the major fuel resources in the XXI century because of its environmental safety, consumption simplicity and relative cheapness.

South Caucasian countries, Turkey, countries of the Balkans and Eastern Europe could become the potential consumers of the Caspian natural gas. Especially steep growth of gas consumption rate is planned in Turkey. This demand will be practically covered in short and medium-terms by the contracts signed by the state company "Botas" and negotiations of the country's Government with Russia, Iran, Turkmenistan and other countries. According to the analysts, demand for the additional natural gas in Turkey would occur from 2010 and it could reach 27 billion m^3 by 2015.

Since 1998 Turkey has been supplied by gas via Russia, the Ukraine and the countries of the Balkans. According to the contract signed between "Botas" and the Russian "Gasprom", the annual capacity of the pipeline has to grow up to 14 billion m^3. "Gazprom" has started the construction of overland section of the Black Sea underwater oil pipeline (so called "Blue Stream") to guarantee the annual delivery of 16 billion m^3 natural gas at the market in Turkey.

Iran, which is the owner of the heaviest explored reserve in the world after Russia, has already finished the construction of gas pipeline on its territory and plans to supply Turkey initially by 2-3 billion m^3 of gas annually and then increase the delivery amount up to 10 billion m^3.

Preparatory work for designing and construction of pipeline carrying natural gas from the Shah Deniz deposit via the Georgian territory to Turkey is at the decisive stage. At first 3-5 billion m^3 and then 30 billion m^3 of natural gas should be supplied through this pipeline to Georgia and Turkey and afterwards to Europe as well. Issue concerning the construction of Trans-Caspian gas pipeline, which is provided to supply 30 billion m^3 of Caspian gas annually (from Turkmenistan and Azerbaijan) to the markets of Turkey and Europe, is under discussion. Its realization would limit Russian hegemony over the Turkish and European markets.

Sharp increase of gas consumption within the nearest decade is planned in the South Caucasian countries as well. Azerbaijan, Georgia and Armenia possess sufficiently advanced infrastructure of gas distribution and consumption; they have accumulated long-term (since the 60's) experience on application of this structure. Apart from the aforementioned, the USA, and in general the West recognizes the adoption, consumption and transit of the hydro carbonic resources as the mainstream of economic and political integration of South Caucasus and Central Asian countries with the West and thus it promotes the development of this process.

3.6.4. Facilities of Delivery

3.6.4.1. Oil Transportation in Short and Medium Terms

First and foremost, already functioning western (Baku-Supsa) and northern (Baku-Novorossiysk) routes of crude oil transportation should be used to export oil extracted in Azerbaijan by short and medium terms (2001-2005).

Current maximum conductivity of Baku-Supsa 500 mm oil pipeline is 5.75 mln t per annum (115 kbrl/day), although its capacity can be considerably increased. Performed technical and economic analysis demonstrates that the least rated expenses for transportation are achieved in case of conductivity increase up to 7.5mln t/y using additional pumping stations located on the territory of Georgia, that will raise electricity consumption up to 12 000 MWh/y. Increase of conductivity up to 9-10 mln t/y (by putting into operation of additional pumping stations with 180-220 kbrl/day located on the territory of Georgia that will increase electricity consumption approximately up to 180 000 MWh/y) will result in raising of rated expenses by 45%.

Current design capacity of Baku-Novorossiysk route equals to 5 mln t/y, though in 2000 it was employed only by 10%. At the initial stage, pipeline (700mm diameter) capacity can be increased up to 9 mln t/y and later - up to 17-18 mln t/y (360 kbrl/day). It should be mentioned that the reliability of this route would be significantly increased after the construction of pipeline around Chechnya, though prospect of its development is still doubtful due to higher tariffs compared with parallel western route and oil quality sharp deterioration because of blending of Azerbaijan oil with Siberian oil that causes about 40$/t additional expenses.

Along with technical and economic parameters other terms, especially, potential of alternative means of oil transportation, pace of construction of new pipelines and others should be taken into account while making a decision about the capacity increase of western and northern routes of Azerbaijan crude oil.

Part of Kazakhstani oil flows to Samara through the acting pipeline that could transit 15 mln. t/y of oil instead of 10 mln. t/y. This oil is blended with West Siberian oil in Samara and then transported towards Novorossiysk through the oil pipeline "Druzhba".

Alternative routes for Kazakhstani oil include Transcaucasian railway with current 3.5 mln. t/y of capacity (increasing up to 6.8 mln. t/y is a prospective and use of barges through the Volga-Don channel with maximum capacity of 3-4 mln t/y).

The first stage of pipeline construction of Caspian Pipeline Company (CPC) has been accomplished. Its initial conductivity is 2.8 mln t/y (560 kbrl/day). Pipeline conductivity would be increased up to 67 mln t/y in pursuance of the second stage of construction (2007-2014).

From the beginning CPC oil pipeline would be mainly used to transfer oil from the Tengiz deposit to "Yuzhnaia Ozerovka" terminal near Novorossiysk that is under construction. Rising of capacity of Tengiz deposit up to 20 mnl t/y and in addition the increase of extraction volume of other deposits of Karachaganak and West Kazakhstan up to 20 mln t/y till 2005 stipulates the necessity to provide about 30-35 mln t of Kazakhstani oil by the means of exportation by the middle of the current decade. Export of this amount of oil from Kazakhstan could be provided through the pipelines of CPC, Samara and "Druzhba", by the Transcaucasian complex (sea transport, pipelines, railway) system, barges and railways via the territory of Russia, exchanges between Russia (substituting the oil products delivered to Kazakhstan) and Iran. Besides, the oil companies show the definite interest on existing and at present inoperative pipeline of Samgori-Batumi ("Macconel Dauel" performs cleaning of pipelines) in order to restore its capacity (5 mln t/y) that will additionally increase the current potential of means of exportation of Caspian and especially Kazakhstani oil.

By this time (until 2005) commencement of large-scale development of new Kashagan deposit that is foreseen approximately by 2006-2010 is doubtful.

Thus, for the projected short and medium terms, annual export from Caspian deposits and Russia by means of the ports of the Black Sea will not exceed 100-115 mln t. that includes about 55-60 mnl t of export from Russia, 30-35 mln t - from Kazakhstan and 15-20 mln t from Azerbaijan and relatively insignificant amount from Turkmenistan and Georgia. Transfer of this amount of oil is possible through the straits of Turkey and in case of necessity from parallel ports of Constantsa (Rumania), Burgas (Bulgaria), Odessa and Pivdenia (Ukraine) through the pipelines under construction towards Brod-Gdansk (Poland) and also using Danube navy at the expense of comparatively small-scale investments.

3.6.4.2. Caspian Natural Gas Export in Short and Medium Terms

By 2005, according to the accessible projection, natural gas export potential in Turkmenistan could reach 40-50 billion m^3. For the time being, Russian "Gazprom" pipelines are still only mean to export natural gas from Turkmenistan. Russia successfully uses natural gas of Turkmenistan for delivering it to Turkey (through the transit pipeline) and South Caucasus (through the North-South Caucasus main pipeline (NSC)).

Project that envisages NSC route renovation and its further development in order to deliver natural gas from the deposits of Turkmenistan and Russia towards the regions of East Anatolia of Turkey and the Black Sea is notable with its high economic efficiency, but taking into consideration the latest events "Gazprom" passes round this route without any persuasive argument in spite of principle consent from the side of both Turkey and Georgia. In return, "Gazprom" choice (motivated more politically than economically) has focused on the "Blue Stream" (BS) project with rather low economic efficiency that foresees the construction of the Black Sea underwater pipeline in order to deliver natural gas from Russia and Turkmenistan to Turkey. Presumably, the NSC pipeline finally will form as route of Caucasian importance, especially for supplying Armenia and partially Georgia by natural gas from Russia.

The alternative 1270 km BS pipeline consists of:

? Compressor stations located on the land territory of Russia and 373 km and 56 inch (about 1400 mm) pipeline;
? Two parallel underwater pipelines with 396 km of length and 24 inch (about 600 mm) in diameter, and
? Pipeline (501 km of length and 48 inch in diameter) connecting the Turkish cities of Samsun and Ankara and compressor stations.

From the beginning, putting into exploitation of the pipeline was planned by 2000, though numerous of problems are to be solved for the successful termination of the project. Contract (costing $ 1.7 billion) signed by "Gazprom" and the Italian company ENI foresees the construction of underwater section of pipeline. In accordance with the contract, ENI will own 20% of projected shares and 50% of pipeline capacity. Its involvement together with preferential taxation regime established by Russia and Turkey, will be recognized as the most favorable term for project implementation. However, in the opinion of some analysts, its total financing (according to estimation an initial investment equals to $ 2.5 billion) will be much complicated because of about $ 10 billion foreign debt of "Gazprom" and delay in the realization of planned development program of its own deposits.

On the other turn, after the liberalization of natural gas market foreseen by 2002 in Italy, ENI monopoly on the territory of the country will be sharply restricted that makes its intervention on the new markets unavoidable. This factor was recognized as one of the basic reasons due to which the company has been involved in the implementation of economically rather risky, the most difficult from the technological standpoint and environmentally hazardous (pipeline passes through the highly seismic zone, in the chemically active environment) project.

There is a consideration that the “Gazprom” as well as ENI are trying to solve their own economic challenges by dint of BS project realization and adoption of winning the growing Turkish market. In addition, the “Gazprom” intends to prolong its hegemony on the export routes of Caspian deposits.

Russia possibly could use natural gas from Turkmenistan to supply Turkey that is cheaper ($ 45/1000 m^3 at the border of the country with only partial repayment by cash) than its own rather accessible and the cheapest “Pur-Taz-Nadim” gas. Though, the absolute compromise was not achieved during the President Putin’s visit in Turkmenistan. Instead of the 30-year contract desirable for “Gazprom” about 50 billion m^3 of natural gas supply, only the letter of intent has been signed that envisages the increase of supplied gas amount for Russia by 10 billion m^3 annually by the period of 2001-2004.

In favor of tight economic and political integration of CIS countries, carrying out of scenario desirable for “Gazprom” is quite expectable, considering the activity from the side of President of Russia and shaky position of the President of Turkmenistan related to the future political orientation of the country, that finally will greatly hamper the independent development of Turkmenistan, because successful operation of one of the basic strategic sub-sectors of economy will depend on export pipelines running through the whole territory of Russia. It is not surprising (moreover, it’s predictable) that Russia will take this situation, traditionally, for its political gains.

The second possible direction to supply natural gas from Turkmenistan to Turkey is pipeline that is under construction via the territory of Iran. According to the 23-year contract signed by “Botas” (Turkey) and NIGC (Iran) in 1996, 3 billion m^3 of natural gas should be supplied annually at the initial stage and 10 billion m^3 – at next stage. Iran is going to use Turkmenistan’s natural gas for re-exportation, because of natural gas deposits of Iran are mainly located in the southern part of the country and its delivery to the border of Turkey faces great economic and technical difficulties. Iran is supplied by gas from Turkmenistan through newly constructed pipeline with limited capacity. The construction of Tebriz-Ankara section of 1174 km pipeline on the territory of Iran has been already completed. Pipeline exploitation starts after the completion of Azzrum-Ankara section on the Turkish territory in the end of 2001.

There are wide prospects for intensive development of Azerbaijan Shah Deniz deposit and gas supply to meet the demand of Turkey and South Caucasian countries. The consortium established under BP Amoco intends to supply Turkey with 3-5 billion m^3 of natural gas at the initial stage (presumably in 2005) from Shah Deniz via the territories of Azerbaijan and Georgia and increase of the amount up to 6.6 billion m^3 by 2007. This pipeline could partially meet the demand of Georgia, thus, its total capacity could reach 27-30 billion m^3 annually. According to the preliminary calculations, the restoration of the 490 km main pipeline existing on the territory of Azerbaijan and the construction of a new 244 km section on the territory of Georgia will require about $ 700 mln. After SOCAR estimation, gas production in Azerbaijan costs about $ 15.5/1000 m^3 (1999). On the other hand, according to WB assessment gas transit on the territory of Azerbaijan could cost $5-8/1000 m^3. As it is clear from the analysis, the construction of Shah Deniz-Georgia-Turkey pipeline needs relatively small initial investment and supplied gas should be the cheapest for the end-user. As the Minister of Energy and Natural Resources of Turkey Mr. Ersumer has declared, agreement on natural gas supply from Azerbaijan is the most convenient for Turkey. Under the experts’ assumption, natural gas delivered from Shah Deniz to the border of Turkey costs about $30/1000 m^3 and the purchasing price will be not less than $ 70/1000 m^3.

Possibility of step by step restoration of the existing main pipeline of Georgia to supply natural gas from Azerbaijan to Georgia and Turkey is open to discuss. As it is seen from the preliminary calculation, at the initial stage about US$ 200 mln of investment is required to provide 5 billion m^3/y capacity for the restoration of Kazakh-Saguramo-Khashuri existing section and the construction of Khashuri-Vale (Georgian-Turkish border) section. In case of capacity increase up to 10 billion m^3/y, the reconstruction of the system will cost about US$ 370-415 mln. To reach 15-18 billion m^3/y of capacity, the necessary investment could be estimated at US$ 425-450 mln (for comparison, cost for the construction of new pipeline on the territory of Georgia stands at US$ 450 mln.).

3.6.4.3. Oil Transportation in Long-Term

As it is evident from the analysis, an export potential of oil from the caspian deposits could be estimated at 90-150 mln t by 2010-2020 (among them 30-55 mln t from Azerbaijan and 60-100 mln t from Kazakhstan). 50-70 mln t of oil from Russia is added to this amount that traditionally is exported at the international market through the route across the black sea. Even total minimum amount of export oil is not possible to take out from the eastern and northern ports of the black sea as well as via the straits of Turkey. Correspondingly, the issues concerning the construction of Baku-Tbilisi-Jeikhan and other alternative routes of oil exportation that will pass apart from the straits of turkey are under intensive examination.

The main advantage of Baku-Supsa new pipeline with 40 mln t/y design capacity is relatively low construction and operational expenses. On the other hand, to confirm the expediency of project realization it would be essential to consider the expenses for its transportation from Supsa by sea and then transportation through the pipelines of Burgas-Alexandrepol, Burgas-Vrole, Constantsa-Triest or Odessa-Gdansk, that could make the specific cost for export of oil at the international market much higher. Besides, in case of using this route the caspian oil potential market should be significantly limited as its exportation via the Bosphorus Strait to the markets of Western Europe and especially to the markets of South America or Southeast Asia is practically impossible.

Development of Baku-Novorossiysk direction for the caspian main oil transportation is considered as less prospective and thanks to relatively high prices, limited capacity of Novorossiysk and nearby ports and mainly due to the desire of oil companies its development was less depended on the pipelines running through the territory of Russia.

At one sight, construction of transiranian (e.g. Baku-Khargi) pipeline could seem attractive for oil companies, though advantages stipulated by the cheapness of the route are neutralized by non-expediency of project realization from political standpoint as well as rather less convenient conditions to transit caspian oil via the Persian Gulf and Ormuz Strait, because this route traditionally exports relatively cheap oil from the Arabian Peninsula. During the transportation of caspian oil by this route, the companies will have to reduce considerably the caspian oil export price in order to win the competition. In general, there is a danger that companies will appear compulsory involved in the rules of play established by OPEC which is dominating in this region.

The process of decision making on the expediency of realization of project concerning the caspian oil main export pipeline (MEP) - Baku-Tbilisi-Jeihan (or Aktau-Baku-Tbilisi-Jeihan - considering the latest events) and its optimal development in time and space is in final phase. Positions of supporters to construct the pipeline were consolidated by the memorandum signed at the meeting of government delegations of Georgia, Azerbaijan, Turkey, Kazakhstan and USA held in Astana, new capital of Kazakhstan. Kazakhstan ones more suggested at this meeting its interest to participate in the construction of MEP.

Realization of main export pipeline project was commenced after the “Agreement of the territory owner country” was signed between the group of sponsor oil companies and the governments of Azerbaijan, Georgia and Turkey in October 2000. The following oil companies are included in the group of sponsors: BP Amoco (Great Britain, 25.41% of shares), UNOCAL (USA, 7.48%), STATOIL (Norway, 6.37%), ITOCHU (Japan, 2.92%), RAMCO (Great Britain, 1.55%), Turkish Petroleum (Turkey, 5.02%), SOCAR (Azerbaijan, 50%), Delta Hess (Saudi Arabia and USA, 1.25%). By the latest information, the American Chevron and French Total-Final-Elf along with some other oil companies are going to negotiate the joining to the group of sponsors. At this stage the basic goal of corporation is connected with anticipated positive results of the first exploring well of an offshore deposit and it envisages guaranteed provision of extracted oil delivery at the international market. In addition, the company recognizes the Baku-Tbilisi-Jeikhan route as alternative one for CPC pipeline in case if the last one, for some reasons, will fail to fulfill its function.

According to the preliminary plan, the main export pipeline will originate from Azerbaijan Sangachali terminal at the Caspian Sea shore (or from the Kazakhstani city of Aktau, as it was mentioned at the meeting held in Astana). This pipeline will pass trough the territories of Azerbaijan (449km), Georgia (235km), Turkey (1059km) and at 1743km it will end at the Mediterranean Sea deepwater port of Jeikhan terminal. Maximum height of pipeline route above the sea level is 2830m. Pipeline diameter equals to 1050mm (40 inch), design capacity – 45-50 mln t/y. The construction economic cost is US$ 2.4 billion. According to the initial plan the construction should be accomplished in 2004 and exploitation should begin in 2005.

10 pumping stations will serve the oil pipeline, out of them three pumping stations will be located on the territory of Azerbaijan, three - on the territory of Georgia and four - on the territory of Turkey. System is equipped by 4 oil metering stations (located in the beginning and end of the routes and among the countries on crossing of the borders) and by 11 inlet and outlet stations of cleaning device. Moreover, 90 units of locking and back valves with the systems of supervisory control, data registration and communication (scada) are included in the pipeline.

The Jeikhan marine terminal comprises 6 oil reservoirs of API-650 specification with 155 000 m^3 of volume (125 000 t of capacity). Marine charging device (SPM) consists of three floating flexible hoses with 350mm in diameter and 320m of length, collector for tanker charging and two pipelines – one of this with 2 km of length and 900 mm in diameter is located above the ground and another one with 3 km of length and 750 mm in diameter is placed on the bottom of sea.

Tender winner American company “Fluor Daniel” has been performing so called basic engineering (designing) activities on the territories of Azerbaijan and Georgia since the autumn of 2000. Similar works are carried out by the local BOTAS and German PLE companies on the territory of Turkey. Relying on the results of basic engineering activities, the decision on the expediency to continue the further operation will be made and also one-year working plan that mainly includes thorough designing will be approved. In June or July of 2002 after getting acquainted with the results of the designing, the group of sponsor companies will run to the final conclusion on the expediency of pipeline construction, data to start and finish and on other basic factors.

The highest level international environmental and technical standards (ISO, API, ASTM, BSI and others) should be used during the pipeline construction. According to the agreement, commencement of pipeline construction is prohibited if the host country has not beforehand approved an environmental impact assessment and relevant engineering and design documentation.

In case of successful realization of the project, pipeline design capacity will be reached after 6 years of operation and the maximum capacity will be kept during 7-40 years. Within 40 years of project operation, 1871 million t of caspian oil will be transported though the main export oil pipeline.

As it has been already mentioned, 2 pumping stations will be disposed on the territory of Georgia. Each station will be equipped by centrifugal pumps. Nominal exploitation load of their autonomous engines will approximately make 10 000 kW. In addition, other significant capital expenses will be required during the construction of pipeline through the territory of georgia; among them are: US$ 88.3 mln (375 $/m) – on pipeline purchasing, US$ 126 mln (average 540 000$/km) – on pipeline construction, US$ 120 mln - for land and harvest compensation, US$ 17.8 mln - on engineering works, US$15 mln - on preparatory activities, US$ 5.7 mln - on communication system, US$ 46.8 mln - on the other unforeseen expenses, US$ 514.7 mln. - total initial investment. Moreover, during 40 years of project realization, additional operational expenses for the oil pipeline section located on the territory of georgia will be equal to about US$ 461 mln (averagely 11.5 mln $/y). By the years of exploitation, taxes for oil transit to be paid to Georgia are the following:

? 1-5 years	12 C/brl (0.89 $/t	$112 mln in total)
? 6-15 years	14 C/brl (1.04 $/t	$566 mln in total)
? 16-25 years	17 C/brl (1.26 $/t	$568 mln in total)
? 26-30 years	20 C/brl (1.48 $/t	$371 mln in total)
? 31-35 years	22.5 C/brl (1.67 $/t	$417 mln in total)
? 36-40 years	25 C/brl (1.86 $/t	$464 mln in total)

Throughout the 40 years of exploitation Georgia will get about US$ 2.5 billion or on the average 62.5 mln $/y in the form of tariff taxes.

3.7. CO_2 EMISSIONS RESULTING FROM NON-EFFICIENT TECHNOLOGIES OPERATING IN ENERGY RESOURCES EXTRACTION AND TRANSPORTATION SECTOR

All four main sectors (extraction and transportation of energy resources, electricity and power generation, transmission-distribution and consumption) were examined in order to evaluate the efficiency in the energy sector within the project. The situation was assessed for 1990 and 1999. 1990 is discussed as baseline year according to the UNFCCC. 1999 actually represents the current state of the sector.

The following situation is defined as a result of energy efficiency inventory of technologies applied in the mentioned sector in 1990 and 1999.

Extraction and transportation of three main energy carriers (coal, oil and natural gas) was discussed in energy resources' extraction and transportation sector.

Six enterprises were functioning in the extraction sector by 1990: five of them were recovering coal and one – oil and natural gas. Technologies used in the soviet period had been operating by this time. Their average efficiency was equal to 80% and it was dropped to 12% in Saknavtobi. Consequently, extra emission per extracted ton of coal was 0.007tCO_2/t on the average (see Table 3.7.1). If it is recalculated on the amount of annually extracted coal, total extra emission would be equal to 1 080 tCO_2/y.

Eight enterprises were operating in 1999. Two of them were recovering coal, six – oil and natural gas. Among the oil extracting enterprises five represent joint companies in association with foreign investors and so the acting technologies are rather new and their average efficiency consists 100% and even more (according to the previous norms). It means that extra emission resulted from ineffective operation of technology has not occurred in this sector or it is not detected at this stage. As to "Imereti", its functioning is ceased. Efficiency of "Aghmosavleti-2" coal mine does not exceed 10%. It means that relatively to the norm, 10 times more electricity is consumed per ton of coal recovery, that makes about 29 900 tCO_2/y GHG emission from only one mine, extraction of which by 1999 (7 260 t/y) makes only 5 % of 1990 recovery (144 300 t/y). From this is evident that in case of the restoration of even design energy consumption, 4 t of CO_2 could be saved per ton of extracted coal.

By 1990 coal was mainly transported through the railway, where electricity losses make 27%, while, complying with a norm, it could not exceed 15%.

As to natural gas transportation and delivery, here losses are quite high that is principally stipulated by the state of the networks. In particular, if assume that technical losses in Tbilisi natural gas distribution network made 25% in 1999, it gives 23.3 million m^3 or 18.6 thousand tons of natural gas losses. Accounting that in the natural gas the content of CH4 makes about 70%, amount of methane emitted from the network could be estimated at 13.0 thousand ton. As it is known, CH4 global warming potential equals to 21. Therefore, in 1999 losses (so called fugitive emissions) from Tbilisi natural gas distribution network because of technical reasons consisted 273 thousand tons of CO_2.

Table 3.7.1. Energy efficiency of energy resources transportation and extraction

Extraction							
1990							
Name	Quantity of output products			Energy efficiency of technologies		Energy efficiency (%)	CO_2 extra emission (ton)
	Accompaning natural gas (m^3)	Oil (t)	Coal (t)	Normative (kWh/t)	Actual (kWh/t)		
State enterprise "Saknavtobi"	50900000	186400	NA	NA	NA	12	
Coal mine "Aghmosavleti 2"			144300	175	204	85	1079,65
Tkvarcheli mine department - 4 coal mines			290200	175	157	100	0
Coal mine "Dasavleti"			70500	175	256	68	1473,3
Coal mine "Okriba"			226600	175	186,5	93	672,32
"Imereti" coal mine			223200	175	174	100	0
Total values			441400				3225,28
1999							
"Kakhetis Navtobi" Ltd						Carries out the regional seismic activities	
Georgian-British Oil Company, Ltd	164000000	55440					
Oil company "Frontera Eastern Georgia" Ltd	1074000	6072				96	
"Ioris Veli" Ltd	2579000	26508				100	
Joint Venture Oil national company "Saknavtobi"	148000	3731				100	
Georgian-German Oil Company							
Coal mine "Aghmosavleti 2" named after E. Mindeli			7260	175	1770	10	2987,56
"Imereti" coal mine				175			0

4. INVENTORY OF TECHNOLOGIES APPLIED IN THE ENERGY SECTOR AND CURRENT STATE OF THEIR EFFICIENCY

Energy production is a leading force of the country's economy. Accurate and effective functioning of energy sector is the basis of sustainable development and it is certain that it has a greatest political, economic, social and environmental function.

Georgia's energy sector has to solve the hardest problems at current complicated historical stage. Full structural reorganization of an economic mechanism is going on in the country. After declaration of independence in 1991, ceasing of traditional economic contacts, sharp increase of prices on energy resources, deficiency of hard currency had a heavy impact upon all spheres of Georgia's economy, particularly, upon the energy generation

One of the determining factors of Georgia's economic crisis is an intolerably low level of the efficiency of energy resources utilization.

Increase of energy efficiency in generation, transmission and end-user sectors has a primary importance for Georgia.

This chapter of the report presents the state of two most important sub-sectors of Georgia's energy sector – electricity and heat generation in 1990 and 1999 years and trends for this period. Complete cutting off the centralized heating systems is one of the main reasons of the hardest crisis in the energy sector.

Georgia's energy sector represents a potentially high profitable sub-sector of the country's economy. At present, the installed capacity of electric stations is 4667 MW with 20,5 billion kWh of electricity annual generation designed potential. The main sources of electricity are thermal (41,53%) and hydro (58,47%) power plants. The structure of installed capacity and generation is as follows:

Hydro power plants – 2729 MW and 10 billion kWh.

Thermal electric stations – 1938 MW and 10,5 billion kWh.

Since 1990, the retreat of the energy system had started. All kinds of economic contacts with the former Soviet republics were broken that result in cutting off of fuel supply to the thermal electric stations operating on the imported fuel. The same situation stipulates the ceasing of spare parts, materials and equipment supply, necessary for maintenance and maintenance.

A total syndrome of non payment for consumed electricity was formed in the country. The state of affairs causes the ceasing of repair works and fuel supply on the one hand, and the draining away of highly qualified personnel from the energy system due to unpaid salaries on the other part have the substantial negative impact upon the level of operation.

As a result of sabotage during the civil war in the country, the energy system was greatly damaged. Large amount of metal and angle bars were plundered from the energy objects. Over two years the energy system has been operating at inadmissible low frequency. This factor resulted in catastrophic consequences. Lots of apparatus and equipment of energy sector were destroyed. General technical characteristics of the energy system were substantia lly worsening.

At present, it could be noted that no electric station operating on the designed parameters exists in Georgia. The similar situation is observed in the transmission and distribution service, mechanized system and relay protection the restoration of which requires rather large investments.

Condition of heat supply system – one of the most important sub-sectors of the energy sector of the country is the grave, as well. After the cutting off the heat and hot water supply in 1993, it became a heavy burden for the energy sector.

Heat supply system is the greatest consumer of energy resources. In the country, where the season of heat supply lasts for 4-5 months, this system consumes 30-40% of primary energy resources. Hence, it is evident how important is the perfection of the heat supply systems from the economic or environmental standpoint.

By the beginning of the 90's, the greatest part of Georgian territory (50-60% of large cities) was provided with heat supply systems, not available even for many developed countries.

The heat supply sector of Georgia produced 9976 MW of thermal energy utilizing 1715 thousand tons of conventional fuel, including 1098 million m^3 of gas and 290 569 tons of fuel oil.

Electricity and heat generation, transmission, distribution and consumption – the main components of the energy sector were discussed in the report so as to analyze the current situation and define future prospects.

Substantial information on three constituents of the energy sector by the state of 1990 and 1999 was collected and archived. Results of analysis will become the basis for consideration and recommendations on energy efficient, economically and ecologically sound technologies.

4.1. GENERATION SECTOR

To analyze the information on the electric ity and power generation sources in 1990 and 1999 and to make appropriate conclusions, their separate examination is reasonable.

4.1.1. Electricity Generation
4.1.1.1. Generation in 1990

Georgia's electricity generation sources have a complicate character, including hydro- and thermal energy plants. Characteristics of the country's energy generation sources are represented by a large number of various hydro power plants with different installed capacities. Run off of their feeding rivers decreases 10-15 times during the low water period in winter as compared with the high water period. This fact substantially reduces the installed capacity utilization factor that is one of the most important values to estimate the energy efficiency of the electric station the designed (Kd) and actual (Ka) values of which are calculated by the formula:

$$K_d = Ý_d /(N_i * 8760) \text{ and } K_a = Ý_r / (N_i * 8760) \qquad (1)$$

where, $Ý_d$ and $Ý_a$ are designed and actual annual energy generation capacities at the electric stations, respectively, N_i is a total installed capacity and 8760 – the number of operating hours per year.

In order to have a full impression on the condition of the Georgian energy generation objects, first of all, it is necessary to become acquainted with the types of electric plants of the country, their main parameters, characteristics, exploitation peculiarities, technical condition of aggregates, energy efficiency, etc. This kind of information has been presented in the Tables to characterize the energy generation sources by the state of 1990 (see Tables 1,2 and 3 of Annex).

From the information presented in the Tables, it is evident that by the year 1990 the country had two electric stations, gigantic for the Georgian scales – Enguri (hydro) cascade-1640 MW and Tbilsresi (thermal) - 1400 MW. By that time, total value of installed capacity of thermal electric plants was 1638 MW, installed capacity of medium and large hydro power plants – 2593.3 MW and installed capacity of small electric stations – 135.8 MW. Thus, total installed capacity of all electric stations of the country was 4367.1 MW in 1990. It should be noted that mainly the basic thermal and hydro power plants of the country were analyzed by the year 1990, as the total value of the installed capacity of small hydro power plants was only 3.2% of the total installed capacity of medium and large thermal and hydro power plants (1638+2593.3=4231.3 MW) on the one hand, and due to the lack of attainable information on hydro-technical constructions, aggregates and equipment of small hydro power plants, on the other hand.

According to data presented in the Table 1 of Annex, the actual generated electricity in 1990 was less than the designed output. In particular, 6018.3 million kW was generated by the country's thermal electric plants instead of 9828 million kWh, i.e. 61.24% of a designed value, while the amount of energy generated by the medium and large hydro power plants made 7305.2 million kWh instead of 9852 million kWh that is 74.15% of the designed capacity. The actual values of utilization factor of TESs installed capacity in 1990 were lower than the designed values. In particular, the designed value of installed capacity utilization factor in thermal electric plants was reduced from 68.49% to 41.94%, in medium and large hydro power plants – from 43.36% to 32.15%. Reasoning from the aforesaid, it may be concluded that the actual energy generation at the country's electric plants is rather less compared with its designed value. Based on the aforesaid, it may be assumed that actual electricity generation in the country's thermal power plants is rather less compared with the designed values observed in the hydro power plants. It should be noted that in 1990, specific consumption of conventional fuel had been considerably increased compared with the designed value. In particular, specific consumption of conventional fuel has been increased up to 467.09 gcf/kWh at Tbilsresi – the only basic thermal electric plant and up to 411.96 gcf/kWh – in Tbilisi thermal electric plant, meanwhile, the design consumption of conventional fuel for Tbilsresi 150-160 MW capacity K-150-130 and K-160-130 energy units, while operating on gas, is 363 gcf/kWh and while operating on black oil it is equal to 365 gcf/kWh. The fuel designed specific consumption for the 300 MW capacity K-300-240-3 energy unit makes 323 gcf/kWh while operating on gas and while operating on mazut – 329 gcf/kWh. Designed fuel specific consumption value for Tbilisi thermal electric station's energy units while operating in energy and heat supply regime makes 370 gcf/kWh.

Much more reduction of actual energy generation in the country's thermal electric plants compared with hydro power plants was resulted from a considerable decrease of efficiency of thermal electric plants by the year 1990. Namely, the plant designed efficiency decreased from 0.388 to 0.26 in Tbilsresi, from 0.332 to 0.298 – in Tbilisi thermal electric station and from 0.311 to 0.205 – in Tkvarchelsresi (see Annex, Table 2.2), conditioned by the expiration of an amortization period of main aggregates in thermal electric plants, i.e. the depreciation period of 8 old energy units of Tbilsresi expired in 1989, while Tbilisi thermal electric station energy units had ended their amortization period long ago. Due to this fact, after remarking (relabeling) of Tbilsresi first 8 energy units the total capacity made [(3x130)+(5x142)]=1100 MW instead of [(3x150)+(5x160)]=1250 MW plus No9 energy unit put into operation in the same 1990 year. So, the value of Tbilsresi installed capacity reached 1400 MW.

By the main Technical Department of the Union Ministry in order to increase the reliable operation of a boiler heating surface metal since the 80's, the temperature of overheated vapor was reduced from a designed value of 570^0C to 545^0C in a boiler inlet and from 565^0C to 540^0C in a turbine inlet of Tbilsresi and similar boilers of thermal electric plants of the same age. As a result efficient of Plants was reduced.

As to medium and large hydro power plants, years of putting into exploitation of the main aggregates, their types and producers, the rated capacity, water specific discharge to generate 1 kWh energy, dam height, useful capacity of reservoir, useful pressure and other parameters are presented in the Table (see Annex, Table 3).

As it is known, three types of hydro power plants are operating in Georgia: those of annual regulation (a); of daily regulation (d) and seasonal regulation (s). Five out of medium and large hydro power plants are of annual regulation, 3 – daily and 7 – seasonal.

Analysis of presented data shows that reduction of energy generation to 74.15% of the designed value in large and medium hydro power plants is caused by their technical conditions and the decrease of their installed capacity use factor, respectively. In particular, a total designed value of installed capacity utilization factor of medium and large hydro power plants had been reduced from 43.36% to 32.15% in 1990.

In 1990, an overall energy generation in the country was 14239.4 million kWh, while the consumption made 17443.9 million kWh (see Table 4 of the Annex). Despite the fact that Georgia's energy sector in 1989-90 was at the peak of its development, reaching its maximum output, it was still in short supply. Namely, by 1990 energy deficiency reached 3204 million kWh, being covered by energy imported from neighboring countries, the largest of which were Russia and Azerbaijan. Total amount of imported energy in 1990 made 4382 million kWh and exported energy – 1177.5 million kWh (see Annex Table 4).

In 1990, 20% of generated energy was supplied to the population and 80% - to the industry and other consumers (see Annex, Table 5). It should be noted that the tariff for energy supplied to population was 4 kop/kWh (2.6 cents/kWh), while the tariff for energy supplied to other consumers – 2 kop/kWh (1.3 cents/kWh). Prime cost of generated energy was the highest in thermal electric plants. For instance, prime cost of the energy generated in Tbilsresi was 1.82 kop/kWh (1.18 cents/kWh), in Tbilisi thermal electric plant – 2.05 kop/kWh (1.33 cents/kWh) and in Tkvarchelsresi – 3.12 kop/kWh (2.02 cents/kWh), while this value for hydro power plants was within 0.31-0.94 kop/kWh (0.2-0.61cents/kWh).

It is remarkable that none of the country's electric plants were privatized or rented in 1990.

4.1.1.2. Generation in 1999

The relevant information was collected and is presented in the Tables 1,2 and 3 of the Annex to characterize the state of the country's electricity generation sources by the year 1999.

The analysis of presented data shows that total value of installed capacity of thermal electric plants in 1999 was 1718 MW, installed capacity of medium and large hydro power plants – 2473.3 MW and installed capacity of small capacity hydro power plants – 135.8 MW. Therefore, total value of installed capacity of Georgia's power plants in 1999 reached 9327.1 MW without consideration of Tkvarchelsresi and Vardnilhesi (No2, No3 and No4) installed capacity and with their consideration – 4667.1 MW. It should be mentioned that the change of installed capacity of thermal electric plants was conditioned by putting into operation of 300 MW capacity energy generating unit No10 in 1994 on the one hand, and the damage and fault of Tskhinvalsresi 220 MW installed capacity on the other. As a result, total value of installed capacity of the country's thermal energy plants reached [(1638-220)+300]=1718 MW (see Annex, Table 1) in 1999.

On the basis of the data analysis it may be assumed that actual quantity of energy generated in 1999 by Georgia's energy generation objects is substantially less than the designed generation value. Particularly, instead of 10308 million kWh designed energy generation there had been generated in fact 1633.8 million kWh by thermal electric plants, i.e. 15.84% of a designed value. In medium and large hydro power plants 6197.9 million kWh was generated instead of a designed value (except No2, No3 and No4 Vardnilhesi) of 9461 million kWh, i.e. 65.5% of a projected value. By the year 1999, actual values of installed capacity utilization factor of electric plants had been considerably decreased compared with a designed one. In particular, a designed value of installed capacity utilization factor of the country's thermal electric plants was decreased from 68.49% to 10.85% in the medium and large hydro power plants – from 43.66% to 28.6%.

Such decrease of generated at the country's thermal electric plants electricity was caused by various factors such as the expiring of the amortization period of 8 energy units of the first series of Tbilsresi, inappropriate restoration and repair works due to insufficient investments, the low level of exploitation and what is most important, by the lack of expensive imported fuel. As a result, just only Tbilsresi plant was operating in a seasonal regime. It should be underlined that from November of 1991 to 1995, general repairs of energy units were not conducted, at all. Since the full-scale repairs were not conducted during the further period and an economic efficiency of energy units was not raised up to the initial level. Due to impermissible low frequency in the grid, operating shovels of No4, No5 and No6 energy units were cutting. In 1995 the country's energy system operated at 44.47 Hz. It is certain that indicated circumstances were resulted in the decrease of efficiency of steam turbine equipment and its capacity, respectively. During the previous year, silting out of salts was observed in the passable section of K-150-130 and 300-240-3 type steam condensation turbines due to insufficient water chemical regimes, causing the decrease of efficiency of a turbine and the increase of fuel consumption rate, respectively. By 1999, the value of conventional fuel consumption rate in Tbilsresi reached 441.4 gcf/kWh and in Tbilisi thermal electric plant – 525 gcf/kWh.

Thus, rather considerable decrease of energy generation in the country's thermal electric plants than in medium and large hydro –electric plants was caused by the decrease of plant efficiency. E.g. the efficiency for 150-160 MW K-150-130 and K-160-130 energy units in Tbilsresi was decreased to 22.87% and in Tbilisi thermal electric plant – to 23.43% (see Annex, Table 2).

Information on medium and large hydro power plants for 1999 is presented in the Table 3 of Annex. The data on main aggregates and parameters of Vardnilhesi-2, Vardnilhesi-3 and Vardnilhesi-4 are not included. The data presented in the Table show that the amortization period had been passed by the aggregates of all hydro power plants, except Engurhesi, Zhinvalhesi and Vardnilhesi-1.

Electricity generation in 1999 made 8097.7 million kWh and the consumption – 8147.5 million kWh (see Annex, Table 4). So, the country's energy sector was still in short supply. The deficit value made 49.8 million kWh. It was covered by energy from the neighboring countries. The energy export and import was maintained with all four neighboring countries: Russia, Armenia, Azerbaijan and Turkey. Total amount of imported electricity in 1999 made 433.9 million kWh and exported electricity – 384.1 million kWh. Difference between imported and exported energy making 49.8 million kWh is just the amount of electricity by which covered the deficit.

The structure of electricity distribution among the consumers was changed considerably in 1999, when the value of electricity supplied to population made 42.9% of the energy generated in the country and the energy consumed by the industry and other consumers made 57.1% (see Annex, Table 5). Tariffs for electricity supplied to population, industry and other consumers were the same. In return, tariff differentiation was happened according to the capital and the regions. In Tbilisi, the price for electricity was 9 tetri/kWh (4.5 cents/kWh) and for other regions - 8.3 tetri/kWh (4.15 cents/kWh).

In 1999, the prime cost of electricity was different for thermal and hydro power plants. The most expensive energy was generated in Tbilsresi. The prime cost of electricity generated by the first series energy units of 150-160 MW capacity at this thermal electric plant made 7.2 tetri/kWh (3.6 cents/kWh) and electricity generated by 300 MW energy units was 5.18 tetri /kWh (2.59 cents/kWh).

As to the privatization problem, it should be indicated that by the year 1999 No9 and No10 300 MW energy units of Tbilisi thermal power plant and Tbilisi thermal electric plant had been already privatized by American "AES Mtkvari" and Russian-Georgian Company "Sakgazi". In the same year, "Khramhesi-1" and "Khramhesi-2" hydro power plants were transferred to "AES Mtkvari" with the right of 25 year management, while Zahesi and Ortachalahesi were given for rent. By 1999, 19 small hydro power plants had been already privatized.

4.1.1.3. Comparative Analysis of Electricity Generation Sources for the Period of 1990-1999

Complex analysis of the state of electricity generation sources – one of the most important parts of power energetic has been carried out for the period of 1990-99 in order to determine the current condition in the energy system of Georgia and to set the future plants.

To make a comparative analysis, information on energy generation sources in 1990-99 periods is presented in the Table (see Annex, Table 6).

The current level of energy sector in Georgia is conditioned by the state of its three main constituents – generation, transmission and distribution. At the same time, in electricity generating sources and in the whole generation sector the value of installed capacity, designed and actual output, consumption, installed capacity utilization factor, conventional fuel consumption specific rate, export and import, cost price of generated energy and tariffs are main characteristics determining the existing situation (see Annex, Table 6).

Comparison of main characteristics of energy generation sources and their analysis showed that installed capacity and energy designed generation in 1999 was increased by 6.87% and 0.44% compared with 1990, respectively. Though, actual value of the country's energy annual generation in 1999 made 39.86% of the designed capacity, i.e. generation was substantially decreased and it was equal to 70.4% of the designed output of 1990. As a result of comparison of the country's actual generation capacity, it was defined that actual annual generation in 1999 is 1.76 times less than in 1990. All aforesaid are proved by the dynamics of relative and absolute values of designed and actual annual energy generation presented on the Figures 4.1.1 and 4.1.2.

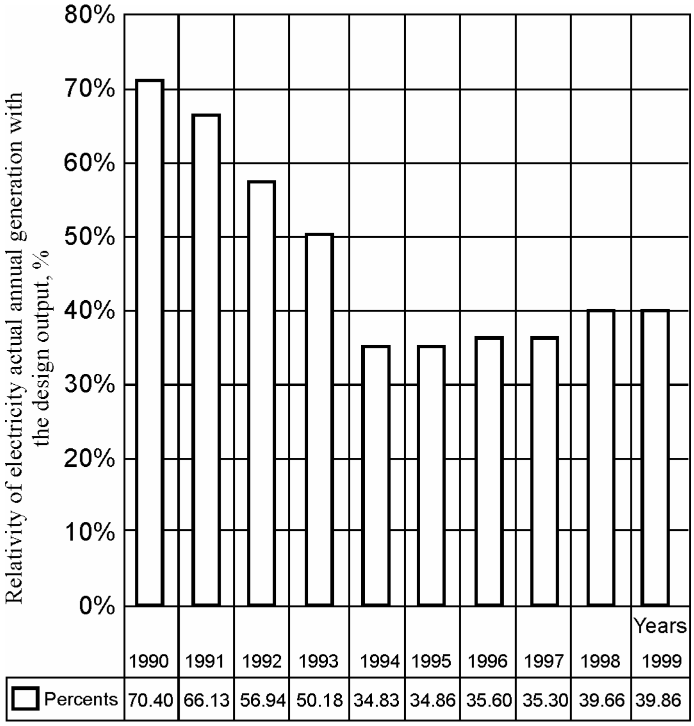


Fig. 4.1.1. Dynamics of relativity of electricity actual annual generation with the design output in 1990-99

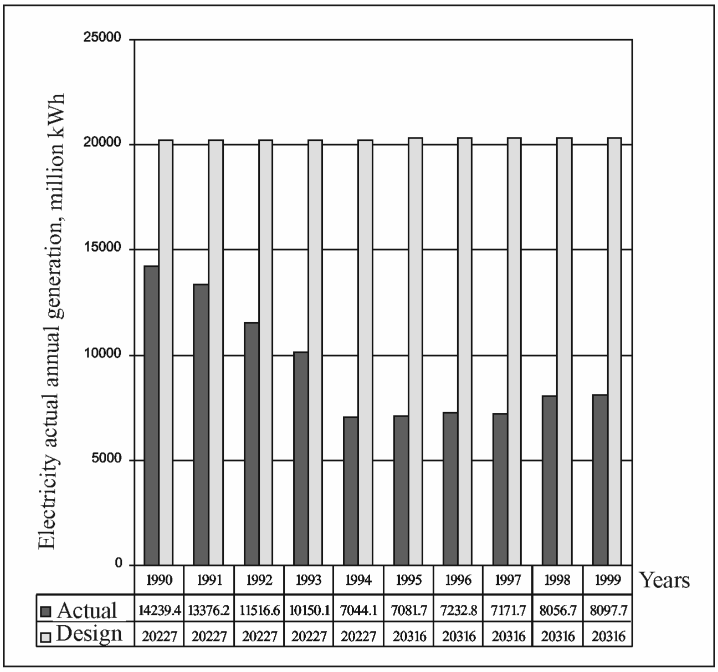


Fig. 4.1.2. Dynamics of electricity actual annual and design generation in 1990-99

It is known that the amount of energy, generated by electric plants directly depends upon the value of installed capacity utilization coefficient of thermal and hydro power plants.

It is certain that the use factor of TES installed capacity is high in relation to high amount of generated energy and vice versa. Reasoning from aforesaid, first of all, the dynamics of the total actual capacities of electric plants in 1990-99 was examined (Fig.4.1.3; Table 6 of the Annex) to determine the coefficient variation by the years.

It should be noted that different total values of electric plant installed capacity in the country during 1990-94 and 1995-99 were resulted from new grading of depreciated blocks in Tbilsresi by 1990 and putting into operation of 300 MW No9 energy block on the one hand and failing (getting out of order) of installed capacities of Tkvarcheli thermal electric plant and Vardnilhesi 2, 3 and 4 on the other. Comparison of electric plants actual capacities with designed values demonstrates that due to technical difficulties created at thermal and hydro power plants, values of actual capacities are substantially less than designed ones, e.g. if in Tbilsresi the actual capacity (812.7 MW) was less than the designed one (1400 MW) by 42% in 1990, it was substantially less by the year 1999 (see Annex, Table 7). The situation in the country's all other thermal and hydro power plants is similar.

Actual capacity of thermal and hydro power plants represents the value, upon which the amount of energy generated by electric plants is directly dependent, as well as, upon the energy efficiency, being estimated by an installed capacity utilization factor. Information on the variation of this important index in 1990-99 is presented in the Table (see Annex, Table 8), demonstrating that the least value of the factor in 1995 and 1994 was 4.14% in thermal electric plants and 21.21% - in hydro power plants, respectively. The situation was caused by economic difficulties created in the country and the grave condition of the energy sector since 1990 reaching the crisis just in these years.

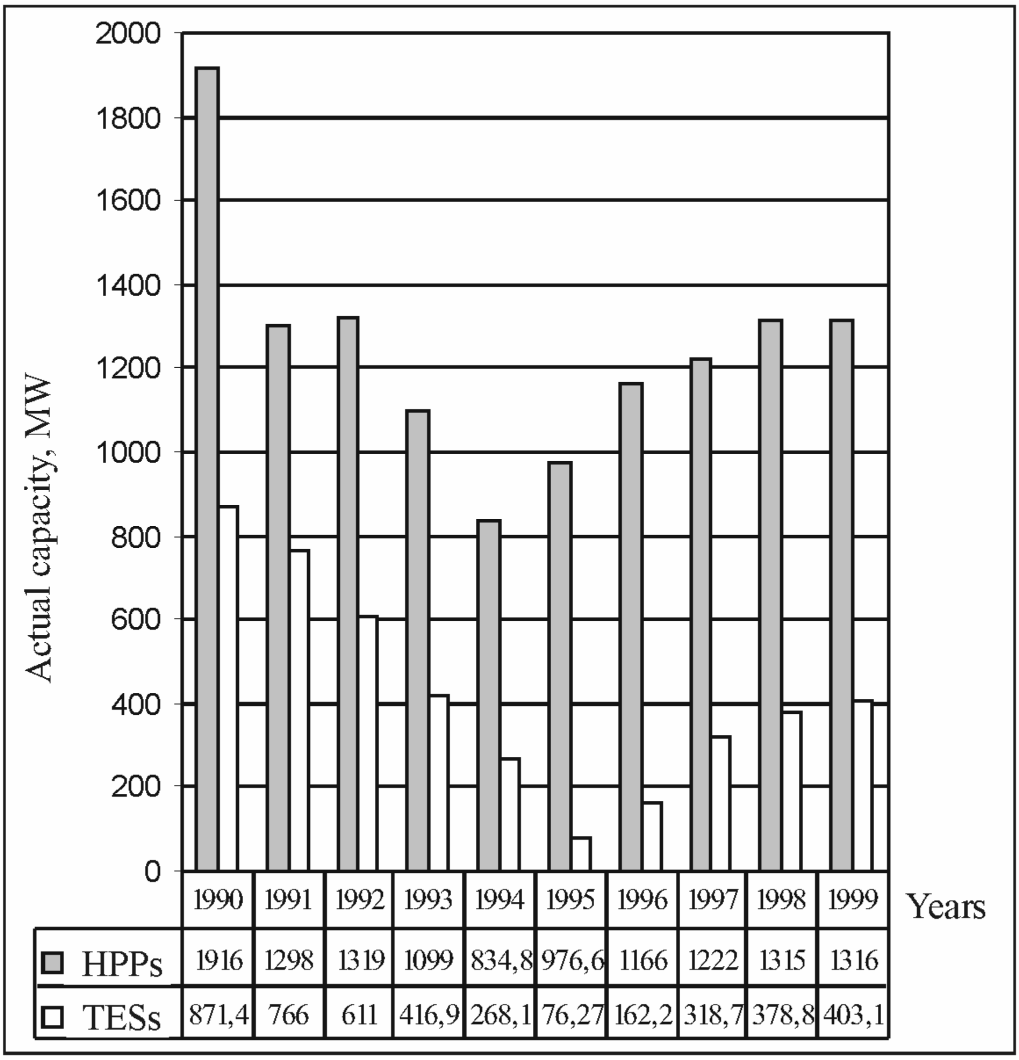


Fig. 4.1.3. Dynamics of thermal and electricity plants total actual capacities in 1990-99

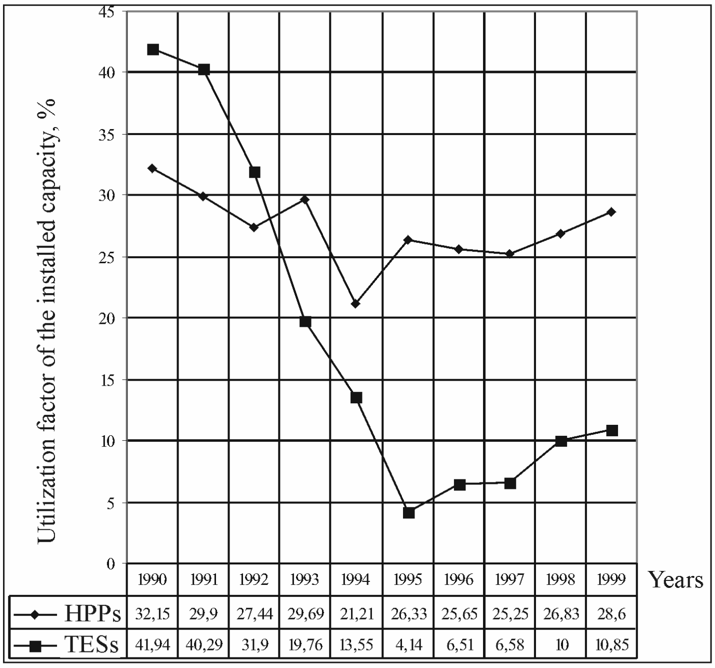


Fig. 4.1.4. Dynamics of installed capacity utilization factor of thermal and hydro power plants for the period of 1990-99

Decline in energy sector since 1990 is evident from the balance of Georgia's electricity, for 1985-1999 (Annex, Table 9). As it is seen from the data presented in this Table, the least values of total energy generation in Georgia – 7044.1 and 7081.7 million kWh were observed in 1999 and 1995, respectively. This is also proved by the dynamics of annual energy generation in Georgia's thermal and hydro power plants by the years, presented on the Figures 4.1.6 and 4.1.7 as a functional relation Ýgen= f(T).

Therefore, based upon the presented data by the year 1999, electricity generation at thermal electric plants made 24,59%, at hydro power plants-85,12%, and the country's total generation was 56,87% as compared with that of the year 1990. The given data makes evident that one of the main reasons of the decline of electricity generation in our country is the decrease of electricity generation at thermal electric plants reaching 20,17% of generation in the country in 1999. Due to the lack of the repairs, the fuel actual annual specific consumption at thermal electric plants was increased, reaching its maximum of 684 gcf/kWh [23] in Tbilsresi by the state of 1995.

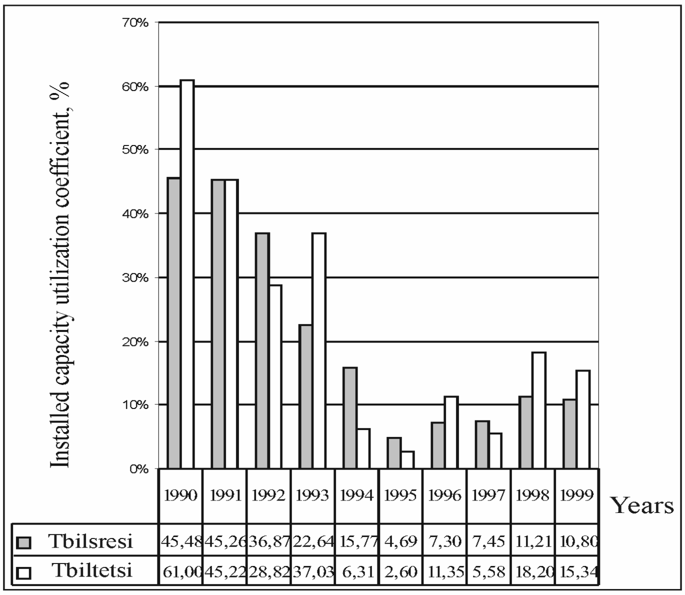
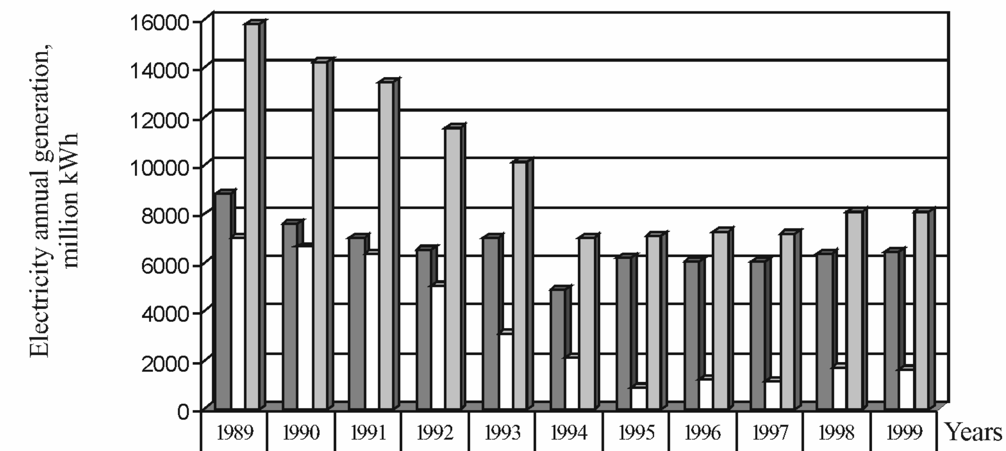


Fig. 4.1.5. Dynamics of installed capacity utilization coefficient in Tbilsresi and Tbiltetsi in 1990-99



	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
HPPs total generation	8786,9	7594,2	7041,7	6501,7	7031,1	4912,8	6207,4	6041,5	6044,2	6358,5	6463,9
TESs total generation	7037,5	6645,2	6335,3	5014,9	3119	2131,3	874,3	1191,3	1127,7	1698,2	1633,8
Total generat. in the country	15824	14239	13377	11517	10150	7044,1	7081,7	7232,8	7171,9	8056,7	8097,7

Fig. 4.1.6. Dynamics of electricity annual output in thermal and hydro power plants and in the country in 1989-99

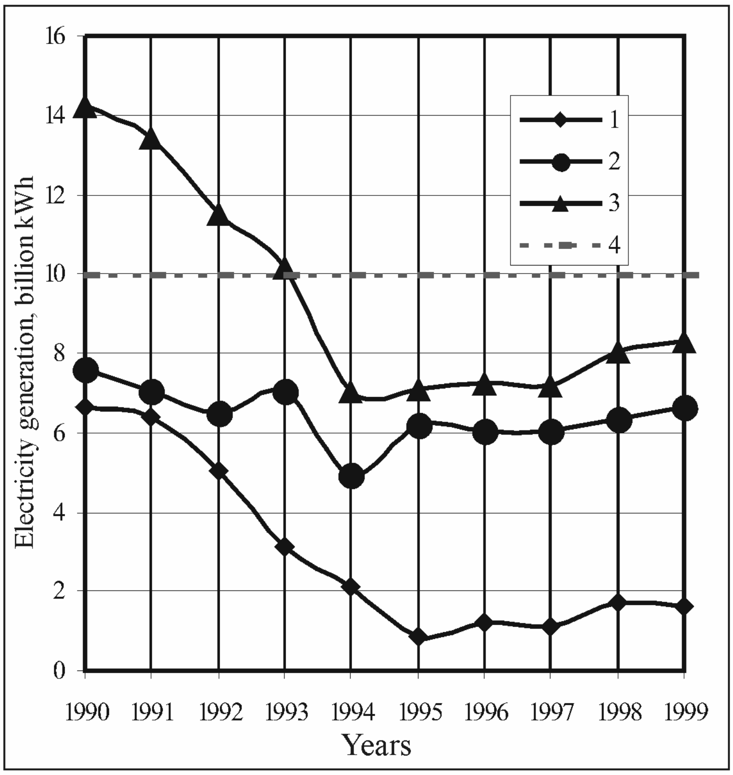


Fig. 4.1.7. Dynamics of annual output of electricity in Georgia's thermal and hydro power plants according to the years:
1-Dynamics of electricity generation by TESs; 2-Dynamics of electricity generation by HPPs;
3-Dynamics of electricity total generation;
4-Heat electric demand in the residential sectors in 1989-90.

During the decline of energy sector, electricity generation sharply decreased at the country's thermal electric plants, though, it cannot be said about hydro power plants, where energy generation decreased only by 35,31% since 1990 to 1999.

As to the departmental thermal electric plants, all of them, except Rustavi Metallurgical Plant, stopped their functioning since 1990 due to heavy technical condition and the lack of funds and fuel. Rustavi Metallurgical Plant stopped its operation actually in 1997.

Since 1990, electricity consumption considerably decreased in the country that was conditioned by the reduction of the amount of its own energy generation and imported electricity on the one hand, and the decrease of electricity consumption in the country's industrial and other sectors, on the other. If energy consumption in the country in 1990 made 17443,9 million kW/h, its value decreased to 8147,5 million kWh in 1999, i.e. 2,14 times (see Annex, Table 4).

Presently, the amount of electricity, generated at thermal and hydro power plants, that makes 8097,7 million kWh, is quite insufficient to satisfy the country's demand. First of all, for unimpeded and reliable electricity supply of consumers, according to their demands, it is necessary to find urgently the ways of increasing its generation based upon a high quality rehabilitation of available equipment or application of modern technologies, which will be energy efficient and economically and ecologically sound in future.

Ensuing from the above-mentioned, it could be summarized that one of the most important conditions to overcome energy crisis in Georgia is the increase of basic capacities and the generation. In this context, first of all, reconstruction of Tbilsresi and Tbiltetsi is necessary. It is essential, as well, to construct medium, 200-250 MW capacity thermal electric plants working on a combined cycle, on the basis of modern gas-turbine equipment. An optimal version of their allocation must be based on the minimization of electricity overflow.

4.1.2. Heat Generation
4.1.2.1. Haet Generation in 1990

Thermal electric stations – sources for generation of thermal energy were constructed according to the ÑÍèÏ. Therefore, technological equipment and exploitation parameters were mainly identical all over the country.

By the year 1990, installed capacity in the generation sector of Georgia's heat supply system made 5559MW, including 4328 MW for the city of Tbilisi (see Annex, Table10).

Tbilisi heat supply system provided with heat and hot water approximately 6500 blocks of flats, up to 1000 residential and administrative buildings. 83% of the city's population used heat for heating systems and 73%- for hot water supply, as well.

During the indicated period, 1570 central and group boiler houses were in operation in Georgia with approximately 4800 boilers: 35% of them were functioning on gas, 50% - on black oil and diesel fuel, 15%-on coal and other types of fuel.

Most important component of the heat supply system is heat generator (boiler), where fuel combustion is going on, i.e. transformation of fuel chemical energy into thermal energy is taking place. From economic and ecological standpoint, the efficiency of fuel resources consumption greatly depends on perfection of boiler construction.

Thermal energy generators are classified according to various characteristics.

? material – iron or steel;

? capacity – boilers for district, group and individual (autonomous) heating;

? consumed fuel – liquid, gas or solid fuel;

? types of generated heat carrier – water-warming or steam.

As it is seen from the Table, mostly used boilers in the heat supply system were water warming boilers of Russian production ÏÒBM and ÊÂÃÌ and steam boilers of ÄÊÂÐ and ÄÅ types. Actual efficiency of boilers was rather low. E.g. ÏÒBM type water-warming boiler was constructed to operate on the self-lifting principle (i.e. installation of smoke extractor equipment was not considered) for Russian climatic conditions (-25^{0}C, -30^{0}C). Productivity of ÏÒBM boiler while working under the Georgian climatic conditions was less by 50% than the designed value.

Boilers installed in the heat supply system created rather hard exploitation terms. Fuel was combusted inefficiently, in irregular combustion regime. Various types of controlling and regulating equipment were installed (e.g. well known equipment of "KP? CTA? ? "- type) at the thermal electric plants to optimize the combustion process. The equipment actually never performed its purposes and was not able to provide optimal ratio of air and fuel required for appropriate fuel combustion process. This process has a decisive importance in formation of economic or environmental characteristics of thermal electric plant.

Environmental characteristics of the Georgian thermal electric plants were deteriorated by the consumption of black oil of high sulfur content (M-100). The boilers were equipped with burners for low sulfur content liquid fuel (M-40), causing fuel over consumption and high environmental pollution accompanied by large amount of harmful substances (NO_x, SO_2, V_2O_5) and especially, CO_2 emission.

Any kind of environmental protecting device was not installed in the Georgian heat supply systems, particularly in boiler houses.

Designed temperature of water supplied from the district thermal electric plants to the system made 130-150^{0}C. In fact, it did not exceed 90-95^{0}C.

Regulation of supplied water temperature according to the outdoor temperature was conducted manually at the boiler. To provide guaranteed high temperature of water returned back from the system on the heating surface of boilers and to avoid condensation, the heating-system water recycling was necessary between delivery and return pipelines. This process was not conducted that resulted in intensive corrosion of a boiler heating surface.

To demonstrate inefficiency of boilers operating in Georgia and, particularly, in Tbilisi, the following figures could be presented:

Out of 4328 MW capacity installed in Tbilisi heat supply objects, thermal energy was actually generated from 1800 MW.

One of the important indices to assess operation efficiency is an installed capacity utilization factor, the designed (K_d) and actual(K_a) values of which are calculated by the following formulae:

$$K_d=Q_d/(Q_i*n) \quad \text{and} \quad K_a=Q_a/(Q_i*n) \qquad (2)$$

where, Q_d and Q_r are designed and actualproductivity of the thermal electric plant per year. n=5000 is maximum operation hours of thermal electric plant per year. K_d and K_a values are presented in the Table (see Annex, Table 10). Their averaged values for the whole country are K_d = 0,57; K_a=0,38.

One of the main reasons of Russian boilers low efficiency was ineffective structure of a boiler furnace. That explains high indices of fuel specific consumption (174-144kg/MWh instead of 155kg/MWh) characteristic for similar boilers of European production.

Finally, it should be noted that the potential of energy efficiency increase by 15-20% was existed at the thermal energy generation units (thermal electric stations) of the Georgian heat supply systems, though little attention was paid to energy saving and energy efficiency problems during the Soviet period, the reason for which was mainly low prices on energy resources.

Cost for heating 1m^2 of living area was 10 kopecks per month that made 50 kop/m^2 per year considering that the heating season lasted for 5 months. Monthly fee – tariff was imposed after calculating energy annual price and it made 4,2 kop/m^2 per month.

Tariff on hot water until July 1992 was 60kop/per capita in a month considering 55^{o}C of hot water consumption according to the norm of 120 liters/daily/per capita. By the year 1990, average annual expenses for central heating and hot water supply made less than 1% of a family's annual income. According to statistics, 99% of consumers were paying regularly for heating and hot water supply.

4.1.2.2. Thermal Energy Generation in 1999

Circumstance diametrically changed in heat supply system. Due to the rise of prices on fuel, all heat supply objects of Georgia ceased the functioning.

Population was not supplied any more by natural gas for cooking. Therefore they appeared in the grave condition. Population used to consume electricity for residential purposes and cutting off of forests.

By the year 1999, approximately 45% of electricity generated in the country, was consumed by the country's population, while in 1990 this value was 20%.

At present, population tries to satisfy the needs on heat energy by using of electricity that is unacceptable from the economic standpoint and results in tremendous overloading in the country's power energy systems, which have not been designed or constructed for such loading. As a result, relevant systems are failing, frequent accidents are occurred. Inactivity of heat supply systems became one of the most important reasons of the energy crisis created in Georgia.

Government bodies (including municipalities), which are responsible for heat and hot water supply, have not done any comparison and assessment as well as no alternative versions for the solution of the problems were found. No one took care to conserve thermal electric stations (except Tbilisi N43 and N58 thermal plants). At present, it is even impossible to discuss the problem of Georgia's thermal plants` rehabilitation because of a complete destruction of an entire infrastructure.

For the year 1999, only one small cogeneration thermal electric plant (CHP) was operating occasionally in Tbilisi, mainly serving the state and non-governmental organizations, located in the city centre.

As a result of complete destruction of heat supply centralized systems, the process of arrangement of individual boilers had started since 1994-1995, especially in the most essential buildings (hospitals, schools) and administrative buildings.

In 1998, approximately 110 objects had autonomous heat sources (among them 57 schools and 12 medical organizations), the overall installed capacity of which was 54,15 MW. Most of boilers were operating on diesel fuel, though along the rehabilitation of the city gas supply systems, these boilers were transferred on natural gas consumption.

It is remarkable that none of the above indicated objects is many-storied building. According to the data provided by the companies specialized in installation of autonomous heating systems, the residents of many-storied houses cannot collect the funds necessary for installation of autonomous heating systems. In some cases, individual heating systems are installed in the flats of many-storied houses by rather rich families. Number of such heating systems in Tbilisi is more than 1000.

By 1999, the main sources of heating were heaters (stoves) functioning on kerosene, liquid or natural gas, fire-wood and coal, the use of which along with inflammability danger, causes a serious negative impact upon the human health and local environment. More than 30 persons were died in Tbilisi in 2001 because of non reliable operation of gas supply system.

4.1.2.3. Efficiency of Fuel Consumption in the Electricity and power Generation Sector

As it has been indicated, heat supply is one of the most important sub-sectors of energy sector. Its share in the country's energy balance is quite substantial. Inactivity of heat supply system of Georgia causes the tremendous damage to the safety of the country's energy supply and finally to the economy and environment of Georgia.

Balanced operation of all composing units of the energy sector is guarantee for energy safety of each country. This balance is completely destroyed in Georgia. All responsibilities of the country's energy supply, including thermal supply, are entrusted to electricity supply system the half of generation capacities of which are not even in operation.

Heating of buildings using electricity is most expensive, requiring 3-4 times much fuel than heating by water heating systems. Even in the former Soviet period, when less attention was paid to energy efficiency and energy saving and there was no electricity deficiency, projected norms did not permit to design buildings with electric heating, because of its expensiveness.

The diagram on the Fig. 4.1.8 based upon the recommendations of international organizations clearly demonstrates the inefficiency of electricity consumption for heating purposes, showing the variation of fuel consumption efficiency according to the different heating methods.

As it is seen from the diagram, fuel initial energy (thermal capacity) is taken to be equal to 100%. The lines in the left rectangle characterize fuel initial energy loss while preparing of energy carrier. The lines in the right rectangle show fuel energy potential variation during its usage in the heating appliances.

Energy potential of any fuel before combustion in the furnace is invariable and equals to its initial energy, to which corresponds position (a) on the diagram. In the CHP, during the burning of any fuel, its initial energy transforms (line 1) into thermal energy and as a result of all other transformations into electric and thermal energies (in case of cogeneration) that corresponds (b) position. During the transformation by this method, 25% of fuel initial energy is lost and about 75% is consumed (line b-c).

As a result of organic fuel initial energy transformation in condensation thermal electric plants (line 2), only the electricity is produced, to which on the graph corresponds (d) position. During energy carrier utilization by this method, ~65% of fuel initial energy is lost that is caused by the substantial losses accompanying the transformation of one type of energy another. In this case, about 35% (line d-e) of fuel initial energy could be usefully consumed.

As it has been indicated above, before putting any organic fuel into the traditional boiler furnaces and starting the combustion process, i.e. before consumption, fuel initial energy is invariable, to which corresponds a-a1 line on the diagram. About 70-80% of fuel initial energy out of the whole amount of heat emitted as a result of fuel combustion in the furnace could be usefully consumed due to various losses (mainly heat emitted into the atmosphere by gaseous products of combustion). The last one, on its turn, depends upon the boiler efficiency and the type of fuel to be combusted. Line 3 on the diagram corresponds to the process of organic fuel combustion in traditional boilers and heat release process.

As a result of examination of the presented diagram, it is evident that the most inefficient way of fuel initial energy consumption is heating using electricity that is caused, on the one hand, by substantial thermal energy losses in thermal electric stations during the process of transformation one type of energy into another and on the other hand, by electric losses during the transportation to consumers and repeated transformation into thermal energy.

By the period of 1999-2000 Tbilisi district thermal electric stations were sold for the different purposes. This process was remarkably active in the prestigious districts of Tbilisi. Their advantageous location is most convenient for construction of the residential buildings, offices, etc. This is an intolerable mistake and shortsighted action. Unreasonable sale of their territories, despite that the equipment in thermal electric plants is depreciated, makes impossible the future development of thermal supply systems in many districts of the city.

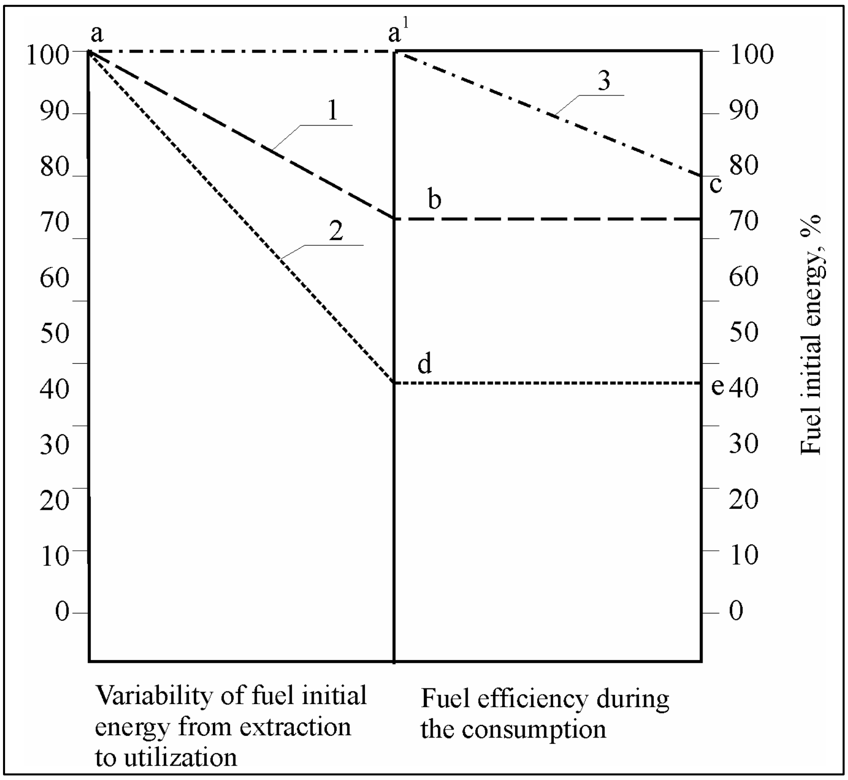


Fig. 4.1.8. Fuel consumption efficiency diagram for the various heating methods

1. *CHP;*
2. *Condensation thermal electric station;*
3. *Traditional boiler.*

The following thermal plants have been sold: N1, N2, N4, N13 (Saburtalo district); N8 (Vake district); N9 (Mtatsminda District); N34 (Nadzaladevi district). Besides, a number of separately located buildings of thermal stations were unduly sold, where the group boilers could be arranged. Disposition of district thermal electric plants and stations was selected considering the economic and ecological criteria, which would facilitate gradual restoration and development of thermal energy generation process even at the present time.

Various international organizations (World Bank, TACIS, USAID), which studied Georgia's energy systems for the period since 1992-93, make a one-valued conclusion that the stabilization in the energy sector of the country cannot be reached without restoration and development of heat supply system. Separation of heating and hot water supply systems from electricity sector is an essential condition for overcoming the energy crisis. The situation needs an urgent reaction.

Restoration of heat supply systems like the previous form is impossible, though provision of consumers with heat sources functioning on the principles of modern energy efficiency is quite essential.

Due to the lack of the infrastructures of heat supply systems in the country, we have to create thermal energy generation and distribution systems anew.

The state priority status has to give to this problem. Heat supply rehabilitation strategy and the relevant program should be worked out. Its realization should be started by the implementation of pilot projects. Rather useful and interesting project was implemented in this direction in 1999-2000, under the support of GEF. Several alternatives for heat supply development were elaborated based on the example of Tbilisi Saburtalo and Didi Digomi districts: district, cogeneration, group, individual and geothermal hot water supply, as well.

Demonstrative project envisages energy efficiency increasing measures (installation of regulating and metering equipment, innovative principles of management) implementation of which provides the decrease of both energy and annual organic fuel consumption by 30-40% in these districts as compared with annual consumption in the Soviet period. Therefore, implementation of GEF project has the greatest importance for the country's economy, energy sector and the environment.

4.1.3. CO_2 Emission Reduction Potential in the Electricity and Heat Power Generation Sectors

Three thermal electric stations were operating in the electricity generation sector in 1990, efficiency of which on the average was 25.5% and the projected value should be equal to 32.8%. Table 4.1.3.1 illustrates data on extra amount of CO_2 per million kWh of generated electricity that corresponds to 406 771 t of extra CO_2 in proportion to the total generated electricity.

Only two thermal electric stations with 25.64% of average efficiency were functioning in 1999. This efficiency is 8% less than the norm (33.65%) i.e. 33 t of extra CO_2 is emitted per million kWh of generated electricity that gives 17 999 t of extra CO_2 for total generation.

Table 4.1.3.1. CO_2 reduction potential in electricity generation sector

Electricity generation units	Efficiency %			Extra CO_2 t per million kWh		Extra CO_2 t/y	
	Design	Actual 1990	Actual 1999	1990	1999	1990	1999
1. Tbilsresi	34.2	26	27.87	251.19	148.43	488604.98	81528.03
2. Tbiltetsi	33.2	29.8	23.4	39.35	170.73	6966.31	3186.18
3. Tkvarchelsresi	31.1	20.5	NO*	0.0	NO	0.0	NO
Total						495571.29	84714.21

NO – Not in operation*

Thorough information on generation units is presented in the Table 4.1.3.2.

Table 4.1.3.2. Efficiency of thermal electric stations from the environmental standpoint

Thermal electric station	Year	Actual production of energy			Efficiency		Fuel annual consumption			GHGs emissions in equivalent of CO_2, t		GHGs Extra emissions in equivalent of CO_2, t	
		Electricity	Thermal	Total	Designed	Actual	Mazut	Natural gas	Natural gas				
		mln.kWh	mln.kWh	mln.kWh	%	%	ton	ton	mln.m^3	Total	per mln.kWh	Total	per mln.kWh
Tbilsresi	1990	5578,10	103,98	5682,08	34,23	26,00	1431900,00	385248,00	481,56	5934473,39	1044,42	488604,98	251,19
	1999	1609,60	1,16	1610,76	34,10	27,87	84070,00	382248,00	477,81	1308636,07	812,43	81528,03	148,43
Tbiltets	1990	96,20	437,02	533,22	33,20	29,80	23613,00	46438,40	58,05	204891,50	384,26	6966,31	39,35
	1999	24,20	32,01	56,21	33,20	23,40	0,00	12176,80	15,22	32512,06	578,40	3186,18	170,73
Tkvarche-lsresi	1990	344,00	0,00	344,00	31,10	20,50	0,00	0,00	0,00	0,00	0,00	0,00	0,00
	1999	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
TOTAL	1990	6018,30	541,00	6559,30	32,84	25,43	1455513,00	431686,40	539,61	6139364,89	1428,68	495571,29	290,54
	1999	1633,80	33,17	1666,97	33,65	25,64	84070,00	394424,80	493,03	1341148,12	1390,84	84714,21	319,16

Taking into account the situation created in the hydro power industry while examining electricity generation sector from GHG extra emissions standpoint is essential, as each not generated 1 kWh of electricity at the hydro power plant is substituted for electricity generated at the thermal electric station. Extra emission that is saved in case the efficiency raising in hydro power industry up to the design value after the rehabilitation is appraised in the Table 4.1.3.3.

Table 4.1.3.3. Efficiency in hydro power industry and extra CO2 emission

Hydro power plants	Efficiency, %			Extra CO_2 t per million kWh		Extra CO_2, t/y	
	Design	Actual 1990	Actual 1999	1990	1999	1990	1999
1. Big and medium HPPs	50.4	36.71	32.24	258*	258*	568735.2	844640.4
Total						568735.2	844640.4

* 0.258 kg of CO_2 emission is taken while generating of 1 kWh of electricity

Detailed information on the HPPs utilization efficiency and possible amount of emission reduction is given in the Table 4.1.3.4.

Table 4.1.3.4. HPP Efficiency

No	Hydro power plant	Year	Efficiency		Electricity generation			Total GHG emission equivalent to CO_2
			Designed	Actual	Designed	Actual		
			%	%	mln.kWh	mln.kWh	%	tones
1	2	3	4	5	6	7	8	9
1	Atshesi	1990	69,2	45,01	97	63,1	65	8746,2
		1999	69,2	41,8	97	58,6	60	9907,2
2	Engurhesi	1990	38,11	31,43	4340	3579,3	82	196260,6
		1999	38,11	23,56	4340	2684,1	62	427222,2
3	Gumathesi-1	1990	66,41	36,58	256	141	55	29670
		1999	66,41	40,47	256	156	61	25800
4	Gumathesi-2	1990	69,09	35,39	138	70,7	51	17363,4
		1999	69,09	39,65	138	79,2	57	15170,4
5	Jinvalhesi	1990	43,9	31,75	500	361,6	72	35707,2
		1999	53,9	31,78	500	362	72	35604
6	Lajanurhesi	1990	51,54	36,44	505	357,1	71	38158,2
		1999	51,54	35,11	505	344	68	41538
7	Ortachalhesi	1990	57,07	43,88	90	69,2	77	5366,4
		1999	57,07	43,5	90	68,6	76	5521,2
8	Rionhesi	1990	77,25	58,76	325	247,2	76	20072,4
		1999	77,25	58,76	325	247,2	76	20072,4
9	Shaorhesi	1990	43,99	40,04	148	134,7	91	3431,4
		1999	43,99	49,7	148	167,2	113	0
10	Tkibulhesi	1990	23,54	23,67	165	165,9	101	0
		1999	23,54	19,09	165	133,8	81	8049,6
11	Varketilhesi	1990	86,85	52,82	1400	851,4	61	141538,8
		1999	86,85	50,19	1400	809	58	152478
12	Vardnilhes-1	1990	36,32	33,39	700	643,6	92	14551,2
		1999	36,32	27,26	700	525,4	75	45046,8
13	Vardnilhes-2	1990	36,24	33,11	127	116	91	2838
		1999	0	0	0	0	0	0
14	Vardnilhes-3	1990	36,24	32,22	127	112,9	89	3637,8
		1990	36,24	32,22	127	112,9	89	3637,8
15	Vardnilhes-4	1990	39,09	32,1	137	112,5	82	6321
		1999	0	0	0	0	0	0
16	Khramhesi-1	1990	21,83	19,94	217	198,2	91	4850,4
		1999	21,83	21,83	217	217,1	100	0
17	Khramhesi-2	1990	38,39	29,6	370	285,3	77	21852,6
		1999	38,39	21,53	370	207,5	56	41925
18	Zahesi	1990	65,14	42,77	210	137,9	66	18601,8
		1999	65,14	43,92	210	141,6	67	17647,2
TOTAL		1990	50,01	36,61	9852,00	7647,60	77,62	568735,2
		1999	52,18	36,27	9588,00	6314,20	73,30	844640,4

So, as a result of restoration of design efficiency could be saved 1064 306.49 t of CO_2 in 1990 and 929354.61 t of CO_2 in 1999 in the generation sector while the production was rather low in 1999.

Thermal energy generation sector is estimated by the state of 1990, because thermal energy supply municipal sector in point of fact was stopped in 1999-2000. Approximate evaluation of emission by the year 1999 was performed in the previous project that was devoted to the examination of removing barriers to energy efficiency in the municipal heat supply sector.

Table 4.1.3.5. CO_2 reduction potential in thermal energy generation sector

Thermal energy generation objects	Efficiency, %			Extra CO_2 per million kWh, t		Extra CO_2 t/y	
	Design	Actual 1990	Actual 1999	1990	1999	1990	1999
1. Tbilisi	88.7	68.4	NA	48.6	NA	303685	NA
2. Batumi	88	73	NA	69.7	NA	13598	NA
3. Kutaisi	85	81	NA	16.2	NA	10148	NA
4. Rustavi	85	77	NA	32.4	NA	22768	NA
5. Televi	87	77	NA	21.0	NA	2928	NA
6. Zestaponi	85	70	NA	30.4	NA	1255	NA
7. Other towns	85	70	NA	58.6	NA	45884	NA
Total						400266	

Detailed information on thermal energy generation sector is presented in the following Table.

Table 4.1.3.6. Parameters of efficiency of thermal energy generation units from the environmental standpoint

N	Unit No	Name of generation unit	Actual production of heat	Efficiency		Fuel annual consumption			GHG emissions in CO_2 equivalent		GHG extra emissions in CO_2 equivalent	
				Design	Actual	Mazut	Natural gas	Natural gas	Total	per mln.kWh	Total	per mln. kWh
			mln. kWh	%	%	ton	mln. m^3	ton	ton	ton	ton	ton
1	2	3	4	5	6	7	8	9	10	11	12	13
1	1	Tbilisi (Saburtalo)	207,4	89	71	754	28,82	23056	42769,90	206,22	7698,58	41,71
2	2	Tbilisi (Saburtalo)	34,9	89	69		5	4000	6972,00	199,77	1394,40	44,89
3	3	Tbilisi (Samgori)	215,5	89	62	2460	26,4	21120	45240,42	209,93	12214,91	63,69
4	4	Tbilisi (Vake)	78,4	89	62		12,7	10160	17708,88	225,88	4781,40	68,52
5	5	Tbilisi (Didube)	79,7	89	60	43	13,4	10720	18832,28	236,29	5461,36	76,99
6	6	Tbilisi (Didube)	408	89	75	20	55	44000	76760,52	188,14	10746,47	29,59
7	7	Tbilisi (Samgori)	58,1	89	54	725	10	8000	16427,94	282,75	5749,78	111,19
8	8	Tbilisi (Vake)	219,6	89	67	1450	31,8	25440	49309,79	224,54	10848,15	55,51
9	9	Tbilisi (Mtatsminda)	70,4	89	67	3065	7,3	5840	20680,18	293,75	4549,64	72,61
10	10	Tbilisi (Saburtalo)	146,8	89	67	2080	20	16000	35014,33	238,52	7703,15	58,96
11	12	Tbilisi (Nadzaladevi)	247,2	89	70	600	35	28000	50859,67	205,74	9663,34	43,92
12	13	Tbilisi (Saburtalo)	131,8	89	68	2030	17,5	14000	31357,02	237,91	6584,97	56,14
13	14	Tbilisi (Vake)	201,7	89	75	815	25	20000	37652,29	186,67	5271,32	29,36
14	16	Tbilisi (Samgori)	106,3	89	66		16,2	12960	22589,28	212,50	5195,53	54,92
15	17	Tbilisi (Gldani)	508,2	89	66		77,3	61840	107787,12	212,10	24791,04	54,81
16	18	Tbilisi (Saburtalo)	267,8	89	58	7010	39	31200	78398,70	292,75	24303,60	101,97
17	19	Tbilisi (Vake)	255,4	89	76	2870	35	28000	58636,96	229,59	7622,81	33,54
18	20	Tbilisi (Isani)	245,5	89	73	890	33	26400	49064,45	199,86	7850,31	35,93
19	21	Tbilisi (Nadzaladevi)	216,4	89	74	1600	28	22400	44524,99	205,75	6678,75	34,68
20	22	Tbilisi (Samgori)	205,4	89	75	3800	23,6	18880	45927,10	223,60	6429,79	35,17
21	23	Tbilisi (Krtsanisi)	103	89	74	250	13,8	11040	20099,25	195,14	3014,89	32,89
22	24	Tbilisi (Isani)	166,6	89	58	1300	27,5	22000	42799,96	256,90	13267,99	89,48
23	25	Tbilisi (Didube)	347,5	89	71	17380	30,8	24640	102493,49	294,95	18448,83	59,65
24	26	Tbilisi (Chugureti)	35,2	89	71		5	4000	6972,00	198,07	1254,96	40,06
25	27	Tbilisi (Mtatsminda)	29,1	89	73	15	4	3200	5628,99	193,44	900,64	34,78
26	28	Tbilisi (Vake)	228,8	89	73	6000	25	20000	55416,72	242,21	8866,68	43,54
27	29	Tbilisi (Samgori)	28,3	89	70		4,1	3280	5717,04	202,02	1086,24	43,13

1	2	3	4	5	6	7	8	9	10	11	12	13
28	30	Tbilisi (Isani)	89,6	89	71	320	12,4	9920	18386,92	205,21	3309,65	41,50
29	31	Tbilisi (Samgori)	85,8	89	71	125	12,1	9680	17300,51	201,64	3114,09	40,78
30	32	Tbilisi (Saburtalo)	88,7	89	73	429	11,8	9440	17923,73	202,07	2867,80	36,33
31	33	Tbilisi (Krtsanisi)	36,1	89	75	193	4,6	3680	7075,48	196,00	990,57	30,83
32	34	Tbilisi (Nadzaladevi)	19,2	87	60		3,3	2640	4601,52	239,66	1242,41	74,38
33	35	Tbilisi (Gldani)	28,7	87	59	150	4,8	3840	7207,04	251,12	2017,97	80,82
34	36	Tbilisi (Krtsanisi)	181,2	89	74	2663	21,9	17520	39661,12	218,88	5949,17	36,89
35	37	Tbilisi (Krtsanisi)	5,5	87	51		1,1	880	1533,84	278,88	552,18	115,40
36	39	Tbilisi (Vake)	13,5	80	72	75	1,8	1440	2766,88	204,95	221,35	20,50
37	40	Tbilisi (Saburtalo)	39,2	87	63		6,3	5040	8784,72	224,10	2108,33	61,82
38	41	Tbilisi (Samgori)	103,5	89	74	579	13,5	10800	20808,12	201,04	3121,22	33,88
39	42	Tbilisi (samgori)	3,5	87	64	50	0,5	400	868,51	248,14	199,76	65,60
40	43	Tbilisi (Nadzaladevi)	342	89	75	2432	43,5	34800	68988,72	201,72	9658,42	31,73
41	44	Tbilisi (Gldani)	285,8	89	70	1018	40,2	32160	59542,67	208,34	11313,11	44,48
42	45	Tbilisi (Isani)	238,7	89	65		32,2	25760	44899,68	188,10	10775,92	50,72
43	46	Tbilisi (Isani)	369,3	89	70	248	53,1	42480	74892,32	202,80	14229,54	43,29
44	47	Tbilisi (Vake)	119,4	89	75		16,1	12880	22449,84	188,02	3142,98	29,58
45	48	Tbilisi (Didi digomi)	165,1	89	70		24,5	19600	34162,80	206,92	6490,93	44,17
Total in Tbilisi			7057,8	88,578	68,378	63439	953,92	763136	1547495,67	219,26	303684,92	48,59
46	1	Batumi	224	87	73	28350	0	0	97130,50	433,62	13598,27	69,78
47	2			88	73							
48	3			88	73							
49	1	Kutaisi	736	85	81	65500	21	16800	253693.26	344,69	10147,73	16,22
50	2			85	81							
51	group boilers			85	81							
52	1	Rustavi	828	85	77	69800	32,6	26080	2846900,62	343,72	22768,05	32,35
53	2			85	77							
54	3			85	77							
55	1	Telavi	160	87	77		21	16800	29282,40	183,02	2928,24	21,04
56	2			87	77							
57	1	Zestaponi	48,6	85	70		6	4800	8366.40	172,15	1254,96	30,38
58	1500	Other Cities of Georgia	921,6	85	70	63480	63,4	50720	305895.06	331,92	45884,26	58,57
Total in the units of the other cities			2918,2	85,923	75,923	227130	144	115200	978968,24	335,47	96581,51	39,91
Total in the Republic			9976,0	88,983	70,069	290569	1097,92	878336	2526463,91	253,25	400266,43	49,16

Thus, by the state of 1990, annual extra CO_2 emission from electric and thermal generation sectors equals to 1 464 573 t.

4.2. TRANSMISSION AND DISTRIBUTION

Transmission and distribution are the main constituents of energy sector, representing the most important ring, connecting generation objects with consumers. Just its efficient performance determines reliable operation of electric and heat supply systems. Therefore, main purpose of the analysis of the current state of this part of energy sector is the revealing of those weak points, to overcome which, conduction of appropriate reconstruction activities and formation of relevant recommendations will be necessary, for the introduction of modern energy efficient technologies.

4.2.1. Electricity Transmission and Distribution
4.2.1.1. Electricity Transmission and Distribution in 1990

Georgia's electricity transmission system comprises 500 kV, 330 kV, 110 kV and 35 kV electricity transmission lines and substations. Electricity distribution system consists of 10 kV, 6 kV and 0.4 kV aerial lines, cables, contact switches and other equipment.

The country's electricity transmission system, by the state of 1990, consisted of the following electricity transmission lines and substations (see Annex, Tables 11, 12, 13).

- 579 km length 500 kV electricity transmission lines;
- 21 km length 330 kV electricity transmission lines;
- 1486,5 km 220 kV electricity transmission lines;
- 4724,8 km length 110 kV electricity transmission lines;
- 3643,4 km length 35 kV electricity transmission lines;
- 500/220 kV 2 substations;
- 220/110 kV 16 substations;
- 110/35 kV 139 substations;
- 35 kV 235 substations.

In the same year of 1990, the electricity system of Georgia was connected with electricity systems of neighboring countries by electricity transmission lines with the following parameters and length:

- with Russia: by one 500 kV electricity transmission line-"Kavkasioni" of 409 km length and one 220 kV line-"Salkhino" of 123 km length;
- with Azerbaijan: by one 500 km electricity transmission line-"Mukhrani" of 286 km length and one 330 kV line-"Gardabani", of 21km length.
- with Armenia: by one 220 kV line- "Alaverdi";
- with Turkey: 220 kV line-"Adjara"

The spine of Georgia's electric system is represented by 500 kV electric transmission lines-"Imereti"(127,77 km), "Kartli-2" (165 km) and "Kartli-1" (91,91 km), of a total 384,68 kV length, connecting 500 kV Enguri hydro power plant open distributing equipment, Didi Zestaphoni 500 kV substation, Ksani 500 kV substation open distributing equipment. The connecting hydro power plants of Western Georgia with Gardabani located Tbilsresi and other main electric plants of Eastern Georgia.

Electricity is mostly transmitted from Western to Eastern Georgia that is conditioned by the fact, that main electricity generating sources - hydro power plants, are located in the western part of Georgia.

Information on Georgia's transmission lines, electric transformers of substations and reactors, open distribution equipment of thermal and hydro power plants by the year 1990, are presented in Tables 11-13 and 19 (of Annex), the analysis of which shows that in 1990, technical equipment of the country's electric system was relatively in better condition, that was the result of appropriate provision of the electric system with spare parts and materials, timely conducted general and current repairs, high level exploitation and appropriate executing discipline.

It is remarkable that during the period under consideration, simultaneous operation with neighboring countries provided a stable preservation of frequency within normal value – 50 Hz even at substantial change of load or consumption. Preservation of frequency and voltage within normal values provided, in its turn, operation of main aggregates of electricity transmission and distribution system and its equipment without accidents.

It should be noted as well, that cases of complete emergency disconnections of the country's electric system were not observed except in some rare cases. During the mentioned period the country's electric system was mainly operating simultaneously with electric systems of neighboring countries and as an exception (for a short time, to eliminate the damages of electric transmitting lines, connecting the systems), in an autonomous-isolated regime. As a result, the country's electric system preserved appropriate norms of the main parameters of electric current-voltage and frequency, so as a result, disconnecting, transmitting, distributing and other devices were less damaged. As it is known, switches and disconnecting devices are mainly damaged by the frequent disconnections, caused by voltage variations or other reasons, very frequently observed in the following period.

Technical losses give a clear impression on the state of the system. Losses in the power network have an ordinary character. As a rule, they occur in case of voltage decrease to the level, acceptable for a consumer, or electricity transportation in the network. The problem arises in case when losses in electricity transmitting lines exceed the level, considered as acceptable or permissible. The latter is determined in each case in advance by the relevant organization (at present by the Electricity Sector Regulatory National Commission). It is known that losses in the power network may be caused by overloading of specific electricity transmitting or distributing lines, as well as both of them. The greater the load, the larger are losses in the power network. Therefore, while assessing the loss level, its specific share in consumed electricity volume is used (out of that being in the network, %). Proceeding from aforesaid, by the state of 1990, the share of electricity losses out of that being in the network according to voltage stages, is as follows: in 500 kV grid-1,04%; in 330 kV grid-0,11%, in 220 kV grid-2,67%, in 110 kV one-3,98%; in 35 kV grid-0,97%; in 10 and 6 kV grids-3,64% and in 0,4 kV grid-2,79%. Share of total losses made 15,2%, main constituents of which are losses in 10 kV, 6 kV and 0,4 kV network (3,64%+2,79%=6,43%). It is evident that the losses in transmitting network itself (500 kV, 330 kV, 220 kV, 110 kV and 35 kV grid) do not exceed (15,20-6,43)-8,77%.

4.2.1.2. Electricity Transmission and Distribution in 1999

By the state of 1999, information on electricity transmitting and district heating networks, substation transformers and reactors, thermal and hydro power plants and their distributing equipment is presented in the (Annex, Tables 11, 12, 13). The data presented clearly demonstrate that in 1999 the situation in electricity transmitting and distributing network, as well as in substations, was heavier than in the 90s. During last period, plundering of electric system objects, with the purpose of carrying ferrous and non-ferrous metals out of the country, reached catastrophic scale. Angle irons and lines on electricity transmitting towers were stolen resulting in a complete or partial fail of electricity transmitting lines of different stages in 1999. In particular, it concerns 35 km of "Mukhrani"-500 kV electricity transmitting line, connecting with Azerbaijan; 58,8 km of 220 kV electricity transmitting line "Senaki-I, II," connecting substations "Menji" and "Tskaltubo"; 43 km of "Ajameti"-220 kV electricity transmitting line, connecting substations "Didi Kutaisi" and "Didi Zestaphoni"; 110 kV electricity transmitting lines of a total length 813 km; 35 kV electricity transmitting lines of total length 525,4 km, etc. It should be remarked, as well, that 220 kV plundered line "Senaki-I, II" was constructed in 1991. In spite of hard situation, in the period under review, several new electricity transmitting lines were constructed and put into operation.

As a result, in 1999, the country's electricity transmitting system included:

? 544 km length, 500 kV 5 electricity transmission lines;
? 21 km length, 330 kV one electricity transmission line;
? 1540,5 km length, 220 kV 35 electricity transmission line;
? 3912 km length, 110 kV 276 electricity transmission line;
? 3118 km length, 35 kV 287 electricity transmission line;
? 500/200 kV 2 substations;
? 220/110 kV14 substations;
? 110/35 kV 138 substations;
? 35 kV 228 substations.

500 kV electricity transmitting lines of the country are at present exploited by Georgian-Russian joint company "Sakrusenergo", including strategically important 500 kV electricity transmission line "Kavkasioni", connecting electric systems of Georgia and Russia. By 1999, there were frequent cases of its emergency disconnections, caused by intended damaging of lines with the purpose of plundering steal and aluminum wires and angle bars.

330 kV transmission line "Gardabani", connecting electric systems of Georgia and Azerbaijan, was undamaged by the state of 1999 and in case of need was functioning (there was not a permanent connection), and 500 kV electricity transmission line-"Mukhrani", as a result of plundering, is still disconnected. At present, restoration works are being conducted.

220 kV electricity transmission lines "Alaverdi" and "Ajara", connecting Armenia with Turkey are in operation, though simultaneous operation with electric systems of these countries has not yet been managed due to various reasons. E.g. electricity was supplied to Georgia by 220 kV electric transmission line, connecting with Armenia, only by Czech scheme. 220 kV line transmitting electricity to Turkey can transmit 250 MW through "Ajara" wires, though proceeding from the network technical condition, today it can transmit only 120 MW electricity. It is clear that to increase the conductivity of indicated line, appropriate restoration works should be carried out. In this direction large scale works have been already started according to RWE program. Therefore, on the basis of all aforesaid, it may be assumed that in 1999 Georgia's electric system was forces to work mainly in an autonomous regime, except that short time period, when it was operating simultaneously with Russia's electricity system. While operating in the isolated regime, even in case of damaging one of the three sections of 500 kV electricity transmission line of Enguri and Tbilisi Thermoelectric plant, there was enough danger of disconnecting the whole system, since, due to its technical condition, the conductivity of 220 kV electricity transmission lines is not sufficient to preserve working regime of the system. Indicated case, i.e. full disconnection of the system, really took place in 1998-1999.

Georgia has a rather well-developed network of high voltage electric transmission lines, though by the state of 1999, a substantial part of technical equipment of electricity transmission and distribution system was in a poor condition at all stages of voltage, due to the lack of funds required for the purchase of spare parts, damages caused by frequent disconnections of switching and distributing equipment, linked with operation in the overloaded regime, the use of obsolete equipment and expiration of its amortization period.

Computer techniques available at the control center of the country's energy system are out of date and their restoration is impossible, or unreliable. The same concerns the equipment, used in dispatcher systems, owned by substations and "Sakenergo" (1999 year name) and information about real working time may be received and fixed only from 6 objects (Enguri, Zestaphoni, Ksani, Gardabani, Kutaisi, and Gldani), instead of 34 substations and stations. Most of "Sakenergo" communication lines at present are not functioning, repairing of the equipment is almost impossible or disadvantageous.

In 1996-1999, the analysis of available information on the disconnections of electricity transmission lines and substations shows that during the indicated period such cases were rather frequent, evidencing the fact that Georgia's energy system is generally unstable and such situation may arise any time, since most equipment of the system is already amortized or is in a rather poor technical condition. E.g. the reason for 220 kV Lisi substation emergency disconnection on the switch was the explosion of the "g" phase of BB6-220 type aerial switch, caused by irregularities in switching insulator and isolation switch. Described case clearly shows that very often, prevention of accidents on high voltage substations is impossible.

Therefore, it may be assumed, that by the state of the year 1999, the energy transmission system requires to be equipped by modern installations.

In Georgia electricity losses are traditionally high. In 1990 the losses in the network of common utilization made 2643,3 million kWh, showing that in spite of the decrease of energy losses in absolute values, they even increased in relative indices in 1995. Particularly, the specific share of losses in consumed total volume of energy made 15,2% in 1990 and 25,4% in 1995.

In 1999 share of loss decreased up to 11,88% (see Table 14 of Annex), however being at higher level than in other countries.

Specific share of losses in the grid, by the state of 1999, out of a total consumed amount was as follows, according to voltage stages: in 500 kV grid-1,25%, in 330 kV-0,13%, in 220 kV grid -3,16%, in 110 kV-5,3%, in 35 kV grid-1,26%, in 10 and 6 kV grids 0,49% and in 0,4 kV -0,29%, making it evident that losses in the transmission network, itself (in 500, 330, 220, 110 and 35 kV grids) made (1,25+0,13+3,16+5,3+1,26)=11,1%, that substantially exceeds the 1990 index of 8,77%. As to a total loss of 0,78% in the distributing network, provided by regime service of "Sakenergo", we consider it unreliable, since this service is not supplied with appropriate correct information by energy companies under municipal subordination.

It is known, that the level of actual energy loss in Georgia is also higher than its standard value, and reaches 20-30% in some distributing energy companies

Investigations conducted on the basis of data provided by Georgia's 32 distributing companies showed that technical losses in the distributing network in 1996 made 18% [34], while in the Soviet period it varied within 9%. On the feeders, serving consumers of densely populated districts, technical losses over passed even 25% [37].

National Energy Regulatory Commission of Georgia established permissible norms of energy technical loss in the country by 1999. They are presented in the Table 15 of the Annex. Their comparison with 1999 data shows that technical losses were especially high in the 110 and 35 kV grids.

4.2.1.3. Efficiency Analysis of Transmission and Distribution Systems for 1990-1999

To overcome the energy crisis, the government is now implementing the program of reforms in the energy sector. One of its important elements is the development of energy wholesale market that will regulate commercial relationship between energy generators, distributors and large consumers. For the provision of wholesale market development, the implementation of following measures is necessary:

? Rehabilitation of electricity transmission and distribution lines and substations up to appropriate level using modern energy efficient technical aggregates and equipment;

? Rehabilitation of control, management communication system, the whole dispatching grid and their equipment up to modern level.

To conduct these measures, preliminary technical and economic assessments have been already started by a consulting company "FIGHTNER". Activities under the first point are financed by KfW "Bank and the second – by the World Bank.

Necessity for the conduction of these is activities clearly indicated by the fact that during the period of 1990-1999 the level of country's energy transmission and distribution systems considerably decreased due to well known reasons. At present, most of the system's technical equipment is in quite a poor condition and requires repairing. Some of the important equipment, such as 220 kV grid switches, 220/110 kV transformers, etc. are out of order and should be replaced at all.

In spite of the fact that some of the equipment was damaged during the civil war, most of existing problems are the result of the lack of financial sources for the exploitation (to purchase spare parts), operation under the regime of maximum load (great number of operations on circuit switches and distributing equipment), their fail and depreciation.

Analysis of the number of disconnections of energy transmission lines and substations shows that since 1990 to 1999 number of disconnections considerably increased. They may be divided into two groups by their characteristics:

- ? Disconnections which does not result in the equipment damage;
- ? Disconnections which caused the damage of equipment (insulators, conductors, towers)

Disconnections took place on the 500 kV lines, as well as on the 220 kV and 110 kV lines. The purpose of such division is to establish the number of equipment to be restored by automated protection system and the period of electric supply disconnection to be avoided. If we compare the total number of disconnections of the country's electric transmission lines with their number in Western countries, it will appear that in Georgia this index is 2-3 times higher.

It is known that automatic re-closing systems are sufficient mean to avoid short circuits (faults). In case of faults, instead of switching off the electric transmission line, it is disconnected only in the damaged phase for a very short time period. As a result of air de-ionization, electric transmission is restored without load losses, overload of electric transmission lines or disconnection of the whole grid. Precondition for the aforesaid is that switches of the circuit should be constructed in such a way that they would be able to perform this function, being impossible to achieve by means of those out of order equipment available at Georgia's substations. So, more attention should be paid to replacing old types of switches installed on electric transmission lines, particularly, on 500 kV lines [15].

The analysis of Georgia's electric transmission lines shows that the country's 500 kV grid is most important, connecting Georgia's large electric plants on the one hand, and providing connection with grids of neighboring countries on another. Therefore, urgent measures must be concentrated on the 500 kV switches, so that to make the grid more reliable and energy efficient in the context of the decrease of load losses and expected damage.

As to substation switching off, especially should be mentioned the accident which took place in Tbilsresi 500 kV open distributing equipment on 20 October, 1998, caused by the explosion of a grid condenser, produced by CEC-Alstom, in the reactor cell at "g " phase of the circuit switch, causing total destruction of one of the switching chambers of the "g" phase. China fragments after the explosion substantially damaged circuit condensers, disconnecting chambers, insulators and "B" phase current transformers. As a result, reactor switches did not function since 20 October, 1998 and its switching on was impossible. Due to this fact, compensation of the system re-voltage and operations optimization for all levels of the grid load were impossible. Damage, done by the accident to high voltage equipment made approximately 1,25 million GEL (2,5 million DM). Reason for the disconnection of Zestaphoni 220 kV substation in 1998, was an explosion of 220kV circuit switch on the AT-1 transformer, caused by the damage of one of the switching off chambers of the "A" phase. Damage done to the equipment made approximately 0,5 million GEL (1 million DM).

In the further period, disconnections due to accidents took place also in other substations, such as the Lisi substation where disconnection was caused by a switch explosion in 1999. Damage caused by the accident to the equipment made 0,35 million GEL (0,7 million DM). Economic loss in this and above cases was assessed by German specialists [15].

Technical condition of current equipment of substations at present is such that it will be necessary to replace most of them so that to provide electric supply in future. These measures are necessary at all levels of voltage from 500 kV down to 0,4 kV. The equipment, requiring restoration, is of wide range including high voltage switches, transformers, and their switches, relay protection and control devices, batteries, etc. So, on the basis of all aforesaid, it may be concluded that most of electric equipment at substations are at present depreciated or their current state requires their replacement by new ones despite the fact whether they are operating or not.

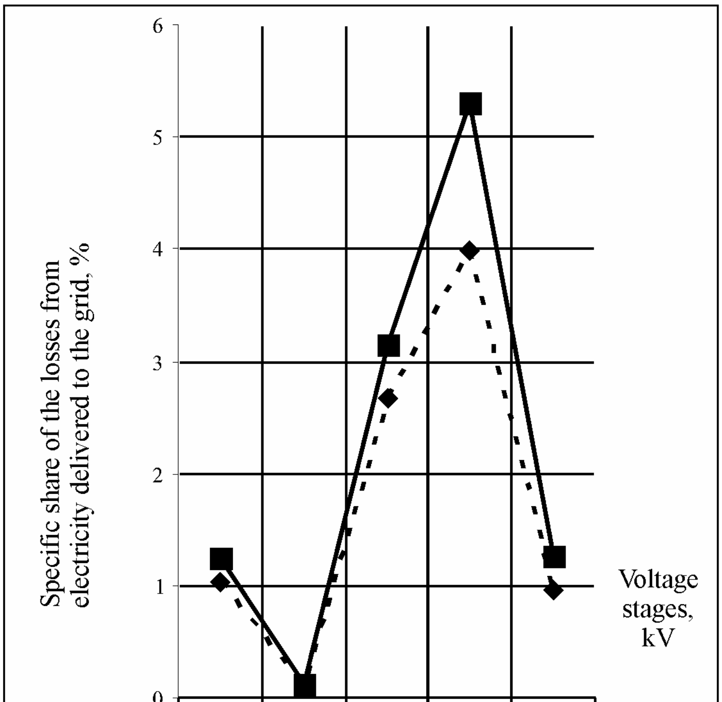
As to a central control unit of the country's grid, its computer system-CM4/CM1420, operating now, was installed in the end of the 80s. In 1993 one PC386 was added to it being connected to FEP processors. Since then no improvements or expansion of a computer system were carried out. At present, computer technologies of the control center are out of date and require modernization. This situation is proved even by the fact that getting and fixing of information by available equipment is performed only from 6 objects instead of 34 substations and plants. Data obtained from other stations are collected by an operator once every hour by telephone and is recorded manually, but since a monitoring screen is controlled by FEP-s, it does not reflect them.

It should be noted that, at present, along with other shortcomings, approximately 80% of a communication system do not operate, creating a serious obstacle to the functioning of the system. Actually, its own telephone and data transmission channels of the system are functioning only on Tbilisi-Kutaisi section. Due to the absence of an exact telecommunication system, the situation is worsened even more.

Therefore, the problem of rehabilitation and equipment on a modern level of control and communication systems and a whole grid dispatcher unit should be considered as a matter of urgent importance. Activities sponsored by the World Bank in these direction- technical and economic assessments, necessary for rehabilitation, have been already started by the foreign company “FIGHTNER”.

Worsening of energy transmission and distribution system since 1990 to 1999 is also proved by the fact that in 1999 specific share of loss in the grid, out of total amount, is higher according to the voltage stages than it was in 1990. In order to make a comparative analysis, the information on the specific losses is presented on the Fig. 4.2.2.

According to the Figure, specific loss in the 500 kV grid in 1999 was higher than that of 1990 by 20,2 %; In the 330 kV grid-by 18,2 %; in the 220 kV grid-by 18,35 %; in the 110 kV grid-by 33, 16 %, and in the 35 kV grid - by 29,9 %. Therefore, even these data indicate the worsening of situation in the energy transmission system, and the necessity of taking above indicated measures.



	500	330	220	110	35
1990	1,04	0,11	2,67	3,98	0,97
1999	1,25	0,13	3,16	5,3	1,26

Fig. 4.2.2. Specific share of losses (%) from the consumed energy in electricity transmission lines according to voltage stages in 1990-1999

Finally, it should be noted that, besides the rehabilitation and replacement of the existing equipment, finding ways and means to complete the 500 kV energy transmission line “Tbilisi-Southern Georgia-Zestaphoni” and continue it up to Turkish substation “Kars”, is necessary, so that to increase the amount of transit energy up to 2.5 billion KWh. At the same time Georgia is to be given a chance to get free 10-15% of this energy for the transit, so that to add up to 250-375 million kWh of electricity to the country. The problem of construction of the 500 kW electric transmission line “Engurhesi-Akhaltsikhe” is to be considered separately. By means of constructing this line, the 500 kV voltage grid of Georgia’s energy system will be closed, its sustainability and transit capacity will be increased, and what is most important, the financial condition of the sub-sector will be improved.

4.2.2. Thermal Power Transmission and Distribution

4.2.2.1. Thermal Power Transmission and Distribution System in 1990

By the beginning of the 90s most part of Georgia's large cities was covered by centralized heat supply system, construction of which started from the beginning of the 60s. Total length of the country's heat supply lines by 1990 was approximately 1600 km, including 1140 km in Tbilisi.

Main types of heat supply system were:

1. Underground, brick or concrete impassable channels;
2. Underground, channelless pipelines, insulated by bitumen pearlite;
3. Underground, passable collectors;
4. Above-ground, located on separate high or low supporters.

Out of above listed types the first (76%) and second (18%) types of heat supply system were most widely used in Georgia. Heat supply systems of relatively small capacity (16%) were constructed with surface mounting. In spite of its cheapness, its wide distribution in cities was actually limited due to architectural and aesthetic considerations. It was mainly implemented in Western Georgia regions (Batumi, Poti, Zugdidi), where level of underground waters is high. It is remarkable that in the heat supply system, constructed recently in Didi Digomi settlement, the newest method of constructing the heat supply system was used: heat supply systems of 4 pipeline design were placed in underground collectors together with other engineering communications of Didi Digomi (water conduit, cables, etc.). Placing pipelines in underground collectors represents rather an effective method of the arrangement of engineering infrastructure of large cities that greatly simplifies it and makes the works on exploitation and repairing of communication systems significantly cheaper.

Main types of thermal insulation of heat supply system widely used in the country are presented in the Table below.

Table 4.2.2.1. Main types of thermal insulation of heat supply system used in Georgia.

	Types of heat supply system	Types of insulation
	Underground, in impassable channels and passing collectors	- Anticorrosion insulation according to Soviet construction norms - thermal insulation with slag wool mattresses blankets and glass wool semi-cylinders (s=40/60mm) - insulation protection layer with asbestos cement cover.
	Underground, channelless	- ready-made bitumen-pearlite insulation for 50-700mm diameter pipelines.
	Above-ground	- The same as in the “a” type, additionally aluminum foil or prepared roofing paper.

Works on insulation of heat supply system pipelines in the country were conducted inadequately and caused substantial losses of thermal energy. Depth of the lines of underground thermal supply system was taken from 0.7 to 1.2 m. In thermal supply system there were used the following types of steal pipes: seamless (Soviet standard 8732-75); electrically welded (SST 10704-76); and air and water conducting (SST – 3262-62). Diameter of pipes varied from 50 to 700 mm. To compensate the pipeline thermal elongation, expansion u-band and sleeve type compensators were mainly used. The latter was installed on large diameter pipelines.

In case of underground type of heat supply system, pipeline locking accessories – valves, locking bars and sleeve compensators were placed in heat supply system wells. Installation of pipeline emptying drainage equipment was also envisaged, though in most cases they were not installed. Due to poor quality of locking accessories and lack of emptying equipment, water spillage and collection were observed in channels and wells, creating heavy exploitation conditions for the system. Particularly, thermal insulation structure was destroyed, pipelines were damaged by corrosion, loss of water and respectively thermal energy was substantial.

In heat supply system of Georgia, its municipal and residential sectors, water of the following parameters was used as heat carrier: for heating and ventilation – with temperature drop of 150/700C, 130/700C, 95/700C; for hot water supply - 55-600C temperature. Steam was used only for heat supply to industrial objects.

As it has been indicated, the main heat supply network was designed for the transfer of t=1500C and 1300C overheated water through the pipelines, though locking accessories of consumption and compensators were not able to transport high pressure and temperature overheated water. So, in fact, the temperature of water in Georgia’s systems was not above 900C. As a result, diameters of pipes were selected in such a way so that to pass large volume of low temperature water, that caused over-consumption of electricity on the system water circulation.

Heat supply systems in Georgia were of closed type, i.e. 100 % of hot water supply was conducted by heat exchanges. The exception was a small number of existing systems of geothermal hot water supply which provided heat supply to consumers directly out of well for residential purposes.

Georgia’s heat supply infrastructure was arranged by independent (separate) or dependant schemes, determined by the conditions of connecting a building’s heating to an external system. Most of heat systems in Tbilisi and all over Georgia were not equipped with secondary tuned circuit and heating water was supplied to radiators directly from a heating system. In relatively new heating systems, heating substations were used in which primary and secondary tuned circuits were separated from each other by heat exchangers. Heating substations were placed both in separately situated buildings and in the halls and basements of residential houses. Secondary tuned circuit water, heated there, was circulating in the local systems (radiators) of consumers. In new districts of Tbilisi (Gldani, Varketili, Vazisubani, Didi Digomi), 100 % of heat supply was performed by heating substations. In independent heat supply systems heating system of a consumer is separated from main heating system by hydraulic and temperature regimes. Such systems are used mainly in large cities, when regime of pressure, developed in heat systems is not acceptable for all local consumers (number of stories, leveling differences, etc.).

Heat supply systems of many cities of Georgia, including Tbilisi, Tkibuli, Chiatura, etc., require independent hydraulic and temperature connection of heating systems, due to the non-uniformity of relief and large differences in markings of the location of residential houses. That was caused by the intention to avoid emergency influence of values of piezometric pressure, higher than permissible one and developed by the heating system of a house, having high marking, upon radiators of houses, located on low markings.

According to the State Policy in Georgia, residential areas were constructed according to a centralized principle, since constructed buildings were multi-story blocks of flats, for which this type of heating was most suitable.

Therefore, in most cities of Georgia heat energy density i.e. an index of heat energy unit load per one square kilometer area was sufficiently high. Particularly, for some districts of Tbilisi, it made from 40 to 90 MW/km^2 (see Table 16 of the Annex).

Length of a district heat supply system, from different thermal plants to consumers, varied within 4-60 km. District heat supply systems were frequently connected with each other. Supplying systems had complicated outlines and intersection points. Such types of connection increased the reliability of heat energy supply system on the one hand, but caused its substantial inefficiency, on the other.

4.2.2.2. Thermal Energy Transmission and Distribution Systems in 1999

As it is known, since 1993 heat supply systems completely stopped functioning in Georgia. The same situation has been existed until now. The only operating system of district heat supply by the year 1999 was Tbilisi thermoelectric plant network supplying heat energy to governmental institutions located in the center of the city, though, irregularly. Most of the heat supply systems, which were not appropriately arranged even in the beginning of the 90s, and represented main sources of heat energy losses in the entire heat supply system, after being inactive during 6-7 years, completely failed. It may be assumed, that 90 % of Georgia’s heat supply systems are completely depreciated. The reason, except of their technical damage and plunder, are intensive corrosion processes on internal and external surfaces of pipelines, occurring in constructions of the heat supply systems, since while being inactive, nobody cared for their conservation. Though, to make exact assessments, it is necessary to conduct rather expensive ground works and hydraulic tests for each specific case.

Comparatively better is the situation in Didi Digomi settlement, where heat supply systems have been constructed recently and according to 1999 assessments, may be put into operation after conducting small rehabilitation (30 %) works.

During the period of 1999, there were constructed and put into exploitation the autonomous systems of heating and hot water supply on a small scale.

4.2.3. GHG Emission Reduction Potential in Transmission and Distribution Systems

Electricity transmission sector has been examined in detail, although due to the absence of relevant statistics, the detailed review of the distribution sector appeared impossible.

All lines of transmission sector and corresponding losses were discussed and thorough information is presented in the Tables 4.2.3.1 and 4.2.3.2.

Table 4.2.3.1. CO_2 reduction potential in electricity transmission sector

Transmission line capacity, kV	Losses, %			CO_2 resulted from losses, t		Extra CO_2 emission, t	
	Design	Actual 1990	Actual 1999	1990	1999	1990	1999
500	1.4	1.04	1.25	44737,2	25284		
300	NA	0.11	0.16	4592,4	3173,4		2158,09
220	3.5	2.67	3.16	115222,8	64242		
110	4.57	3.98	5.3	171570	107586		14786,90
35	1.06	0.97	1.26	41667	25542		4017,48
10	2.14	3.64	0.47	156864	9546	64609,72	
6							
0.4	3.18	2.79	0.23	120382,8	4644		
Total				655036.20	240017.40	64609,72	20962,48

Table 4.2.3.2. Electricity transmission efficiency and related CO_2 emissions

Electricity delivered to the grid		Transmission line	Transmitted electricity by voltage levels	Total energy loses of electricity			GHGs Extra emission in equivalent of CO_2 (Tones)	Total emission related with transmission loses
				Absolute	Designed	Actual		
mln.kWh			mln.kWh	mln.kWh	%	%		tons
1990	16709,1	500	7525,5	173,4	1,4	1,04		44737,2
		330	2068,3	17,8	N.A.	0,11		4592,4
		220	12736,6	446,6	3,5	2,67		115222,8
		110	14685,8	665	4,57	3,98		171570
		35		161,5	1,06	0,97		41667
		10	2425,7	608	2,14	3,64	64609,72	156864
		6						
		0.4		466,6	3,18	2,79		120382,8
1999	7870,6	500	3296	98	1,4	1,25		25284
		330	145,4	12,3	N.A.	0,16	2158,09	3173,4
		220	5536,3	249	3,5	3,16		64242
		110	7008,7	417	4,57	5,30	14786,90	107586
		35		99	1,06	1,26	4017,48	25542
		10	740	37	2,14	0,47		9546
		6						
		0.4		18	3,18	0,23		4644
TOTAL		1990		2538,9	2,64	2,17	64609,72	655036,20
		1999		930,3	2,64	1,69	20962,48	240017,40

In Georgia, during the Soviet period, heat supply centralized networks – means of thermal energy transportation – were the most inefficient out of three parts of acting district heat supply systems (thermal energy generation, distribution, consumption).

Heat networks used to be constructed under the gross violation of designed extent and inclination. Thermal insulation constructions were of low quality or did not exist at all. Low quality of closing accessories and compensators resulted in substantial heat losses and chemically treated expensive water running through the network. Water loss was caused by its leakage as well.

According to the assessment of TACIS experts, water losses in Georgia's thermal networks made 20-25%, e.g. losses in Tbilisi networks made 2900t/h or 25% of total circulating water (approximately 11600 t/h).

Heat losses as a result of imperfect insulation of pipelines should be noted separately. According to the data, presented in the Table 16 of Annex, actual heat losses in the networks during the year made 1150 thousand MWh that is equal to 141.260 tons of conventional fuel consumption.

Available information on heat networks allow assuming that making use of heat distribution network is not possible because of its poor present condition except of separate parts such as Didi Dighomi.

Restoration and development of heat supply system should be started anew due to the absence of heat supply systems infrastructure in the country. Profitability of district system, an essential component of which are heat networks, should be assessed for each specific case taking into account economic, social, technical and environmental aspects of local conditions. A decisive role belongs to the value of thermal energy consumption density measured in MW/km^2. Heat consumption density, as it has been already indicated, is high and varies within 40-90 MW/km^2 for the large cities of Georgia, especially for most districts of Tbilisi. Hence, the systems of heat distribution, will certainly take their appropriate place in future, in process of energy efficient technology development and introduction. As it has been already mentioned, usage of heat networks under the present state is inadmissible. Therefore, the only way for the effective development of these networks will be technically and economically justified projection. E.g. the lines of heat networks should be projected only by the double-pipeline scheme, i.e. with separate, independent systems of heat supply, arranging local heating substations in each building.

Such scheme of heat consumption is more flexible, since in this case, regimes of water, circulation in the heat networks and energy consumption parameters may be chosen according to the wishes and financial abilities of consumer that corresponds to the principles of market economy and is one of the essential terms of energy efficiency increase. In future, the implementation of all contemporary measures for the reduction of heat energy losses in the heat networks should be considered. Most important will be the use of modern, highly efficient, industrially manufactured pre-insulated metal pipelines in the heat distribution systems to minimize losses during the transportation of thermal energy. The use of such pipelines for heat distribution will reduce the energy losses down to 3-4%, instead of 20% loss typical for the Soviet period.

Condition of heat transmission sector was critical even in 1990. This situation was described in detailed in the previous project that was concerned to heat supply systems. Existing data has been reexamined in the framework of the present project and the obtained results are presented in the Tables 4.2.3.3 and 4.2.3.4.

Table 4.2.3.3. Extra CO_2 emission in heat transmission sector by the year 1990

Heat transmission (cities)	Losses, %			Extra emission, tCO_2/mln.kWh		Extra CO_2 t/y	
	Design	Actual 1990	Actual 1999	1990	1999	1990	1999
1. Tbilisi	5	16	NA	217.5	NA	259802.44	NA
2. Batumi	5	20	NA	325.21	NA	14569.58	NA
3. Kutaisi	5	20	NA	274.39	NA	40390.03	NA
4. Rustavi	5	20	NA	279.69	NA	46316.52	NA
5. Telavi	5	20	NA	210.3	NA	6728.40	NA
6. Zestaponi	5	20	NA	197.64	NA	1917.13	NA
7. Other cities	5	20	NA	287.19	NA	52929.22	NA
Total						422653.30	

Table 4.2.3.4. Heat energy distribution efficiency and related GHG emissions

N		Thermal station	Annual thermal losses		Emission related with heat losses	GHG extra emission in CO_2 equiv.	
			Absolute	Relative			
			mln.kWh	%	ton	ton	per mln.kWh
1		2	3	4	5	7	8
1	1	Tbilisi (Saburtalo)	41,48	20	12828,56	9621,42	231,95
2	2	Tbilisi (Saburtalo)	5,23	15	1600,47	1066,47	203,91
3	3	Tbilisi (Samgori)	21,55	10	6481,87	3240,93	150,39
4	4	Tbilisi (Vake)	11,76	15	4069,08	2712,72	230,67
5	5	Tbilisi (Didube)	15,94	20	5753,94	4315,46	270,73
6	6	Tbilisi (Didube)	122,4	30	35264,56	29387,13	240,09
7	7	Tbilisi (Samgori)	7,55	13	3098,48	1906,28	252,49
8	8	Tbilisi (Vake)	26,35	12	8746,46	5101,82	193,62
9	9	Tbilisi (Mtatsminda)	10,56	15	3914,08	2609,39	247,10
10	10	Tbilisi (Saburtalo)	22,02	15	7476,95	4984,63	226,37
11	12	Tbilisi (Nadzaladevi)	49,44	20	15363,13	11522,35	233,06
12	13	Tbilisi (Saburtalo)	19,77	15	6650,25	4433,50	224,25
13	14	Tbilisi (Vake)	30,26	15	8430,24	5620,62	185,74

1		2	3	4	5	7	8
14	16	Tbilisi (Samgori)	15,94	15	5188,85	3458,69	216,98
15	17	Tbilisi (Gldani)	76,23	15	24766,92	16511,28	216,60
16	18	Tbilisi (Saburtalo)	34,81	13	13950,14	8584,09	246,60
17	19	Tbilisi (Vake)	38,31	15	12688,94	8459,30	220,81
18	20	Tbilisi (Isani)	36,83	15	11032,08	7355,22	199,71
19	21	Tbilisi (Nadzaladevi)	32,46	15	9793,47	6528,98	201,14
20	22	Tbilisi (Samgori)	41,08	20	12685,77	9514,33	231,60
21	23	Tbilisi (Krtsanisi)	15,45	15	4550,00	3033,33	196,33
22	24	Tbilisi (Isani)	24,99	15	9479,09	6319,40	252,88
23	25	Tbilisi (Didube)	69,5	20	25066,95	18800,21	270,51
24	26	Tbilisi (Chugureti)	3,52	10	1068,00	534,00	151,70
25	27	Tbilisi (Mtatsminda)	4,36	15	1287,83	858,06	196,80
26	28	Tbilisi (Vake)	34,32	15	11093,51	7395,67	215,49
27	29	Tbilisi (Samgori)	4,25	15	1315,19	877,31	206,43
28	30	Tbilisi (Isani)	11,65	13	3586,37	2207,24	189,46
29	31	Tbilisi (Samgori)	11,15	13	3414,38	2100,68	188,40
30	32	Tbilisi (Saburtalo)	13,31	15	4002,69	2668,96	200,52
31	33	Tbilisi (Krtsanisi)	3,61	10	1048,68	524,34	145,25
32	34	Tbilisi (Nadzaladevi)	2,88	15	1057,32	704,88	244,75
33	35	Tbilisi (Gldani)	4,31	15	1616,88	1078,55	250,24
34	36	Tbilisi (Krtsanisi)	36,24	20	11180,43	8385,32	231,38
35	37	Tbilisi (Krtsanisi)	1,1	20	469,92	352,44	320,40
36	39	Tbilisi (Vake)	1,35	10	410,18	205,09	151,92
37	40	Tbilisi (Saburtalo)	7,84	20	2691,36	2018,52	257,46
38	41	Tbilisi (Samgori)	15,53	15	4624,45	3083,46	198,55
39	42	Tbilisi (Samgori)	0,7	20	247,86	185,90	265,57
40	43	Tbilisi (Nadzaladevi)	54,72	16	16199,73	11137,32	203,53
41	44	Tbilisi (Gldani)	28,58	10	8935,50	4467,75	156,32
42	45	Tbilisi (Isani)	64,45	27	18570,67	15131,71	234,78
43	46	Tbilisi (Isani)	66,47	18	20567,59	14854,03	223,47
44	47	Tbilisi (Vake)	17,91	15	5158,44	3438,96	192,01
45	48	Tbilisi (Didi Digomi)	33,02	20	10466,40	7849,80	237,73
Total in Tbilisi			1191,18	16	377893,69	259802,44	217,90
46	1	Batumi					
47	2	Batumi	44,8	20	19426,10	14569,58	325,21
48	3	Batumi					
49	1	Kutaisi					
50	2	Kutaisi	147,2	20	53853,37	40390,03	274,39
51	gr.b.	Kutaisi					
52	1	Rustavi					
53	2	Rustavi	165,6	20	61755,36	46316,52	279,69
54	3	Rustavi					
55	1	Telavi	32	20	8971,20	6728,40	210,3
56	2	Telavi					
57	1	Zestaphoni	9,7	20	2557,93	1917,13	197,64
58	1500	Other Cities of Georgia	184,3	20	70574,84	52929,22	287,19
Total			1774,78	16,47	595032,49	422653,30	256,04

Thus, total emission resulted from the losses in electric and heat supply sector was equal to 487263,02 t CO_2 in 1990.

4.3. CONSUMPTION

In the 80[th], Georgia's electricity and power generation and consumption balances substantially differed from each other. In particular, electricity balance was traditionally deficient while heat generation and consumption were compatible. So, in the 80s, actually, all consumers were supplied with thermal energy, necessary for heating and hot water supply. Though, it should be noted that consumption of heat was extremely inefficient by that time. By the assessment of TACIS experts, almost half of thermal energy, generated in Georgia's thermal supply sector was spent unreasonably.

The country's electric balance deficiency during the indicated period is clearly demonstrated by the data, presented in the following Table:

Table 4.3.1. Main indices of Georgia's electricity sector development

Years	Installed capacity thousand kW	Electricity generation, million kWh	Electricity consumption, million kWh	Electricity deficit, million kWh
1980	4155	14 687.4	NA	NA
1985	4389	14 421.3	16 741.0	2 319.5
1986	4385	14 570.8	NA	NA
1987	4391	14 549.7	NA	NA
1988	4412	14 599.7	18 114.6	3 564.3
1989	4412	15 824.5	17 969.0	2 144.6
1990	4327	14 239.4	17 443.9	3 204.5

The data presented in the Table demonstrate that the installed capacity of electric plants increased by 6.18% and electricity generation – by 7.74% during the decade of 1980-89, that was resulted from the introduction of new capacities. During this period, several hydro power plants were put into operation, such as Zhinvalhesi (1985), the Vartsikhe cascade fourth hydro power plant (1988), the Enguri HPP arch dam reached a design mark (1989) improving productivity of the plant to some extent, etc. Though, Georgia's electricity sector still remained deficient that especially was increasing in 1984-1988. Its value that time increased approximately 5.3 times due to insignificant rise in electricity generation and substantial increase of consumption. Electricity deficiency in the country reached 3 564.33 million kWh in 1988. Such shortage had not ever been observed in the history of electricity sector development. It should be underlined, as well, that electricity consumption in the country decreased in 1989 for the first time compared with previous years that was conditioned by the beginning of formation of complicated social and political conditions in the Soviet Union.

Compared with 1989, electricity generation in 1990 decreased by 1585.1 million kWh and the consumption – by 525.1 million kWh, i.e. electricity generation decreased rather sharply than consumption. So, by the year 1990, the country's electricity deficiency made 3.2 million kWh satisfying its demands only by 86.63%.

During the further period after 1990, sub-sectors of fuel and energy sector, such as electricity sector and fuel supply, appeared in a critical situation. Complications, created in fuel supply (rising prices on imported fuel) substantially worsened the country's crisis in industry and national economy, as a whole. Indices of energy sector of this period are characterized with clearly distinguished decreasing tendency. All aforesaid is evident out of the country's energy balance, presented below in the Table 4.3.1.

As it is seen from the data, presented on the graph, electricity consumption in the industry in 1990-1999 reduced from 8054.4 million kWh to 742.8 million kWh; i.e. 10.8 times. For the same period, electricity consumption in transportation decreased 3.04 times, in agriculture – 121.8 times and in construction – 32 times, etc.

During the investigated period, forced reduction of electricity consumption was mainly conditioned by the decrease of electricity generation, as a result of which in 1999 its consumption in agriculture decreased down to 12 million kWh and in construction – down to 9.7 million kWh.

In the same period, since 1993, due to the cut-off of heating and hot water supply and complications, created in gas supply, substantially raised electricity consumption by the population. Particularly, if in 1990 the population consumed 2885.6 million kWh, by the year 1999 the consumption made 3475.5 million kWh, i.e. was increased by 20.4%.

Table 4.3.2. Electricity balance of Georgia (mln kWh) 1990-1999

No		Years									
		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
1	Production	14239.4	13376.2	11516.6	10150.1	7044.1	7081.7	7232.8	7171.7	8056.7	8097.7
2	Import	4382.01177.5	3845.1	1632.0	1050.6	948.6	754.2	408.8	705.3	809.9	433.9
3	Export	17443.9	1593.0	633.2	338.1	31.7	-	305.2	514.4	904.6	384.1
4	Consumption		15628.3	12515.4	10862.6	7961.0	7835.9	7336.4	7362.6	7962.0	8147.5
5	Industry	8054.4	6780.4	5452.2	3846.2	1882.5	953.2	812.2	945.9	965.0	742.8
6	Transport	1004.1	840.0	654.7	607.6	386.6	253.6	249.8	231.0	240.0	342.8
7	Agriculture	1461.0	991.9	731.0	380.0	129.0	95.6	25.9	14.4	30.0	12.0
8	Residential	2885.6	3832.0	3343.0	3609.0	3220.0	2831.0	2857.5	2927.0	2749.0	3475.5
9	Construction	310.0	382.1	197.0	170.0	110.6	51.3	45.4	38.1	40.0	9.7
10	Other consumers	3692.8	2801.9	2137.5	2249.8	2232.3	3681.2	3346.1	3206.1	3938.0	3564.7
11	Deficit (-) Excess (+)	- 3204.5	-2252.1	-998.8	-712.5	-916.9	754.5	-103.6	-190.9	+94.7	-49.8

Note: position 4.4 includes total consumption of electricity by population and municipal users

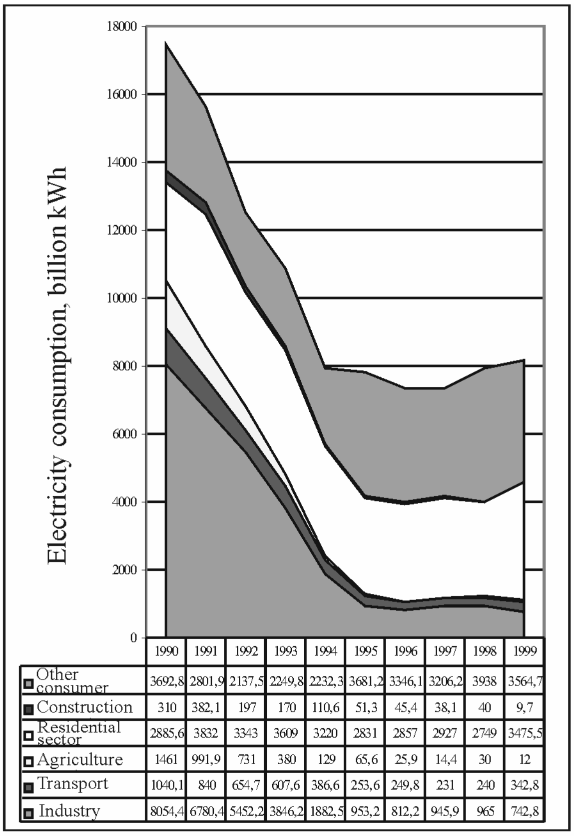


Fig. 4.3.1. Dynamics of electricity consumption in various fields of Georgia's national economy in 1990-1999.

To make a comparison, the percentage of electricity, consumed in various sub-sectors of national economy out of a total consumption in 1990 and 1999 is demonstrated on the Fig.4.3.2. According to these data, electricity, consumed by population in 1999 made 42.7% of a total consumption. Amount of electricity, consumed by population this year is higher than that consumed in the industry 4.68 times, 10.77 times larger than consumed in transportation and 289.6 times higher than in agriculture.

Peculiarities of Georgia's electricity balance are expressed in a large specific share of "losses" from total consumption. E.g. in 1990, the losses in the system of a common consumption made 15.2% of electricity, consumed in the country and 17.83% of generated energy. During the further period, the share of "losses" increased even considerably and by the year 1994 made 31.3% and 35.4%, respectively. Decrease of losses started only since 1997 and by 1999 its value made 11.8% of the electricity supplied to the grid.

Therefore, it is evident that Georgia's energy balance since 1990 until 1999 was permanently deficient. Only once, in 1998 electricity generation surpassed the consumption by 94.7 million kWh, though in 1999, this correlation was broken again, when generation was 8097.5 million kWh and consumption – 8147.5 million kWh, i.e. the shortage made 49.8 million kWh.

To make a deep analysis of electricity consumption inefficiency in 1990-99, the paper considers and presents in detail:

? Areas of electricity consumption (municipal and residential, electric transport) and their energy parameters;
? Areas of heat consumption (municipal and residential) and their main parameters.

4.3.1. Electricity Consumption
4.3.1.1. Electricity Consumption in Municipal and Residential Sectors in 1990

Electricity consumption is as important in the electricity sector, as generation and transfer. Under energy crisis, when generated energy is insufficient, along with creation of new generation sources, it is reasonable to conduct correct policy of electricity consumption, that implies not only energy saving, but utilization of new technologies, as well.

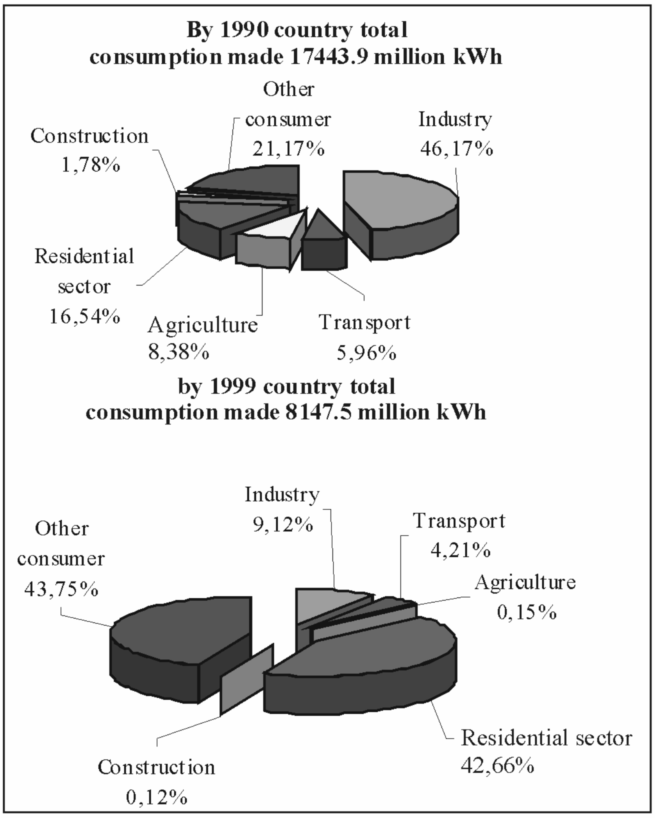


Fig 4.3.2. Percentage of electricity consumption in various fields of Georgia's national economy in 1990 and 1999

By 1990, household economy was represented by seven various electric appliances of long use (see Tables 17-18 of Annex). Among them, the greatest amount of energy (45.3%) was consumed by refrigerators, 33.5% - by TV sets and 13.0 – by irons.

The review of presented data shows that the lighting of apartments was mainly performed by filament lamps and that of streets – by gaseous discharge lamps. Amount of electricity, consumed for apartment illumination in Tbilisi made 306.6 million kWh over the indicated period that was 29.17% of total electricity, consumed for the country's apartment lighting (1051.2 million kWh). It should be indicated that energy, consumed for apartment illumination entirely in the country, was 9.25 times more that the energy, consumed for street lighting. At the same time, 78.49 million kWh of electricity was consumed for Tbilisi illumination, making 69.14% (113.53 million kWh) of a total amount, consumed for street lighting in the country, while the number of illuminated streets in Tbilisi is twice as much than in the rest of Georgia.

In 1990, 8500 lifts were operating in Tbilisi, while in the rest of Georgia, there were 4000 lifts. Electricity, consumed by them made 49.64 million kWh and 23.36 million kWh, respectively.

In 1999

Information on the electricity consumption for residential purposes, apartment and street lightening and functioning of lifts by the state of 1999 is presented in the Table 17 and 18 of the Annex. As the analysis of the data presented in the Tables shows the number of types of electric appliances has increased up to 10 in 1999. This was conditioned by the use of new types of items, such as computers, water heating devices and electric heaters. Introduction of computers for the residential use was caused by the adoption modern living standards and a wide use of water heating devices and electric heaters – by the lack of traditional sources of thermal energy.

By the state of 1999 most energy capacious out of household electric appliances, appeared to be electric heaters, since the electricity, consumed by them made 1576,8 million kWh, i.e. 51,11% of 3085,13 million kWh, consumed in the country's residential sector. The percentage of electricity, consumed by other types of electric devices of long use is less than the whole amount of electricity, consumed for residential purposes in the country and makes 15,97% for water heating appliances, refrigerators – 8,97%, irons – 77, 03% and TV sets – 5,45%.

On the basis of the analysis of presented data, it may be assumed that in 1999, electricity consumed in the residential sector, as a whole, increased 1,88 times, compared with 1990. This is caused by the fact that in 1999, powerful consumers, such as electric heaters and water heating devices were introduced in use, though the duration of their operation is small due to energy crisis. As result of the country's energy crisis, energy consumption by small capacity electric appliances, such as refrigerators and TV sets, substantially decreased by the year 1999.

In 1999 (see Table 18 of Annex), apartments and streets were illuminated by the same types of lightening devices as in 1990. Electricity, consumed that year for apartment lighting in Tbilisi made 204,4 million kWh, but it makes 62,18% of a total electricity, consumed for apartment illumination (328,5 million kWh). The amount of the electricity consumed for lighting of the rest of the country's apartments made 37,82%. All aforesaid indicates to the poor electricity supply of Georgia, as a whole, compared with Tbilisi.

In 1999, the amount of electricity consumed for apartment illumination in Georgia was 34,7 times higher than the amount, spent on street lightening. The amount of electricity, consumed for street illumination in Tbilisi made 6,54 million kWh, that was 63,13% of the amount, consumed totally for street illumination in the country (9,46 million kWh).

Therefore, in 1999 the amount of electricity, consumed for apartment lightening in Tbilisi was 1,5 times less than in 1990, and over the rest of Georgia – the amount was 6 times less. The amount of electricity, consumed for street illumination in Tbilisi and over the whole of Georgia in 1999 was 12 times less than in 1990.

By the state of 1999, large number of lifts in Tbilisi and all over Georgia was out of order. E.g. in 1999, in Tbilisi there were operating only 2500 lifts, that number being 3,4 times less than in 1990. In the rest of the country the number of operating lifts was 400 that are 10 times less. Electricity consumption in lifts decreased 17,24 times, respectively.

Analysis of electricity losses in municipal and residential sectors for the period of 1990-1999

Information, to be used for the assessment and comparison of energy efficiency of the residential sector during the years of 1990 and 1999 is presented as Tables (see Tables 17-18 of the Annex).

By the period of 1990, TV sets and videos of so called low frequency electric supply units were mainly used. Their capacity coefficient –H, which under sinusoidal currents is equal to the deflection angle COSf , is relatively high and is equal approximately to 0,9. Entirely for this year, inactive energy, generated by electric appliances in the grid, particularly, the deflection reactive energy, made 97,74% of consumed active energy and the losses in electric appliances were equal to 27,26%.

Reactive energy is calculated as follows:

$$A_r = A_a \text{ tg } f , \qquad (3)$$

were A_a is active energy, and f is a defection angle between voltage and current. By means of reactive energy compensation, i.e. by the increase of the capacity coefficient of each consumer up to 0,95 it was possible to reduce the losses of active energy in the grid caused by consumer by the value of ?A. The latter is calculated by the formula:

$$?A = ?A_{act} (1- H_1^2/H_2^2), \tag{4}$$

where $?A_{act}$ is losses of energy, caused by the generation of reactive energy in the grid; H_1 is an existing capacity coefficient, and H_2 is a desirable capacity coefficient.

By the year 1990, additional losses of active energy, caused by reactive energy generation in the grid by TV sets made 10,25% and those, caused by audio devices – 19,94%.

By the year 1999, TV sets, audio apparatus and computers a new type, with so called "impulse" electricity supply units and low capacity coefficient, not exceeding 0,6 (see Table 17 of the Annex) were already in a wide use. They required non-sinusoidal current from the grid and respectively distortion reactive capacity, the share of corresponding energy of which is 8,6%. By the year 1999, the part of deflection reactive energy was reduced down to 24,3% compared with 1990, that was caused by the increase of the share of active energy consumption. Particularly, such new consumers of active energy are represented by water heating devices and electric heaters, the capacity coefficient of which is equal to 1. For the same year, the value of relative active losses of domestic electric appliances remained almost unchanged, being equal to about 27%. It is remarkable that by the year 1999, additional losses in the grid increased considerably. Namely, the latter rose 5,46 times by TV sets, and 3 times - by audio apparatus. In this case, the losses in the grid were also estimated by the formula (4). It has been calculated that additional losses of active energy due to reactive energy generation by TV sets and audio apparatus made 60%.

As it has been indicated, apartment illumination in 1990-1999 was performed only by filament lamps, having very low efficiency (~0,1), that makes clear that energy losses in filament lamps is ~90%. The light output of lamps is also low, equaling to about 10 lum/W. Reactive energy generation takes place only in street lightening lamps, making 173,2% of consumed active energy (see Table 17 of Annex). This is mainly caused by a low capacity coefficient of starting up equipment of street illumination lamps, that is equal to 0,5. Efficiency of the starting device is 0,8, but that of lamps, themselves – 0,2. So, the efficiency of a street lightening lamp and its starting device totally equals to 0,8x0,2=0,16, that exceeds an efficiency of apartment starting illumination lamps by 6% (see Table 18 of the Annex).

Lifts, being in use in 1990 and 1999 were the consumers with low energy efficiency. By means of the increase of their capacity coefficient, reduction of losses, caused by the reactive energy generation by 66,48% was possible.

Therefore, on the basis of a comparative analysis of the state of electricity consumption for municipal and residential purposes it may be concluded that in 1990 and 1999, as well as at present, inefficient domestic electric appliances were in use, characterized by large energy losses and capacities, long operation period, creation of distortion capacities in the grid, etc. All these are caused by the fact that they are produced according to non-energy technologies. It should be noted, that in foreign countries, connection of some electricity consumers of low energy indices, such as low capacity coefficient, to the grid is prohibited by a special standard that dues not occur in Georgia, yet.

Finally, it should be concluded, that in 1999, the largest consumer of electricity for municipal and residential purposes were lamps of apartment illumination. Namely, the amount of electricity, consumed for apartment lightening in 1990 was equal to 1051200 thousand kWh, while in 1999 it made 328500 thousand kWh, representing the second largest amount, after the energy consumption in electric heaters. Due to the low values of light output and the efficiency of apartment illumination lamps, electricity losses are large, making 946080 thousand kWh and 295650 thousand kWh in 1990 and 1999, respectively. Thus, in 1990-1999 about 90% of electricity, consumed for apartment lightening, was lost. Unfortunately, indicated situation is still continued in Georgia. If we consider the average duration of functioning of lamps for apartment illumination during the year, equal to 4x365=1460 hours, then capacities of 640 and 202.5 MW will correspond to the amount of electricity, lost over 1990 and 1999, respectively.

Proceeding from all aforesaid, saving of electricity (by means of reduction of losses), consumed for municipal and residential purposes, will be most reasonable by new, energy efficient lumps of apartment and street illumination. Particularly, if there are to be used luminescent gaseous discharge lamps, produced under the modern energy efficient technologies, such as lamps produced by "OSRAM", "Prolite", etc., the efficiency of which is equal to ?=0,2, and the light output coefficient is K_e˜50, then the active energy losses will decrease 5.625 times, and the consumed to save approximately 1 billion kWh of electricity.

4.3.1.2. Existing State of Above-Ground Urban Transport in 1990

In 1990

In Georgia, above-ground electric city transport – trolleybuses were used in several cities, while trams were used only in Tbilisi. Here will be considered main energy parameters of these transportation networks in the case studies of Tbilisi and Kutaisi.

The main constituents of an electric transportation system are: a rolling stock and a traction system. The latter consists of traction substations and contact lines. The main energy capacity ele ments of traction substation are converter transformer, converter itself and transformers of own use. Let's consider each of listed elements separately. The information about them is presented in the Table 19 of the Annex. It is evident that in 1990, 11 substations of trolleybus traction, 3 substations of trams and 5 substations of their general traction were functioning in 1990 in Tbilisi, while in Kutaisi 5 substations of trolleybus traction were operating. In each substation 2, 3 or 4 converters and the same number of converter transformers were installed. The nominal capacities of the latter varied within 685-1385 kVA, and that of converters – within 600-1200 kW. The number of transformers of own use was 1 or 2, the capacities of which varied within 25-100 kW. Traction substations were supplied with 6 kV (10 kV) voltage from the grid.

By the year 1990, the depreciation period (23 years) was expired in Tbilisi by the converter transformers, installed only at 5 substations (Saburtalo – II parking, Ortachala, Navtlugi, Grmagele) and in Kutaisi –only at one substation ("Tseva-I"). Out of converters, the depreciation period (14 years) was expired by 16, except Depo-Avchala, Navtlugi, Digomi-II traction substations. Therefore, in Tbilisi, the converter aggregates, installed only at two substations (Depo-Avchala, Digomi-II) were not depreciated, white in Kutaisi – only one aggregate at the substation "Tseva-V".

By 1990, 120 trolleybuses and 52 trams were functioning in Tbilisi, while in Kutaisi there were 40 trolleybuses. For a contact line, the M? -85 type shaped copper conductors were used at a total long the in Tbilisi of 250km and in Kutaisi – 120km.

In 1999

The information on the 1999 state is presented in the Tables (see Table 19 of Annex).The data, presented in the Tables clearly show that, by that time, 12 trolleybuses traction substations were functioning in Tbilisi, there were 4 substations of tram traction and 3 substations of a general traction. That year, as well as in 1999, 5 substations of trolleybus traction were operating in Kutaisi. Each of the substations has 2,3 or 4 converters, the same number of converter transformers and a converter, itself. Their capacities are equal to 685-1385 kVA and 600-1200 kW, respectively. The number of transformers of own use is 1 or 2 and the capacity – 25 –1000 kVA. The traction substations were supplied with electricity of 6 kV (10 kV) voltage from the grid.

By 1999, the depreciation period was expired for all substations converter transformers, except one (Digomi –I). The converters of all substations are depreciated, as well. In Kutaisi, transformers of only two substations are depreciated and converters at all substations. Therefore, it may be concluded that the power units of all substations of trams and trolleybus are completely depreciated.

By 1999, 68 trolleybuses and 25 trams were functioning in Tbilisi, and in Kutaisi –30 trolleybuses. For contact lines, the same conductors are used. Out of them the contact line with traction substations "Varketili" has been jobbed. The total length of a contact line in Tbilisi is 250km and in Kutaisi – 120km.

Analysis of electricity losses by urban above-ground transport for the period of 1990-1999

The information, necessary for the assessment and comparison of the efficiency of electricity consumption has been collected and presented in the Table 19 of the Annex. They demonstrate the results of calculations of design and actual energy losses in all electric transport elements. The calculations were conducted by a unified method for transformers and converters. The formula, defining the main losses, is as follows:

$$?A_e = A_e (1-?_e) \quad (5)$$

where A_e is average energy, supplied to the equipment; $?_e$ - mean efficiency of the equipment.

As a rule, the equipment instantaneous efficiency is known from the equipment data for nominal (maximum) load. In real conditions (regimes, load value, age) an averaged actual efficiency must be defined according to concrete loads and age. The relationship between variable (dependent upon the load) and constant losses (that of idle running) is changed by the load value. As a result, the efficiency is changed according to the dependency known in the theory. The age determines magnitude of changes of magnetic circuit parameters, change of losses in the construction, etc. These factors cause the change of efficiency, particularly, the decrease of a nominal value by a certain ?? magnitude. ?? values for power transformers, converter, transformers, the converters, themselves and the transformers of own use are presented in the Table of efficiency coefficient correction with the consideration of above presented factors:

Table 4.3.3. Efficiency correction Table

No	Power transformers		Converter transformers		Converters		Transformers of private use	
	Age, year	Correction value ??, %	Age, year	Correction value ??, %	Age, year	Correction value ??, %	Age, year	Correction value ??, %
1	0-5	0	0-5	0	0-5	0	0-5	0
2	6-10	1,0	6-10	3,0	6-9	1,0	6-10	12,7
3	11-15	2,0	11-15	3,9	10-14	1,5	11-15	13,6
4	16-23	2,9	16-23	5,9	15-20	2,0	16-23	14,6
5	24-29	3,9	24-29	7,9	21-25	3,0	24-29	15,5
6	30-35	4,9	30-35	10,8	26-30	3,4	30-35	16,5
7	?36	5,9	?36	11,8	31-35	3,9	?36	17,5
8					?36	4,4		

Losses in contact lines were determined by the method of load, equally distributed according to average distances of movement. By 1990, the losses were determined without consideration of the line wear while by the year 1999, a normal 25% and additional 35% wears were considered.

Energy loss in the contract lines was determined by the following formula:

$$?? ?? T ?^{2} n_{aver} \, rl \, 10^{-3} /12, \qquad (6)$$

where ?T is average working time interval per year (?T=2076 hr; I is an average value of the current, demanded from the contact line by a rolling stock; n_{aver}, is average number (pieces) of rolling stocks at the supplying section; r is the line resistance without wear (r=0,22 ohm/km) and l is the line length (km).

A contact line wear is considered by the changes of the value of r without wear. Average number of rolling stocks at the supplying section by the state of 1990 and 1999, is presented in the Table 4.3.4.

Table 4.3.4. Number of rolling stocks at the supplying section in 1990 and 1999

Parameter	Number of rolling stocks (pieces)			
	Tbilisi		Kutaisi	
	1990	1999	1990	1999
n_{aver}	6	3	8	5

By means of calculations it has beer determined that in 1990, the loses in contact lines, considering normal wear made 2,99% of supplied value in the Tbilisi network of trams and trolleybuses, and in Kutaisi – 9,98 %. In 1999, the losses under conditions of contact lines wear above the norm made 3,05% in Tbilisi and in Kutaisi – 11,5%. Presented data show that by the year 1999, the electricity loses had been considerably increased in the Kutaisi trolleybus contact lines the absolute value of which is equal to 273,581 thousand kwh.

In 1990, total actuallosses of electricity in Tbilisi network trams and trolleybuses made 15,85% of supplied energy (4849,184 thousand kWh) and in Kutaisi – 21,18%. These values of losses are greater than designed values in Tbilisi by 8,62%, and in Kutaisi –by 6,88%.

By the state of 1999, total actual losses are 20,12% for Tbilisi and 27,32% for Kutaisi, respectively. These values of actualtotal losses are greater than the designed in Tbilisi by 12,91% values and in Kutaisi –by 12,76%.

Therefore, as it is evident from these data, total actual losses of electricity in the network of trams and trolleybuses had been considerably increased by 1999, compared with 1990 total actuallosses, indicating that all rings of above-ground urban electric transport – traction substations, contact lines rolling stocks, etc. are completely out of date obsolete and inefficient.

Proceeding from the aforesaid, it may be assumed, that it is necessary to find modern and ecologically and energy efficient types of above-ground urban electric transport, that would replace above described types of transportation and decrease the movement of vehicles with engines of internal combustion in cities and towns of Georgia. In this context, the use of electric motor cars and electric buses, justified from their energy, ecological and economic standpoint, should be considered along with modern above-ground electric transportation in large cities of Georgia.

4.3.1.3. Electricity Over-Consumption by Urban Underground Electric Transport in 1990

In 1990

The Tbilisi underground is in operation since 1965, representing one of the most complicated constructions in the city. Its exploitation and operation is provided by various electricity consumer units and objects, including the most important – traction substations. By the state of 1990, the underground was served by lowering and compatible substations, as well as by traction substations – particularly, 3 traction substations, 9 lowering substations and 11 compatible substations. The lowering and compatible substations are located under ground except one compatible substation "Eldepo" while traction substations are of above-ground location. Characteristics of substations` main units (power transformers, illumination transformers, converters, etc.) by the state of 1990 are presented in the Table 20 of Annex. Power transformers of 320-1000 kVA capacity and 1or 2 illumination transformers of 40-150 kVA capacity each are mainly installed at these substations. Converters are installed only at traction and compatible substations. Their number varies from 1 to 4. Capacity of a converter transformer is within 1385-2850 kVA and that of converter within 1300-4120 kVA.

In lowering substations all the power transformers are depreciated, as well as all illumination transformers. Converter (traction) transformers are depreciated only at two traction substations ("Samgori", "Avlabari"). A rectifying unit is depreciated at the same traction substations, as well as at 4 compatible substations, where respective transformers are not depreciated. The Underground has 147 railroad cars of rolling stocks of 11 types, including 18 depreciated cars. The number of escalators is 59 total length of the chain is 19 516 m, and the number of steps-24 900 (see Tables 25 and 16 of the Annex).

Despite the fact that in 1990, a certain part of the main units had expired the period of amortization due to good exploitation conditions, they were functioning normally. This is proved by the fact, that actual total losses of electricity in the Underground exceed the designed values by 6% Table 20 of Annex.

In 1999

By 1999, the Tbilisi Underground was enriched by the only lowering substation "Vazha Pshavela", i.e. by that period its network was served by 3 tractions, 10 lowering and 11 compatible substations Table 20 of Annex. Except new substations the period of amortization was expired by the power transformers in all the lowering substations. Out of traction substations, the period of amortization was expired by power transformers, installed only at the substation "Samgori" in 1994. All illumination transformers expired the period of amortization except the lowering substation "Vazha Pshavela". All the traction transformers, operating with converters, are in good condition, except 4 of them, installed in the substation "Samgori", "Avlabari", "Marjanisvili" and "Eldepo". As to the converters themselves, the amortization period had not been expired in 8 substations out of 14. The traction, i.e. converter transformers and transformers are installed only in compatible and traction substations.

By the year 1999, 220 railway cars of 15 different types of rolling stock were operating in the Underground. Among them 18 had expired the amortization period even in 1990.

As to the number of escalators, total length of chains and the number of moving steps, their values did not change since 1990. Total length of escalators, including moving side-walks made approximately 10 km by the year 1999.

It should be noted that out of examined objects, the Underground is the only one, the energy equipment of which, despite of the expiration of the amortization period, is still functioning normally due to a good maintenance and appropriate preventive measures, conducted timely.

Since 1990, despite of very hard conditions, by the year 1999, the normal functioning of the main and supporting units of the Underground is also proved by the fact that overall actual losses of electricity are not considerably increased compared with the 90s and _ exceed electricity losses designed values only by 7.81%.

Analysis of electricity losses by city underground transport for the period of 1990-1999

As it is known, Georgia is facing substantial energy crisis for last years. As a result, proceeding from objective reasons (lack of electricity, generated by the country itself), the cases of disconnection of a large number of consumers (including the Underground) are very frequent. Each such a disconnection causes the damage to electricity consuming units and equipment, reduction of energy efficiency and substantial economic losses.

Values, determining the Undergrounds energy efficiency by the state of 1990 and 1999, are presented in the Tables Table 20 of Annex. Energy consumption by the Underground in 1990 made 78 288 thousand kWh and in 1999-67 250.9 thousand kWh, that is less by 16.4 %.

In 1999 and during the previous period, despite of frequent cut-offs in electricity supply, as a result of normal functioning of the main units and supporting equipment of the Underground, the losses in the grid did not increase considerably. Particularly, if in 1990 actualoverall losses of electricity in the grid made 8 989.3 thousand kWh, this value by 1999 made 8 740.63 thousand kWh. Percentage shares of indicated losses out of electricity, supplied to the grid made in 1990 11.48%, and in 1999-12.99%, respectively, i. e. total value of relative losses by the year 1999 was increased by 1.51%.

Electricity losses in the grid of the Underground were defined by the same method, as it was in case of trams and trolleybuses.

Therefore, it may be concluded that at present the main with and supporting equipment of the Underground electric grid are operating normally, though to reduce losses down to designed value and to increase energy efficiency, it is necessary to replace depreciated units and equipment by modern and more energy efficient installations.

4.3.1.4. Electricity Consumptions by Railway in 1990

As it is known, electricity represents a product, generation, transmission and consumption of which make a continuous process and is simultaneous in time. However, the efficiency of supplied electricity consumption is considerably dependent upon the present state of the grid and equipment of the object, particularly, upon the energy efficiency of each consumer. According to this, energy efficiency of electricity consumption by Georgia's railway system has been analyzed.

For this purpose substantial information on Georgia's railway system, has been collected, particularly, on the railway traction substation main units (power transformers, traction-converter transformers, converters), contact lines, their age, depreciation (amortization) period and rolling stock, presented in the Tables 21, 22 of the Annex.

As the analysis has shown, by the year 1990, in the railway system functioned 34 fraction substations of 110kV voltage, 12 traction substations of 35kV voltage 10kV 14 traction substations and 6kV 10 traction substations making altogether 70 traction substations. Power transformers were mainly installed at 110kV substations and partially – at 10kV substations. Their number in each substation was mainly 2 and only some traction substations had one power transformer. Number of traction transformers and converters was the same, respectively. Nominal capacity of power transformers, installed at 110kV traction substations varied within 5.6-20 MV? , that of traction transformers – from 3.5 to 11.84 MV? and that of converters – mainly to 9.9 MV? . Nominal direct current was 3 000A and its nominal voltage was 3 300V.

By the state of 1990, there were 71 feeder zones in the railway system. Conductors of M-100+ 2M? -100, M-120+ 2M? -100+A types and other were used as contact lines. Cross-sections of the main conductors varied within 100-185mm^2, and those separate lines-within 25-70mm^2.

By the year 1990 the period of amortization was expired by power transformers of 17 traction substations, converter transformers at 18 traction substations and converters of 29 traction substations. Concerning the railway rolling stock, it may be noted that by the year 1990, there were functioning: BË type 313 electric locomotives of 5 modifications out of which BË-8 type 28 locomotives and BË-22 type 10 locomotives were depreciated; ?P2 and CP? type 187 electric train railway cars, out of which 87 were depreciated; out of 6439 freight cars and open platforms, 5352 were in operation. Out of total number of tank-cars –2885, only 2627 were in operation; Out of total number of passenger railway cars, 1300, 900 were functioning, etc. Detailed information is presented in the Table 30 of the Annex.

Thus it is evident, that by the state of 1990, the condition of the railway, system and its rolling stock was poor, that is proved by overall actualactual energy losses in the railway grid, the absolute value of which is 144859,32 thousand kWh, and its percentage share in the electricity, supplied to the grid makes 22,69%.

In 1999

After 1990, complicated political and heavy socio-economic situation, created in the country had a substantial impact upon various sub-sectors of the country's economy, including transportation. Both the railway rolling stock and electric grid were greatly damaged and plundered.

To make an analysis, data on the main equipment of railway traction substations and their characteristics, contact lines and rolling stock, their age and the period of depreciation were collected, which are presented in the Tables 21, 22 of the Annex.

As it has been indicated, by the state of 1990, there were 70 traction substations in the railway grid of the country, the number of which increased in 1991 up to 71, due to putting in operation of a 110 kV traction substations "Samtredia II". As a result of well known processes, developed in 1993, 13 traction substations appeared within the territory of Abkhazia (in the conflict zone). So, it is impossible to get reliable information, on their current state. For this reason, by the year 1999, there were actually 58 traction substations in the country's railway grid. By the period of making the analysis, there were damaged and inactive 110kV traction substations "Pokani", 35kV substations "Iori" and 6kV substations "Tkibuli" and "Samtredia-I". The main Characteristics of power transformers and converters, existing at the fraction substations in 1999 are the same, as they were in 1990, though their efficiencys are decreased.

By the state of 1999, feeder zones in the railway system decreased by 13 and their number made 58. As it has been indicated, 13 feeder zones are located in the conflict zone. Types of contact lines and their cross-sections are the same as in 1990.

By the year 1999, out of 58 traction substations remaining within the country, the amortization period was expired by lower transformers of 19 traction substations, converter transformers of 21 traction substations and transformers of 48 traction substations.

Concerning the rolling stocks of railway by the year 1999, there were functioning 228 electric locomotives of BË type, including 102 depreciated ones, 184 electric train railway cars including 132 depreciated ones; out 16367 freight cars, 3611 are operating; out of total 1011 number of passenger cars, 856 are in operation.

Therefore, by 1999, the state of railway electric grid and rolling stock is much more worse than it was in 1990. During the period under analysis the actual total losses in the grid were substantially increased. Their absolute value reached 53236,09 thousand kWh and their percentage share in electricity supplied to the grid made 26,77%.

Comparative analysis of electricity consumption by the railway system for the period of 1990-1999

Railway is a strategic mean of transportation for any country. Country's economy substantially depends upon its regular functioning. Therefore, it is evident, that independent Georgia should hare a railway, reliably functioning and equipped at modern level. In this direction much has been done for last two years, though much is still to be done.

Main characteristic values are presented in summarizing Tables 4.3.5 to make a comparative analysis of the state of electricity consumption by the railway and rolling stocks in 1990 and 1999.

As the data show, the state of main units of railway traction substations and rolling stocks was much more grave by 1999, than in 1990. Particularly, by 1999, the number of traction substations decreased from 70 to 58, including 4 inactive substations. The number of feeder zones decreased from 71 to 58, as well, including 4 inactive zones. The number of depreciated main equipment is increased in the traction substations. In particular, number of power transformers increased from 17 to 19; that of converter (traction) transformers –from 18 to 21 and that of converters – from 29 to 48, i.e. the amortization period is expired by the most part of the main units.

By 1999, the state of the railway rolling stock was worsened, as well, particularly, the total number of freight cars decreased from 20204 to 16967, and that of those being in operation – from 16456 to 3611. Total number of passenger cars decreased from 1300 to 1011 and that of those in operational state – from 900 to 856.

Table 4.3.5. Basic parameters of railway technical condition and consumed electricity

No	Name	1990	1999
1	2	3	4
1	Traction substations -Total number - Inactive	 70 -	 58 4
2	Nominal capacity of power transformers, MVa -at 110 kV substations -at 35 kV substations	 5,6 – 2,0 1,0 –5,6	 6,3 –2,0 1,0 –5,6
3	Nominal capacity of traction (converter) transformers, MVa	1,85– 11,84	1,85 –11,84
4	Number of feeder zones; - Total - Inactive	 71 -	 58 4
5	Depreciated: - Power transformers - Converter (traction) transformers - Converters	 17 18 29	 19 21 48
6	Number of freight cars: -Total -Active	 20204 16456	 16367 3611
7	Number of passenger railway cars: -Total -Active	 1300 900	 1011 856
8	Electricity supplied to the grid thousand kWh	638300,0	198817,445
9	Actual total losses in the grid: -Absolute, thousand kWh -Relative of the supplied to the grid, %	 144859,32 22,69	 53236,09 26,77

As a result of aforesaid and despite of the fact that by 1999 the amount of electricity supplied to the grid decreased from 638300 to 198817 thousand kWh, the percentage share of actual total losses of electricity in the grid is increased from 22,69% to 26,77%.

Therefore, on the basis of the analysis of obtained information, it may be assumed that at present, the state of Georgia's railway system and its rolling stock is rather poor and doesn't meet the facing problems. It is very essential that Georgia, as an important transportation country (proceeding from its geographical position) would possess a railway system of appropriate level, the normal and continuous functioning of which is a determinant factor for the country's economic growth. The latter requires, first of all, the replacement of electricity consuming depreciated equipment by modern and energy efficient units along with conducting repair and rehabilitation works. This will minimize electricity actual total losses in the railway grid.

4.3.2. Heat Consumption

4.3.2.1. Heat Consumption in Georgia in 1990

Out of three main constituents of a thermal supply system in Georgia, characteristics of heat consumption efficiency were one of the lowest one. Unsatisfactory quality of engineering constructions of building in the country, neglect ion of the requirements of heat saving caused large heat losses, due to which the energy, consumed per unit of a heating area was unreasonably high. Wrong consideration of Georgia's climatic conditions, reduction of designed thickness of walls of buildings, due to so called "warm climate" (that even in summer creates poor living conditions in the building), wide apertures for the windows and a single-pipeline heating system caused large heat losses. Values of heat load consumed by district heating systems of Georgia by 1990, according to the categories of buildings (residential, social, industrial) are presented in the Tables 23 of the Annex. Table 23 presents thermal and technical characteristics (W/m^2, W/capita) according to categories of buildings, as well. In Georgia, as well as in all other Soviet Republics district heating systems were improved merely by the government resolutions. The purpose of such improvement was to reduce amount of metal used in the system and the volume of works, required for the installation. Since the 70s, double pipeline systems in local heating were replaced by simple, single pipeline systems. In most cases, closing and regulating equipment was not used. As a result of such modernization, the heating system became so simple, that its installation did not require special qualification and connection was performed without regulation, as well. The only reaming problem was the problem of leakages.

Internal system of building heating in Georgia by 1990 was characterized by a single pipeline system, in which heat transfer line passes from upper floors down to lower floors and its temperature falls in the same way, respectively. In order to provide a uniform heating of rooms on any floor, the number of heaters on lower floor should exceed that of heaters on the upper floor. Due to the lack of regulatory equipment and measuring devices, the single pipeline system did not allow to regulate and register heat consumption in separate flats. There was no possibility to disconnect those consumers who did not pay for consumed thermal energy. Therefore, single pipeline heating systems of building will not be acceptable for functioning under conditions of market economy.

In most cases, heating systems of buildings in Georgia (except new residential districts and tall buildings) were directly connected with external heating network. In accordance with soviet engineering norms and rules (ÑÍèÏ) temperature on the surface of heating devices should not exceed t=90-95^{0}C considering sanitary and hygienic conditions. To meet these requirements, a special device – mixing hydro elevator was installed in the inputting points of each building to convert external network heat carrier temperature (t=150^{0}C) to low parameters, though actually there was no need of this equipment, since the water, circulating in the external heating network never was hotter than 90^{0}C.

In residential houses Georgia's heat supply system mainly used M-140 type iron radiators.

As it has been indicated, the heat consumption efficiency in Georgia was rather low by 1990. Except low thermal resistance of external walls of buildings, their thermal insulation was not provided due to incorrect construction and architectural solutions. Particularly, most of residential houses used to have open entrance halls and thus walls were in fact, external. According to construction norms glazing everywhere was single. Low thermal and technical characteristics of buildings were worsened by a low quality of construction. Heat insulating layer, of garrent cover, as a rule, was not of sufficient thickness, and in most cases did not exist, at all. Constructions of windows were performed especially on a low level, gaps in window frames considerably increased air infiltration and as a result, air exchange rate reached 2 m^3/h, instead of normative 0,5 m^3/h. Wealthy part of population, after moving into new flats as a rule, replaced doors and windows, though most of population could not afford to make such substitution. During the Soviet period general repairs of buildings were conducted, though with long intervals. At present, owners of apartments do not have even such a possibility.

It is also important to mention, the unawareness of population on heat saving problem that is conditioned by the inertia of energy unreasonable consumption habits during the Soviet period. The population does not take even such a simplest measure, as thermal insulation of windows, while this method saves heat consumption by 5-10%.

Main thermal technical characteristics of buildings in Georgia, such as actual and design values of thermal conduction coefficient, i.e. losses of heat (W) released into the environment by 1m^2 surface of constructions of garret and basement cover, glaze and exterior walls of a building under conditions of 1^0 C temperature difference are presented in Table 23 of the Annex. Besides, the same table presents the values of thermal conductivity coefficients, corresponding to international standards, for above listed parts of buildings. The analysis of the data indicates the existence of a substantial potential for the decrease of heat losses of buildings by about 35-40%.

4.3.2.2. Assessment of Heat Consumption Sector in 1999

Heat consumption values were sharply decreased by the year of 1999. Due to the absence of district heating systems since 1993 in Georgia, limited amount of delivered electricity, autonomous boilers of low capacity, furnaces burning oil, natural gas and wood were used as the source of heat. These types of heat supply are connected with high economic and environmental losses.

It has to underline that in case of the arrangement of autonomous boilers the most part of the building's interior required no capital repairing. Only in some rare cases (10-15%), pipelines and radiators were replaced.

4.3.3 GHG Emission Reduction Potential in the Heat and Electricity Consumption Sectors

As it has been indicated above, the greatest potential (~40%) of energy efficiency raising in the heat supply systems is related to heat local consumers. Two concepts on heat consumption should be distinguished: energy peak loads (MW) and energy annual consumption values (MWh). Energy efficiency increasing measures affect on the indicated categories differently.

Reduction of a peak load consumed by buildings requires quite high investments since it is associated with the improvement of thermal insulation of buildings, double glazing, warming of entrance halls, arrangement of local heating substations for each building, application of variable flow, etc. Potential of peak energy saving in residential and public buildings according to the various measures and components are presented below in the Table 4.3.6.

Table 4.3.6. Possible amount of heat saving

Measure, component	Saving potential	Realization forecast for 2010	
		Energy	Heat load
Heat losses during the distribution	-12%	-8%	-3%
Arrangement of heating substations in each building and application of the variable flow	-20%	-10%	-1%
Structure of buildings and internal heating systems	-40%	-5%	-2%

Saving of thermal energy, consumed by the buildings is paid the great attention in the developed countries. Putting into practice of „super reinforced" thermal insulation as energy saving technology is advisable both for the existing and being under construction buildings. Considerable modifications regulating thermal and other technical characteristics of fencing constructions of the buildings are introduced in construction standards to improve the thermal protection of buildings [1].

As a result of the implementation of heat losses providing measures corresponding to the international requirements, heat energy peak consumption possible reduction value are quite high in Georgia (~928,9MW). Though, the measures to be realized could be considered as a long-range problem due to its high cost. Measures to be taken relatively in the short period of time in order to increase energy efficiency in local consumers of the heat supply system will insignificant by affect the peak values (MW) of heat load of buildings, but their introduction will substantially reduce (25-30%) annual consumption of thermal energy (MWh). These measures are: registration and regulation of heat consumption using variable flow for heat carrier, provision of an independent connection of a heat supply system of each building with the external network by arranging the local heating substations.

A variable flow model represents one of the most important modern ways to increase the heat supply efficiency. This model allows consumers to check, regulate and reduce heat amount received from the network and its cost that compels to save the energy. E.g. the consumer is able to reduce heat consumption in residential houses at night or during the weekends in public buildings.

Heat supply systems in Georgia were operating according to a permanent flow scheme that did not allow regulation of heat consumption. At present, due to the absence of heat supply system infrastructure, it is necessary to create a system anew and to plan its functioning according to the variable flow scheme. Energy efficiency measures should be simultaneously taken in the heat generation, distribution and consumption systems, since a tight interrelation between heat sources and consumption components stipulates the energy efficiency.

Finally, it should be concluded that in the contemporary world energy policy, the special attention is drown to energy efficiency increasing, especially, in energy consumption field, since there are the largest energy saving reserves and potential. Making use of these reserves is very important for sustainable development of the society [39].

At this stage, evaluation of consumer sector appeared quite difficult. Thorough examination of this sector like other ones was not possible, but we made some general conclusions and they are given in the Tables 4.3.7 and 4.3.8.

Table 4.3.7. Assessment of extra emissions in residential and municipal sectors

Electricity consumer	Losses, %				CO_2 emission resulted from actual losses, t		Extra CO_2 emission, t	
	Design		Actual		1990	1999	1990	1999
	1990	1999	1990	1999				
1. Residential	NA	NA	63.4	60	542136,60	408812,70	NA	NA
2. Urban above-ground transport	7.16	15,25	18,77	24,28	1671,62	373,63	965,67	130,79
3. Urban underground transport	5.48	5.18	11	13	2 319,24	2 255,08	1 213,12	1 355,60
4. Rail transport	15.32	15.04	27	29	37 373,70	13 734,91	15 862,40	6 660,91
Total					583507,16	425176,32	18041,19	8147,30

4.3.8. Emissions resulted from losses of energy consumed in residential and municipal sectors in 1990 and 1999

N	Consumers			Year	Electricity consumption	Normative electricity losses		Actual electricity losses		Emission related with loses in CO_2 equivalent	Extra emissions in CO_2 equiv.
						Absolute	Relative	Absolute	Relative		
					mln kWh	mln kWh	%	mln kWh	%	Ton	Ton
1	Residential sector	Household appliances		1990	1645,13			1049,80	64	270 848,62	
				1999	3085,13			1280,49	42	330 366,37	
		Interior lighting	Tbilisi	1990	306,60			275,94	90	71 192,52	
				1999	204,40			183,96	90	47 461,68	
			Other Cities	1990	744,60			670,14	90	172 896,12	
				1999	124,10			111,69	90	28 816,02	
		Elevators	Tbilisi	1990	49,64			9,93	20	2 561,42	
				1999	3,65			0,73	20	188,34	
			Other Cities	1990	23,36			4,67	20	1 205,38	
				1999	0,58			0,12	20	30,13	
		Street lighting	Tbilisi	1990	78,49			62,79	80	16 200,28	
				1999	6,54			5,23	80	1 350,01	
			Other Cities	1990	35,04			28,03	80	7 232,26	
				1999	2,92			2,33	80	600,11	
2	Urban above-ground transport		Tbilisi	1990	29,30	2,2110	7,55	4,85	17	1 251,09	680,64
				1999	3,67	0,5844	15,93	0,78	21	200,75	49,99
			Other Cities	1990	7,76	0,5252	6,76	1,63	21	420,53	285,03
				1999	2,45	0,3569	14,57	0,67	27	172,88	80,80
3	Urban underground transport			1990	78,29	4,2873	5,48	8,99	11	2 319,24	1 213,12
				1999	67,25	3,4864	5,18	8,74	13	2 255,08	1 355,60
4	Rail transport			1990	544,30	83,3772	15,32	144,86	27	37 373,70	15 862,40
				1999	182,30	27,4186	15,04	53,24	29	13 734,91	6 660,91
TOTAL				1990	3542,51			2261,63	47,22	583 501,17	18 041,19
				1999	3682,99			1647,97	46,54	425 176,29	8 147,30

According to these Tables, total emission resulting from actual losses in the electricity consumption sector made 583 501.16 thousand tons of CO_2 in 1990, and 425 176.32 tons – in 1999. CO_2 extra emission, considering the design values, made 18 041.2 ton CO_2 in 1990 and 8147.3 ton CO_2 in 1999. Due to the absence of data on normative losses, relevant evaluations were not performed for the residential sector despite the high value of discussed parameters. Reduction of above stated figures would be possible in case of the restoration of energy efficiency design values.

Losses and corresponding emissions from the public and residential buildings are presented in the Table 4.3.9.

4.3.9. Emissions resulted from losses of heat consumed in the residential and municipal sectors in 1990

Unit		Year	Heat consumption	Heat losses		CO_2 emission related from losses, t
				Absolute	Relative	
			mln. kWh	mln. kWh	%	ton
Public and residential buildings	Tbilisi	1990	5866,62	1191,18	20	261 178, 54
	Other cities	1990	2334,60	583,60	25	127 960, 34
TOTAL		1990	8 201,22	1 774,78		389 138, 88

Hence, in 1990 emission related to the losses in both thermal and electricity consumption sectors made 972 640.04 ton in CO_2 equivalent.

4.4. Structure of Computer Database for Energy and Industry Sectors (1990 and 2000)

Georgian version of the energy efficiency inventory computer database for the units and technologies operating in energy and industry sectors in 1990 and 2000 has been prepared within the project framework. It consists of two sectors: fuel and energy sector, and industry. Base structure is prepared for both sectors in the frames of the project. From the informational provision standpoint, fuel and energy sector, which includes generation, transmission, distribution and consumption, is almost completely filled up. Due to objective reasons, data gathering for the industry sector turned out very complicated. Therefore, the base has been filled for only some (4) large enterprises for demonstration.

Let's discuss each sector separately.

Two sub-sectors are examined in the fuel and energy sector: energy supply and fuel industry. The first part (energy supply) is divided into two sections: power energy sector and heat supply. All units of generation, transmission and consumption (more or less) are discussed for both electricity and heat supply sectors.

Thermal electric stations (2 units in total), hydropower plants – large and medium HPPs (18 units) and small HPPs (27 units) and cogeneration unit – CHP (1 unit) are considered in the electricity generation section. 45 Tbilisi sub-stations are thoroughly examined in the heat generation sector. Summarized characteristics are presented for other 6 cities, where district heating systems (DHS) were functioning. General parameters for each thermal electric station and their component energy blocks are described in detail – energy-efficiency of each boiler, generator and turbine are given. Large and medium HPPs, small HPPs and cogeneration unit are described in the same way as the thermal electric stations. Specific features are taken into account during the description of heat supply systems, particularly the boilers.

In the ring of energy transmission, electricity transmission lines and sub-stations are examined. 500 kV (5 units), 330 kV (1 unit), 220 kV (33 units), 110 kV (9 units) and 35 kV (7 units) transmission lines and existing transformers and reactors in correspondence to the sub-stations (26 units) are discussed separately. Outdoor switchgears (21 units) located near TESs and HPPs are considered in the transmission part as well. Detailed data on the efficiency of existing transformers and reactors for each outdoor switchgear are also given.

5 types of consumers are discussed in the electricity consumption sector:

? Subway (24 units);
? Railway (70 units);
? City above-ground transport – trolleybus and tram (19 units in Tbilisi and 5 units in Kutaisi);
? Residential and household sector (10 long-lived appliances);
? Lighting (apartment and street lighting and lifts).

Every Tbilisi subway station is discussed separately: transformer parameters of all 4 types and operating escalators' parameters for each station. Description of rolling-stock is given separately. Railway and city above-ground transport is described in the same way.

As to the residential sector and lighting, especially energy consuming appliances (such as TVsets, electric stoves, PC, indoor and street lighting devices and lifts) are discussed and their parameters are presented.

Heat supply constitutes of generation, distribution and consumption. Due to the fact that heat supply municipal system was completely out of order by 2000, the base is filled up only with the 1990 data.

Residential and public buildings are discussed separately in the heat consumption sector by 1990. Thermal parameters and amount of heat consumed by these buildings are given.

To get the detailed information on any above stated specific object, it is possible to obtain copy of initial form of database (only in Georgian). Summary tables of energy efficiency and corresponding GHGs emission estimations in CO_2 equivalent are accessible both in Georgian and in English.

Fuel industry is reviewed in fuel and energy system along with the energy supply. Technological and economic parameters for all coal, natural gas and oil extracting units (5 coal and 5 oil and gas) existing on the territory of Georgia are described in the part that concerns the extraction, along with their prospective plans. Economic indices of the enterprises that transport the primary energy resources and relevant technological processes are given in the section of fuel industry. Information on these objects is available only in Georgian.

As to the industry sector, only few enterprises are as far as possible described. Their economic features and energy consumption by separate rings of technological cycle are given.

The database is realized in MS ACCESS (see Annex A).

4.5. Scenarios of Electricity Demand and Development of Electric-Power Industry till 2015-2020
4.5.1. Projection of Energy Demand in Georgia for the Period of 1999-2020

Long-term (about 20 years) forecasting activity on energy demand in Georgia is not easy. Difficulties are stipulated by the fact that at present, a perfect model of macroeconomic development of the country has not been elaborated and formed at the state level yet. Proceeding from the aforementioned, searching, acquainting, analyzing of the activities performed by the different organizations in this direction and relying on them elaboration of the economy development rough scenarios became necessary in order to project the energy consumption in the country. This examination served as a basis to establish the projective indices on electricity consumption in the country.

4.5.1.1. Projection of Electricity Demand

Power supply at the relevant level (ensuing from the demand) is one of the main conditions determining the development of economy of any country. To meet this demand, the country should hold the corresponding generation sources.

Reasoning from the above stated, the main point of the given part of this work is the determination of corresponding projected electricity consumption value and designing of optimal generation sources based upon the different scenarios concerning the economic development of the country.

Gross domestic product (GDP) and its evolution are determining factors for the development of country's economy and consequently projected consumption of electricity. Three scenarios on development of Georgian economy were examined relying on the various data in order to elaborate the method to forecast the electricity demand in the country:

<u>I scenario</u> – Slow restoration (GDP annual increase by 6% in 1999-2001) and slow growth (GDP annual increase by 4.5% in 2002-2020);

<u>II scenario</u> – Quick restoration (GDP annual increase by 10% in 1999-2001) and high growth (GDP annual increase by 6.5% in 2002-2020);

<u>III scenario</u> –Quick restoration (GDP annual increase by 10% in 1999-2001) and accelerated growth (GDP annual increase by 6.5% in 2002-2020) with the rapid structural changes of GDP in favor of service sphere. This scenario is called corrected high growth scenario.

Three different levels of electricity consumption (corresponding to the demand) were evaluated for each scenario related to the development of economy of the country:

? Demand conditioned by the proportions (factors) and rates of economic development;
? Demand stipulated by the influence of prices variation;
? Demand conditioned by the consideration of energy efficiency measures and variation of prices.

a) Scenario of the slow restoration and slow development of country's economy

Slow restoration of economy of the country is considered in the first period of the scenario (1999-2001). It represents a case when GDP of the country increases by 6% annually. Slow development of economy is foreseen in the second period of scenario (2002-2020). GDP increases by 4.5% annually in the given period. According to this scenario, by 2020 GDP level of the country will be 25% higher than in 1990. The most dynamic components of country's GDP will be: construction, industry and agriculture. In particular, construction level will be increased 6.2 times and industry level – 5.4 times in 2020 compared with 1999.

Results of forecasting activity on electricity demand for the given scenario are presented in the Table 4.5.1.1.

Table 4.5.1.1. Projection of electricity consumption by 2020 (mln. kWh)

No	Levels of electricity consumption	Y E A R S						
		1990	1998	1999	2005	2010	2015	2020
1	Due to economic development factors	17444	7962	8147	11334	14069	16071	19976
2	Considering the influence of prices	17444	7962	8147	10524	12803	14648	18186
3	Energy efficiency impact	17444	7962	8147	9946	11911	13396	16488

As it is evident from the analysis of data presented in the Table, as a consequence of increased demand for electricity stipulated by economic development of the country the projected consumption will reach 19976 mln.kWh by 2020 that is 14.5% higher than 1990 level and 145.2% higher than 1999 level. Price increase on the electricity unit will result in decrease of its consumption and so electricity consumption will be decreased down to 18186 mln. kWh by 2020. Price variation influence and adoption of energy efficient technologies will further decrease the consumption down to 16488 mln. kWh by 2020 that makes 94.5% of consumed electricity in 1990. Thus, it could be concluded that for the country's economy development scenario, the least amount of electricity is consumed considering the prices variation and the energy efficiency, i.e. in case of the third level of consumption.

According to the leading sub-sectors of economy, the distribution of electricity consumption for this scenario is presented in the Table 4.5.1.2.

Table 4.5.1.2. Electricity consumption by the sub-sectors of economy (mln. kWh)

No	Sector	1990	1999	2005	2010	2015	2020
1	Industry	8054	743	2607	3848	4783	6483
2	Construction	310	10	97	146	188	261
3	Agriculture	1461	12	637	815	941	1192
4	Transport and communication	1040	343	421	495	511	679
5	Commercial sector	288	133	160	186	197	234
6	Services (municipal sector)	566	445	854	870	920	1092
7	Residential sector	2320	3030	2907	2769	2661	2588
8	Other consumers	330	1746	313	440	540	725
9	Final consumption	14369	6462	7997	9570	10741	13225
10	Self consumption	431	150	138	132	124	114
11	Losses in the network	2643	1535	1811	2209	2531	3149
12	Total	17443	8147	9946	11911	13396	16488

Note: Values of estimated losses in the network in 1999 were determined rely on the permissible norms of technical losses, established under the NERCG, as the collection of reliable data on losses in 10; 6 and 0.4 kV networks is impossible at this stage.

As it is clear from the analysis of data given in the Table 4.5.1.2, the growth of electricity consumption level by 2020 is mainly caused by the increase of demand in the sectors of industry and agriculture. At the same time the consumption in the residential sector is almost unchangeable except for the period of 1999. Aforementioned is conditioned by the fact that the level of electricity consumption for heat and hot water supply was high in 1999.

Winter peak load projections from 1997 to 2020 for this scenario have indicated that the load will be increased 2.2 times by 2020 compared with 1997.

Estimated capacities of peak load for the winter are presented in the Table 4.5.1.3.

Table 4.5.1.3. Projection of average daily peak load for winter period (January)

Years	1997	1999	2005	2010	2015	2020
Load, MW	1418	1498	1973	2363	2658	3271

b) Quick restoration scenario and accelerated development of the country's economy

Quick restoration of country's economy with 10% annual increase of GDP is examined in the first period of quick restoration and accelerated development scenario of economy (1999-2001) and GDP annual increase by 6.5% - in the second phase of the scenario (2002-2020). According to this scenario, GDP future increase reflects the economy and relevant GDP development proportions among the sectors typical for the countries of former Soviet Union. Therefore, sectors of industry, construction and agriculture contribute the main share in GDP growth in this scenario.

We should suppose that the development of Georgian economy according to this scenario is not possible. Considering the natural conditions (resources) of the country, the development of industry (especially heavy industry) and construction sectors in this direction is not anticipated. Though, elaboration of this scenario as groundwork for the third scenario was essential, where the main emphasis is placed on the development of service sector and adoption of energy efficient technologies. According to our consideration and the results of earlier analysis, the third scenario on the development of economy of the country will be the most realistic.

c) Quick restoration scenario and accelerated development of the country's economy based on GDP rapid structural changes

In this scenario, accelerated development process of economy of the country was examined under such structure of GDP in which dominates the sphere of services, especially trading, hotels, restaurants, resorts, tourist centers, health care objects, etc.

GDP structures of the countries similar to Georgia (Greece, Portugal) were studied and analyzed so as to work out the analogous scenario. This analysis gave us a possibility to design the desirable structure of GDP of Georgia. GDP structure of quick restoration and accelerated development scenario oriented on the sphere of services substantially differs from the GDP structure of the second scenario. GDP structures of Georgia for the second and the third scenarios by 2020 are presented for comparison in the Table 4.5.1.4.

It is evident that according to the third scenario, structural changes in the sub-sectors of economy condition the reduction of electricity consumption in comparison with the second scenario. In particular, by the state of 2020, the estimated electricity consumption will be increased up to 24542 mln. kWh that would be conditioned only by the factors of development of country's economy. But, in its turn, anticipated price increase on energy resources (approaching to the international prices) will cause the electricity consumption decrease down to 21795 mln. kWh. Besides the foregoing, adoption of energy efficiency measures (energy efficient technologies) in the fields of electricity generation, transfer, distribution and consumption will influence on electricity consumption in future. All these will reduce the total electricity consumption for the same period down to 20156 mln. kWh that exceeds the 1990 level by 15.5%.

Table 4.5.1.4. Comparison of GDP structures for two scenarios (%) by the state of 2020

No	Sectors of economy	Quick restoration and accelerated development scenario (the second scenario)	Quick restoration and accelerated development scenario addressed to the services sector (the third scenario)
1	Industry	28	20
2	Construction	13	7
3	Agriculture	34	15
4	Transport and communication	5	10
5	Trade, restaurants, hotels	11	18
6	Services	5	30
7	Others	4	0
8	Total	100%	100%

According to this scenario the dynamics of electricity projected consumption till 2020 is presented in the Table 4.5.1.5.

Table 4.5.1.5. Projected consumption of electricity up to 2020 (mln. kWh) according to the third scenario

Electricity consumption levels	YEARS						
	1990	1998	1999	2005	2010	2015	2020
Stipulated by the economic development factors	17444	7962	8147	10706	13826	18255	24542
Considering the prices variation impact	17444	7962	8147	9924	12442	16310	21795
As a consequence of energy efficient measures implementation	17444	7962	8147	9405	11636	15141	20156

Estimated capacities of peak load in winter for this scenario are presented in the Table 4.5.1.6.

Table 4.5.1.6. Average daily peak load projection for the winter period (January)

Years	1997	1999	2005	2010	2015	2020
Load, MW	1418	1498	1659	2053	2671	3555

4.5.1.2. Regional Projection of Electricity Demand

a) Identification of the power industry regions

Proceeding from the technical peculiarities of the energy system of Georgia, application of model in which energy system would be presented as several power industry regions, is appropriate for the optimal planning of country's energy sector. Main criteria acting as a basis for such classification of energy system are as follows:

? Balance between generation and demand in power industry region;
? Existing and prospective generation sources of electricity;
? Make use of high voltage electric transmission lines to establish links among the regions, inside them and with energy systems of the neighboring countries.

Energy system of the country is divided into five power industry regions according to EEPPS as well as to Integral Planning Model (IPM), introducing relevant adjustments and additions. State of the regions, their main characteristics and connections are presented in the Table 4.5.1.7.

Table 4.5.1.7. Characteristics of power industry regions

Power industry regions and their designation	Load	Generation	Connection
I – Eastern (E)	High load compared with generation	-Tbilsresi; -Tbiltetsi; -Khrami HPP-1; -Khrami HPP-2; -ZA HPP; -Ortachala HPP;	To Azerbaijan and Armenia
II – Central (C)	High load compared with generation	-Zhinvali HPP	To Azerbaijan
III – Western (W)	Load balanced with generation	-Vartsikhe HPP; -Lajanuri HPP; -Tkibuli HPP; -Rioni HPP; -Shaori HPP; -Gumati HPP; -Gumati HPP	No connection
IV – Southwestern (SW)	High load compared with generation	ATS HPP	To Turkey
V – Northwestern (NW)	Low load compared with generation	-Enguri HPP; -Vardnili HPP -1;	To Russia

As it is apparent from the data presented in the Table, correlation between load and generation by the regions is uneven. In particular, load in eastern, central and southwestern regions is higher than generation, but in northwestern region the generation prevails the loading. Only in western region load is balanced by generation.

Mentioned classification of energy system of the country served as a basis to project the electricity consumption by the regions, to assess the current state of hydro and thermal electric plants and establish the order of their restoration, to determine the prospective thermal stations' location and their characteristics, to define the capacities of high voltage transmission lines to establish links among the regions as well as inside and outside them, etc.

b) Electricity consumption projection for the power industry regions

As it has been already mentioned, the power network of the country has been divided into five zones in order to make a projection on electricity consumption for the different regions of Georgia. Such division was conditioned by the location of electricity generation stations and routes of the main transmission lines.

The division of the territory of Georgia into power industry regions is presented in the Figure 4.5.1.1.

Two scenarios of economy development were analyzed meanwhile the projection of energy consumption by the regions, in contrast to the projection of electricity consumption all over the country in which three scenarios on economy development of the country were examined:

? Slow development scenario (so called baseline scenario), in which the GDP of the country is expected to increase by 6% annually in 1999-2001 and by 4.5% - in 2002-2020;

? Corrected rapid increase scenario, in which the GDP of the country is anticipated to increase by 10% annually in 1999-2001 and by 6.5% - in 2002-2020.

Like previously discussed all three scenarios on the development of country's economy, three different levels of electricity consumption in each region were evaluated for both scenarios:

? Demand stipulated by the proportions and rates of economic development;

? Demand conditioned by the influence of price variation;

? Demand due to the consideration of energy efficiency measures and variation of prices.

Levels of electricity consumption by each region presented in below-given Tables correspond to that level of demand that envisages price variation impact and energy efficiency improvement measures.

Statistic data on economic state and electricity consumption structure is quite limited not only for the regions, but also for the whole country as well. Regular collection system of statistic data at the regional level had not been functioning since 1990. Partial collection of regional statistic data on GDP structure turned out to be possible in the State Department of Statistics, Ministry of Economy, new structures established after disintegration of the former "Sakenergo" and in the Power Engineering Research Institute. Valuable projection of future evaluation of GDP sectors for separate regions is impossible rely on such poor statistic basis. Therefore, some expert estimations and assumptions were made throughout the elaboration of future economic development scenarios for each region.

c) Slow development scenario of economy of the power industry regions

As it has been already mentioned, according to this scenario during the first period of the regional economy development scenario (1999-2001) the GDP of the country is increased by 6% annually and in the second period (2002-2020) – by 4.5%.

Within this scenario it has been assumed that the rate of GDP growth at the regional level is the same as for the whole Georgia, meanwhile introducing some amendments for each region in view of their peculiarities. This assumption automatically satisfies Georgian GDP annual increase norms.

Features of loading were assessed for each region by the period of 1997-2020. In particular, peak loads in winter for each region are presented in the Table 4.5.1.8.

Table 4.5.1.8. Projection of average daily peak load for the winter period (January)

No	Regions	L O A D, MW					
		1997	1999	2005	2010	2015	2020
1	East	736	630	1133	1391	1605	2016
2	Central	175	180	194	228	240	292
3	West	250	430	322	373	428	507
4	Southwestern	174	180	203	224	229	262
5	Northwestern	83	78	121	147	156	194
6	Total	1418	1498	1973	2363	2658	3271

Electricity consumption projection for each region is presented in the Table 4.5.1.9.

Table 4.5.1.9. Projection of electricity consumption for the power industry regions under the slow development scenario

No	Region	C O N S U M P T I O N, mln. kWh						
		1990	1997	1999	2005	2010	2015	2020
1	East	-	-	-	5487	6662	7601	9454
2	Central	-	-	-	1069	1271	1385	1701
3	West	-	-	-	1744	2051	2333	2821
4	Southwestern	-	-	-	1076	1235	1323	1578
5	Northwestern	-	-	-	570	692	754	934
6	Total	17444	7363	8147	9946	11911	13396	16488

d) Revised of the accelerated development scenario of regional economy

Quick restoration and development scenario, according to which the GDP of Georgia increases by 10% annually in 1999-2001 and by 6.5% - in 2002-2020 while the soviet period GDP structure remains invariable, has been considered as impracticable. This conclusion was made in agreement with experts and specialists of the Ministry of Economy. It was taken as a foundation for the elaboration of more realistic – corrected quick development scenario for the Georgian economy.

Projected values of electric load in MW for the period of 1997-2020 were estimated for each region according to the corrected quick economy development scenario and they are presented in the Table 4.5.1.10.

Table 4.5.1.10. Projection of average daily peak load for the winter period (January)

No	Region	L O A D, MW					
		1997	1999	2005	2010	2015	2020
1	East	736	630	818	1004	1315	1728
2	Central	175	180	169	191	237	324
3	West	250	430	349	459	605	757
4	Southwestern	174	180	191	223	278	397
5	Northwestern	83	78	132	176	236	349
6	Total	1418	1498	1659	2053	2671	3555

Results of forecasting activities on the electricity demand for the corrected quick development scenario were defined for each region and are presented in the Table 11.

Table 4.5.1.11. Projection of electricity consumption for the power industry regions under the quick development scenario

No	Region	C O N S U M P T I O N, mln. kWh						
		1990	1997	1999	2005	2010	2015	2020
1	East	-	-	-	4789	5932	7752	10268
2	Central	-	-	-	1022	1236	1569	2109
3	West	-	-	-	1932	2400	3157	4076
4	Southwestern	-	-	-	1057	1279	1617	2235
5	Northwestern	-	-	-	605	789	1046	1468
6	Total	17444	7363	8147	9405	11636	15141	20156

4.5.1.3. Electricity Generation Sources

Information on the existing and prospective hydro and thermal electric plants to design an optimal development plan for the energy sector of the country is given in this part of the work. Both types of existing and prospective power plants have been selected and evaluated in order to accomplish the task and to include it in the plan. The examination primarily is based upon the earlier processed and recently accumulated information as well.

According to various sources of information, about 100 projects of different level exist for the prospective HPPs, starting from the conceptual outline and ending with the construction projects. From the thermal electric stations standpoint, TESs operating under the combined cycle on the basis of gas turbines was considered as prospective. During the selection and investigation of the versions, strategic need for energy independence of the country, requirements to increase reliability of power supply and necessity to satisfy environmental protection terms have been envisaged.

a) Characteristics of existing and prospective Hydro Power Plants

Total installed capacity of HPPs of Georgia is equal to 2729 MW, which is distributed among nearly 100 stations. In pursuance of elaboration of optimal development plan of the country's power sector, only HPPs with more than 10 MW capacity were considered on the basis of which the hydropower component of power balance of Georgia is being formed. Below are given the characteristics of these hydro power plants: installed capacity, actual capacity and amount of generated electricity (see Table 4.5.1.12).

More than half of the HPPs represented in this Table are above 40 years old and most of the rest of them are more than 20 years old. Exploitation terms together with old age of the HPPs have negative impact on the state of HPPs. In particular, during last decade, the lack of necessary finance required for their maintenance caused a sharp decrease of actual capacity of the units (down to 60 %) that is shown in the Table.

Table 4.5.1.12. Features of HPPs by the state of 1999

No	Name of region	HPPs existing in the region			
		List of HPPs	Installed capacity, MW	Actual capacity, MW	Actual generation, mln. kWh
1	I – Eastern	Khramihesi-1	113,45	86,2	217,1
		Khramhesi-2	110,0	55,8	207,5
		Zahesi	36,8	24,3	141,6
		Ortachalahesi	18,0	11,1	68,6
Total for region I			278,25	177,4	634,8
2	II – Central	Zhinvalhesi	130,0	80,1	362,0
Total for region II			130,0	80,1	362,0
3	III – Western	Vartsikhehesi	184,0	122,3	809,0
		Lajanurhesi	111,84	57,3	344,0
		Tkibulhesi	80,0	20,0	133,8
		Rionhesi	49,0	23,3	243,8
		Shaorhesi	38,4	23,5	167,2
		GumatihesiP -1	44,0	36,4	235,2
		Gumatihesi-2	22,8		
Total for region III			530,04	282,8	1933,0
4	IV – Southwestern	Atshesi	16,0	8,8	58,6
Total for region IV			16,0	8,8	58,6
5	V – Northwestern	Engurhesi	1300,0	670,7	2684,1
		Vardnilhesi–I	220,0	96,3	525,4
		Vardnilhesi–II	40,0	0	0
		Vardnilhesi–III	40,0	0	0
		Vardnilhesi–IV	40,0	0	0
Total for region V			1640,0	767,0	3209,5
Total for the country			2594,29	1316,1	6197,9

As it is seen from the presented data, HPPs are diversely distributed by the regions according to their quantity, installed capacity and electricity generation ability. For example, total value of installed capacity of HPPs in the densely populated Eastern region of the country makes 278.25 MW, but in the northwestern part notable for its low loading, it equals to 1640 MW. That causes a power outflow from the northwestern part of the country to the Eastern and Central regions that brings an increase of losses in transmission lines.

At present, the principal goal of energy sector of Georgia along with restoration of small hydroenergetics is the rehabilitation of large and medium size HPPs, repairing and reinforcement of high voltage transmission system. Implementation of the most part of these activities is possible using relatively moderate expenses compared with the construction of new plants, reasoning from the estimation of cost, required for the rehabilitation of 1 kW. Necessary investments surely should be attracted to fulfill the valuable restoration activities.

List of those HPPs that primarily require the restoration, reasoning from their utmost importance, is represented in the Table 4.5.1.13.

Table 4.5.1.13. List of HPPs to be restored at the first stage (2001-2005)

No	HPP	Actual capacity by the state of 1999, MW	Capacity after restoration, MW	Restoration cost, mln. USD
1	Engurhesi	670,7	1300	91,9
2	Vardnilhesi –I	96,3	220	5,7
3	Khramhesi –I	86,2	113	14,4
4	Khramhesi –II	55,8	110	16,2
5	Lajanurihesi	57,3	112	25,3
6	Zhinvalhesi	80,1	130	22,8
7	Vartsikhehesi	122,3	184	54,3
8	Sum	1168,7	2169	230,6

With respect to restore the main HPPs should be attracted the financial sources. The list of these HPPs, their parameters and estimated costs required for their rehabilitation are presented in the Table 4.5.1.14.

Table 4.5.1.14. Main HPPs to be rehabilitated at the second stage (2006-2010)

No	HPP	Actual capacity by the state of 1999, MW	Capacity after restoration, MW	Estimated restoration cost, mln. USD
1	Tkibulhesi	20,0	80,0	21,2
2	Rionhesi	23,3	49,0	17,7
3	Gumathesi -1	36,4	44,0	21,4
4	Gumathesi -2		22,8	17,4
5	Shaorihesi	23,5	38,4	16,8
6	Zahesi	24,3	36,8	16,1
7	Ortachalahesi	11,1	18,0	12,0
8	ATS HPP	8,8	16,0	9,2
9	Vardnilhesi -2	0	40,0	36,0
10	Vardnilhesi -3	0	40,0	36,0
11	Vardnilhesi -4	0	40,0	36,0
Total		147,4	425,0	239,8

All hydro power plants listed in the Tables 4.5.1.13 and 4.5.1.14 are regarded from rehabilitation standpoint as economically profitable versions, because (2169-1169)=1000 MW installed capacity could be rehabilitated using $230.6 million in the nearest future and at the second stage (425-147.4)=277.6 MW – using $239.8 million. At the same time, the construction of a new HPP of the same installed capacity requires rather much amount of investments.

The construction of new hydro power capacities that will provide application of existing hydro power potential in Georgia along with the rehabilitation of HPPs is necessary to work out an optimal development plan of country's energy system. A lot of HPP projects elaborated at the different levels are designed. They are listed below in the Table 4.5.1.15. Besides the list of prospective HPPs, Table illustrates their features, estimated cost and region where the given plants should be built.

Table 4.5.1.15. Prospective HPPs

Region	Main data on prospective HPPs				
	HPPs and their location	Installed capacity, MW	Electricity generation, mln. kWh	Estimated cost: Total, mln. USD	Estimated cost: Specific, USD/kW
Eastern (I) E	Paravani	120,0	443	168	1400
	Abuli (located on the R. Paravani in Ninotsminda region)	8,5	37	18	2080
	Ponichala	20	120	39	1940
	Rustavi (both on the R. Mtkvari)	14	55	33	2350
Central (II) C	Stori cascade (Akhmeta region, source of the R. Alazani)	11	65	29	2600
	Khadori HPP (Akhmeta region, source of the R. Alazani)	24	140	28	1167 Construction is under way
	Minadze (Akhaltsikhe region, on the R. Mtkvari)	41	108	70	1700
Western (III) W	Tvishi	100	404	141	1410
	Namakhvani	250	928	259	1036
	Zhoneti (all three on the R. Rioni)	100	346	134	1335
	Tsageri (on the R. Tskenistskali)	140	488	174	1240
	Orbeli (on the R. Tskenistskali)	80	?270	?100	
	Zestaphoni cascade (on the R. Kvirila)	118	610	136	1900
	Dzevra (on the R. Dzevrula)	25	55	54	2200
	Gubazeuli (Chokhatauri region, on the R. Gubazeuli)	80	327	84	2350
Southwestern (IV) SW	-	-	-	-	-
Northwestern (V) NW	Khudoni	638	1450	338	530 Construction was started and stopped
	Cheri (both on the R. Enguri)	107	347	120	1401

In our opinion, despite the fact that several of these plants seem profitable, none of them is economically attractive (they require considerable capital investment per 1 kW of installed capacity) to be implemented in the scheduled period. This suggestion is also proved ensuing from the fact that Georgia has already got excess peak capacity (from the Enguri HPP and others), but due to the lack of water resources, the utilization of these capacities is possible only in the short period of time. Most of proposed HPPs have low capacity in winter, when the demand for electricity in Georgia reaches its maximum.

b) Characteristics of existing and prospective thermal stations

In order to work out an optimal development plan for the country's electricity sector, issues related to the improvement of characteristics of existing thermal power generation units and construction of new ones have to be discussed, along with the increase of hydro power capacities. Despite the high hydro power potential of Georgia, to meet base electricity demand in the autumn-winter season, the effective sources for thermal generation are necessary because of low-water of rivers during that period. Results of research and analysis carried out by different international organizations show that the increase of a share of electricity, generated at the thermal stations would be required after 2002-2003 in energy balance of Georgia. That will have a great importance in overcoming the energy crisis in the country. The necessity to increase base capacities is testified by our examinations, as well.

Installed capacity, actual capacity and output of thermal electric stations existing in the country, brief description of their state and location according to the regions are presented in the Table 4.5.1.16.

Table 4.5.1.16. Thermal electric stations' characteristics by the state of 1999

Region	TESs existing in the regions				
	TES	Installed capacity, MW	Actual capacity MW	Actual output, mln. kWh	Note
Eastern (I)	Tbilsresi	1700	400	1609,6	1) 8 energy units of the first group have passed the amortization period. 2) No 3; 4 and 8 energy units will be able to operate after some repairs. 3) No9 and No10 energy units each of 300 MW are privatized, new owner is "AES Mtkvari "
	Tbiltetsi	18,0	10,0	24,2	All units have passed the amortization period and require reconstruction.
	CHP of Rustavi metallurgical works	124	0	0	Branch CHP has not been functioning since 1997. Needs reconstruction.
Central (II)	-	-	-	-	-
Western (III)	CHP of Kutaisi machine works	10	0	0	Branch CHP is robbed and is not functioning for a long time.
Southwestern (IV)	CHP of Batumi oil refinery	19,5	0	0	Branch CHP is not operating for a long time and now is plundered.
Northwestern (V)	Tkvarchelsresi	220	0	0	Has not been operating since 1993. From the political standpoint, at present, its future is uncertain and from the economic standpoint its reconstruction is doubtful.

As it can be seen from the data presented in the Table, only base station – "Tbilsresi" plays significant role in the formation of country's energy balance. From this standpoint the role of "Tbiltetsi" is not important. In the nearest future, basic rehabilitation and reconstruction activities have to be directed towards the improvement of technical state and characteristics of these thermal stations.

As it is known, since 2000 the owner of 300 MW energy units of "Tbilsresi" has become an American company "AES". This part of thermal electric station was named after "AES - Mtkvari". As to No 1; 2; 3; 4; 5; 6; 7 and 8 energy units of "Tbilsresi", they are still under the state ownership. These energy units are in a grave technical condition. In particular, No 1 and 2 units are to be written off as obsolete equipment. None of the energy units except No3, No4 and No8 operate. All energy units are out of amortization period.

Thermal electric station – “Tbiltetsi” located in the center of Tbilisi is in the same poor condition. Amortization period for the boilers, steam turbines and other auxiliary technological equipment installed at this station was terminated long ago. Rehabilitation and reconstruction activities are required for the restoration of “Tbiltetsi” operation in a proper manner.

Other thermal electric stations represented in the Table, except “Tkvarcheli TES”, are of sectoral subordination. Majority of them is not functioning and plundered long ago. Their rehabilitation and reconstruction will require significant investments. The fact, that prospects for the rehabilitation and reconstruction of sectoral TESs are not clear yet is a considerable point, as the need for their restoration is directly connected with current uncertain prospects of enterprises’ operation.

From those thermal electric stations that took part in the formation of energy balance of the country, the future of only “Tkvarcheli TES” is not defined (due to the political situation existing in the region). Future restoration of this TES considering the current condition and efficiency of its technologies is doubtful.

The list of those TESs that require essential rehabilitation, their actual capacities by the state of 1999 and after restoration, specific costs of total and installed capacity restoration are presented in the Table 4.5.1.17.

Table 4.5.1.17. TESs to be restored in the nearest future (2001-2114)

No	TES	Actual capacity in 1999, MW	Capacity after restoration, MW	Reconstruction cost	
				Total, mln. USD	Specific, USD /kW
1	Tbilsresi	350 130	I version 420 I I version 320	75 136	179 425
2	“AES Mtkvari”	270	600	Restoration is to be performed by the owner	
3	Tbiltetsi	10	?65-70	35	?500

Activities in order to improve the characteristics of No3, No4 and No8 energy units are included in the first version of “Tbilsresi” rehabilitation. The second version envisages the reconstruction of one of the units so as to operate in combined cycle along with the gas turbine. During the realization of this version, existing steam boiler will be replaced by boiler-utilizer and the steam turbine will be overhaul repaired. Consequently, efficiency of a new unit will rise.

As for “Tbiltetsi”, here is suggested the total reconstruction of thermal electric station, i.e. placing of two gas turbines with corresponding boiler-utilizers instead of old water heater and steam boilers and overhaul repair of steam turbines. As a result of these measures, “Tbiltetsi” will be rebuilt into the co-generation thermal station operating on the combined cycle based upon gas turbines.

Discussion on the possibilities to construct the prospective TESs in the country, along with the rehabilitation of the existing thermal electric stations, is necessary in order to work out an optimal development plan for the energy sector of Georgia. Furthermore, one of the most important reasons causing an energy crisis is the lack of basic capacities. Moreover, as it was mentioned before, examinations carried out by the different international organizations suggest that the increase of thermal electric stations’ share in the total energy output of the country will be necessary in the future. Such an approach will be preconditioned by less prospectiveness of the construction of HPPs with large water reservoirs (large-scale capital investments, environmental problems, etc.) and by the smaller possibility to satisfy basic electricity demand with the aid of seasonal hydro power plants.

The list of prospective thermal electric stations, their possible location according to the regions, main characteristics, estimated total and specific costs required for their construction, are presented below (see Table 4.5.1.18).

Table 4.5.1.18. Prospective Thermal Electric Stations of Georgia

Region	Main parameters of TESs				
	TES and its location	Installed capacity, MW	Electricity output, mln. kWh.	Estimated construction cost	
				Total, mln. USD	Specific, USD/kW
Eastern (I)	Tbilisi TES (in the Eastern part of Tbilisi)	300	1800	150	500
Central (II)	–	-	-	-	-
Western (III)	Zestaponi TES (on the territory of Ferroalloy plant)	?90		40,5	?450
	Tkibulsresi (Tkibuli)	220		–	
Southwestern region (IV)	Kobuleti TES	15	–	6,75	~450
	Meria TES (on the territory of vil. Meria in the Guria Region)	300	1800	150	500
Northwestern (V)	-	-	-	-	-

4.5.1.4. Existing and Prospective Electricity Transmission Lines and their Features

Analysis of existing and prospective electricity transmission lines of Georgia is presented in this part of the work. On the one hand, the increase of the electricity generation existing capacities and corresponding output is required to improve the sustainability of country's energy system. And on the other hand, simultaneous operation with energy systems of neighboring countries – Russia, Azerbaijan, Armenia and Turkey is necessary to achieve this goal. Functions and roles of the Joint Control Department of energy systems of Transcaucasia existing in the 80's have to be restored and developed. From its part, it should serve as a basis for establishing the united energy system of the Black Sea countries. Simultaneous operation with energy systems of the neighboring countries and implementation of generation increasing measures should provide the establishment of a balance between the generation and consumption of electricity in the country that should considerably improve the energy system's operation.

a) Existing electricity transmission lines

Strategic geo-political location of Georgia provides an opportunity for the country to participate in the implementation process of many projects, related to the development of infrastructure of the regional energy sector. Connection of Georgian energy system with the neighboring countries' systems will be profitable for all participants that, as a result, will create a strong united energy system. This reason is proved by the world experience and the work implemented by Verbundplan GMBH Vienna-Lahmayer International Frankfurt under TACIS in 1997, which was dedicated to the "Study of unification possibilities of energy systems of the Caucasus countries with the energy system of Turkey". Several versions of unification of Georgian and Turkish energy systems are discussed and analyzed in this work.

Existing 500, 330 and 220 kV electricity transmission lines of Georgian energy system are presented in the Fig. 4.5.1.2. As it can be seen in the Figure, high voltage internal transmission system of the country consists of 500 kV and 220 kV electricity transmission lines. Electricity transmission from west to east and vice versa is not reliable, because 220 kV lines could not transmit required amount of power in case of accident occurred at 500 kV line, e.g. 200 kV electricity transmission lines – "Egrisi", "Kolkhida-II[a]", "Kolkhida-II" and "Kolkhida-I" parallel to the 500 kV el. transmission line "Imereti" connecting Enguri HPP – substation Didi Zestaponi – are damaged and need restoration. The double-circuit 220 kV line "Ajameti" has been plundered and its restoration was an absolute necessity. By the current state, this work is completed. Double-circuit line "Senaki – I, II" which connects substations of Menji and Tskaltubo is also embezzled.

List of 500 kV and 220 kV electricity transmission lines of the country, with substations and outdoor switchgears connecting through these lines, their length and the year of putting them into operation are given in the Table 4.5.1.19.

Fig.4.5.1.2. 500, 330and 220 kV existing and prospective electricity transmission lines of the Georgian energy system

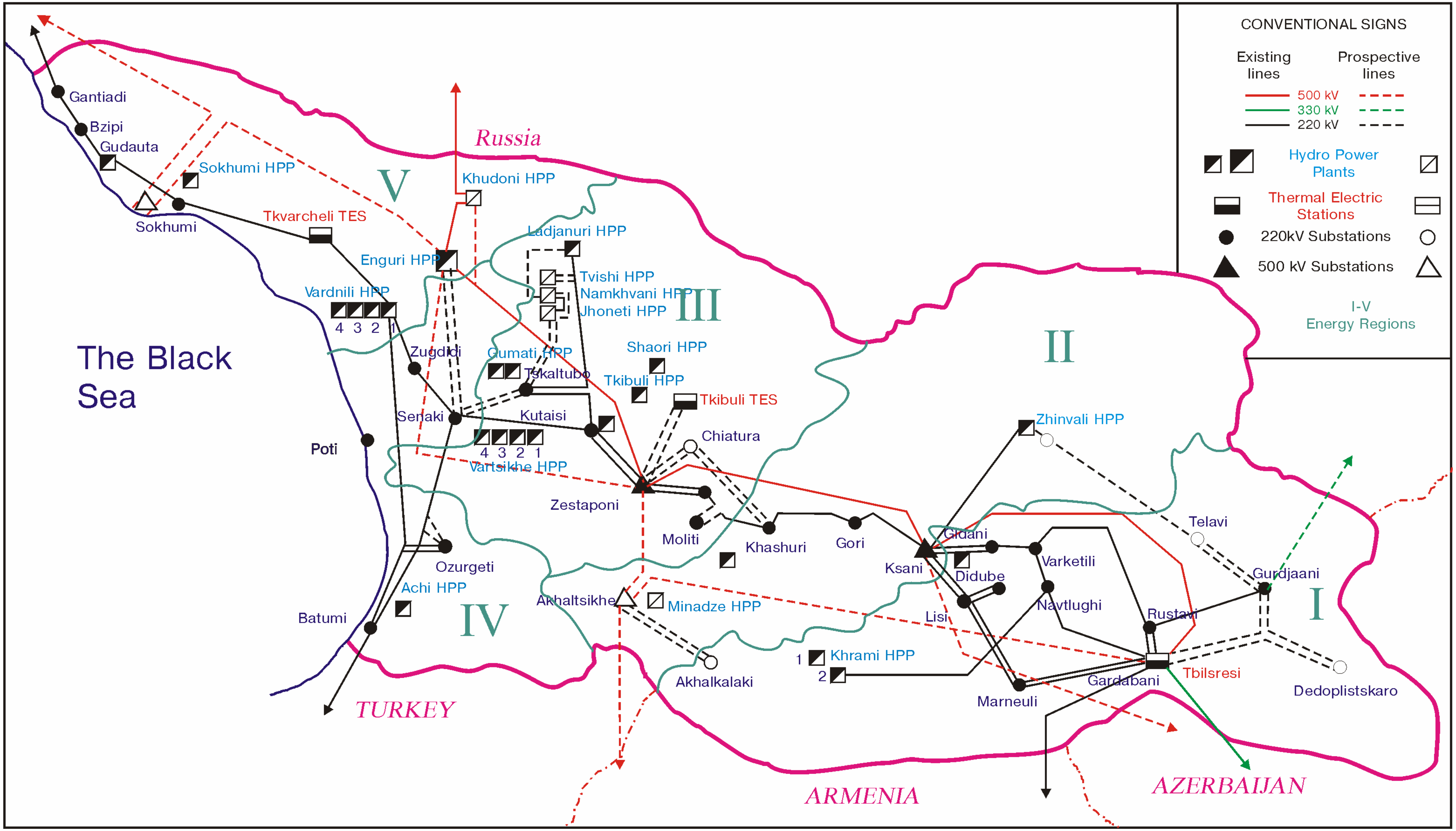


Table 4.5.1.19. 500 kV, 330 kV and 220 kV electricity transmission lines of Georgia

No	Transmission line	Location (connection)	Steps of voltage, kV	Year of putting into operation	Length of the line, km	Transmission capacity, MW	Note
1	2	3	4	5	6	7	8
1	Imereti	Enguri HPP – Substation Didi Zestaponi	500	1978	127.8	650	-
2	Kartli-II	Subst. Didi Zestaponi - Substation Ksani	500	1968	165,0	500	-
3	Kartli-I	Substation Ksani – Tbilsresi	500	1968	91,9	500	Needs the restoration
4	Mukhrani	Substation Ksani – border with Azerbaijan	500	1987	92,0	500	-
5	Adjara	Border with Turkey - Substation Batumi	220	1979	12,0	220	-
6	Paliastomi -I	Substation Batumi – Subst. Menji	220	1973	98,0	130	-
7	Paliastomi –II	Substation Batumi – Vardnili HPP-I	220	1981	149,6	130	-
8	Kolkhida- III	Vardnili HPP-I - Tkvarchelsresi	220	1956	31,5	180	-
9	Iveria - I	Tkvarchelsresi – Subst. Sokhumi	220	1964	61,8	150	-
10	Iveria – II	Substation Sokhumi - Substation Bzipi	220	1964	78,2	150	-
11	Salkhino	Substation Bzipi – Russian border	220	1969	38,4	150	-
12	Egrisi- I, II	Enguri HPP - Vardnili HPP -I	220	1977	2X11,5	350	Double circuit
13	Kolkhida – II[a]	Vardnili HPP -I – Substation Zugdidi	220	1956	20,1	180	-
14	Kolkhida – II	Substation Zugdidi – Subst. Menji (Senaki)	220	1956	47,0	180	-
15	Kolkhida – I	Substation Menji – Substation Didi Kutaisi	220	1956	66,7	100	-
16	Adjameti – I, II	Substation big Kutaisi – Subst. Didi Zestaponi	220	1959	26+21,5		
17	Senaki - I, II	Substation Menji – Substation Tskaltubo	220	1991	2X58,8	400	Needs the restoration Double circuit
18	Sataplia	Substation Tskaltubo – Subst. big Kutaisi	220	1990	26,8		

1	2	3	4	5	6	7	8
19	Derchi	Substation Tskaltubo –Lajanuri HPP	220	1960	47,8		
20	Ferro- I,II	Subst. Didi Zestaponi – Ferro	220	1979	2X7,5		Double circuit
21	Surami	Subst. Didi Zestaponi – Subst. Khashuri	220	1959	71,8	220	
22	Urbnisi	Subst. Khashuri – Subst. Gori	220	1959	42,2		
23	Liakhvi	Subst. Gori – Subst. Ksani	220	1959	56,6		
24	Lomisi	Subst. Ksani – Zhinvali HPP	220	1985	40,5		
25	Aragvi	Subst. Ksani – Subst. Gldani	220	1959	31,7	220	
26	Didgori- I,II	Subst. Ksani – Subst. Lisi	220	1984	2X19,05	440	Double circuit
27	Koda- I	Subst. Lisi – Subst. Marneuli	220	1979	33,3		
28	Koda- II	Subst. Lisi – Tbilsresi	220	1979	56,5		
29	Lomtagora	Subst. Marneuli – Tbilsresi	220	1979	23.,2		
30	Kukia	Subst. Gldani – Subst. Didi Navtlughi	220	1959	17,7		
31	Navtlughi	Subst. Didi Navtlughi - Tbilsresi	220	1958	36,3		
32	Varketili	Subst. Gldani – Subst. Rustavi	220	1966	48,6		
33	Veli- I	Subst. Rustavi – Tbilsresi	220	1976	26,0		
34	Veli- II	Subst. Rustavi - Tbilsresi	220	1974	21,5		
35	Manavi	Subst. Rustavi – Subst. Gurjaani	220	1970	75,0		
36	Alaverdi	Tbilsresi –border with Armenia	220	1960	38,9	200	
37	Didube	Subst. Lisi – Subst. Didube	220	1991	8,2		
38	Algeti	Khrami HPP-2 – Subst. Didi Navtlughi	220	1963	65,2		
39	Gardabani	Tbilsresi – Azerbaijan border	330	1958	21,0	350	

As we have mentioned above, numerous 500 kV and 220 kV el. transmission lines of Georgian energy system are plundered and some of them, due to their technical condition, have low capacity (transmission possibility). Therefore, their restoration and rehabilitation is required. As it can be seen from the data presented in the Table 4.5.1.19, double-circuit 220 kV electricity transmission line Senaki –I, II connecting substation Menji with substation Tskaltubo and the line of “Mukhrani”, connecting substation Ksani with Azerbaijan are plundered and have to be restored. Transmission line with 2x29.4 km of length is stolen at Senaki I, II line and 35 km electric cable – at the “Mukhrani” line.

b) Prospective electricity transmission lines and their main parameters

Construction of high voltage electricity transmission lines provides the sustainability of energy system of the country on one hand, and reliable connection with energy systems of neighboring countries on the other hand. That will promote the reliable transmission of electricity between the country regions and the transit between the energy systems of the neighboring countries.

Perspective electricity transmission lines of country’s energy system are represented in the Fig. 4.5.1.3, and their list is given in the Table 4.5.1.20.

Table 4.5.1.20. Features of prospective electricity transmission lines

No	Electricity transmission lines' connection	Voltage stages, kV	Transmission possibility (capacity), MW	Length, km	Estimated cost, 1000 USD	Period of construction, y
1	Enguri HPP-Sukhumi- Russian border	500	500	166+73= 179	79590	2,5
2	Enguri HPP - Subst. Menji (double circuit)	220	400	2X77	41356	2,0
3	Enguri HPP - Subst. Didi Zestaponi	500	650	194	71060	2,3
4	Subst. Didi Zestaponi - Subst.Chiatura- Subst.Khashuri (double circuit)	220	400	(2X45)+ (2X60)	47550	2,5
5	Subst. Didi Zestaponi - Subst. Akhaltsikhe	500	650	71	12000	1,1
6	Tbilsresi - Subst. Akhaltsikhe	500	650	205	67615	1,9
7	Subst. Akhaltsikhe – Border with Turkey	400	700	46	52021	2,0
8	Zhinvali HPP - Subst. Telavi	220	220	62	10958	1,7
9	Subst. Telavi - Subst. Gurjaani (double circuit)	220	400	2X45	20500	1.2
10	Subst. Gurjaani - Subst.Dedophlistskaro - Tbilsresi (double circuit)	220	400	2X140	63000	2,4
11	Subst. Gurjaani – Dagestan (Russian border)	-	-	-	-	-

c) Brief description of the prospective electricity transmission lines

? Total length of 500 kV electricity transmission line of Enguri HPP – Sukhumi – Russian border is 179 km. Out of them the length of Enguri HPP – Sukhumi section is 106 km, and from Sukhumi to the border with Russia it equals to 73 km. In case of this line construction, it will be necessary to install one new 500 kV cell in the outdoor switchgear of Enguri HPP. New substation of Sukhumi will be installed on the basis of three single-line autotransformers with 167 MWA of capacity.

? Total length of 220 kV double-circuit electricity transmission line of Enguri HPP – Menji is 2x77 km. Connection of this transmission line requires improving of the existing substations. Namely, two new switches of 220 kV and three single-line autotransformers with 167 MWA of capacity and 500/220 kV of voltage have to be installed in the outdoor switchgear of Enguri HPP, and two switches of 220 kV – in the Menji substation.

? Total length of 500 kV electricity transmission line of Enguri HPP – substation Didi Zestaponi makes about 194 km. Construction of this transmission line also requires the reinforcement of substations. Namely, one 500 kV switch has to be installed in the outdoor switchgear of Enguri HPP. Overall reconstruction of 500 kV circuit diagram must be done in the Didi Zestaponi substation.

? Total length of 220 kV double-circuit line of substation Didi Zestaponi – substation Chiatura – substation Khashuri equals to [(2x45)+(2x60)] km. Length of substation Didi Zestaponi – substation Chiatura is (2x45) km, and the length of substation Chiatura – substation Khashuri is (2x60) km. In case of this line construction, it will be necessary to install two (in total four) 220 kV switches at the substations of Didi Zestaponi and Khashuri. Five 220 kV switches and one autotransformer with 125 MWA of capacity and 220/110 kV of voltage have to be installed at a new substation of Chiatura.

? Total length of 500 kV electricity transmission line of substation Didi Zestaponi – substation Akhaltsikhe is 71 km. Construction of this line requires installation of at least one 500 kV switch in the substation of Zestaponi and construction of new substation in Akhaltsikhe in which 500/400 kV three single-line autotransformers (each of 150 MWA capacity) will be installed.

? Total length of 500 kV electricity transmission line of Tbilsresi – Akhaltsikhe equals to 205 km. In case of this line construction, it will be necessary to install one switch in the outdoor switchgear of Tbilisi with 500 kV of voltage. Construction of this line has started in 1989 and due to known events it has been stopped in 1992.

? Total length of 400 kV line linking substation Akhaltsikhe with the Turkish border is 46 km. One 400 kV switch has to be installed at the substation of Akhaltsikhe in case of this line construction.

? Total length of 220 kV electricity transmission line connecting substation Zhinvali HPP with substation Telavi is 62 km. Construction of this line requires reconstruction of outdoor switchgear of Zhinvali HPP and installation of a new 220 kV substation with corresponding autotransformer in Telavi.

? Total length of 220 kV double-circuit electricity transmission line connecting substation Telavi with substation Gurjaani is 2x45 km. Construction of this line requires reconstruction operations in the existing substation of Gurjaani.
? Total length of 220 kV double-circuit electricity transmission line that connects substation Gurjaani, substation Dedoplistskaro and Tbilsresi with each other is (2x140) km. In the event of this line construction a new 220 kV substation has to be built in Dedoplistskaro.
? There are several ideas concerning the construction of line connecting substation Gurjaani with the Dagestani border:

- The first of them implies the construction of 110 kV electricity transmission line, which will be built not from Gurjaani substation, but from any 110 kV substation located near the border.
- The second means the construction of 330 kV electricity transmission line from Gurjaani substation that requires building of 330 kV wing with the corresponding 330/220 kV autotransformers at the 220 kV substation of Gurjaani.
- The third is based upon the construction of 330 kV electricity transmission line, which will be built from Tbilsresi instead of Gurjaani substation that requires reconstruction of existing 330 kV wing of the Tbilsresi outdoor switchgear.

Note: It has to be mentioned that throughout the construction of prospective electricity transmission lines, precise list of required equipment for the construction and rehabilitation of separate substations, their quantity and corresponding parameters will be determined while elaborating the design for given specific unit.

4.5.1.5. Inter-Regional Connections of the Georgian Transmission System and Links with the Nearest Energy Systems

From the standpoint of connections between the energy systems of neighboring countries, Georgia with its northwestern (NW) power industry region is connected to Russia (R), with southwestern (SW) region – to Turkey (T), and with eastern (E) region to – Armenia (Ar) and Azerbaijan (Az). Connections of Georgian energy systems with energy systems of neighboring countries and between inside the country regions are given schematically in the Fig. 4.5.1.2.

As it is clear from this scheme, according to current state, Georgian energy system is connected with Russia by 500 kV line "Kavkasioni" and 220 kV line "Salkhino", with Turkey – by 220 kV electricity transmission line "Ajara", with Armenia – by 220 kV line "Alaverdi" and with Azerbaijan – by 330 kV line "Gardabani". The continuation of new lines' construction and restoration of plundered ones is foreseen for the future in order to improve the connections with the energy systems of neighboring countries.

The 500 kV embezzled electricity transmission line "Mukhrani" connecting Georgian energy system with Azerbaijan has to be rehabilitated. Construction of 500 kV line (abandoned in 1992) that connects Georgia with Turkey has to be accomplished. It represents the complex of Tbilsresi-Akhaltsikhe, Zestaponi-Akhatsikhe and Akhaltsikhe-Karsi transmission lines. Construction and putting into operation of this line has significant strategic importance for development of energy sector and the whole economy of the country. Construction of 500 kV line "Enguri HPP-Sukhumi-Russian Border" connecting Georgia with Russia, is in sight for the future. The issue concerning the construction of "Gurjaani-Dagestan" line linking Eastern Georgia with Russia is under discussion. There are several project proposals related to the building of this "Gurjaani-Dagestan" transmission line.

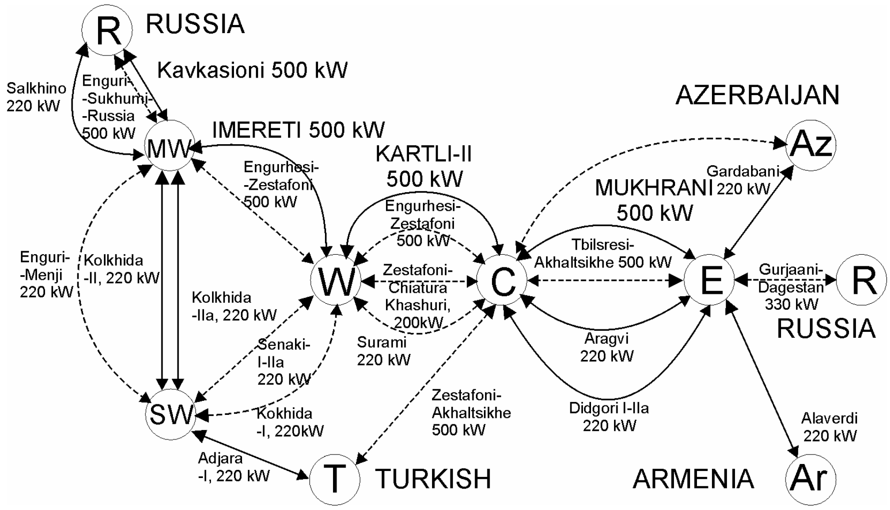


Figure 4.5.1.2. Inter-Regional Connections of the Georgian Transmission System and Links with the Nearest Energy Systems

Table 4.5.1.21. Parameters of inter-regional connections of Georgian transmission system and links with the nearest energy systems

Regions	Transmission line	Location (connection)	Voltage stages, kV	Length, km	Transmission possibility (capacity), MW	Status
Northwestern – Southwestern	Kolkhida - II[a]	Vardnili HPP-I – Subst. Zugdidi	220	20,1	180	Existing
	Paliastomi - II	Vardnili HPP - I – Subst. Batumi	220	149,6	130	Existing
	-	Enguri HPP – Menji	220	2X77	400	Prospective (double-circuit ETL)
Northwestern - Western	Imereti	Enguri HPP – Subst. Didi Zestaponi	500	127,8	650	Existing
	-	Enguri HPP – Subst. Didi Zestaponi	500	194	650	Prospective
Southwestern - Western	Kolkhida - I	Subst. Menji - Subst. Didi Kutaisi	220	66,7	100	Existing
	Senaki- I, II	Subst. Menji - Subst.Tskaltubo	220	2X58,8	400	Rehabilitation (double-circuit ETL)
Western – Central	Kartli- II	Subst. Didi Zestaponi – Subst. Ksani	500	165	500	Existing
	Surami	Subst. Zestaphoni – Subst. Khashuri	220	71,8	220	Existing
	-	Subst. Didi Zestaponi – Subst. Akhaltsikhe	500	?30	650	Rehabilitation, Prospective
	-	Subst. Zestaphoni – Subst.Tchiatura - Subst. Khashuri	220	(2X45) + (2X60)	400	Prospective, (double-circuit ETL)
Central - Eastern	Kartli – I	Subst. Ksani – Tbilsresi	500	91,9	500	Existing
	Aragvi	Subst. Ksani – Subst. Gldani	220	31,7	220	Existing
	Didgori I, II	Subst. Ksani – Subst. Lisi	220	2X19,05	440	Existing (double-circuit ETL)
	-	Zhinvali HPP – Subst.Telavi	220	62	220	Prospective
	-	Subst.Akhaltsikhe – Tbilsresi	500	205	650	Rehabilitation (Prospective)
Northwestern- Russia	Caucasus	Enguri HPP – Russian border	500	102,3	400	Existing
	-	Enguri HPP –Sokhumi – Russian border	500	106+73 = 179	500	Prospective
	Salkhino	Subst. Bzipi – Russian border	220	38,4	150	Existing
Southwestern – Turkey	Adjara	Subst. Batumi- Border with Turkey	220	12	220	Existing
Central-Turkey	-	Subst. Akhaltsikhe - Russian border	400	46	700	Prospective
Central –Azerbaijan	Mukhrani	Subst. Ksani–Azerbaijan border	500	92	500	Rehabilitation
Eastern - Azerbaijan	Gardabani	Tbilsresi - Azerbaijan border	330	21	350	Existing
Eastern –Armenia	Alaverdi	Tbilsresi – Border with Armenia	220	38,9	200	Existing
Eastern – Russia	-	Subst. Gurjaani- Russian border	-	-	-	Prospective

There are some project proposals concerning the construction of "Gurjaani-Dagestani" electric transmission line.

Construction of the line such as 500 kV transmission line connecting of Enguri HPP with Zestaponi or Enguri HPP with Akhaltsikhe holds much promise in order to develop the internal regional connections and sustainability of country's energy system. On the one hand, the rehabilitation of 220 kV plundered double-circuit line "Senaki-I, II" and on the other hand the construction of 220 kV transmission double-circuit lines connecting Enguri HPP with Menji and Zestaponi, Chiatura and Khashuri with each other, has significant importance for the improvement of country's regional links.

Characteristics of existing and prospective transmission lines connecting power industry regions with each other and with energy systems of neighboring countries are given on the Table 4.5.1.21.

From the analysis of basic characteristics (voltage stage, length of the line, capacity) of transmission lines presented on the Table it is evident that the rehabilitation of existing plundered lines and the construction of new ones will significantly improve interrelation between the energy systems of neighboring countries and among the regions.

4.5.2. Assessment of Electricity Demand in Georgia for the Period up to 2020

4.5.2.1. General Remarks

Within the implementation of the present project, several groups of experts were working on forecasting of electricity demand in Georgia for the nearest 20 years. They used various approaches to this issue and consequently the results were different. Though, it has to be underlined that these results, granting the estimation inaccuracy, are quite close to each other.

Estimations reviewed in the previous chapter are based on the lineal growth assumption of the country's economy by two different rates that could be achieved after the stabilization of its development. The second group of experts does not agree to this assumption. They have performed their estimations considering the non-linear processes ongoing in the economy. Below are presented the results obtained by this approach to the projection.

The present investigations are aiming to assess the anticipated levels of demand for electricity in Georgia in the prospective period up to 2020. Estimation is based on the works carried out in this field by the Georgian and foreign experts during the previous years. At the same time, unconformity of methodological approaches, based on the linear models, with special peculiarities of Georgian economy at the contemporary level appeares obvious on the basis of critical analysis of the existing data and out of the actualdata for last years. Conclusion is made on the necessity to consider the non-linear processes ongoing in the economy, in particular, whereby using the expert estimations on possible parameters of such processes, while forming the forecast.

4.5.2.2. Existing Forecast of Electricity Demand in Georgia

The only complete forecast on electricity demand in Georgia up to 2020 is presented in the work carried out by the energy efficient center – CENEF (the Russian Federation) under the request of USAID contractor company – Burns & Roe Enterprises in 1998.

Methodology, on which the named work is based, was critically assessed by one part of experts (including the author of the present estimation) at the seminar organized by Burns & Roe Enterprises in autumn of 1998 that was directly devoted to this issue. Unfortunately, this criticism has been ignored without any definite argument.

First of all, the criticism was concerning the consumption data of 1997 taken as a baseline level for demand projection by CENEF. In terms of 20-30% payment of electricity taxes, huge losses and thefts, large scale of corruption and limited supply, equation of electricity consumption level to the demand does not stand up to any criticism. The simple economic truth that the expression „demand" equals to unlimited consumption only in case of 100% payment should be recalled.

On the other turn, we should touch on the projection methodology that rolls to the consnant slow growth of demand for electricity. Such picture is a result of projection on the basis of lineal models that is unuseful for economic evolution forecasting of the country, like Georgia, being involved in the crisical structural trasformations. It goes without saying that the case concerns essentially non-linear processes ongoing in the economy and energy sectors.

Among them are the following processes: improvement of payment system, step by step growth of electricity tariff and restoration and expansion of natural gas full-scale operation system. Their termination is expected within the nearest 2-5 years. Consequently, we will get qualitative improvement of energy consumption structure that will end by the replacement of electricity with natural gas in several sub-sectors (first of all, due to the sharp reduction of inefficien consumption of electricity for heating purposes and to the replacement of vast majority of electric appliances with the devices using natural gas for water heating) and by electricity maximum saving from the consumer side.

Besides, at present (2001), the actualstatic data of recent years could be used for the estimation of the mentioned approach.

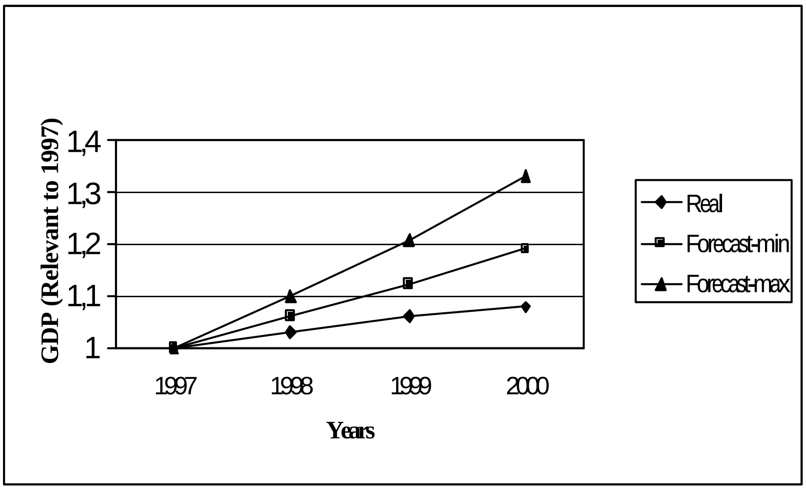


Fig. 4.5.2.1. Projected and actual growth of the country GDP in 1997-2000

Unreality of previously made projections is displayed in contrast to the selected ranges of economic growth rate possible variation with the country GDP growth actual rate (Fig. 4.5.2.1.). For example: by 1998-2001 GDP growth rate in the mentioned forecasting is determined within the range of 6-10% while in fact this value was equal to 2.9% in 1998, 3.0% – in 1999 and 1.9% – in 2000. Thus, the actual growth rate has not fall even in quite wide forecasting range; it appears two or three times lower than the forecasted minimum.

Incidentally, this very fact demonstrates the unconformity of the above mentioned technical approach applied in the projection to the economy of the country like contemporary Georgia.

According to their methodology, they forecasted "smooth slow" continuation based upon the previous years actual data on GDP growth rate (11,2% in 1996, 10,7% in 1997). But in reality, 1998 appeared the "record-holder" of non-linear variations when growth rate has dropped almost 4 times.

In this regard the projection authors have failed – unfortunately it became clear that they made their forecasting just during the most inappropriate moment for their methodology, when the sharp non-linear events have developed in the economy.

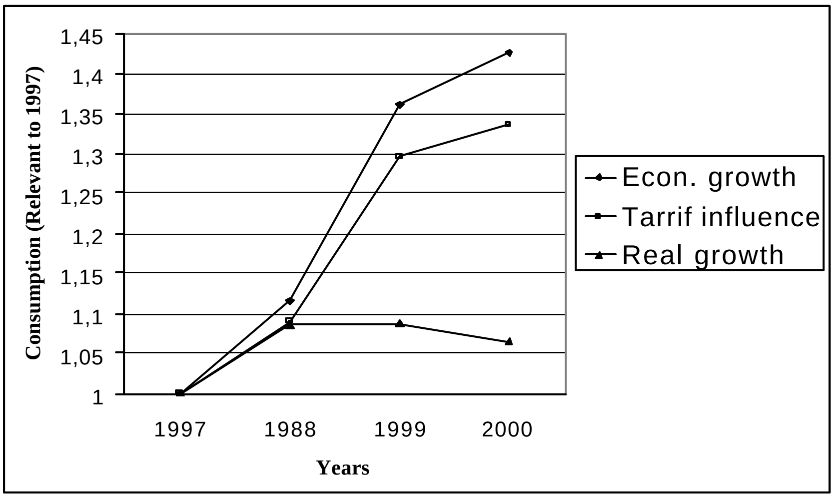


Fig. 4.5.2.2. Projected and actual growth of electricity consumption in the country in 1997-2000

The same situation is in the electricity consumption projection section (Fig. 4.5.2.2). For instance: according to the minimum growth forecasting version of CENEF, consumption increase in 1999 relative to 1998 was to be 16.7% (according to the other version it should be more) while the actual growth made only 2%. As to 2000, the consumption sizeable decrease is evident instead of great forecasted increase.

Therefore, it is evident that electricity demand projection issue in Georgia has to be solved anew. Moreover, obtaining somehow of satisfactory result is possible only based on current and anticipated large-scale non-linear events. At the same time we may suppose that the most optimal way to solve the problem is linked to the application of expert analysis on non-linear processes along with the existing evaluations.

4.5.2.3. Processes Ongoing in the Georgian Economy and Possible Principles of Forecasting

Degradation processes ongoing in the Georgian economy are clearly reflected in electricity consumption structural change according to the years (Table 4.5.2.1).

Table 4.5.2.1. Electricity consumption structure in 1990 and 2000

Sectors	1990 (billion kWh)	2000 (billion kWh)	Change (%)
Industry	8.054	0.56	-93
Agriculture	1.46	0.007	-99
Transport and communications	1.04	0.35	-66
Constructional engineering	0.31	0.20	-35
Municipal economy and services	1.20	0.445	-63
Residential (population)	2.32	2.949	+13
Others	0.003	2.507	+ ?
Total consumption	14.39	6.32 (7.02)	-51
Supply	17.45	7.85	-55

From the given data it is obvious that the Georgian economy in 2000 was still far from the renovated structural stabilization and actually was at the stage of disruption of old structure. Unfortunaly, according to last years statistics, the Georgian economy has not actually taken any important steps on the way to the formation of modern economic structure.

Enormous high level and share of electricity consumption by the residential sector clearly demonstrates this situation that on the one hand is resulted from the profound degradation of the other sub-sectors of consumption, and on the other hand it is connected with the substitution of natural gas – the major primary energy resource for the last decades by electricity. Electricity consumption further transformation would be mainly related to formation of the new structure of the economy and restoration of natural gas status as the leading energy resource (more than 60% of total initial consumption).

Out of two values given in the consumption column for 2000, the bigger one (7.02) is the figure presented in the annual energy balance of SEMEK that considers the technical losses (10.5%) of only high voltage sector of energy system (electricity transmission). Smaller figure (6.32) is determined by us as energy consumed by consumers (i.e. delivered to them) assuming that the losses in the distributing networks make on the average 10%.

Below, due to poor condition of the energy system whole infrastructure, to characterize the starting situation, total technical losses are taken as 20% of energy delivery (sum of energies from the power stations' busbars and coming and outgoing through the state border) that is close to the current norms accepted by SEMEK (10,5% on electricity transmission and 10-15% on distribution).

If consider that this parameter was equal to 12% in old, adjusted Sakenergo system that as contrast to 9% of losses in the former Soviet Union was considered as gargantuan high value and in Austria which is of the same shape as Georgia makes 5.5%, we should suppose that this important parameter after the sub-sector rehabilitation and modernization process could be decreased at least to 10%.

Also the consumption item - "others" – in 2000 with its hypertrophically increased value as compared to 1990 in the Table 1 pays attention. This fact maybe denotes the unreliability of the current static data.

While making the forecasting estimations, the following preliminary assumptions concerning the possible terms of development of the country's economy and energy system were made deriving from the entire political, social and economic condition of the country and from the above presented circumstances:

? The years of 2001 - 2002 represent a turning point in the transition of the society and state bodies from the priorities of mentality falsification and total corruption to the starting conditions of legal business development. Since 2002-2003, the real process of thorough transformation and development of the Georgian economy have started that goes under the stable international and domestic conditions. The main factor for this crucial moment is the conversion of USA-Russian relations from competition to partnership in the Region (and not only there) after the 11th of September 2001 tragedy. It is supported by the beginning of the creation by Western countries of vitally important energy arteries in our Region and the shift towards the restoration of realistic thinking in the Georgian society as well. As the major basis for that process serves, indeed, the natural, geostrategic and intellectual potential of Georgia.

? During the same period, the priorities of the state interests and the economic expediency are introduced in the management of energy system of the country and on the basis of entirely balanced energy policy starts the optimized process of rehabilitation and modernization of the country energy system remains and adoption of new trends of development, and the barriers on the way to rapid broadening of natural gas effective utilization are completely removed.

? In 2002 – 2005, improvement measures complex is introduced for commercial relations, including the privatization of the distributing networks, bringing tariffs in balance with expedient expenses and investments (possible enhancement), total payback of consumed energy fee is provided in energy natural monopolies (electricity and natural gas systems).

? Restoration process for the provision of full scale functioning of natural gas existing system will terminate in 2002 – 2003.

? In 2002 – 2004 the process of heating system transition and in 2003-2006 – hot water supply transition to the natural gas in the regions with natural gas network will come to an end, including networks modernization and providing the individual heating and hot water supply with required capacity.

Deriving from the presented assumptions, the following principal suppositions serve as a basis for the forecasting:

? Within 2001 – 2020, the Georgian economy passes three different phases: the first – bringing the investment climate into a healthy state and getting out from the economic drawdown phase on the basis of radical legislative and administrative reform (2001-2003, 2.5% annual growth rate of GDP), the second – quick relative growth phase (2004-2008, 10% annual growth rate of GDP) and the third – stable development phase (2009-2020, 5% annual growth rate of GDP).

? For the starting conditions of the disorganized and actually criminal electricity market typical for Georgia, we introduce two different meanings of electricity demand: "unbalanced demand" (that would be created in terms of fee official payment during the electricity unlimited supply) and "balanced demand" (that would be created during existing consumption structure in terms of official total repayment of electricity tax). In addition we introduce one more parameter - "conditional demand", that creates the specific comparative basis while estimating the other parameters. It equals to the hypothetic demand that could take place in recent and the current years in case of optimum structure together with fee entire payment (if electricity considerable part is not consumed for substitution of other energy resources). As to real value of electricity annual consumption throughout the recent and current periods (that equals to not one value of demand in the mentioned market conditions), it is called "consumption" and is used as a basic statistical parameter. Besides the listed parameters there is "delivery", that is required to meet the given demand considering the technical losses at the transmission and distribution stages.

? By the end of 2006, the energy system rehabilitation and modernization principal stage and optimization of electricity consumption structure would be ended (including the minimization of electricity share by natural gas application in heating and hot water supply fields), that is preceded by the improvement of commercial relations on the electricity market by 2005 and settlement of the problem related to fee complete repayment. Since 2007, the Georgian energy system transfers to the state of normal and optimally balanced from the commercial standpoint operation.

4.5.2.4. Assessment of Non-Linear Processes Impact on Electricity Demand

Fee repayment improvement process, proceeding from the existing data (results of USAID Rustavi project), causes about 40% reduction of consumption. Considering the implemented measures (among them in Tbilisi), the remaining reserves are estimated at 25% of 2000 consumption. We assume that this process will come to an end in 2005. Meanwhile, as we determine only the balanced demand, forecasting estimations by 2001-2005 are made considering this 25% amendment.

Decrease of demand for electricity resulting from step by step increase of electricity tariff, is evaluated at 10% of consumption in 2000. We assume that this process will terminate in 2007 reflected in investment tariff of rehabilitation on modernization completed in 2006.

As a result of electricity consumption structure improvement by force of restoration and enlargement of full scale operation of natural gas system, electricity demand reduction is assessed at 30% of the consumption in 2000. We suppose that this process including the restoration of natural gas role in hot water supply will be accomplished in 2006.

While determining the required delivery to meet the demand (own generation + import - export), reduction of technical losses share to the modern standards in the components of energy system (transmission and distribution) will give the additional effect that according to the existing estimations will give the possibility of 10% reduction of delivery required to balance demand. Presumably, this reserve will be put into practice in 2007 (after the accomplishment of technical rehabilitation and modernization of energy system in 2006).

4.5.2.5. Parameters of Baseline 2000

According to data presented in the Table 1, baseline consumption of 2000 made 6.32 billion kWh. Correspondingly, ensuing from our assumption, improvement of fee collection gives opportunity to reduce annual consumption of demand by 1.58 and electricity consumption optimization – by 1.90 billion kWh. Besides, deriving from the same assumptions, the impact of tariff raise could save annually 0.63 billion kWh.

Actual supply, according to the Table 1, deriving from own production, import and export balance, consisted 7.85 billion kWh in 2000.

Unbalanced demand in 2000 is evaluated by comparing 1990 data with 2000 data on energy supply in such periods when the demand was actually unlimited or existed at minimum level (summer months, New Year's days). From the analysis it became clear that the unbalanced demand of 2000 throughout 7 months of summer and autumn is half of 1998 consumption and during winter 5 months it was 1.5 less than 1990 consumption in the corresponding period. Finally, baseline 2000 unbalanced demand is estimated at annual 8.19 billion kWh. To meet this demand in 2000, in terms of 22% total losses supply was to be equal to 10.5 billion kWh.

Balanced demand in 2000 is evaluated according to unbalanced demand in view of above sited estimation of fee collection improvement possible effect. Respectively, baseline 2000 balanced demand is estimated at annual 6.61 billion kWh, with relevant supply equaling to 8.26 billion kWh. Thereafter, in compliance with our estimation, even only in case of providing fee repayment, total balancing of 2000 demand was not facing so vast amount of imports.

Conditional demand in 2000 is assessed according to unbalanced demand taking into account the above stated estimation of fee collection and possible effect of consumption structure improvement. In view of that baseline 2000 conditional demand is estimated at 4.71 billion kWh (under the appropriate delivery of 5.89 billion kWh). Thus, if optimal consumption together with fee total repayment was to be present in this hypothetic case in 2000, there will be the possibility of electricity immense export from Georgia. Hence, this parameter contains the crucial psychological function during the following analysis – it supports us not to consider projected values on demand incredibly small in a number of years ahead.

4.5.2.6. Projection Electricity Demand for 2001-2020

Balanced demand for electricity in 2000 is taken as projection starting value of electricity demand in 2001-2020 and simultaneously we consider the demand growth in conformity with estimated rates of economy development and demand reduction as a result of discussed above non-linear processes.

Besides, demand decrease by varying rate for each non-linear process is assumed within the mentioned years taking into account the corresponding stages. In particular, it is supposed that the impact of tariff increase will at every turn have an effect in 2001-2007, optimization of consumption structure – in 2001-2006 (here, uppermost, contributes the transfer of heating system to the use of natural gas that would be acomplished in 2004 and the transfer of hot water supply system to the natural gas that will terminate in 2006), normalization of network losses – in 2001-2006. As to the influence of fee repayment improvement (its full operaion is expected by the year 2005), as it has been already mentioned, it is entirely considered from the first forecasting year.

As far as the mentioned reserves of demand decrease are quite important, overall demand in the examined period could be even reduced.

Growth rate of electricity demand, related to economy development, generally, in regard to implementation of energy effeciency increase paralell process, should be less than GDP growth rate. At the first stage (2001-2007), this fact is reflected by the action of above-stated factors. Related to this fact, at this stage the estimation is made by raising of balanced demand of 2000 according to the GDP annual growth rate and by introducing the corresponding year corrections ensuing from the given factors.

As to next years (2008-2020), simultaneously with the sharp improvement of living conditions the electricity consumption additional considerable increase is expected related to wide spread of air conditioning in our climatic conditions (among them, on the basis of thermal pumps operating all around the year). Therefore, for the mentioned years, electricity demand increase rate is considered as equal to the GDP growth rate.

In the respect of the electricity consumption this assumption does not ignore the estimated effect of energy efficiency contineous increase, as the GDP specific energy content in general energy balance will be reduced on the account of specific decrease of other energy resources' consumption. Hypothetically, at the mentioned stage electricity effective utilization sphere will be enlarged that will result in more significant reduction of other energy resources consumption in the total annual balance of primary energy resources.

Forecast evaluation of electricity demand in 2001-2020 is presented in the Table 4.5.2.2. The same evaluations in a graphic form are reflected on the Fig 4.5.2.3. Below we don't repeat the expression „balancing", as according to the general principles of the market economy, demand provided by payment from the consumer side is considered in this Table.

Table 4.5.2.2. Projection of electricity demand and required supply in 2001-2020

Year	Demand, billion kWh	Required supply, billion kWh	Year	Demand, billion kWh	Required supply, billion kWh
2001	6,43	7,94	2011	10,07	11,19
2002	6,24	7,61	2012	10,57	11,74
2003	5,97	7,19	2013	11,10	12,33
2004	6,23	7,42	2014	11.66	12,96
2005	6,71	7,80	2015	12,24	13,60
2006	7,12	8,09	2016	12,85	14,28
2007	7,89	8,77	2017	13,50	15,00
2008	8,70	9,67	2018	14,17	14,74
2009	9,14	10,16	2019	14,88	16,53
2010	9,59	10,66	2020	15,62	17,36

Thus, according to the given forecast evaluation, realization of energy system commercial balancing and remission potential from its improper functions creates the demand minimum in 2003 - annual 5,97 billion kWh (for which 7.19 billion kWh supply would be required).

It is desirable that such result should not cause astonishment, as in accordance with our estimation the demand reduction potential related to only structural optimization and tariff rising equals to 2.53 billion kWh per year in total.

For the examination of given results from the methodological standpoint, more intense stress should be placed on proposed principal scheme of projection that should be considered as the major positive moment. As regards the assumptions concerning the parameters of each specific unequal process and other correlations, in this respect the given final results of estimation could be considered as one of possible examples of realization of the indicated principal approach that should not have any claim to the final estimation within the proposed frames.

Regarding the precision of obtained results, only one circumstance of the presented evaluations should be underlined – during their formation neither the demand reduction reserves are over-estimated nor the demand increase rate is taken very carefully in time. Thus, the given figures more reliably characterize the demand possible maximum increase.

Related to this fact, the most important conclusion that derives from the given results is concerning the priority of rehabilitation and modernization of the Georgian energy system existing capacities that is not still officially admitted and recognized by the public.

As it is well known, in case of realization of such process annual generation potential of our energy system will exceed 17 billion kWh by putting the minimum investments (minimum annual 9 billion kWh on HPPs of Georgia and more than 8 billion kWh on the rehabilitated and modernized units NN 3, 4, 7, 8, 9 and 10 of Gardabani TES in case of not less than 7000-hour operation per annum that is usual for them).

As long as according to the obtained results this potential meets 2010-2015 forecasting demand by the sufficiently immense reserve and also preserves the considerable export opportunities, it should be concluded that the realization of the mentioned priority has the decisive meaning for the economic development of the whole country.

We should hope that the presented forecast evaluation will attract not only specialists' interest, but also will become the subject of further refinement and will gain multi-version holding of the productive content. In this regard, each of non-linear processes should become the object of detailed examination and modeling. Here we witness vast area for the fruitful collaboration of energy, economy and modeling experts.

5. INDUSTRY SECTOR

5.1. STATE OF GEORGIAN INDUSTRY SECTOR IN 1990 AND 2000

5.1.1. Industry Sector by the State of 1990

Industry is the leading sector of the Georgian national economy that is destined to produce not only great bulk of compound output in GDP, but also to create favorable terms for development of other sub-sectors of national economy at the high technological level. Proceeding from the sub-sector specific character and in case of proper integration in the international economic relations, industrial complex of the country could become the basic, reliable and in point of fact unlimited source for the continuous increase of the national produce.

Despite the fact that the Georgian industry had been irregularly developing for some decades, by 1990 it was represented by almost entire spectrum, possessing a powerful research base and it was provided with qualified industrial and scientific staff. About 460 thousand people were engaged in the electricity. Industrial product made 65% of the GDP and provided more than 40% of the national income, it got more than half of the profit from all sub-sectors of economy.

The following high-end technologies such as airplanes, electric locomotives, cars, powerboats, machinery for agriculture and food industry, metal-cutting tools, tower cranes, items of microelectronics and information-processing technology and other numerous technical and household articles were produced in the electricity. Furthermore, types of various kinds outputs were produced in the enterprises of chemical, metallurgical, mining, food and light industry. Existing industrial capacities were used within 85-95%. 65-75% of produced goods were intended for export.

The structure of industry sector of the country was mainly comprised electric-power industry, fuel industry, ferrous and non-ferrous metallurgy, chemical and oil-processing industry, machine-building and metal-working, timber, woodworking and cellulose-papermaking industry, constructional materials industry, food industry, light industry and other sub-sectors of economy. Industrial products costing 12 billion rubles (about US$ 6 billion) were manufactured by the above-listed sub-sectors in 1990. Specific share of produces of separate sub-sectors in total industrial output is presented in the Table 5.1.1.

Table 5.1.1. Specific share of individual sub-sectors in total output by the state of 1990

Sub-sector	Specific share, %
Ferrous metallurgy	3.7
Machine building and metal-working	14.3
Chemical and oil processing industry	4.4
Constructional materials industry	5.1
Timber, woodworking and cellulose-papermaking industry	3.3
Light industry	21.2
Food industry	37.4
Electric-power and fuel industry	3.5
Other sub-sectors	7.1
Total	100.0

The mentioned indices more or less correctly demonstrated the real state of demand and delivery relationship by this period. Power and fuel industries can be regarded as exception. Their low specific share was resulting from low prices on electricity and fuel.

Till 1990, Georgian industry had been developing according to the decisions made by the governing bodies of the Soviet Union that were disregarding the local conditions, reasonable use of raw materials, manpower recourses and others. As a result of these decisions, numerous industrial enterprises (in the 50-80s, more than 100 enterprises were constructed only in machine-building) with enormous capacities (Rustavi Metallurgical Plant, Kutaisi Automobile Plant, Gori Cotton Factory, Rustavi Chemical Fibre Plant, etc.) were put into operation. Raw and auxiliary materials necessary for the most enterprises were imported from the various regions of the Soviet Union while domestic materials, processing of which to the final product was more profitable for the country (manganese, copper, gold containing quartzite, etc.) were imported from Georgia. The aforementioned tendency of industry development was destructive for the Georgian villages seeing that the workers required by the enterprises were deserted the villages so as to work in the factories. Moreover, it has to be underlined that the inner infrastructure of the country has been developing along with this huge construction process. Though, in conclusion, industry development process was incorrectly going in Georgia, without any scientific planning, damaging the country and based on compulsory integration that brings great detriment to it after declaring independence and its correction will take a lot of time.

450 deposits with reserves registered on the state balance comprise Georgian mineral and resource potential the value of which, according to experts assessment, is estimated at US$ 55-60 billion and under the optimistic estimation it exceeds US$ 90 billion.

Manganese, copper, fireproof argil, dolomite, fluxing limestone, molding sands and other minerals necessary for developing the metallurgical industry are spread over the Georgian territory. Among them should be mentioned manganese and copper deposits. 90.7% (245 million tones) of manganese ore is still accumulated in Chiatura reservoir. Prospected reserves are enough to meet the demand of manganese processing industry of the country for 50-60 years.

The country holds copper, zinc, gold, silver, arsenic and other mineral deposits necessary for developing the non-ferrous metallurgy and gold mining industry. Among them should be emphasized copper polymetal deposit. At the present time, its reserve equals to 213.5 thousand tones of metal copper that will provide industry for 20-25 years.

The following minerals required for the mining industry are being recovered in Georgia: barite, andesite, benthonic clay, diatomite, calcite, mineral paints, talcous, etc. Among them the barite deposits are quite important. They mainly consists of Chordi (Zemo Racha), David Gareji (Kvemo Kartli) and other mineral beds. Total barite reserve makes 9174 thousand tones. Benthonic clay deposits are widely distributed as well. Their total reserve equals to approximately 17 million tones. Arsenic deposits have to be especially underlined. Diatomite of Kisatibi deposit located in Akhaltsikhe region is not worse with its quality than the famous diatomite from the Lampoke deposit (USA). Furthermore, the country has vast reserve of raw materials for the development of chemical and pharmaceutical industry.

There is considerable base of raw materials in Georgia to develop the building materials industry. In particular, three deposits of limestone total reserve of which makes 200 million tones and three deposits of clay (75 million tones) are revealed for cement industry. These deposits will provide cement industry for more than 50 years. About 60 deposits of clay for the brick production with 46.5 mln.m^3 of clay reserve will provide the country over 20 years.

Georgia is rich in pearlite (the Paravani deposit), reserves of which constitute 14 million m^3. This mineral is widely used in the various sub-sectors of industry (food industry, constructional materials industry, etc.). Increase of export demand for this mineral is expected.

Facing stones reserves (marble, marble like limestone, teschenite, tufa) are prospective due to their industrial value and qualitative properties. Deposits of gypsum, drywall, ceramic clays, chalk limestone and other constructional materials make the considerable base of raw materials as well.

Both qualitative and quantitative supply of electricity to the industrial enterprises was provided till the end of 80’s. By 1990, industry sector had consumed 8055 million kWh of electricity annually or 56.5% of total electricity generated in the country, agriculture had consumed 14.8% and population – 11.0%. Losses in the grid made 18.6%. By this time the largest electricity consumers were: Rustavi Metallurgical Plant, Zestaponi Ferroalloys Plant and Rustavi Chemical Enterprise. Agreements between electricity supplier (Sakenergo) and consumers were periodically signed in the 80’s that was ignored from the supplier side. Emergency blackout and electricity supply in compliance with standard parameters that damages industrial enterprises regularly takes place.

5.1.2. Industry Sector by the Year 2000

Unbearable political and economic situation created after 1990 has greatly damaged the national economy and especially, the industry. The vast deal of industrial enterprises had stopped operation and only few of them were periodically acting under the inconsiderable loading. Specific share of industry was two fold and more times reduced in the GDP structure of the country. Old economic relations were destroyed, significant portion of fixed capital stocks were plundered during the civil war and as a result of tremendous criminogenic situation. In such conditions industry of the country has reached the critical point in 1994; there was a real danger for total deindustrialization. Political and economic stabilization measures implemented in the country at that time, carrying out of partial economic reforms created the definite prospect for the revival of industrial complex of the country. Great parts of the enterprises became privatized and were transformed into joint stock companies. Economic mechanisms, legislative measures to create macroeconomic environment had occupied the leading place in state regulation system of the industry. Proceeding from this downward tendency of the industry was stopped and some rise of industrial production was noted, though it is notable back than 1990 level.

Despite the mentioned positive trends, current situation in the industrial complex of the country is crucial. Industrial capacities of separate sub-sectors are loaded only by 5-10%. Average number of employees, according to the main activities, engaged in the industry sector is 5 times less than in 1990. Their number totaled 94.4 thousand persons by the end of 2000, but the number of actually working persons was rather less.

Keeping and putting into operation of individual enterprises of light industry, timber industry, machine-tool construction, agricultural and transport engineering industry, instrument-making industry, electrical engineering and defense industry and numerous enterprises of other sub-sectors was put under question due to loss of local and international markets, lack of fixed assets, inaccessibility to the bank credits, helpless credit debits and consequently to the impossibility of industrial restructurization, reconstruction and to the absence of funds required for manufacture of competitive products.

Scales of industrial capacities' operation are still inconsiderable. Good deals of enterprises are not able to provide the profitable activities. Downward tendency of foreign investments had occurred in the industry during last period. Negative influence of shadow economy on the industry rehabilitation process is momentous. Specific share of unregistered products in the industry exceeds 45%. Output produced in the legal sector can not compete with the same kind of duty free output produced in the shadow sector, the smuggled produce or with the output imported in dumping prices.

Acting tax and customs codes create the additional difficulties for the industrial enterprises that as well are in the severe economic conditions. Debts for the previous years lay as a heavy burden on the industry, overcoming of which even in case of attraction of notable amount of investment is problematic on the example of separate enterprises ("Kaspicement", "Maudi", etc.). Moreover, the great part of acting enterprises that are established under the partial share of the state is not profitable and majority of privatized enterprises (especially sold at the zero auction) are not operating at all.

By the state of 2000, 2840 enterprises were operating in the electricity. Out of them 797 ones or 28.1% of the total number of the enterprises were not operating by the end of this year. According to the data obtained from the State Department on Statistics, the volume of the output generated in the industry sector made 1051.8 million GEL in the established prices and including output generated by the informal and shadow industry it equals to 1918.2 million GEL (expert estimation) that exceeds by 6.1% the actual level of the previous year. Furthermore, it has to be mentioned that the level of 2000 is only 18.5% of 1990 level, though output of the industrial produces has increased almost by 5% as compared with extreme decrease of industry in 1995.

By the year 2000, specific shares (%) of individual sub-sectors in the volume of the total output generated by the industry are presented in the Table 5.1.2.

Table 5.1.2. Dynamics of the sub-sector structure of the industry in 1990-2000

Years	1990	1995	1996	1997	1998	1999	2000
Industry in total Including:	100	100	100	100	100	100	100
Energy sector	3.5	26.7	24.2	31	34	32.7	35.2
Main sub-sectors of the industry	55.3	34.1	31.2	28.1	31.3	32.9	34.7
Food industry	41.2	39.2	44.6	40.9	34.7	34.4	30.1

As it is evident from the Table, the share of energy sector in total volume of the industry was increased 10 times that was mainly caused by raising of tariffs on energy carriers and considerable decrease of specific share of industrial production. Specific share of food industry was reduced from 41.2% to 30.1% and specific share of the main sub-sectors of industry – from 55.3% to 34.7%.

Under our assumption, such structural change of the sub-sectors (taking place by the year 2000) is unacceptable for the development of national economy. Numerous measures that would promote the revival and development of the main sub-sectors of the economy within the short period of time (attraction of foreign investments, amendment of tax and customs activities, regulation of intrusion of smuggled and dumping goods on the local market) should be implemented in the state and private sector as well.

The approximate description of changes ongoing during last decade in the Georgian industry sector is possible based on GHG emissions data obtained from the different sub-sectors of the sector. The 1990 data are basically based on GHG national inventory materials presented in the Initial National Communication of Georgia under the UNFCCC [16]. 2000 data are obtained as a result of approximate calculations carried out according to the inventory acting methodology [19, 20, 21], and based upon official state statistic data as well as on the critical analysis of the initial information collected directly in the separate enterprises [7, 10].

General features of GHG emissions from the Georgian industry sector in 1990 and 2000 describing the share of the main sub-sectors of industry is given in the Tables 5.1.3 and 5.1.4.

On account of the fact that 2000 GHG inventory data for Georgia do not still exist, the inventory data of 1997 are taken as total emission for the conditional assessment, according to which CO_2 total emission that year was equal to 9.177 teragram, relative to which the 2000 industry sector emission makes 20.8%.

Table 5.1.3. GHG emissions from the Georgian industry sector and subsectors in 1990

Emission source: Sub-sectors of industry	Emission, Tg/%	
	CO_2	Total GHG emissions in CO_2 equivalent
Total from the industrial processes including emissions resulted from heat- and power supply together with "net" technological emissions, among them:	14.2063 100	16.658541 100
1. Metallurgical production in total, including:	9.718219 68.41	9.784087 58.73
1.1. Iron and steel industry	8.798995 61.94	8.864163 53.21
1.2. Ferroalloy industry	0.919224 6.47	0.919924 5.52
2. Engineering and metal-working industry	0.617161 4.34	0.675342 4.05
3. Chemical industry	1.16838 8.22	1.843407 11.07
4. Constructional materials industry	1.04125 7.33	1.30623 7.84
5. Timber, woodworking and cellulose-paper industry	0.09653 0.68	0.122511 0.74
6. Light industry	0.16124 1.14	0.209290 1.26
7. Food industry	0.83568 5.88	1.02234 6.14
8. Other industrial sub-sectors	0.56784 4.0	1.6953343 10.18

Table 5.1.4. GHG emissions from the Georgian industry sector and subsectors in 2000

Emission source: Subsectors of industry	Emission, Tg / %	
	CO_2	Total GHG emissions in CO_2 equivalent
Total from the industrial processes including emissions resulted from heat- and power supply together with "net" technological emissions, among them:	1.200720 100	1.91308 100
1. Metallurgical production in total, including:	0.20847 17.36	0.208702 10.91
1.1. Iron and steel industry	0.009947 0.83	0.010022 0.52
1.2. Ferroalloy industry	0.198521 16.53	0.19868 10.39
2. Engineering and metal-working industry	0.00512 0.43	0.0056 0.29
3. Chemical industry	0.588122 48.98	1.185778 61.98
4. Constructional materials industry	0.20893 17.4	0.2779 14.53
5. Timber, woodworking and cellulose-paper industry	0.0072 0.60	0.0076 0.40
6. Light industry	0.015 1.25	0.0165 0.86
7. Food industry	0.15078 12.56	0.1889 9.87
8. Other industrial processes	0.0171 1.42	0.0221 1.16

The fact that the volume of the industrial production is directly connected with the energy resources consumption that from its side is reflected in the total GHG emissions has to be considered during the analysis of information presented in last two Tables. On the score of the fact that new energy efficient technologies were not adopted in the major part of Georgian industry sector within last decade, total emissions reduction could be used as the indices demonstrating the decrease of industrial production, evaluation of which relying on the above given Tables is presented in the Table 5.1.5.

Table 5.1.5. Reduction of energy consumption and GHG emissions in the Georgian industry sector according to 1990 and 2000 data

Industry subsectors	Total energy consumption, 10^{12} J		Energy consumption reduction factor	Total emission equivalent to CO_2, 10^3 t		Emission reduction factor
	1990	2000		1990	2000	
1. Ferrous metallurgy in total	43763	649	67.4	9784.087	208.702	46.9
1.1 Rustavi Metallurgical Plant	31064	36	863	8864.163	10.022	884
1.2 Zestaponi Ferroalloys Plant	12699	613	20.7	919.924	198.680	4.6
2. Metal-working and engineering industry	11152	35	319	675.342	5.63	120
3. Chemical industry	8965	6997	1.3	1643.200	530.910	3.1
4. Constructional materials industry	7663	2276	3.4	1306.200	352.700	3.7
5. Timber, woodworking and cellulose-paper industry	1243	75	16.6	122.511	28.180	4.3
6. Light industry	1479	86	17.2	209.290	41.860	5.0
7. Food industry	8960	2222	4.0	1022.341	306.800	3.3
Total	83225	12340	6.7	14762.971	1474.772	10.0

From the data presented in the Table it is evident that disintegration of the Soviet Union and demolition of so called “planned economy” fatally impacted on the main enterprises of ferrous metallurgy – Rustavi Metallurgical Plant, as well as machine-building and metal-working sub-sectors. Emission level from these sub-sectors was decreased 884 and 120 times, respectively. In contrast to the Rustavi Plant, the same parameter for Zestaponi Ferro Plant was equal to 4.6 that indicate on relative viability of this sub-sector of industry. The average value of mentioned indices in the industry sector is 10.0, though its mean value for the other sub-sectors of the industry except metallurgy and engineering equals to 3.9. This parameter is rather high and indicates that the Georgian industry sector is still in the critical condition.

There are numerous conditions that are causing the above stated situation. Among them could outlined three groups of reasons – economic, organizational and technological. Let’s discuss each of them.

High prices (as compared with the Soviet period) on energy resources, fixed among the former Soviet republics as a result of establishing market relations after disintegration of the Soviet Union, takes one of the major place among the economic reasons. By 1990, Georgia was more or less provided only with electricity due to the sufficient development of hydro energetics, though import of 25% of such kind of consumed energy was still required in order to meet the demand of the Republic. As to fossil fuel, it was entirely imported from the other republics, mainly from Russia, Turkmenistan and Azerbaijan.

Lack of raw material and absence of market are not less important factors. Georgian industry sector was supplied with raw material actually from all republics of the Soviet Union that was the result of politically deeply motivated socialist principle of inner-subsector cooperation. Mostly it applied to sub-sectors of metallurgy and machine-building and for that reason these sub-sectors suffered the most dramatically by the beginning of the 90’s. Breakdown of Soviet internal cooperation system less impacted the sub-sectors using the domestic raw materials, namely, food, timber and constructional materials industries. Though there arose other barriers connected with taxation and searching for the market problems. The great part of industrial output produced in Georgia that was characterized by high energy and raw materials consumption and poor quality, was easily finding the market at the large territory of the Soviet Union protected from the foreign imports. Opening of the borders after the disintegration of the Soviet Union has raised problem related to the competitiveness of local produce at the world market that has led a lot of enterprises to the bankruptcy and liquidation. Therefore, there is necessity to introduce the advanced technologies in the country as solution of this problem has economic, social and political significance. Most enterprises survived the collapse and liquidation throughout the 90’s managed to adopt the advanced technologies, produce competitive commodities and succeed at the local and international markets in cooperation with foreign investors. First and foremost, there should be named numerous of enterprises, including in the food industry sub-sector, that are using the domestic raw materials and are producing wine, beer, nonalcoholic beverages, milk and tea.

The second group of reasons has an organizational feature. Union planning committee and republic departments under this committee were managing economy development in the socialist system that excluded any private initiative. The last one was possible after removing the huge barriers only for small-scale enterprises within the possibilities of the local industry.

Privatization process has begun in the industry and in the other sub-sectors of the economy after the breakdown of the socialist system. Implementation of the privatization and making use of its results was quite unusual for staff brought up in the Soviet period. The mentioned barriers were rather easily surmounted for the small enterprises set up by the beginning of the 90's, but as to big enterprises this process complicated because of numerous reasons; and for some enterprises it has not terminated yet.

For example, the owners of the most important enterprises such as Rustavi Metallurgical Plant, Rustavi Chemical Plant "Azoti", Kutaisi Automobile Plant and others have not been defined yet. On account of this uncertainty, the technical reequipment of these enterprises, transferring to the modern technologies, searching for the market and other procedures are being protracted until now and therefore the industry sector is actually in active state that in its turn results in social strain and worsening of criminal situation. This condition increases the risk factor and makes Georgian economy less attractive for the foreign investments.

Among the organizational barriers imperfection of legislative base acting in the country, together with uncertainty in forms of ownership on the property, is very important that in the most cases delays industry development process and at the same time it becomes the vigorous source for corruption. Primarily, here have to be named the notable shortcomings of taxation system that constrain producer manufacture unregistered output. Consequently, by 2000 according to the various assessments, "shadow economy" has covered 50-70% of total industry that makes statistical data in the industry sector unreliable.

Issues related to technological backwardness of the main sub-sectors could be attributed to the third group of reasons of the inactivity of electricity. As it is known, because of huge amount of fuel and energy resources and raw materials, Soviet economy was characterized by rather low energy efficiency and by inefficient consumption of raw materials that was resulted from the application of old-fashioned technologies and equipment. Isolated local market and non-competitive environment created no necessity to adopt any novelties. Therefore, Georgia entered the transitional period practically unprepared – during the civil war (1992-1994) majority of the enterprises were robbed and destroyed. Outdated devices that could not produce competitive products are remained in the enterprises survived this process.

For example, Kaspi cement plant – one of the objects of cement industry has not been operating since 1997 due to its low efficiency. Some thousands of million US$ investment is required for its modernization and re-equipment. As to the second acting object – Rustavi cement plant, about US$ 130 million is necessary to improve its efficiency up to the modern level and for this reason numerous organizational and technical barriers should be removed. This issue is examined more detailed in the relevant chapter.

Despite the above discussed problems, total volume of industrial produce has increased in 2000 by 107.9 million GEL or by 6.1% in comparison with the year of 1999. According to the main activities, the share of the separate sub-sectors in the volume of the industrial output was distributed in 2000 as follows:

- Manufacturing industry – 54.7%;
- Electronics/electronic engineering, natural gas and water supply – 38.7%;
- Mining industry and surface mines processing – 6.6%.

By the year 2000, as compared with the previous year, production volume in the mining industry has increased by 75.6%, in manufacturing industry – by 10.7% and in power industry – by 4.7%.

In accordance with the same data, 2436 small industrial enterprises (up to 40 persons were engaged) were operating in Georgia by the year 2000 that makes 85.8% of total number of registered enterprises. According to the main activities (industry), the volume of the output and the services was equal to 161.3 million GEL or 15.3 % of the total industrial product volume of the main production. The volume of output and the services as compared with the previous year (1999) has increased by 11.4%.

Based upon the given information, it could be concluded that the Georgian electricity, which was impacted as a result of disintegration of the Soviet Union in 1991, is still under collapse in 2000 and has not transformed yet to adopt successful and flexible mechanisms typical for new types of industrial relations. Despite this fact, the crisis has been overpassed in some sub-sectors and efficient functioning of enterprises has been provided in terms of market economy.

5.1.3. Examples of the Revival of Individual Sub-Sectors of Industry

Among the previously acting enterprises JSC "Ferro", JSC "Madneuli", JSC "Rustavcementi", JSC "Azoti", specific enterprises of food industry (wine material, beer, mineral water production, etc.), some enterprises of constructional material industry and others are more or less effectively operating. Viability of the listed enterprises is mainly conditioned by the export demand for their output (ferroalloys, copper concentrate, nitric fertilizers and mineral water). It has to be mentioned that export of copper concentrate almost equivalent to the export of raw materials, therefore technology for local processing should be created.

According to the tendency formed during last time, predominantly small and rarely medium sized enterprises are set up in the country, large part of them are producing articles of food. There are a lot of such enterprises operating in the industry. Among them beer productions ("Kazbegi"), tea processing factories ("Martin Bauer"), shoe industry ("Isani-Kartu") and others are operating highly productively. There are following reasons for success of these and other small or medium enterprises that are mainly established thanks to the foreign investments: mobility, high labour grade, adequate level of management and marketing, effective utilization of raw materials, energy resources and auxiliary materials, high quality of manufactured commodities, etc.

Despite the difficulties created in Georgia, production of industrial output is characterized by increasing tendency in 1996-2000 as compared with the year of 1995 that according to three main activities of the industrial enterprises is presented in the following Table.

Table 5.1.6. Increasing indices of industrial production in comparison with 1995 (%)

Sub-sectors of economy	1996	1997	1998	1999	2000
Industry, overall	108.4	117.3	115.2	123.7	137.1
including:					
1. Mining industry and surface mine processing	139.1	114.9	102.3	115.6	203.0
2. Manufacturing industry	108.9	123.4	115.9	125.9	139.4
3. Electricity, natural gas and water supply	103.0	106.0	112.3	118.3	123.9

As it is evident from the Table, production volume has sizably increased by 2000 as compared with 1995, though industry sector of the country is quite far from the desirable result. Dearth of output products, competitiveness (low quality of export goods) and what is all-important, application of old-fashioned and depreciated techniques and technologies are considered. For instance, after the 90's, ensuing from the created situation, re-equipment of machinery and technology had not taken place in the enterprises of almost every sub-sector of the industry sector (expect only few ones) and consequently output products are mainly characterized by low competitiveness and high prime cost. Thanks to this fact the major part of the factories are unprofitable. For example, JSC "Chiaturamanganum" (11 026 thousand GEL), JSC "Kutaisi Automobile Plant" (3 475 thousand GEL) and others appeared at a loss in 2000. It has to be emphasized that unprofitableness of the enterprises is not resulted only from the absence of technical re-equipment.

Large enterprises of the industry sector require technical re-equipment, including JSC "Madneuli" seeing that 75-80% of its fixed capital stock is obsolete and adoption of new technologies is necessary to process open-cast mines. The situation is same (from the re-equipment standpoint) in JSC "Kutaisi Automobile Plant" and in JSC "Saktractori".

As to JSC "Kaspicementi", it appeared under the property of tender winner company "Intertrans" (owner of 50.6% of share capital). New owner performs rehabilitation works for the basic assets (due to the absence of great amount of investments, entire technical re-equipment of the factory is not possible) and in the nearest future the enterprise will be in operation. Investor has allocated 4 270 thousand GEL for the rehabilitation and re-equipment of the enterprise in 2000-2002 and about US$ 7 million of investment is foreseen by 2000-2005.

Morally outdated and physically obsolete processing facilities are installed in the most enterprises of the industry, bulk of them is more than 30 years old (Rustavi Metallurgical Plant, Rustavi JSC "Azoti", JSC "Ferro", JSC "Madneuli", Kutaisi Automobile Plant, Kutaisi Lithopone Factory, Zugdidi former papermaking mill, JSCs "Rustavcementi" and "Kaspicementi", food and light industry enterprises, etc.).

Industry can not develop with the aid of existing technique and technologies. Urgent restructuring of industrial enterprises (division into independent small enterprises) and their privatization (the state should promote acceleration of this process) is necessary. Later their owners would decide themselves the future development prospects of the enterprises.

By last time the definite positive steps (though on the limited scale) were taken in order to put the industrial enterprises into operation.

As it was indicated above, 2840 industrial enterprises were operating in 2000, out of them 2436 ones were small enterprises. 85.8% of total number of industrial enterprises are under the private property. According to the results of statistical research, 57.3% of the enterprises were operating in the state sector and 42.7% – in the private sector. Among the small enterprises, only 14.5% were acting in the state sector and 85.5% – in the private sector.

It should be noted that the volume of output produced in the state sector equals to 58.5% of the total industrial output and output produced in the private sector – to 41.5%.

The beginning of partial operation of the following big and medium enterprises such as JSC "Madneuli", JSC "Ferro", "Kvartsiti" Ltd, JSC "Rustavcementi", JSC "Isani-Kartu", JSC "Maudi" and others could be considered as positive shifts that have been commenced in the industry sector since 1995. Bulk of output produced by these enterprises is mostly meant for export. Specific share of export production in the output produced by the industry sector is continuously increasing and by 2000 it has reached 26%.

Putting of small enterprises into operation is positive event as well. At the present time, hundreds of small enterprises are functioning specific share of which in total volume is within 30%. As it is obvious from the analysis of current processes, this tendency would gain the momentous in the future.

Major part of the acting enterprises are mainly using domestic raw materials, among them are – JSC ”Ferro” (manganese concentrates from the Chiatura basin), JSC ”Madneuli” (from the local copper-pyrite deposits), “Kvartsiti” Ltd (gold containing quartzite from JSC “Madneuli”), JSC “Lithopone Factory” (domestic raw materials), etc. JSC “Azoti” is only one big enterprise that operates on exported raw materials (natural gas is exported from Russia).

It is evident that local raw materials are profitable for successful operation of the enterprises, though there are some sub-sectors (engineering, metallurgy, light industry) that are not able to operate without exported materials.

Among the numerous reasons that hamper stable functioning and development of the industry in the country, one of the main obstacles is intermittent supply of electricity and its unconformity to the standards that often causes partial or complete stopping of the enterprises. Consequently, expensive processing facilities are appearing out-of-commission that results in millions of GEL losses to the enterprise as well as to the budget of the country.

Issue related to the energy resources (including electricity) supply was examined on the example of some large industrial enterprises. In particular, according to the existing data, 1006.8 furnace/day has been missed in JSC “Ferro” of Zestaponi in 2000 as a result of breaks in electricity supply. Consequently 35700 tones of ferromanganese was not produced (marketable produce costing 26.8 million GEL). Blackouts of electricity caused damage to metallurgical and mechanical parts of 21 electric furnaces. 1.5 million GEL is required for its restoration. By this period, total loss of the enterprise exceeded 38 million GEL that considerably worsened financial state of the plant.

The same situation was at the Rustavi JSC “Azoti” the largest electricity consumer of the country that was operating under the medium loading in 2000. Electricity frequent switching off, voltage dropping and fluctuation that decreased output production and caused great losses to the enterprise. For instance, losses due to electricity blackout made 6.7 million GEL in 2000 and consequently the factory was not able to produce 70 000 tones of ammonium nitrate in a year, causing the acute shortage of fertilizer supply to the rural economy. Reasoning from this, in 2000, the enterprise had lost opportunity to produce product costing more than 11.5 million GEL, furthermore according to the results of accounting year, JSC “Azoti” became unprofitable and the loss was equal to 3.5 million GEL.

It has to be noted that in September 2001 the international gas distributing company “Itera” became shareholder of JSC “Azoti”. Considering the fact that natural gas is basic raw material for JSC “Azoti”, we hope that new owner should arrange qualitative and uninterrupted supply of electricity to the enterprise that has represented a question for permanent debate between supplier and consumer until now.

The situation was not better in “Chiaturamanganumi”. Because of broken supply with electricity, production was stopped 41 times only in October and November of 2000. Electricity supply was completely ceased from December. Because of this fact, factory could not produce marketable product costing 13.7 million GEL. Due to low quality of electricity, losses resulting from damages to the processing facilities were equal to 280 thousand GEL.

The same situation is in the other big and middle-size enterprises of industry. In particular, according to data of 2000, due to breaks in electricity supply and its low quality JSC “Madneuli” had lost more than 160 thousand GEL, JSC “Kutaisi Automobile Plant” – 25 thousand GEL, JSC “Saktraktori” – 186 thousand GEL, JSC “Elektomekanikosi” – 165 thousand GEL, JSC “Orioni” 115 thousand GEL, etc.

The fact that bilateral agreement has not been still signed between electricity provider and consumer that releases contractor from an obligation to recoup consumer for losses and that creates crushing terms for the enterprises is one of the reasons of this grave condition.

As evidenced from the foregoing, nonsystematic supply and its improper parameters of electricity have created a danger for stable functioning of an industry. Owing to this fact the industry sector was not enable to output products costing about 80 million GEL and could not contribute more than 20 million GEL to the state budget in 2000.

However, it should be mentioned that power suppliers from their part have reasonable claims against some large consumers concerning the repayment of electricity bill. For example, due to systematic nonpayment for the consumed electricity JSC “Azoti” had more than 60 million GEL delinquencies by the end of 2000, JSC “Rustavi Metallurgical Plant” – 869.7 thousand GEL, JSC “Kaspicementi” – about 150 thousand GEL, JSC “Electromechanikosi” – 11.6 thousand GEL, JSC “Madneuli” – 700 thousand GEL, “Tbilaviamsheni” Ltd – 118 Ltd, etc. The generation of required amount of superior quality electricity is quite impossible under these circumstances.

It has to be underlined that electricity is not effectively consumed in the industry. Its consumption share in output prime cost is quite significant (it varies up to 5-30%) and that is one of the factors defining low competitiveness of local output. Analysis of consumed electricity specific share per GEL of industrial product produced in 1990 and 1997 shows that ratio among them has considerably changed. In particular, according to the relevant re-calculation, 0.67 kWh was consumed per GEL marketable products production in the industry by 1990 while 1.16 kWh was consumed in 1997 or in other words electricity consumption has been 1.7 times raised. The main reasons for this seems to be the significant increase of shadow economy, depreciation of fixed assets, application of old-fashioned technologies, ineffective consumption of electricity, blackout and poor supply of electricity.

5.1.4 Regional Features of the Industry Sector Functioning

The country was divided into administrative-territorial regions in 1994. According to that Georgia consists of two autonomous republics and 10 regional units. Aforesaid regions have significant industrial potential and they had important share in the national economy development.

Below presented diagram illustrates specific share of large industrial regions of the country, the total volume of output is rather high in comparison with the other regions (Fig. 5.1.1).

Given diagram shows that in the past decade, the processes ongoing in all regions were more or less the same as in the whole industry sector – drastic production decrease in 1991-1994 and its gradual increase since 1995. At the same time, fundamental differences can be noted between the regions. Specifically, the Kvemo Kartli region is characterized by the most rapid and stable rates of industrial development, where the output volume of 1994 was decreased till 70 million GEL, and by the year 2000 it exceeded 254 million GEL that is 3.6 times more than the maximum level of decrease. Almost the same situation is in the Imereti Region, where the output volume was 2.5 times increased in comparison with the minimum of 1994. Shida Kartli region is characterized with the highest rate of the industrial output increase, where the production volume was 10 times increased as compared with 1994, though this region with its absolute value of output is considerably back than the indices of Imereti and Kvemo Karti regions.

Among the discussed regions Ajara and Kakheti are characterized by the smallest industrial production volume. Moreover, if production volume in Kakheti was 5 times raised in comparison with 1994, in Ajara this value was increased only insignificantly. In 1996-1997 almost all regions are characterized by maximum increase of production that was followed by the notable decrease in 1998. Taking into account close relationship of Georgia with the Russian economy, this condition is resulted from the influence of financial crisis occurred in the Russian Federation in 1998. As for Tbilisi data, character of its production variation is analogues to the most developed industrial region – Kvemo Kartli. In 2000 the production volume constituted only 20% of 1990, though it has been continuously rising since 1993. Production was rapidly growing (47-43%) in 1995-1996 and 1999-2000, but its rate was slowed down (2-4%) in 1997-1999.

Data, according to the state of 1998, on distribution of manufactured output volume among the enterprises of the state and private sectors through the different regions is given in the Table 5.1.7. The Table shows that the several regions that are not even included in the data of the Fig. 5.1.1 due to insignificant volume of industrial output (Guria, Samtskhe-Javakheti) are characterized by quite high share of the privatized enterprises (approx. 70%). This index surprising appeared quite low in two strongest industrial regions – Kvemo Kartli and Imereti (correspondingly 41 and 34%). The share of the private sector is sufficiently high (63%) in Tbilisi that could be considered as one of the factors promoting the continuous growth of output.

Table 5.1.7. Output of the products according the forms of property by 1998

Name of the region	mln. GEL in total	Including			
		State		Private	
		mln. GEL	%	mln. GEL	%
Tbilisi	812.6	301	37.0	511.6	63
Ajara	146.6	109.5	74.7	37.1	25.3
Guria	13.7	4.0	29.0	9.7	71.0
Racha-Lechkhumi and Kvemo Svaneti	7.1	4.0	29.0	9.7	71.0
Samegrelo-Zemo Svaneti region	90.3	42.6	47.1	47.7	52.9
Imereti	136.4	90.3	66.2	46.1	33.8
Kakheti	25.5	9.7	38.2	15.8	61.8
Mtskheta-Mtianeti	33.5	21.5	64.0	12.0	36.0
Samtskhe-Javakheti	19.1	6.1	31.8	13.0	68.2
Kvemo Kartli	191.4	113.5	59.3	77.9	40.7
Shida Kartli	54.2	25.0	46.2	29.2	53.8
Georgia in total	1692.5	888.5	52.5	804.0	47.5

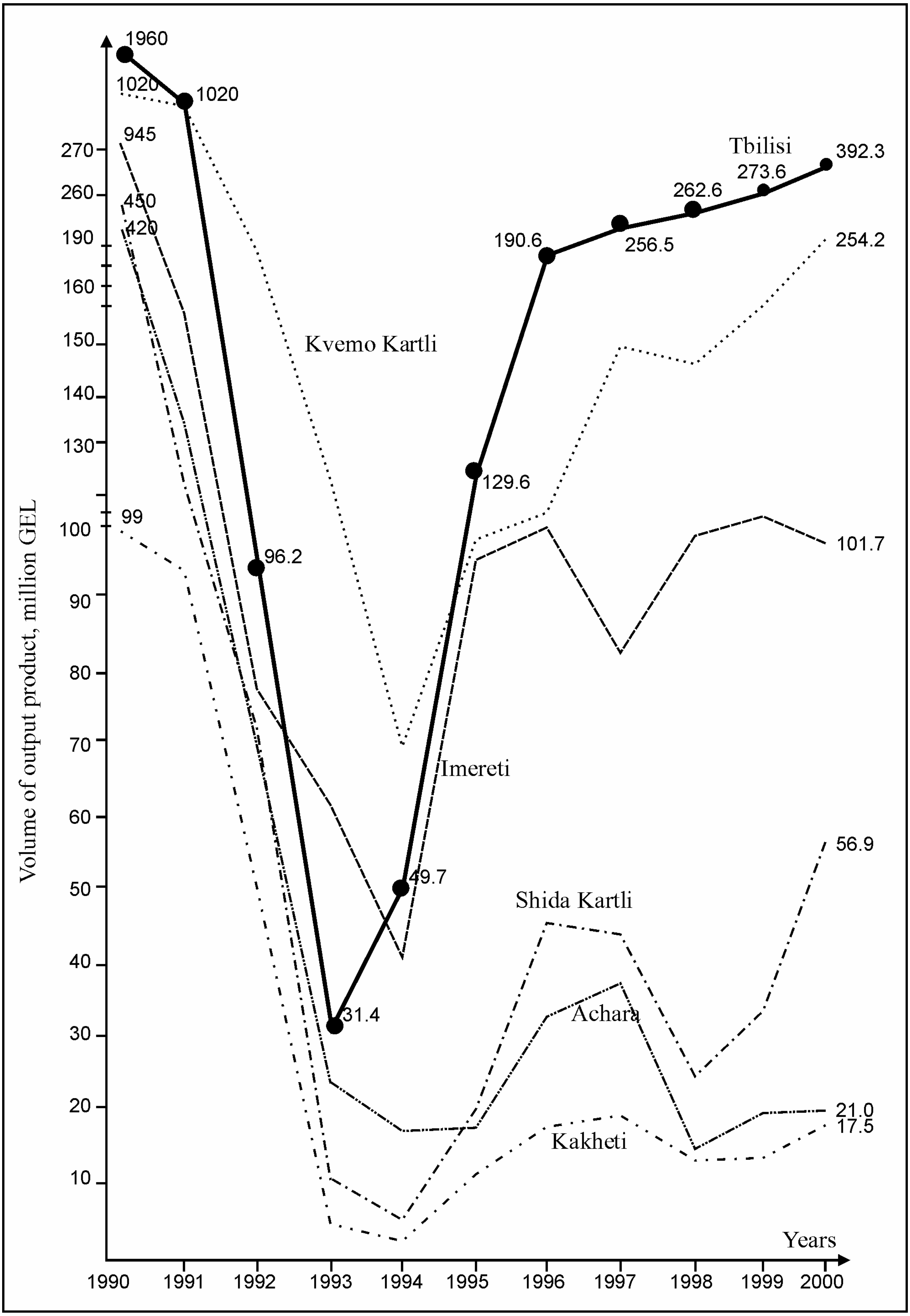


Fig. 5.1.1. Dynamics of industrial production

Due to the economic crisis, the provincial industrial units were enormously damaged as a result they have stopped functioning. Putting the enterprises into operation even under the inconsiderable load will require the years. Since 1994 up to present, existing industrial potential of the regions is slowly revitalizing. The dynamics of produced output raise demonstrates the revival process, though, the rate of production growth and the volume of industrial output is still far from the desirable level. We suppose that the analysis of the below discussed economic activities undergo in the regions will serve as confirmation for this.

Tbilisi is the largest industrial center of the country. Almost one third of the total output of the country had been produced here and this tendency, although in smaller scale continues for the time being. Enterprises of all sub-sectors or sub-sectors (metallurgy, engineering, light and food industries, chemical and pharmacy industry, aircraft building, etc.) are located in Tbilisi.

The volume of the output produced at the industrial enterprises of Tbilisi in 2000 constituted 392.2 mln GEL in the current prices that is 37.7% of the whole industrial produce output. In comparison with 1999 the production output was increased by 25.9%. However, it has to be mentioned that the volume of industrial output has decreased approximately 5 times in comparison with 1990. As it was mentioned before, the most part of the country's industrial enterprises are located in Tbilisi that basically promoted unreasonable rapid increase of population in the capital. Number of residents has raised 1.8 times in last 30-40 years and reached the dangerous (in the settling and demographic viewpoint) level. By the beginning of the year 2000, number of population constituted 1.2 million that is 22.2% of the country's whole population, whereas this index for the former Soviet Union did not exceed 5.8%. Population of Ankara, does not exceed 4.4% of Turkey's population. No more than 1% of the whole population lives in the capitals of the biggest countries like China, India, and Brazil. These examples have been brought to identify as is it necessary or not to rehabilitate and develop the existing industrial capacities of the capital. In our opinion, it is impossible and not that much necessary to restore industrial capacities, especially when 28-30% of the enterprises located in Georgia are not in operation and even acting enterprises are insignificantly loaded. As for unjustified growth of population, this will be regulated by reasonable disposition of industrial (and not only industrial) capacities over the country's territory.

There are more than 50 large industrial units in Tbilisi, majority of them have not been operating for many years. Loading of many of the units is insignificant. For example, JSC "Elmavalmshenebeli", which was not operating for many years, produced only 4 main electric locomotives in 2000, but 86 ones - in 1990. JSC "Charkhmshenebeli" produced insignificant number of metal cutters (3 pieces) in 2000 and 1568 ones - in 1990. There are many such examples. For the time being, it is impossible to set the large industrial enterprises of Tbilisi in operation within the range of the current capacities. Restructuring and privatization of the promising enterprises such as JSC "Elektroavtomati", JSC "Charkhi-Khazi", JSC "Elmavalmshenebeli", the State Aviation Association of Tbilisi have to perform as fast as possible in order to improve the situation. In case of the reliable investor the listed companies have good chance to place again in operation under the optimal loading. The situation is much better in the viewpoint of rehabilitation and development of the small and medium enterprises of Tbilisi. Foreign investors are much more interested in investing in such units. Operating enterprises enlarged the volume of production created by means of the foreign investments. Enterprises created or operated by American, English, Italian, Korean and other investments have started functioning, among them are: JSC "IsaniKartu", JSC "Tbiltambako", JSC "Opizari", etc. The same process is occurred in the enterprises of thermal and power, light and food industries. Result of such tendency is that specific share of industrial enterprises of the private sector constitutes almost 40% of the whole output of Tbilisi industry. In our judgment, in future, industrial potential of Tbilisi should be dominated by small and medium industrial units, while the large industrial enterprises should be developed only deriving from the vital interests of the country.

By the year 2000, there were 148 industrial enterprises operating in the Autonomous Republic of Ajara. The volume of its industrial output overpasses 21 million GEL. This exceeds by 4% the actual level of the previous year, but significantly remains behind the volume of production in 1997 (54.4%). The reason for the aforesaid is the stoppage of Batumi Oil-Refinery due to the absence of raw materials. Although, it has to be mentioned that this enterprise is out-of-date from the technological standpoint and requires thorough reconstruction and renovation as the products manufactured by force of present technology is less competitive because of its high prime cost.

80% of industrial commodities of Ajara are produced in Batumi. Following main industrial enterprises are located in Batumi: oil-refinery, machine-building and mechanical plants, chemical-pharmacological plant, tobacco industrial complex, sewing-industrial association, shipyard, etc. Privatization of the afore-listed enterprises is not completed yet, they are promising and after attraction of investments their profitability is guaranteed. Fundamental reconstruction of oil-refinery plant that requires large-scale investment is paid important attention for the economic development of the region. Existence of Supsa Terminal and completion of Baku-Tbilisi-Jeihan pipeline construction in the nearest future creates good perspective for the oil-processing plant and makes it undoubtedly attractive for large investors. Foreign investments will be more profitable for the development of food and light industries.

Industry is rather less developed in the Kakheti region, though it has its modest share in the country's economy. Until now the economic potential of the region has not been completely used that will be undoubtedly considered in the future. 130 enterprises out of 188 ones existing in the region were functioning in 2000, i.e. a little bit more than 69%. They have produced industrial products estimated at 17.5 million GEL. The volume of the production constituted 103.3% in comparison with the previous year, though this significantly remains behind the level of 1990.

Elaboration and implementation of the investment programs used to attract the serious attention in last period. For example, the American-Georgian joint venture "Chala's Wines" that operates in Sagarejo has high potential to export Georgian wines. Foreign investments have been put into the wine plant of the Telavi region. Installation of modern teeming line and implementation of refrigerator technologies are in course. And, as the essential moment, the program envisages planting of new vineyards of unique sorts. The French-Georgian joint venture "I Alazani" has been created in the town of Kvareli having foreign investments of 2.25 million GEL. Harvesting and processing of 12-15 thousand tons of grapes is foreseen.

Along with this Gurjaani tinning plant, brick plant, diary factory, sewing factory of Kachreti were placed in operation. 40 small enterprises have been set up in Telavi: backeries, mills, wood-processing plants, oil-presses, etc.

As analysis of economic activities conducted in the regions industry sector indicates, setting up and development of small and medium-sized enterprises in the Kakheti region on the basis of domestic raw materials hold much promise. They require small investments that would be covered in the short run. Production of wine materials from the unique sorts of vines, manufacturing of tinned products, tobacco, oil and other scare goods of food industry, light industry and others are considered as promising sub-sectors. Region holds the momentous potential for electricity generation and oil products processing.

Kvemo Kartli region is at the second place after Tbilisi in terms of its industrial potential. Here are located some of the largest enterprises of Georgia such as: Rustavi Metallurgical Plant, Rustavi JSC "Azoti", JSC "Rustavcementi", TES of Gardabani, JSC "Madneuli", "Kvartsiti" Ltd, enterprises of machine-building, food and textile industries, enterprises of constructional materials and chemical industries. More than 185 large and medium-sized enterprises are functioning in the region. In 2000, the volume of produced output exceeded 254 million GEL. Rate of production as compared with the previous year made 6.7%. Production increase is significant, but if compared with 1990 data, the production output is 8 and more times reduced. Moreover, JSCs "Rustavi Metallurgical Plant", "Rustavi Chemical Fibre Plant" are not operating, JSC "Azoti", JSC "Rustavcementi", Gardabani TES, JSC "Madneuli" and others are functioning under the reduced load. Cast iron, steel, steel pipes, rolled metal, chemical fibre, reinforced concrete goods and others are not supplied to the consumers. Control stocks of the great part of the listed enterprises is still owned by the state that, seemingly, is one of the barriers to effective operation of the enterprises, because the state, in terms of lack of finances, is not able to reequip these enterprises. Privatization process is unreasonably delayed, investors have not performed the tender agreements and relations with them were ceased. Besides, food, light and constructional material industries are highly developed in the Kvemo Kartli region, but efficiency of the enterprises is not considerable regardless the fact that the region is rich in domestic resources. In our opinion, authorities of the region and enterprises and the corresponding ministries should actively promote the attraction of the investors to use the existing potential on the full scale.

Imereti region is a large industrial region. On account of economic collapse, maximum decrease of production volume was registered in 1994 when it fell down to 40 million GEL. As a result of putting the enterprises into operation, industrial output costing 102 million GEL was produced in 2000. This value is 9 times less than 1990 data and this decrease is 2 times more than average indices of the industry sector of the country. This negative result is purpose of inactivity or insignificant load of the following large enterprises: JSC "Kutaisi Automobile Plant", JSC "Saktraktori", JSC "Kutaisi Lithophile Plant", JSC "Chiaturamanganumi", etc.

Imereti region is industrially developed region and occupies the important place in the industry sector of the country. By 2000, there were functioning 704 industrial objects. Some of them were operating under the different loading: JSC "Kutaisi Automobile Plant", JSC "Electromechanikosi", JSC "Saktraktori", JSC "Sakkabeli" of Zestaphoni, JSC "Ferro", JSC "Chiaturamanganumi", JSC "Kutaisi Lithophile Plant", JSC "Medea", JSC "Imereti" tea plant, champagne and wine factory of Terjola, etc. Industrial products costing 101.7 million GEL were produced by the listed and other medium and small enterprises in 2000. Economic indices of the region were significantly reduced (by 13.1%) in 2000 as compared with last year that is caused by breaks of electricity supply. In case of adequate provision of region industrial objects with electricity, it would be possible to double the industrial output in the short run (2-3 years) as there is sufficient industrial potential and increased demand for the produced commodities (ferroalloys, cables, lithophile, paints, manganese, wine materials, tea, clothing industry output, etc.) at the local, as well as, at the foreign markets. At the same time, it is important to note that the number of small enterprises in the region is continuously increasing and the specific share of their products in output produced of the region is increasing from day to day.

The region holds the significant reserves to increase the export produce. Uninterrupted operation of Zestaponi Ferroalloys Plant is very important, the main product of which is destined for exportation and retains high demand at the international market. The managing company – Russian-Georgian Bank has put sufficient investments for factory rehabilitation and the activities of the enterprise were improved, but making use of its full capacities is not still possible.

Zestaponi cable plant, Kutaisi natural water bottling plant, sewing factory "Imereti", JSC "Imereti" tea plant, champagne and wine factories of Terjola and others were put into operation during last period. There were established new enterprises: "Reno" Ltd in Tkibuli, "Kometa" Ltd in Khoni region, "Salkhino" Ltd in Vani region, etc. Reorganization and privatization process of large and medium companies is still underway in Kutaisi region that makes them less attractive for the large-scale investments. Among them have to be emphasized: Kutiaisi Automobile Plant, JSC "Chiaturamanganumi", JSC "Saktraktori", Kutaisi Lithophile Factory, etc.

Huge industrial potential is in the region for the development of light and food industries (with respect to enlarge the existing capacities as well as to create new productions). Constructional and facing materials are not yet widely engaged in the industry. Energy activity should be conducted in order to attract the investors in this sub-sector of industry.

In <u>Shida Kartli</u> region, as a result of inactivity of the enterprises, the volume of production had reached the critical level in 1994 and at that moment it constituted only 5 million GEL. Due to placing enterprises in operation the production volume was increasing throughout the following years and by 2000 it had reached to 57 million GEL that is 11.4 times more than indices of 1994. As to volume decrease, it is 8 times less than in 1990 and is notably less than the average indices of the country's industry.

209 industrial objects were operating in Shida Kartli region in 2000. Cost of the industrial products produced in these enterprises was equal to 60 million GEL and exceeded the level of the previous year by 37.3%. Despite the swift growth of industry, only 15-20% of the existing industrial potential is used that requires the acceleration of the further economic activities. In this regard, considerable works are being performed in the region, namely, the definite measures are conducted to set the promising but stopped (by various reasons) enterprises in operation. 51% of control stock of JSC "Sakisari" is purchased by the investment company "MCAG" (USA) that intends to put solid investments in the enterprise. Significant works are being performed to restore JSC "Kaspicementi". Increase of the region is economic indices depends on its faultless operation.

New small enterprises are established in the Shida Kartli region in cooperation with the foreign investors and companies. Georgian-Swiss company has planned industrial reconstruction of JSC "Elita" and JSC "Gorkoni" and adoption of the advanced technologies. German company and "Eko" Ltd are producing 70% concentrated juices and this product is imported in Austria and Germany.

Italian-Russian-Georgian joint venture "Sakartvelo" Ltd is producing sparkling wines. This product has large markets inside and outside of the country. Small enterprises were set up in Gori: Tkviavi canning factory, reinforced-concrete factory for highway reconstruction, "Building constructions" Ltd, "Narma" Ltd, "Meridiani" Ltd, etc. Here has to be emphasized the largest enterprise of the region – Gori cotton industrial complex. Operation of this large enterprise was depended on 100% of imported raw materials and due to the break down of existing relations it has stopped functioning for some years. Restoration of Gori cotton industrial complex in present terms seems impossible and its operation is not perspective. It would be reasonable to abolish this enterprise and establish some small ones in order to manufacture prestigious and competitive products.

On account of different reasons, industry is weakly developed in the other regions. Restoration and renovation activities of the existing capacities are going under slow pace (or it is completely stopped). Though, some experience has been gained in creation of small enterprises and definite positive results are obtained. For example, "Martin Bauer" (Germany) enlarges its activity area and production volume year by year in the Samegrelo region. Events ongoing in Poti are becoming more and more momentous. The significance of this most important port city is continuously growing.

Following the discussion of the listed issues, it could be concluded that the regions as well as the whole country hold quite rich raw materials base and considerable industrial potential, but due to the various reasons (that have been already examined) their effective utilization is not possible for the present time. Therefore, the country is at the brink of deindustrialization. Irrespective of the positive trends going in last years, the volume of industrial output produced in the industry sector is inconsiderable that impacts the development of the whole economy of the country.

We suppose that the following measures should be carried out in order to survive the industry sector out of crisis:

? The priority trends should be chosen in the electricitys that should be mainly based on the consumption of the local raw materials. It would promote attraction of the foreign investments;

- ? "Law of Georgia on Bankruptcy Proceedings" should be put into practice in Georgia. Consequently, unviable enterprises would be abolished and objects with new profile would be created instead of these enterprises;
- ? Rearrangement of some large enterprises (restructuring into medium and small enterprises) and their submission at the privatization tender should be carried out in the short period of time. In such case, allocation of the funds would be profitable for the foreign investors;
- ? Physically depreciated and morally outdated technologies should be gradually replaced in the large energy-consuming enterprises the control stock of which is under the state property. (Fixed assets of the industrial enterprises with rare exception have not been renovated since 1990 and therefore the age of the equipment has exceeded 30 years. As to applied technologies, most of them are depreciated and in view of this the energy resources are not effectively utilized and prime cost is correspondingly growing);
- ? The special attention should be paid on setting up and development of the middle-sized and small enterprises. The government should assist in this process. Namely, at the initial stage, tax and custom advantages should be established for the small enterprises;
- ? Recovered minerals should be treated under the closed circle so as to use the domestic resources effectively. Thereafter it would result in decreasing of imports of ore and concentrates. In particular, JSC "Madneuli" is exporting some thousands of copper concentrate abroad. After processing at the place, up to 6 thousand tons of copper should be got and then various products of different destination could be produced. This fact would cause 3-4 times increase of production volume;
- ? In order to protect the local market, the government should carry out the active measures with the purpose to limit smuggled and dumping goods.

5.2. ASSESSMENT OF CURRENT STATE IN SOME SECTORS OF THE INDUSTRY

5.2.1. Metallurgy

5.2.1.1. Contemporary Levels of Energy Consumption and CO_2 Emission in the Iron and Steel Industry†

The iron and steel industry is the largest energy-consuming sub-sector of the world industry. 18-19 EJ of energy was consumed in the world by 1990, which constituted 10-15% of the total annual industrial energy consumption. CO_2 emissions accompanying to this amount of energy was equal to 1425 million tons. In 1995, this amount reached 1442 million tons that made 7% of global anthropogenic CO_2 emissions. Consumption of fossil fuel in the nonferrous metallurgy sector represents the main source for GHG emissions, and energy expenses are equal to 10-15% of the prime cost. GHG emission (mainly CO_2) stipulating factors are fossil fuels combustion, electricity use as well as coal and limestone consumption, which are applied as feed stock [9].

The iron and steel making process could be divided into 5 different steps depending on each other: ore and fuel treatment, iron making, steel melting, steel casting and steel rolling.

Main industrial unit of the ferrous metallurgy are integrated steel mill (metallurgical plant), in which steel is produced from ironstone through the above-mentioned 5 steps or mini-mill, where steel is produced from scrap or substitutes through 3-5 steps. At present, 4 process routes to produce molten steel are used:

1. Blast Furnace – Basic Oxygen Furnace (BF-BOF);
2. Blast Furnace – Open Hearth Furnace (BF - OHF);
3. Scrap Electric Arc Furnace (Scrap - EAF);
4. Direct Produce Iron (DRI) – EAF (gas) or EAF (coal).

Blast Furnace (BF) represents the most energy-consuming link of steel making process and requires approximately 11-15 GJ energy to produce 1 ton of pig iron. Out of it about 7GJ of energy is used for the chemical reduction of iron ore to pig iron and the rest of energy is consumed to rise temperature up to the level, at which the mentioned process runs with due rate.

There are 2 ways to smelt steel at the integrated mills from pig iron obtained from the blast. Basic oxygen furnace (BOF) is used in the first method. This version has been developed in the 50's and is widely used in all developed countries. The second – more outdated method is based on application of open-hearth furnace (OHF) and it is mainly functioning in the former USSR republics, China and India. The latest and most energy efficient method of steel production is "Corex" that is under the introduction in the most developed countries. Rather less energy is consumed to produce steel from pig iron in the DRI-EAF burning gas and large amount of energy – in the DRI-EAF coal based methods. The lowest energy consumption per ton of molten steel is characteristic for

† This part of the Report is oriented predominantly for the Georgian specialists

the scrap electric furnace, where steel from the scrap recycling coefficient consists about 0.65. Existing data on specific energy consumption for the production of cast steel in various countries with developed ferrous metallurgy are gathered in the Table 5.2.1.1.

Table 5.2.1.1. Energy intensities of steel production applying different processes

Process	Energy intensity GJ/t
Integrated steel plant (ISP)	22 – 36.4
Advanced technology – Corex	19
Scrap electric furnace (Scrap-EAF)	7.7 - 18.8
DRI-EAF (gas)	22 - 26
DRI-EAF (coal)	25 - 36

Values in the Table represent state of steel production in USA, China, Japan, Germany, Brazil, Poland and India in the period of 1990-1996 [9]. In regard to GHG emissions, iron and steel production goes with the emission of different GHGs, the greatest share in which (more than 90%) belongs to CO_2.

Specific CO_2 emissions from the above discussed process are presented in the Table 5.2.1.2.

Table 5.2.1.2. CO_2 emission intensities for the different process routes of steel production in various countries (t CO_2/t cast steel)

Process	Country		
	India	Brazil	Poland
ISP	3.7	1.32	3.6
Scarp-EAF	1.4	-	-
DRI-EAF-gas	1.6	-	-
DRI-EAF-coal	3.6	-	-

775 million ton of steel was produced by the world ferrous metallurgy in 1998 and according to the data of 1999 the demand for steel was increased by 2% in comparison with the last year. Considering the existing tendencies it is assumed that till 2005 the demand for the produce will increase annually by 1.6% on the average.

87% of the global steel production is provided by 20 countries, out of them first 5 places were occupied by China (123.3), USA (97.2), Japan (94.2), Russia (49.8) and Germany (42.1) in 1999. Quantity of crude steel produced in 1999 is given in brackets is in million tons.

5.2.1.2. Iron and Steel Production in Georgia

In Georgia, modern metallurgical industry was founded at the beginning of 1930, when the Zestaponi Plant of Ferroalloys had been put into operation. Rich deposit of Chiatura manganese was used as raw material base and energy base was represented by powerful hydropower plants' cascade on the R. Rioni. Zestaponi plant was one of the largest manufacturers of ferroalloys in the Soviet Union and within the II World War was considered as an important strategic object. Rustavi Metallurgical Plant was placed in operation at the beginning of 1950. Ore and coal necessary for its functioning was supplied from the other republics of the USSR. Since 1960 natural gas imported from Russia and Turkmenistan had held the significant position in energy supply of the mentioned enterprises. Design capacity of Rustavi Metallurgical Plant equaled to 1 million ton of steel articles, with its industrial capacity it was regarded as the large manufactures. Numerous environment protection measures were undertaken in these enterprises, especially in Zestaponi plant, in the 80's. Despite this, both plants were significant polluting units over Georgia at the end of 80's.

Production volume of these two plants has significantly reduced after the dissolution of the USSR. Let's examine separately the production and economic characteristics of these two major enterprises of Georgian metallurgy according to the state of 1990 and 2000 and assess the possibility to apply the advanced technologies in these enterprises.

a) Rustavi Metallurgical Plant

At the Rustavi Metallurgical Plant (RMP), before the disintegration of the Soviet Union, pig iron, steel and rolled metal were produced by the old-fashioned, multistage, high energy-consuming and environmentally hazardous technological scheme, the essence of which and the links between the main rings are sited in the

Table 5.2.3. Steel production by this scheme requires arrangement of multistage, complicated and energy-consuming productions in the plant, such as: 1) Pig iron production by its serving sintering plant, lime production and coke-chemical shop providing faultless operation of the blast shop – most important component for pig iron production, 2) Steel production according to open hearth method (8 open hearth furnaces), 3) Rolled metal production: rolling, pipe-rolling and pipe-drawing shops, repairing and heat supply with the different auxiliary services.

Table 5.2.1.3. Energy consumption percentage –inter-structural distribution in the RMP by the years of 1990and 2000 among main industrial units

No	Name of the main industrial unit	Energy consumption share, %	
		1990	2000
1	Sintering plant	25	-
2	Lime production	11	-
3	Blast furnace production	1	-
4	Open-hearth furnace production	18	36
5	Ingot casting production	3	11
6	Rolling mill	4	20
7	Pipe-rolling mill	7	9
8	Pipe-drawing mill		10
9	CHP	27	12
10	Coke production	3	-
11	Auxiliary services	1	2
Total		100	100

After the disintegration of the Soviet Union, due to the lack of raw materials, pig iron production was ceased in the enterprise and there was only small-scale steel production that was used to manufacture pipes and rolled metal by the year 2000.

Table 5.2.1.4. Major steps of pig iron and ingot steel production applied in the RMP by the years of 1990 and 2000 and their share in specific energy consumption per ton of produce output

No	Steps of technological process	Specific energy consumption			
		1990		2000	
		%	GJ/t	%	GJ/t
1	Treatment of raw materials and fuel: pelletisation, screening, cleaning and sintering	54	17.6	-	-
2	Pig iron production: smelt production of iron using coke as the source of energy	10	3.2	-	-
3	Steel production in the open-hearth furnace or electric arc furnace	29	9.4	72	9.7
4	Steel ingot casting	7	2.3	28	3.8
5	Total	100	32.5	100	13.5

Main industrial indices of Rustavi Metallurgical Plant together with the corresponding features of energy consumption and GHG emission by the state of 1990 and 2000 are given in the Table 5.2.1.5.

From this Table it is evident that the RMP was operating under design overloading in 1990 (if steel pipes are included along with cast steel in the output produce). In this year about 32.5 GJ of energy was averagely consumed in the plant to produce 1t of cast steel that gives quite satisfactory result compared with the data presented in the Table 5.2.1. CO_2 total emission associating 1t of steel output from the technological processes together with emissions resulted from fuel and electricity consumption consisted 6.741 t equivalent to CO_2 in 1990 that exceeds by 80-90% data of the ISP type enterprises in India and Poland (Table 5.2.1.2). This gloomy situation was the result of imperfect technologies applied at the enterprise and the neglect of environmental aspect that was typical for the Soviet system of production.

Table 5.2.1.5. Main features of Rustavi Metallurgical Plant operation and resulting GHG emissions in 1990 and 2000

Parameters	1990	2000
Date of foundation –1950		
Type of property	State enterprise	Joint Stock Company
Actual capacity of the enterprise according to the main products:		
Pig iron, thousand tons	625.0	-
Cast steel, thousand tons	816.0	5.9
Steel pipes, thousand tons	499.0	1.1
Rolled ferrous metal, thousand tons	1109.0	5.4
Coke (recalculated on 6% humidity), thousand tons	362.0	-
Consumed energy resources:		
Natural gas, million m^3, (10^6 MJ)	514.6; (13148.03)	1.544; (39.4565)
thousand tons	360.22	1.081
Black oil, thousand tons (10^6 MJ)	255.4; (11441.92)	0.766; (34.3168)
Electricity, million kWh; (10^6 MJ)	533; (1918.8)	1.6; (5.76)
Total (10^6 MJ)	26508.75	79.5333
Energy consumed per ton of cast steel production, GJ/t	32.49	13.48
Total GHG emission equivalent to CO_2, thousand tons, including:	8864.163	19.312
from the technological processes,	7027.205	12.163
from fuel consumption,	1528.1	5.363
from electricity consumption	308.858	1.786
Total GHG emission associated with 1t of steel production (including steel pipes) equivalent to CO_2, t/t	6.741	2.759
Total GHG emission related to 1 GJ of consumed energy equivalent to CO_2, thousand t	0.334	0.243
Total GHG emission in CO_2 equivalent according to the components, thousand tons (%), including:	8864.163; (100.0)	19.312: (100.0)
Carbon dioxide - CO_2,	8797.97; (99.253)	19.167; (99.25)
Methane - CH_4	6.626; (0.075)	0.006; (0.03)
Nitrogen protoxide - N_2O	1.084; (0.012)	0.0019; (0.01)
Carbon acid - CO	0.357; (0.004)	0.071; (0.37)
Nitrogen oxides - NO_x	57.101; (0.644)	0.064; (0.33)
NMVOCs	1.025; (0.012)	0.0019; (0.01)
Total dust emission, ton, including:	5942.7	5.43
from organized sources of emission	5073.1	4.53
from non-organized sources of emission	869.6	0.9
Prime cost of 1 t of output produce: steel, $/t		129.4
Selling price of 1 t of produced product , pipes $/t		350
Export price of 1 t of produced product, $/t		350
Export volume of output product		100%

Because of absence of raw materials and advance in prices on energy carriers as well as a result of major institutional changes, industrial features of the plant appeared very low by 2000. Production of the main commodities was reduced in comparison with 1990: cast steel production was reduced 187,9 times, pipes production - 453,6 times and rolled ferrous metal production – 205,4 times. Energy consumption per ton of produced steel fell to 13.5 GJ/t by this year that is 2.4 times less than the same figure of 1990. It happened not on account of steep increase of energy efficiency, but due to the fact that the most energy-consuming rings – ore treatment and iron making were withdrawn from the production cycle. Steel was produced from already processed metal. By the same reason, total GHG emission per consumed energy was 1.4 times reduced and total amount of emitted dust - 10^3 and more times in 2000.

Total GHG emission per 1t of produced steel in 1990 was 80-90% higher than the same feature in India and Poland in 1990-1996. This fact is conditioned by the timely transfer from open-hearth furnaces to basic oxygen furnaces, continuous casting and other advanced technologies in these countries. These measures were not undertaken in the RMP for various reasons. Thus, the decrease of this feature in 2000 down to 2.8 ton in the Rustavi plant is linked with abolishment of the main rings of production.

Some major economic characteristics on Rustali Metallurgical Plant operation in the discussed period are also given in the Table 5.2.5.

Adoption of specific technological changes at the Rustali Metallurgical Plant is planned in coming years that will promote the use of energy rather effectively and thus reduce product prime cost and save financial resources, manufacture relatively competitive goods, increase the production volume and win the place at the new markets.

The draft of the project proposal, related to the mentioned problem and elaborated by RMP specialists is presented in the second part of the project report (Proposal No5).

b) Summary and Recommendations

1. In 1990, the Rustavi Metallurgical Plant was operating under the most multistage, energy-consuming technological scheme overloaded by complicated processes, that resulted directly in produce (iron, cat steel, rolled metal) price increase, high specific energy consumption and large amount of hazardous emissions (among them – greenhouse gases).
2. On the basis of analysis of world experience in the iron and steel industry, the arrangement of industrial processes is recommended for the Rustavi Metallurgical Plant in order to reduce specific energy consumption and hazardous emissions, namely:

For dust –100g/t, dust concentration in emission 50 mg/m^3 (open hearth furnace, basic oxygen open hearth furnace), 300g/t, dust concentration in emission 500 mg/m^3 from sinter plant;

SO_X – 1200g/t from sinter plant;
NO_X – 500g/t, 750 mg/m^3 in emission;
Fluorides -1.5 g/t, 5 mg/m^3 in emission.

(a) The following is recommended to manage the industry under such parameters in case of placing the metallurgical plant under the complete circle operation:

In contrast to multistage steel production complete scheme overloaded by complicated processes, steel production should be performed by the rather simplified scheme. Its limited (close to theoretical) version envisages steel production from the ore by direct reduction (under the scheme: unit ? ore ? steel), that abates sintering and blast industries in steel production circle;

(b) Application of highly efficient powerful units under the existing technological terms;

(c) Integrated mechanization of the production and its autoimmunization.

3. <u>In iron production</u>:

a) Making use of fluxing sinter;

b) Coal, black oil or natural gas utilization in blast furnace instead of coke so as to increase blast furnace efficiency and decrease emissions from the furnace;

c) Entering of gas exiting from the blast furnace in the regenerator and its further consumption as a fuel;

d) Increase of fuel consumption efficiency and decrease of emissions from its combustion;

e) Increase of blast efficiency by optimization of furnace charging and discharging processes;

f) Blast furnace surplus gas pressure increase up to 1.5 atm;

g) Humidity optimization in blowing;

h) Blowing of air rich in oxygen or use of pure oxygen instead of air in the furnace;

i) Complete covering of furnace charge delivery unit in the blast furnace, air catching and cleaning from the casting site, suppression of dust and CO emissions on the loading section of blast furnace, unloading of dust catchers without dust raising (about 3 times reduces emissions from the blast furnace);

g) Recirculation of materials rich in iron (such as: catch dust by dust-catching system, rests of sound iron ore, iron off-cuts) in the sintering plant;

k) Heat regeneration from sinter cooling and emitted gases;

l) Use of pneumatic transport, belt transporter (semienclosed and closed conveyer systems) during the transportation of dust producing substances to reduce dust raising;

m) Reduction of dust emission while discharging the molten iron by closing casting runner.

<u>4. In steel production</u>:

a) Making use of air emitted from the open hearth furnace;

b) Application of dry catching systems to suppress hazardous atmospheric emissions (namely, dust emission) and emergence of polluted waste products;

c) Regulation of non-organized emissions (approximately 10 times reduces emissions from the converter and about 6.6 times – from the electric arc furnaces);

d) Adoption of continuous casting (that decreases consumed energy and time required for this process and improves steel quality).

<u>5. General measures</u>:

a) Recurring utilization of slag containing lime;

b) Use of slag for constructional purposes (slag production recommended level is 180 kg/t steel; slag is produced at the rate of 50-120 kg/t of steel from the BOF depending on raw material content).

c) Zestaponi Plant of Ferroalloys

Zestaponi Ferroalloy Plant was placed in operation in 1933 and was recognized as one of the largest units of the industry sector of Georgia. It was still under the state property in 1990 and was turned into Joint Stock Company in 1995. 51% of holding of shares is under the state property, foreign investor possesses 46% and the rest 3% is distributed among the staff.

The plant operated under 100% loading in 1990 and was producing 4 types of product: carbonaceous ferromanganese, medium carbonic ferromanganese, silicomanganese and electrolytic manganese. At the present time, its capacities are loaded not more than 18% and it is mainly producing 3 types of product except electrolytic manganese. The major product of the plant in 1990 as well as at present time, is silicomanganese.

426 024 t of silicomanganese was produced at the plant in 1990. The plant consumed 4200 kWh of electricity and 500 kg of coke per ton of silicomanganese production. Mainly, Chiatura manganese was the raw material base, quartzite was imported from the Ukraine, coke – from Ukraine and Russia. At present (1999-2000), the plant is producing about 27 thousand ton of silicomanganese annually. 5 570 kWh of electricity and 420 kg of coke is consumed on production of 1t of product. Natural gas consumption in the plant is inconsiderable.

The main technical and economic parameters of Zestaponi Ferroalloy Plant operation are presented in the Table 5.2.1.6. Design capacity of the plant during operation under the maximum load is: silicomanganese - 311.8 thousand ton, metallic electrolysis manganese - 4 thousand ton, medium carbonic ferromanganese of 80% - 156 thousand ton, ferromanganese and carbonic electro ferromanganese of 76% - 100 thousand ton. These products are manufactured by pirothermal reduction of manganese and iron ores, using SiO_2 – to produce silicomanganese, by electrolyze (cathodic reduction) method – to produce metallic electrolyze manganese from manganese sulfate water solution. The major processes in this enterprise are pirothermal reduction processes and the main raw materials are manganese, iron ores and SiO_2. Industrial processes are multistage and energy-consuming. Their realization requires the arrangement of the following complicated and multistage processes at the auxiliary enterprises, such as: lime production, preparation of furnace charge, sintering plant and so on, that promotes significant emission of the following hazardous substances during the plant operation: dust (manganese, silicium, iron, soot and ash content), nitrogen oxides - NO_x, carbon oxides -CO and CO_2, sulphur dioxide SO_2 (other components emission is not significant). Features of these emissions are presented in the Table 4.4. Here has to be underlined that data about fuel (for instance, black oil) consumption by this enterprise are not presented is the information official sources (they were placed on secret list under the strategic consideration), therefore their relevant emissions are not presented in the above-stated Table. This situation could not notably change the description of emissions from the enterprise as emissions from the fuel combustion are indirectly enclosed in the specific factor of technological emissions, where combustion (as pirothermal reduction process) is considered as direct component of technological processes. At the same time should be mentioned that amount of emissions is somehow reduced due to the omission of fuel combustion (and resulted emissions) in the boiler house.

Description of differences in produce output technologies that have occurred in the last decade should be started from the content of furnace charge material that is different at the present time in contrast to 1990. In particular:

In 1990 furnace charge material consisted of:

- Manganese concentrate sinter
- Quartzite
- Medium carbonic ferromanganese
- Coke

In 2000 furnace charge material consisted of:

- Silicomanganese accompanying slag (earlier it was dumped after the process, but at present is utilized. Its amount is limited and poorly concentrated (15% content), therefore much electricity is required to produce 1t of silicomanganese.
- Crude slag
- Coke

Technological circle consists of the following main stages:

- Preparation of furnace charge substances, sorting (getting of sinter, breaking and sorting of slag);
- Dosage of fusion mixture substances;
- Transportation of fusion mixture substances to the furnaces (by belt transporters);

- Melting of fusion mixture substances in the thermal-arch electric furnaces (93% of electricity is required for this process)
- Discharging of molten metal from the furnace, separation of slag from the metal;
- Metal casting (silicomanganese) – by casting machine;
- Slag evacuation on slag processing furnace;
- Metal breaking and sorting according to the standards.

Stages included in the technological circle virtually are the same now as before, but at present the rest slag is not usable differing from the previous period. Slag obtained during the previous period is used today as a row material.

As to exports and imports, importation of this kind of product is not taking place in Georgia, and the export was made 33% by 1990. At present, 100% of produce is exported. The plant was reconstructed in 1983-85 and old-fashioned dust-catching system was replaced by dry cleaning handle air cleaning system. Consequently the concentration of main emitted gasses (CO_2, CO-small amount, SO_2, NO_2) was decreased from 76% to 2-4%. Japanese furnaces have been installed and 380 000 tones of raw materials (volcanic material containing small amount of phosphorus) used to import from Australia. It is known that CO_2 emitted as a result of these processes is trapped and utilized in Japan. At the present time, the filters are not operating because of absence of handles, purchasing of which is connected with vast expenses.

The plant does not posses long-range action plan as it is not acquainted with the market and has no plans for selling the produce abroad. The exact amount of local raw material reserves is unknown as well, but in the nearest 1.5 year the plant intends to increase its capacity up to 50%, that is based on utilization of remaining raw materials but quite much electricity is to be used for its processing.

Table 5.2.1.6. Main parameters of Zestaponi Ferroalloy Plant operation and related GHG emissions in 1990 and 2000

Parameters	1990	2000
Date of foundation – 1933		
Types of property	State enterprise	Joint Stock
Actual capacity of the enterprise according to the main product: Medium carbonic ferromanganese of 80%, thousand tons Carbonic electro ferromanganese of 76%, thousand tons Metallic electro manganese of 90%, ton Silicomanganese of 82%, thousand ton	 81.6 42.4 1736 300.288	 6.088 0.582 - 20.458
Consumed energy resources: Electricity, million kWh; (10^6 MJ) Natural gas (thousand m^3) Coke (thousand ton)	 1244; (4478,4) 21 000 180	 269; (968.4) 25 20
Energy consumed per 1t of conventional product, kWh/t; GJ/t	9893.8; 35.618	9915.95; 35.697
Total GHG emissions in CO_2 equivalent, thousand tons, including: from the technological processes, from electricity consumption	979.924 198.960 780.964	198.680 42.980 155.700
Total GHG emissions in CO_2 equivalent emitted per 1 t of conditional produce, t/t	7.794	7.324
Total GHG emissions in CO_2 equivalent, according to the components, thousand tons (%), including: Carbon dioxide - CO_2, Methane - CH_4 Nitrogen protoxide - N_2O Carbon oxide- CO Nitrogen oxides- NO_x NMVOCs	922.771; (100) 844.8; (91.55) 0.483; (0.052) 1.550; (0.168) 0.780; (0.085) 72.320; (7.837) 2.838; (0.308)	199.771; (100) 182.678; (91.55) 0.104; (0.052) 0.335; (0.168) 0.216; (0.108) 15.638; (7.837) 0.567; (0.284)
Selling price of 1 t of produced product, silicomanganese ruble/t ($/t)	360	(400)

5.2.2. Cement Production

5.2.2.1. Cement Production Current Tendencies in the World[‡]

Cement is produced in more than 80 countries. Its manufacture is very energy intensive and results in significant emissions of greenhouse gases. Primarily, CO_2 emission is a result of chemical properties of main raw material – calcium carbonate ($CaCO_3$) used for cement and limestone production. CO_2 is emitted during $CaCO_3$ decarbonisation process. Besides, heat, for the generation of which the great quantity of fuel is consumed, is necessary for decarbonisation. High temperature (2000^0C) combustion regime is formed in the gyratory kiln producing clinker for cement; consequently the quantity of N_2O is increased.

It is possible to reduce considerably the emission of above-mentioned gases influencing on climate in case of GHGs "conservation" and effective utilization and partial replacement of carbon containing raw materials with useless mineral substances keeping the main chemical ingredients of cement and also in case of replacement of fossil fuel by the secondary fuel and by the addition of some soil elements and soot.

Cement production has begun since 1824. Almost during century and a half cement production technology was characterized by significant conservatism. The data for the basic changes in technology can be considered 1973, when precalciners were introduced into the technology that led to the reduction of energy intensity of clinker production from 4.7 GJ/t clinker in 1973 to 3.7 GJ/t clinker in 1995.

There are three main steps in cement production:

1. preparing raw materials;
2. producing an intermediate "clinker";
3. grinding and blending clinker with other products to make cement.

Clinker can be produced by a number of different technological processes. The "dry" process is much more energy-efficient than the "wet" process. The last one is gradually being phased out and is replaced by "dry" process of technology.

Thus, the following factors affect on CO_2 emission intensity in cement production:

? type of cement that is produced;
? the physical and chemical properties of the raw materials used;
? the proportion of clinker (the main source of emission) with other components of cement;
? technology applied in manufacture;
? electricity consumed for cement production;
? types of used fuel.

If discuss the cement production from GHGs reduction standpoint, emission mitigation related to the energy consumption as well as to the chemical processes have to assess.

In case of the first category of projects energy-related GHG emissions from clinker manufacture could be reduced by:

? increasing the energy efficiency of cement production and correspondingly by optimizing heat recovery;
? changing in the production process (replacing "wet" with "dry" technology), or
? fuel substitution (increasing the proportion of biomass in used fuel).

Non-energy related emission reduction from the clinker production (i.e. related to the chemical processes) is limited. This is conditioned by the fact that emissions caused by the clinker production are the inseparable part of the transition process of lime-stone into the lime. In spite of this, it is possible to reduce the CO_2 emission significantly by the input of various additions to the row material prepared for the production of cement (e.g. blast furwace slag, pozzolana), that gives actually the reduction of clinker shares in the cement.

Blending projects would also need to take into account the GHG emissions related to additive preparation. This will vary according to which additive is used.

The quantity of fuel and electricity consumed in cement manufacture depends on the technologies used in different stages of production ([8], (see Table 1)), but also on such specific data as the moisture and silica contents of raw materials.

[‡] This part of the Report is intended predominantly for the Georgian specialists

Table 5.2.2.1. Variations in fuel and electricity intensity of different components of the cement manufacturing process

Manufacturing step	Unit	Range	Lower intensity technology (typical value of "best practice")	Higher intensity technology (traditional business - related technology)
Blasting/transport of raw materials	GJ/t clinker	0,023 (est. avg.)		
Crusher (raw materials)	kWhe/t input [?]	0,3-1,6	Roller crusher (0,4-0,5 measure) or gyratory crusher	Hammer crusher (1,5-1,6 measure)
Crinder (raw materia ls)	kWhe/t input *	12-22	Roller press (integral), (12)	Ball mill (22)
Kiln (electricity use only)	kWhe/t clinker	26-30	5-stage pre-heater, pre-calciner (26)	Semi-dry (30)
Kiln (direct fuel use)	GJ/t Clinker	2,9-5,9[1]	Short kiln, 5-stage pre-heater, pre-calciner (2,9-3,2)	Wet kiln (5,9)
Grinder (clinker)	kWhe/t cement[2]	24,5-55	Roller press (24,5)	Ball mill (55)
Sub-total (electr.)	kWhe/t clinker	70,8-124		
Sub-total (fuel)	GJ/t Clinker	2,9-5,9		
Total[3]	GJ/t clinker	3,69-7,25		

Energy consumption at the lowest end of the range corresponds to clinker production at different GHG intensities, depending on which fuels are used and how efficiently electricity is generated.

For example, using residual fuel oil and gas-fired electricity would result in energy-related emissions of 248 kg CO_2/t clinker, whereas using coal and coal-fired electricity would result in energy-related emissions of 341 kg CO_2/t clinker.

From GHG emission reduction potential standpoint, the priority is adjusting to construction of new plants after the comparison analysis between two possible actions – rehabilitation of old plant and construction of new one. Though, for developing and economy in transition countries, rehabilitation of old plants is more reliable because they consider this conclusion as optimal. At present 5-stage pre-heater precalciner is applied in the technologies of new plants constructed in the various countries of the world. It is mostly used as initial baseline level in GHGs mitigation projects.

In Table 5.2.2.2 are presented the above-mentioned baseline energy components of cement production and different assumptions related to energy section.

Table 5.2.2.2 Baseline energy components necessary for cement production

Process	Energy use (unit)
Raw materials preparation	16 kWh_e/t raw material input (or 27 kWh_e/t clinker)
Combustion process	3,0 GJ/t clinker +26 kWh
Cement grinding (new plants)	28,2 kWh/t cement (assuming a roller press, 1-4% moisture content and ground to 3 500 Blaine)
Cement grinding (capacity upgrades)	36,8 kWh/t cement (assuming a two-stage grinder with roller press, 1-4% moisture content and ground to 3 500 Blaine)
Additive grinding	32, 8 kWh/t

Source: "Cembureau 1997" and "IEA GHG R&D 1999"

[?] 1,5-1,75 t input of raw material is needed for 1t output of clinker.
[1] Shaft kiln, found in China, have a range of 3.7-6,6 GJ/t clinker.
[2] Data for Portland cement: 95% clinker (type - 3500 Blaine) cement, or cement with additives that need grinding would require more electricity for this grinding step. For example, grinding portland cement to 4000 Bleine with a roller press requires 28 kWh/t, whereas grinding portland cement to 3500 Bleine with the same technology requires only 24.5 kWh/t (Cembureau 1997).
[3] Assuming generation efficiency of 33% and 1.65 t raw material input needed for 1 t output.

In case of projects prepared for the third important stage of cement production – series of blending (using additives), GHG reduction effect may exceed the result of GHG reduction obtained by energy efficiency increase projects. Though, using of these additives is not always possible because they are expensive and are not located nearby.

The volume of cement production means that small changes of the clinker proportion assumed in an emissions baseline would have large effects on the number of credits generated by a project. For example, if a factory producing 1 Mt clinker per year reduced the clinker content of its Portland flyash cement by 10 percentage points, e.g. from 94% to 84%, it could reduce its clinker production by 100,000t.

Below given example illustrates the magnitude and importance of potential CDM revenues that could be generated from a project that increases energy efficiency or changes the production process in a cement industry.

For example, the range in electricity use for clinker production is 70.8 – 109 kWh/t clinker produced (Table 5.2.2.1). Major refurbishment of an inefficient plant may lead to energy efficiency improvements that reduce electricity consumption by 30 kWh/t clinker produced. This would avoid 10-30 kg CO_2 emissions per ton of clinker produced, depending on the assumptions used to calculate the CO_2 intensity of avoided electricity. Taking the highest assumption (corresponding to emissions of 1 kg CO_2/kWh, i.e. inefficient coal-fired production) and assuming a price for avoided C emissions of US$10-25/t C (US$2.7-6.8/t CO_2) would give a benefit of 8-20 cents/t clinker produced. This corresponds to an extra income of US$240-600/day for a standard new plant with capacity of 3000 t clinker/day, assuming that the baseline is continued operating of the old plant, which may or not be a valid assumption.

However, these CDM revenues are tiny compared to the revenues of that plant, which would be of the order of US$110,000-US$210,000/day depending on the assumptions of clinker cement content (70-95%) and price of cement (US$35-50/t) used.

5.2.2.2. Cement Production in Georgia

Cement production in Georgia started in 1930 when the Kaspi cement plants went into operation. In 1956 the Rustavi cement plant began production using the same "wet" technology. Despite the similarity of technology used, there were some differences in the use of row materials and fuel, conditioned by the local circumstances.

Man parameters of operation and efficiency of both plants by the state of 1990, when these plants were put into practice, are presented in the Table 5.2.2.3

Table 5.2.2.3 Efficiency features in Georgia's cement industry in 1990

No	Characteristic features	Kaspi plant		Rustavi plant	
		Actual	99% dust-catching	Actual	99% dust-catching
1	2	3	4	5	6
1	Year of foundation	1930		1956	
2	Area of territory, ha	30		25.6	
3	Number of personnel	876		451	
4	Rated capacity				
	Cement, 10^3 t	865		864	
	Roofing slate, 10^3 conditional slates	40.0		-	
5	Manufacturing technology	wet		wet	
6	Type of cement produced	"300" and "400"		"400"	
7	Quantity of cement manufactured, 10^3 t	583.5	693.0 (616.3) *	706.5	811.6 (741.2) *
8	Fuel used	Natural gas		Natural gas	
9	Consumption of energy resources for the production of 1t of cement (specific energy consumption)				
	- Electricity, kWh (MJ)/t	140.5 (505.8)	117.3 (422.3)	130.7 (470.5)	113.8 (409.7)
	- Natural gas, m^3 (MJ)/t	224.1 (5728.3)	187.1 (4780.9)	250.0 (6387.5)	217.6 (5560.4)
	- Black oil (mazut), kg (MJ)/t	2.9 (130.9)	2.5 (111.2)	-	-
	Total, GJ/t	6.365	5.314	6.858	5.970
	Saved specific energy consumption, GJ/t		1.051		0.888

1	2	3	4	5	6
10	Total consumption of row materials for the production of 1t of cement, t	1.715	1.605	1.758	1.754
11	Total quantity of generated kiln-dust, 10^3 t	110.6	110.6	105.1	105.1
12	Total quantity of kiln-dust, picked up by the dust-catching system, 10^3 t	46.1	109.5	76.9	104.0
13	Quantity of kiln-dust dispersed into the atmosphere, 10^3 t	64.5	1.1	28.2	1.1
14	Dust-catching efficiency, %	41.7	99.0	73.2	99.0
15	Concominant emissions to the production of 1t of cement (specific emissions)				
	- kiln-dust, t/t	0.11	0.0016	0.04	0.0013
	- total greenhouse gases, CO_2 equivalent, t/t	0.9917	0.8365	1.0297	0.8962
	- including CO_2, t/t	0.9471	0.7990	0.9832	0.8557
	- other GHGs, CO_2 equivalent, t/t	0.0446	0.0375	0.0465	0.0405
	Among them CO_2:				
	- technological, t/t	0.5438	0.4579	0.5574	0.4852
	- from fuel consumption, t/t	0.3303	0.2781	0.3578	0.3115
	- from electricity consumption, t/t	0.0730	0.0630	0.0680	0.0590

* In the case of transformation efficiency of kiln-dust into cement, equal to 0.3

a) Cement Plant of Kaspi

The main raw material – limestone was extracted for the Kaspi plant by the open method at the Kavtiskhevi open-cast mine, distanced 4 km from the plant. The clay was mined also by open method at the local pit.

In 1997 the production at Kaspi plant was temporarely seized.

The main pollutants of the atmosphere from the plant were the kiln sector, clinker and additives store-houses, grinding sector and the cement production sector.

The kiln sector was equipped with 3 rotating kilns of 30-32 t/hr capacity. They were supplied with the dust-catching electric filters, the actual efficiency of which did not exceed 10-20%. In the cement sector 6 different mills were operating with the capacity ranging from 15 to 50 t/hr. The efficiency of filters mounted at them varied between 60 and 90%. Large amount of kiln-dust was dispersed unpremeditatedly in the atmosphere during the leading and transfer of cement.

The most intense consumption of energy resources in the process of cement manufacturing usually takes place in pyroprocesses, to which about 80% of total energy is applied. Nearly half of that energy is related with the burning of fossil fuel, and relatively small part with the electricity consumption. The rest part of energy consumed is conditioned by the chemical process of $CaCO_3$ decarbonization. As it was mentioned above, the emission of GHG is mainly initiated by the pyroprocesses.

Quantities of row materials and energy resources used for the production of 1t of cement at the Kaspi plant in the period of 1990-1996 are given in the Table 5.2.2.4

Table 5.2.2.4. Raw materials and energy resources consumption for the production of 1 t of cement at the Kaspi plant

Year	Row materials consumption, t							Use of energy resources		
	Total	Including						Electricity, kWh	Natural gas, m^3	Total, kWh
		Limestone	Clay	Pumice	Zeolite	Gypsum	Blast-furnace slag			
1990	1.715	1.236	0.220	0.186	-	0.053	0.020	140.5	224.1	165.8
1991	1.717	1.204	0.238	0.206	0.010	0.038	0.021	180.3	226.0	205.8
1992	1.899	1.459	0.261	0.137	0.002	0.016	0.024	216.8	296.9	250.3
1993	1.660	1.308	0.219	0.083	0.029	-	0.021	217.7	290.7	250.5
1994	1.885	1.483	0.287	0.080	-	0.014	0.021	272.7	245.1	300.4
1995	2.199	1.714	0.410	0.030	-	0.011	0.034	401.4	406.2	447.3
1996	1.873	1.242	0.406	0.087	0.034	0.070	0.034	342.7	333.0	380.3

Based upon the data given in the Table 5.2.2.4 the efficiency of plant was determined for the period of 1990-96. For the efficiency criteria the ratio between the masses of used row materials and the produced cement was taken. The estimation of plant’s technological efficiency by this way is justified because during the examined period the components of row materials did not change. It can be seen on the Fig. 5.2.2.1. that the decrease of Kaspi cement plant's functioning efficiency was caused by the significant increase of energy resources, used for the production of a unit mass (1t) of cement in the given period.

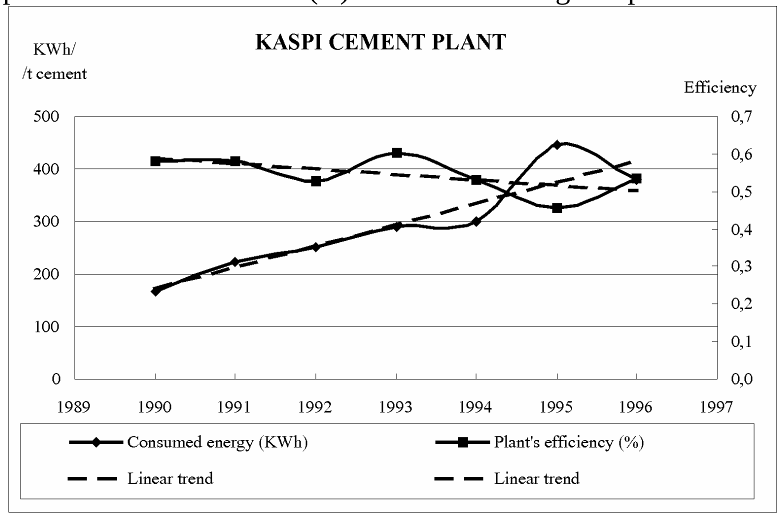


Fig. 5.2.2.1. Changes of Kaspi cement plant efficiency and consumed energy in 1990-96

While calculating the GHG emissions from cement manufacturing, on the basis of the assumption that the average content of CaO in cement is 63.5% and in clinker - 64,6%, in international practice for the value of cement emission factor is used EF_c=0,4985 and for clinker EK_k=0,5071.

Using the data from the Table 5.2.10 and the formula EF= Fraction CaO x 0,785 [36] it has been determined that in Kaspi cement plant in 1990-96 the deviation of CaO proportion in cement from the mentioned above average value is positive and varies between 3.4 and 15.3%. As it is known, the proportion of clinker in portland cement equals to 95% while for other types of cement it can vary from 20 to 94% [8].

The economic decline of the 90's has caused the sharp decrease of technological and economic indices of Kaspi cement plant that was actually expressed by the stopping of the plant in 1997. This is illustrated on the Fig. 5.2.2.2 by the negative regression equation describing the adverse relationship between the energy consumed for the manufacturing of 1 t of cement and the kiln-dust capture efficiency (with the correlation coefficient equal to 0.84).

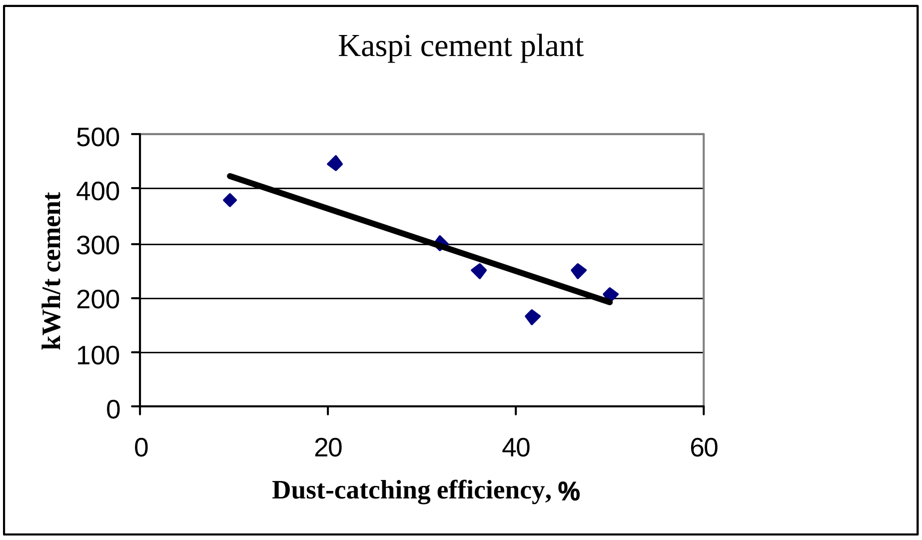


Fig. 5.2.2.2. Correlation between specific energy consumption and dust-catching efficiency

The dust-catching efficiency of plant's equipment in 1990 was equal to 41.7% (as it is very low index), but in 1996 it dropped to 9.5%. Accordingly, in 1990 the plant produced 583.5 thousand tons of cement and in 1996 – only 29.8 thousand tons. At the same time the increase of emission factor from clinker production takes place – in 1990 it equaled to 0.90 t CO_2/1t cement and in 1996 it grew up to 1.02 t CO_2/1t cement.

Parameters of operation of Rustavi Cement Plant and efficiency increase potential are discussed in the II part of the report, proposal 7.

5.2.3. Timber, Wood-Processing, and Cellulose and Paper Industry

Georgia was rich in forest from the remote past. At present, forests occupy up to 30% of its territory. Therefore, timber, wood-processing, and paper and cellulose industry takes the deginite place in the Georgian industry sector that is confirmed by the data presented in the Tables 5.2.3.1-5.2.3.3. In particular, 4% of total number of the industrial units of Georgia registered in 1990 were wood-processing enterprises (6.48% in 2000), and 0.44% - were paper and cellulose processing enterprises (0.53% in 2000). 5.19% of staff engaged in the industry sector by 1990 was operating in timber, wood-processing, and cellulose and paper industry (4.29% in 2000). The data demonstrates that all necessary conditions for the successful development of this sub-sector of industry are existing in Georgia.

Table 5.2.3.1. Changes of number of enterprises in timber, wood-processing, and cellulose and paper industry for 1990 and 2000

Parameters	Years	
	1990	2000
Number of enterprises in the Georgian industry	1365	2840
among them, timber, wood-processing, and paper and cellulose industry including:	110[?] (8.09%)	209[??] (7.36%)
timber,	49	NA
wood-processing	55 (4.03%)	184 (6.48%)
paper and cellulose industry	6 (0.44%)	15 (0.53%)

Note: [?] Data corresponds to old classifier used in the Soviet Union;
[??] Data corresponds to new national classifier harmonized with European classifier (due to the different technical approaches, there is definite incompliance between the data of 1990 and 2000).
NA ? Data not available
[??] Out of 209 enterprises 128 ones are small enterprises with 552 employees.

Table 5.2.3.2. Variation of number of employees engaged in timber, wood-processing, and cellulose and paper industry during 1990 and 2000

Parameters	Years	
	1990	2000
Average annual number of workers and employers: including:	458 900	99 600
timber, wood-processing, and cellulose and paper industry	23 800 (5.19%)	4 268 (4.29%)

Since 1991, after the collapse of the Soviet Union, economic crisis in Georgia put an obstacle to the overall development of the industry. Surely this had an impact on the timber, wood-processing, and paper and cellulose industry, especially the most energy consuming sub-sectors of this industry that is the reflection of energy crisis formed in Georgia. Therefore, the following downfall is observed in 2000 as compared to 1990: 1) sawed timber production was reduced 13.84 times, plywood (veneer) glued by synthesized pitch production - 2166.7 times, output of the most energy consuming sub-sector – papermaking – 717 times, chips and pasteboard productions were stopped. Main parameters of this sub-sector operation, related energy consumption and GHG emissions, taking into account the estimated prospect of the sub-sector development, are presented in the Table 5.2.3.3.

Table 5.2.3.3. Main operational features of timber, wood-processing, and cellulose and paper industry in 1990 and 2000

No	Parameters	Years	
		1990	2000
1	Main output produce: 1.1. Sawed timber ?, m^3 1.2. Plywood glued by synthesized pitch (veneer), m^3 1.3. Chips, m^3 1.4. Paper, ton 1.5. Pasteboard, ton	 551 000 6 500 7 500 26 600 42 500	 39 815 3 - 37.1 -
2	Consumed energy resources: 2.1. Natural gas, million m^3 (TJ) 2.2. Mazut, thousand ton (TJ) 2.3. Electricity, million kWh, (TJ) Total, TJ	 5; (126.0) 20; (800.0) 88; (316.8) 1242.8	 0.3; (7.56) 1.16; (46.4) 5.98; (21.53) 75.49
3	Energy resources consumption per ton of conditional produce: 3.1. Natural gas, MJ/t 3.2. Mazut, MJ/t 3.3. Electricity, MJ/t Total, MJ/t	 266.8 1 693.7 670.7 2 631.2	 270.9 1.662.4 771.4 2 704.7
4	Emissions associated with manufacture of 1ton of conditional produce: 4.1. Dust (sawdust), kg/t 4.2. Carbon dioxide ? CO_2 kg/t 4.3. Other GHGs – in CO_2 equivalent, kg/t GHGs in total – in CO_2 equivalent, kg/t	 0.2 204.36 55.0 259.36	 0.2 257.96 14.33 272.29

** Note: the following losses accompany the sawing process:*

- 6% due to natural drying (moisture evaporation),

- 10% as a sawdust,

- 24% as the scraps and other similar mechanical remains. Consequently from 100m^3 of logs could be produced about 60m^3 of sawed board. During this process, 0.7 t/m^3 is taken as wood (and timber) average density.

Reasoning from the data analyses it could be concluded that:

1) Major share of produce output in the sub-sector in 1990 as well as in 2000 comes on timber sawing. This process is performed in the sawing shops all over the regions of Georgia, especially in the shops of low capacity and sawing at place is performed using gasoline handsaw;

2) In 1990, according to produce volume the paper and pasteboard industry occupied the second place after the timber sawing that was reduced to the inconsiderable level by the year 2000. The highest energy consumption of this sub-sector resulted in substantial reduction of total energy resources consumed in the sub-sector (natural gas and mazut – 17 times, electricity – 15 times). Concerning the specific consumption of energy resources per ton of conditional product, sizable changes have not occurred as the applied technologies were not replaced by new ones during the discussed period.

3) In the Table 5.2.3.3, the considerable increase of share of CO_2 emission accompanying 1 ton of conventional produce output (by 26%), and reduction (by 74%) of the share of other greenhouse gasses (most of them are CH_4, CO and NO_X) attract the attention while comparing 1990 and 2000 data. This circumstance is explained by the fact that domination of timber sawing processes in total produce of the sub-sector resulted in increase of CO_2 share as a result of application of the petrol handsaw. In return, after the significant reduction of cellulose and paper production, other accompanying GHG emissions were decreased that are directly connected with implementation of the technological cycle.

Characteristic of energy consumption according to the sub-sectors and comparison of the specific consumption with the recommended values for the discussed sub-sector are given in the Table 5.2.3.4

Table 5.2.3.4. Main parameters of specific energy consumption and GHG emissions by 1990 and 2000 in timber, wood-processing, and paper and cellulose industry

N	Industrial sub-sector	Energy consumption per ton of produce output, MJ/t				Specific emissions, in CO_2 equivalent, kg/t			
		1990		2000		1990		2000	
		Actual	Recommended	Actual	Recommended	Actual	Recommended	Actual	Recommended
1	Timber sawing	60.3	50.2	66.4	42.7	5.9	5.1	6.5	4.7
2	Production of plywood glued by synthesized pitch (veneer)	44.7	37.5	45.9	32.5	4.4	3.8	4.9	3.5
3	Chips production	55.3	44.2	-	38.3	5.5	4.9	-	4.4
4	Papermaking	2234.5	1785.0	2592.7	1638.5	220.3	192.5	260.9	183.5
5	Pasteboard production	236.8	190.5	-	165.7	23.1	20.2	-	18.7
Total:		2631.6	2107.4	2705.0	1917.7	259.2	226.5	272.5	214.8

Features cited in the Table demonstrate that actual total energy consumption in the discussed sub-sector by 1990 was exceeding the recommended value by 24.8% on the average and this value has increased up to 41.0% by 2000. This fact could be explained by the objective reason that the technical and technological re-equipment of the sub-sector was not performed through the last decade. Therefore, application of ineffective and depreciated machinery and devices resulted in low energy efficiency of the sub-sector.

Analysis of the data also demonstrates that, according to the current state, the major source of GHGs emission in this sub-sector are timber sawing processes and papermaking. This last one is characterized by the highest specific energy consumption and GHGs specific emission. Timber sawing is the most extensive sub-sector among the discussed sub-sectors.

Thus, the most priority sub-sectors for the reduction of energy consumption and GHG emissions (considering the extensive as well as the intensive factors) are the following:

1) timber sawing,
2) papermaking

Energy saving and related GHG emissions reduction measures have to be taken in these two sub-sectors.

5.3. GHG Emission Reduction Potential in the Energy and Industry Sectors

As it is well known, energy efficiency was always very low in the former Soviet Union and it was not exceeding 50% of design value due to the absence of economic inducements, management centralized system, artificially low prices on energy resources and the state subsidies in all sectors of economy. This situation continues even after the disintegration of the Soviet Union that is conditioned by the fact that the applied technologies, machinery and equipment become more outdated as well as by the acute deficit of spare parts.

As a result of analysis of gathered data on the efficiency actual and design vales at the principal enterprises in the energy generation, distribution and consumption sub-sectors, the energy losses related to the difference between these values were assessed and the corresponding GHG extra emissions in CO_2 equivalent. CO_2 extra emissions from the electricity generation sub-sector, with respect to ineffective consumption of fuel (mazut and natural gas), were calculated reasoning from data on fuel consumption. Results of the estimation of GHGs reduction potential are given in the Table 5.3.1.

Table 5.3.1. GHG emissions reduction potential from the various modules of the energy sector

Sub-sector	Efficiency and losses, %				GHG extra emission in CO_2 eq., t/y	
	Design		Actual			
	1990	1999	1990	1999	1990	1999
Energy generation						
1.1 Electricity						
- Thermal electric stations	32.8	33.65	25.5	26.64	495 571	84 714
- Hydro power plants	50.4	50.4	36.7	32.2	568 735	844 640
Sub-total					1 064 306	929 354
1.2 Heat generation	86.2	NA	73.8	NA	400 266	
Sub-total					1 464 572	929 354
Distribution						
2.1. Electricity					64.6	21.0
2.2 Heat	5	5	20	NA	324 958	NA
Sub-total					325 023	21.0
Consumption						
3.1. Residential	NA 9.32	NA	63.4	60	542 136	408 812
3.2. Municipal		11.9	18.9	22.1	41 365	16 364
Sub-total					583 501	425 176
Total					2 373 096	1 354 551

Note: Efficiency is given for energy generation, losses – for distribution and consumption.

The obtained results demonstrate that Georgia possesses the significant potential of GHG emissions reduction in the energy sector. In 1990 it consisted 2.284 Tg (million t) in CO_2 equivalent that is 18.8% of total emissions from this sector. This last one, according to the data of the first GHG national inventory, was equal to 12.165 Tg.

Assessment of GHGs reduction potential in the heat supply sub-sector, due to the collapse of heat supply municipal system after the disintegration of the Soviet Union, appeared impossible because of data absence. Despite, GHG emissions accompanying the energy consumed for heating purposes in the cold period of the year should make the significant value. This issue requires thorough investigation that is not possible at this stage.

Since 1998, the inventory of GHGs emission and absorption sources had not been performed in Georgia. Taking into account CO_2 emission dynamics from the energy sector in 1995-1997, approximately 5 Tg/y could be considered as the characteristic value of 1999, to which corresponds to 26% of emission reduction potential.

Efficiency in the consumption sub-sector was evaluated separately for the various consumers and devices, efficiency of which varies in the wide range from 0.1 to 0.9. In spite of this it is evident from the given Table that in 1990 energy losses and corresponding CO_2 extra emissions were mostly associated with the residential module. In 1999 this value has increased up to 96%. This fact demonstrates very low efficiency of electric appliances used in the mentioned module.

Results of assessment of CO_2 emissions reduction potential as a result of implementation of the above mentioned project proposals are cited in the Table 5.3.2.

Table 5.3.2. Combined data on CO_2 emissions reduction potential owing to the implementation of project proposals in the energy sector, discussed in the project

No	Project Proposal	CO_2 emissions reduction potential, t/y	CO_2 emission reduction potential as compared to 1999, %
1	Modernization of Tbilisi CHP	98 000	61
2	Introduction of "Elegas" switches	1 060	100
3	Introduction of new starting devices in the street lighting system	942	31
4	Production of energy efficient lamps and their application for indoor lighting	37 700	80
5	Modernization of Tbilisi natural gas distributing system [§]	253 000	25-45 (40)
Total		487 702	

[§] Bulletin of the National Agency on Climate Change No10, 2001. p. 18-26

As to the electricity, evaluation carried out for the largest enterprises of the most energy consuming sub-sectors has disclosed GHG emissions reduction considerable potential. Results of these estimations are presented in the Table 5.3.3.

*Table 5.3.3. GHG emissions reduction potential in the leading subsectors and enterprises of the electricity***

No	sub-sector/enterprise	Energy consumption on 1 ton of produce output, GJ		CO_2 emission reduction potential	
		Existing	New	t/y	%
1	Rustavi Chemical Plant “Azoti”	40	34.4	31 000	14
2	Rustavi Metallurgical Plant	23.13	15.03	307 800	73
3	Tbilisi Bakery Plant No4	6.6	5.2	413	20
4	Rustavi Cement Plant 4.1. Increase of dust-catching efficiency 4.2. Replacement of “wet” method by the “dry” one	6.86 6.86	5.97 5.14	107 000 206 00	13 25
5	Wood processing industry (total)	2.7	1.6	3 000	40
Total				655 213	

As it is obvious from the comparison of the last two Tables, GHG emissions reduction potential in the industry sector is quite high. It demonstrates the necessity and valuable prospects to adopt the energy efficient technologies in this sector that requires more intensive study of this issue.

5.4. Barriers to the Technology Transfer in the Industry Sector and the Ways to Remove Them

Two sectors of the Georgian economy – energy and industry were examined within the project. Barriers to the energy efficiency in the energy sector and the ways to remove them were carefully examined in the project GEO/98/G42 “Removing barriers to energy efficiency in municipal heat and hot water supply in Georgia”. Therefore the same issues are considered in the current project for the industry sector.

In order to assess the energy efficiency of applied in Georgia technologies, survey of industrial enterprises operating in 1990 and 1999 was planned in the project. The most energy intensive technologies and industrial process related GHG emissions were to be revealed as well. Proposals on the improvement of energy efficiency or reduction of process related GHGs emission in industry sector were to be prepared as well. The project also envisaged searching for technologies existing at the international market and assessment of their acceptability for local industry and market considering current social and economic conditions. Special questionnaire has been designed for this reason. The different options for gathering the information has been planned: there was official request on information from the Ministry of Environment to enterprises; the members of the executing team individually worked with the technical staff of surveyed enterprises interpreting them the rules for submission of relevant information; officials of these entities were as far as possible involved in this process. It should be mentioned that the principal barrier related with the information gathering that hampers the ongoing in the country changes appears almost impossible to overcome. Besides the fact that these enterprises are in informational blackout, it is very difficult to get access to the information from outside. So, there are identified two types of barriers: the first one has emerged during the implementation of the project and overcoming of them was essentially depended on the executive group; the second type of the barriers is related to the Technology Transfer process and only some recommendations were elaborated to remove them.

Thus, among the barriers defined within the project implementation should be underlined the following:

? *Low level of public awareness concerning the mentioned problem i.e. the expressions “sustainable development” and “energy efficiency” are not still sufficiently realized by the mentality of the Georgian society and especially by the representatives of the industry sector;*
One of the ways to surmount this most important barrier is to use at most any project or program in order to prepare the awareness of managers for the above stated processes that should be done not only by workshops and articles, but also by organizing the on-site meetings even if it is difficult at the initial stage;

? *Complete disorder of coordination and subordination processes;*

** Data on additional enterprises see in the II Part of the Report.

Overall collapse of authoritarian regime and subordination system accompanied the democratization and disintegration processes in the transitional period makes it impossible to realize political, economic or environmental decisions even if there is political will of the government and corresponding legislative basis. At the current stage the personal relations were used to overcome this important barrier.

? *There are no managers at the old industrial objects (under this item are considered enterprises that have not been restructured yet and management of which is in absolute disorder) who possesses information on the basic economic and energy-intensity parameters related with the enterprises and main technological processes. Industrial enterprises practically have not information on the local and international markets especially concerning the technologies. Due to the fact that information is archived in different divisions of enterprises the major part of that is in disarray. Arrangement the meetings with all necessary persons possessing the information appeared almost impossible;*

This barrier would be partially removed by promotion of privatization process and by re-arrangement of state statistics system, the data of which notably differs from the data existing at the enterprises.

? *It should be emphasized that it was not easy to draw an interest of these enterprises neither to the energy efficiency problems nor to the concessionary investments for restructuring them;*
Privatization of the existing industrial enterprises (if Law of Georgia on Bankruptcy Proceedings is in force) will greatly improve the situation that from its part will facilitate the management of enterprises by persons having market-oriented mentality.

? *In spite of considerable international assistance that country gets under the various programs, we should mention the shortcomings that were revealed within the fulfillment of this or other similar programs and the surmounting of which will significantly promote more efficient implementation of the projects with sizeable results. In particular, we mean the technology transfer process that was not developed in a proper manner after the Rio Summit and has not given the results that was expected by the international society. It was several times faced the problem concerning the computer programs and models elaborated specially for transitional and developing countries that are not freely accessible for these countries;*
More active position of the international institutions, direct obligation of which is to facilitate the sustainable development and technology transfer process, will promote to remove the barrier. Indeed, the activities of national structures and experts in this direction are not less important.

Barriers to the energy efficient technologies transfer:

1. *Environmental protection is not the priority issue for Georgia and in general for the countries with economy in transition that are facing acute economic problems;*
   - Rising of the awareness on energy efficiency problems the economic effect of this phenomena (moreover in countries experiencing energy crisis and being in lack of energy resources) should be emphasized that of course is accompanied by environmental effect as well.

2. *Due to the fact that energy efficiency has no real priority inside the country, correspondingly there is no relevant obligatory legislative basis that would assist to improve the processes;*
   - Giving the priority to the energy efficiency within the energy security program and putting it in range of the state policy by the Ministry of Fuel and Energy and by those entities whose obligation is to facilitate the sustainable development of country would significantly decrease this barrier.

3. *There is no national authority that will coordinate energy efficiency improvement processes and will facilitate them. Though, there are separate international and national structures that are involved at the different stages and different issues of energy efficiency improvement process, but the level of coordination among them throughout the country is very low;*
   - Improvement of energy efficiency takes the major place in the National Environmental Action Plan prepared by the Ministry of Environment and if it becomes part of the policy of the Ministry of Fuel & Energy as well, the establishment of appropriate structure responsible for the implementation of the relevant legislative base would be one of the ways to improve the situation.

4. *Concluding the recommendations on the first and the second barriers it is clear that everything depends on the manufacturers' consciousness. Their awareness is not adequate to the anticipated benefits from the energy efficiency measures considering neither environmental nor economic effects;*

- Along with the international and national programs aimed to the awareness raising concrete demonstration projects should be realized with maximum involvement of national experts and managers. The results of these projects would be more noteworthy having strong legislative background. Considering other countries experience, the relevant legislation base and implementation mechanisms are not sufficient instruments without appropriate level of awareness.

5. *Delay in restructuring and privatization of one-time integrated state enterprises operating under the general planning system;*
   - At present, there are numerous international and national programs that promote the acceleration of privatization process and the development of private sector that finally should remove this barrier.

6. *Debts accumulated by the enterprises after 1990 that makes these enterprises less attractive for the investors;*
7. *The mentality of some managers and technical staff not always follows the quick structural and economic changes ongoing in the world and in the countries in transition. Due to the fact that the privatization process is occurring under the legislative contempt, the former directors are still managing the most of the enterprises. They are lack in initiative passively waiting for changes from outside. The lack of interest to the implementation of current projects is an explicit demonstration of this;*

- Training of new managers, establishment of joint enterprises and putting of bankruptcy mechanism in force would partially solve this problem.

8. *Frequent cut off electricity and unfix frequency;*

- One of the critical issues identified during the preparation of country report to the Johannesburg Summit is energy safety, the main indicator of which is accessibility to the high quality energy. The level of energy safety, the measures for improvement of energy safety and the political solutions on this issue at the national level greatly depend on the international programs and decisions adopted at the Rio+10 meeting.

9. *To pay for the consumed electricity is still unusual process for Georgian society, which is inherited from the soviet time when energy resources were very cheap;*

- Along with the raising of consumer mentality, privatization of distributor companies and arrangement of energy market, improvement of legislative basis for signing the direct contract with the consumer would assist to remove this barrier;

10. *Difficulties in forecasting the price of energy resource which affects the prime cost of the product and other economic parameters as well;*

- Significant assistance should be rendered to the countries with economy in transition by the international programs projecting the basic macroeconomic parameters and prices.

11. *Lack of technical personnel acquainted with advanced technologies. Relevant survey has demonstrated that experience accumulated by the scientists and engineers is not sufficient at this stage as it is based on the technologies produced in the former Soviet Union;*
    - The current project is directly aimed to overcome this barrier. It is evident that solution of all problems within one project is impossible, but situation would be step by step improved in this direction. It is also important to use computer data base on energy efficient technologies prepared by different international programs. Furthermore, the national experts should be trained in this field. This is one of the key issues of the “Technology Transfer” process adopted at the Rio Summit.

12. *Lack of local financial resources to become familiar with new technologies, develop indigenous know-how and implement the energy efficient measures;*

- Trust Funds that offer concessionary loans for environmental effect and additionality should be created to facilitate the energy efficiency as well as the use of renewable energy resources.

13. *Difficulties in attraction of necessary investments to introduce the energy efficient technologies and conduct the relevant measures;*

- The same as in 12.

14. *Existence of very old and completely outdated technologies;*

- This barrier significantly increases initial investment for energy efficiency measures and in the most cases the complete renovation of the enterprise is more effective. The accurate comparative analysis between complete renovation and implementation only energy efficiency measures and making the correct conclusions is important for assessment technical and economic feasibility of each option.

15. *High initial investment and long-term payback period while the finances are limited and the interest rate and the risk are high;*
- The same as in 12. Access to the concessionary loans and rising of public awareness on the economic and environmental benefits related with this issue could partly remove this barrier.

16. *The quality of metering the consumed electricity is still very low thought it is on the way of improvement. As a rule the share of energy expenses in the overall cost of product is known only approximately and in percentage.*
- Coming in force of market regulations, strict competition, entering in force the Georgian Law on Bankruptcy Proceedings, management based on the market principles, arrangement of accountability from the energy distributing private companies would facilitate overcoming of this barrier.

17. *The absence of fiscal and financial incentives. Regardless of the high risk investment in energy efficiency would be more reasonable and effective after putting the incentives in force.*
- Adoption of legislative basis, elaboration of proper policy and, what is the most important, its implementation would be the principle conditions to overcome this barrier.

6. GHG EMISSIONS ABATEMENT TECHNOLOGIES AND MEASURES[††]

6.1. ENERGY SECTOR

6.1.1. Degasification of Coal Layers

Important prospects are emerging concerning the application of modern degasification technologies to the gas-bearing beds of Tkibuli coal deposit. The introduction of these technologies makes it possible to produce at least 30-40% of total gas content of the seams (approximately 10-15 m^3 per 1 ton of coal or about 3.5-5.0 billion m^3 of gas for the total prospected deposit), and in case of the adoption of latest modern technologies-up to 70% of their total content [4]. Furthermore, the great amount of methane emission into the atmosphere could be averted and the ecological situation would be improved significantly.

The effectiveness of pre-mining degasification of coal in the Tkibuli deposit conditions is determined by the microporous structure and macrocracks at the deposit that provides high air-intruding and gas-conducting capabilities of local layers. On the basis of relevant research carried out by Georgian scientists, the projected parameters of Tkibuli deposit coal seams degasification are determined [41].

It has to be mentioned that in the deep horizons (1000-1200 m and lower) the coal beds abundance of methane is growing up to 40 m^3/t, that significantly increases the potential volume of methane which could be obtained as a result of the application of pre-mining degasification technology.

In recent years the recovery of methane from the worked out coal mines using the so called “Gob Well” method is widely advertised [5]. The space of these mines is filled, as a rule, by the mixture of coal and dead rock, and the area between the solid particles-by methane. The technology implies the intrusion into the crumbled area by the vertical boreholes or drilling of horizontal wells into the worked out dirt. Using traditional technologies it is possible to get from these wells 30-50 % of methane emitted in the air. In case of the preservation of relevant conditions the obtained gas contains up to 97% of methane which could be successfully utilized to produce heat and electricity. At the same time the safety of miners increases significantly and the expenses on the ventilation of worked out space are reduced.

The higher efficiency is achieved while applying modern technologies to the pre-mining degasification of coal beds [4]. This technology implies the drilling of degasification wells 2-10 years ahead of the recovery of layers by traditional method. The time period is dependent on the geological conditions of the deposit and planned volume of methane extraction. The technology enables to take away in advance from the coal layer 50-70 % of gas containing 95 % of methane. The obtained fuel is used in energy and residential sectors. By the way the safety of further treatment of the mine is improved and the ventilation expenses are cut short.

The coal beds degasification technologies are being widely adopted in recent years in different countries. In 2002 under the financial support of Russian corporation “Gazprom” the implementation of the project is starting in Kuzbass, which implies at the first stage to drill 3 degasification boreholes with the further development of the program. The total cost of the project makes US$ 34 million [14].

Under the parallel project, supported by the company “Kusbassgazprom”, the drilling of 10 experimental wells is foreseen in 2002-2005. In case of obtaining positive results the company plans to drill hundreds of wells for the degasification of coal seams. The financing of the initial stage of the project is estimated at US$ 15 million [26].

6.1.2. Underground Gasification of Coal Beds

The prospectiveness of the application of coal bed underground gasification technology in the Tkibuli deposit conditions is determined by the deep bedding of the strata, their low quality, the abundance of tectonic raisings, the existence of untreated areas in the worked-out space, etc. This technology requires about 2 times less initial investments, compared with the traditional methods of coal extraction. The time period necessary for the putting in operation the technology is also shortened significantly. These factors might play a decisive role in the conditions of current economic crisis in Georgia.

Modern technologies of coal underground gasification are elaborated at the Laramie Energy Research Center, Wyoming, USA.

By the simple calculations it could be deduced that as a result of the conversion of Tkibuli out of balance coal reserve (about 3.5-4.0 million ton) into the fuel gas 7 billion m^3 of gas could be obtained with the heat capacity of 5 MJ /m^3, which contains thermal potential equivalent to 1.1 billion m^3 of natural gas.

The application of underground gasification method is perspective for the revealing of Tkibuli deposit’s balance reserve coal with high content of ash. The use is such cases of traditional methods of extraction are

[††] This part of the Report is oriented predominantly for the Georgian specialists

economically inefficient. The practice shows that the prime cost of obtained fuel, translated into 1 ton of conventional fuel is 11 times higher than the cost of coal recovered at the open-cast mine and 1.5 times less than the cost of coal extracted by traditional methods in the mine. According to the information got from the USA, the prime cost of 1 ton of conventional fuel obtained by the underground gasification of coal varies in the range of US$ 7-17. As compared with the Tkibuli coal mines, the approximate prime cost of the extraction of 1 ton of coal with the heat capacity of 4 100kcal /kg using traditional technologies makes about US$ 30.

Coal Gasification Technologies
Incoming Flow Principle

In the gasification operating at the incoming flow principle, the coal is pressed in the form of powdered mass and is rapidly gasified in the high temperature suspended area. The size of particles is usually less than 100 microns that promotes the quick transformation of coal into gas. For the blowing flow the oxygen is used, that additionally requires the expensive separator, which must be included into the technological scheme.

The basic fraction of coal is mainly transformed into carbon monoxide and hydrogen. The gas, according to the sphere of its application, could require the chemical purification to separate hydrogen sulphide. The separation of ash is performed by the liquid slag. There are different versions of the process.

The first incoming flow gasificator has been constructed for the gas synthesis in chemical industry to obtain ammonia and methanol.

In recent years many electricity generating units using integrated gasification combined cycle (IGCC) have been put into operation in Europe. Gasification with high pressure incoming flow is applied in these units. The gasificators produced by Texaco and Shell, working on this principle are well known. First of them has been constructed to utilize the oil sediment and was adapted to use the carbon suspension, containing only 25-30 % of water. The Shell technology is less widely used though it is more energy efficient because it utilizes dry coal. In case of IGCC technology application it might be taken into account that usually it is intended to use large quantity of coal (in the electricity generating units of 250-400 MW capacity). Due to the high contents of ash in the Georgian coal a great amount of liquid slag is produced in gasificator that will cause the decrease of efficiency by some percent. This circumstance, for its turn, would condition the missing of major advantage of technology in comparison with the traditional technology of coal burning.

The remarkably high temperature of melting of ash in the Georgian coal complicates or even makes it impossible to separate the ash.

Fixed layer gasificator

A fixed layer gasificator initially has been created to produce gas from the coal for the residential and industrial purposes. This method provides the generation of low thermal capacity to use in industry or energy generation.

Gasification in fixed layer requires sorted and crushed to pieces (12-50mm) coal with low caking ability and low content of ash (usually of 10-15 %). The smallest fractions of Georgian coal need briquetting before the gasification, that increases the process expenses.

The coal and /or briquettes are delivered from the store or piles to the small feeder at the top of gasificator. A typical gasificator has two steps. First of them represents low temperature carbonization chamber, mounted upon the separate reservoir. At the second stage gas, heated up to 550^0C passes through the carbonizer. Gas having a temperature of 120-150^0C leaves the gasificator. The separation of pitch is provided by the wet electrostatic sedimentor. The clean gas passes through the cyclone to collect the remaining dust and then is delivered to the boilers to carry out industrial processes.

In view of high ash content of Georgian coal it will become necessary to take it away. Though it is practically possible, but is connected with additional expenses. Such two-step gasificator utilizes gas and produces heating gas of 9-10 MJ /m^3 thermal capacity, which does not require the addition of oxygen.

More pretentious to the quality of coal gasification units are known. E.g. the “Thermo” type gasificators produced in Russia are used to utilize the crushed coal with moisture content up to 30-35 % and high concentration of ash [13]. These devices are being applied to provide with heat brickworks of 10-12 mln t capacity.

Liquefied (Boiling) Layer

This technology is most appropriate to be used in the conditions of Georgia.

The liquefied (boiling) layer gasificators are more contemporary compared with the fixed layer gasificators. Both for the circulation and boiling layer gasificators the high ash content is permissible and the presence of small coal particles does not create any problem. The small fraction could be returned back and reprocessed to increase the gasification efficiency. At the same time the selection and crushing of large particles (>15 mm), or their utilization for other purposes is necessary. According to the ERC practices the Georgian coal is suitable to be used in the device of such type. The liquefied layer gasificator usually produces low thermal capacity (4.0-4.5 MJ /m^3) heating gas.

In compliance with the typical scheme, the coal is delivered from the ground level to the small feeding unit by the pneumatic transportation system. The additional installation is used to press the coal into the gasificator operating on gas, or possibly on the steam (according to the reactivity of coal and the desirable thermal capacity of produced gas). The steam could be used as a mean of transportation for the recurrence of small fraction picked up by the initial cyclone. As the system is entirely mixed, the temperature of the layer must be stable and regulated. Its value is determined by the desired thermal capacity of gas to be obtained. According to the reactivity of coal the temperature varies in the range of 900-1000^{0}C. Due to such high temperature the pitch is also disintegrated easily and transformed into the gas components. The row gas passes through two stages of cyclones. 90% of sedimented small fraction particles are caught at the first stage and are returned to the process. Small fraction of the second stage has smaller sizes and higher ash content, and is unfit for the further use.

As it is known, the ash of Tkibuli coal is difficult to melt. Thus they are the best mean to be used in the liquefied layer gasificator. Since for the Georgian coal the difference between the initial deformation temperature of ash and the normal operational temperature of the layer makes 400^{0}C, so the chance of loosing the fluidity stands at minimum.

The exact determination of operational temperature for the Georgian coal is impossible without the laboratory investigation. Whoever, we suppose that it would be in the standard interval i.e. below 1000^{0}C.

Recently the results became known of successful application of liquefied layer small capacity gasificator to the utilization of low quality coal [40]. The pilot CHP unit installed under this technology in the Chinese city of Weihan provides the production of 6 MW of electricity and 4 MW of heat. Corresponding to this information, it would be possible to use the Tkibuli coal in the unit of this type.

6.1.3. Modern Technologies for the Restoration and Reduction of Emissions from the Oil and Gas Pipelines

The adoption of contemporary technologies for the restoration of existing oil and gas pipelines is very urgent problem for Georgia. Their introduction would make it possible to increase the capacity of pipelines and, that is most important, to exclude the pollution of environment by the leakages of oil and gas. For example, losses from the Tbilisi gas distributing network are reaching 25 %, while in the international practice they do not exceed 2%. For this reason in 2001 about 40 mln m^3 of methane containing gas was emitted into the atmosphere. At the present time working out of a project on the restoration of Tbilisi gas distributing network is underway. Hence, the collection of information on the modern technologies for the restoration of underground pipelines is acquiring rather great importance.

In Europe and America the so called “N-Dig” technologies are widely known for the construction and restoration of underground pipelines, when they are put into the ground on the territory of settlements without digging of a canal (technology elaborated by the German company Ditch-Witch [6] and “Swage Lining” method worked out by the company Aarself [31]).

Various technologies for the rehabilitation of pipelines damaged by corrosion and fallen into disuse are known. While applying the American “CUES” technology the inner damaged surface of pipeline is covered by the special layer (1-3 mm thick) of epoxide resin, depending on operational pressure and the pipeline diameter.

The pipeline restoration technology using so called “stocking” or “Phoenix” method is widely applied as well, when the plastic mass surface is being introduced into the damaged pipeline and then under the pressure the inner corroded wall is filled up [30].

Contemporary technologies aimed at the reduction of emissions from the pipelines are broadly advertised. To decrease the gas losses by 70-80 % during the repair and restoration works on the pipeline it is recommended to use so called Low-Emission technologies instead of the application of traditional high-pressure technology [29].

Significant reduction of emissions is possible also by the use of different types of leak detectors and by the timely conduction of maintenance works. For this purpose the gas leak indicators and hydrogen ionizers could be used. The leak detectors are known applying the measurement of frequency and pressure, or using magnetic and acoustic transmitters. The detection by these devices of pipeline sections with possible leakage or already damaged parts, and proper planning of preventive maintenance makes it available to reduce gas losses due to leakages by 60% [30].

6.1.4. Industrial Co-Generation Units

The co-generation or CHP units are used to produce simultaneously electric energy and heat for industrial processes or heating. The application of CHP units is efficient in such places where both forms of energy-electricity and heat are needed [22].

Depending on the kind of fuel used, typical size and other requirements, for the efficient generation of electricity and heat the following units are used:

- Steam turbines: capacity 30-300 MWe, efficiency 25-30%, obtained temperature 93-316^{0}C;
- Gas turbines: capacity 10-100MWe, efficiency 25-30%, obtained temperature 370-480^{0}C;
- Open cycle gas turbines of indirect pressure: capacity 10-85 MWe, efficiency 25-30%, obtained temperature 370-480^{0}C;
- Closed cycle gas turbines of indirect pressure: capacity 5-350 MWe, efficiency 25-30%, obtained temperature 370-480^{0}C;
- Diesel motors: capacity 005-25 MWe, efficiency 35-40%, obtained temperature 260-370^{0}C.

(Here the efficiency of electricity generation cycle is given. The overall efficiency of fuel consumption makes 80-85%).

In the industrial co-generation systems coal, gas, mazut or diesel fuel, biomass and industrial byproducts (wastes), e. g. oilcoke could be used as fuel. Correspondingly the waste products would be solid, or emitted into the air or water as a polluting substances. In general, the specific emission from CHPs is significantly lower compared with the utilization of fuel by traditional methods.

Co-generation systems for the energy sector are reviewed in relevant project proposal, discussed in the Part II of this Report. Energy efficient lamps and energy efficient technologies for the electricity transmission sub-sector are examined in this part as well.

6.1.5. Use of Biomass in Electricity Generation

Biomass is widely used in co-generation systems for the production of electricity, steam and thermal energy. The capacity of such systems varies in the range of 2-100 MWe. More common are units of 20 MWe or less capacity.

As a fuel could be used wood, chips, agricultural wastes, peat, fuel wastes with 50% moisture content. The efficiency of biomass fired unit for the electricity generation process makes 15-30%, while applying to co-generation systems it rises up to 60%.

These technologies are commercially viable and are widely used in practice. In the near future multi-fuel boilers will come into operation as well, in which different kinds of biomass and wastes are used simultaneously. The development of Biomass Integral Gasification Cycle Technology (BIG/ CT) is underway as well. The systems are also worked out utilizing coal and municipal wastes along with the biomass. This technology makes it possible to generate electricity in a stable manner despite of seasonal variation in biomass production [2].

For Georgia which is rich in wood and possesses huge amount of sawdust, it is very important to adopt its palletization process. In the process of project implementation it appeared impossible to contact the companies manufacturing devices of this kind.

6.2. INDUSTRY SECTOR

From the branches of industry which were well developed in the Soviet period and are considered as significant emitters of GHGs, we have to discuss the following branches: iron and steel industry, cement production, chemical industry, food industry and timber and wood processing industry. They are to be reviewed from the standpoint of application to them modern energy efficient and GHGs emission reducing technologies.

6.2.1. Iron and Steel Industry

The emission of carbon dioxide in the iron and steel industry is predominantly caused by the use of fossil fuel, consumption of electricity and application of coal and lime as an initial row material.

On the Fig. 6.1 the Integrated Steel Plant's technological process is given which consists of 5 main steps, though the number of steps in the contemporary energy efficient plants is less.

From the reviewed steps iron making in the blast furnace is most energy-intensive process in the ferrous metallurgy and it requires about 11-15 GJ of energy per ton of pig iron produced. Of this amount approximately 7 GJ is used for the chemical reduction of iron ore to pig iron. Carbon (from coal or coke) is used both as the reducing agent and as the energy source. About 50% of energy consumed by open hearth furnace is used to support the reduction chemical process. The electric arc furnace is regarded as less energy consuming and more energy efficient alternative to the open hearth furnace. The electricity consumption by the electric arc furnace has decreased from about 550 KWh per ton of liquid steel to 350 KWh in the late 1990s. The theoretical minimum is 300 KWh/ t. In the Table 6.2.1 the energy consumption to produce 1t of cast steel (tcs) by different methods is given.

Table 6.2.1. Energy intensity of different processes of steel making, GJ/ tcs

N	Process	Lowest (best actual)	Average	Technological steps
1	1.1. Basic oxygen furnace 1.2. Open hearth furnace	22 NA	26 38	1-5 1-5
2	Scrap-electric arc furnace (Scrap-EAF)	7.7	10	3-5
3	Direct Reduced Iron (DRI)-EAF (gas)	22	26	3-5
4	DRI-EAF (coal)	25	36	3-5
5	Corex	19		

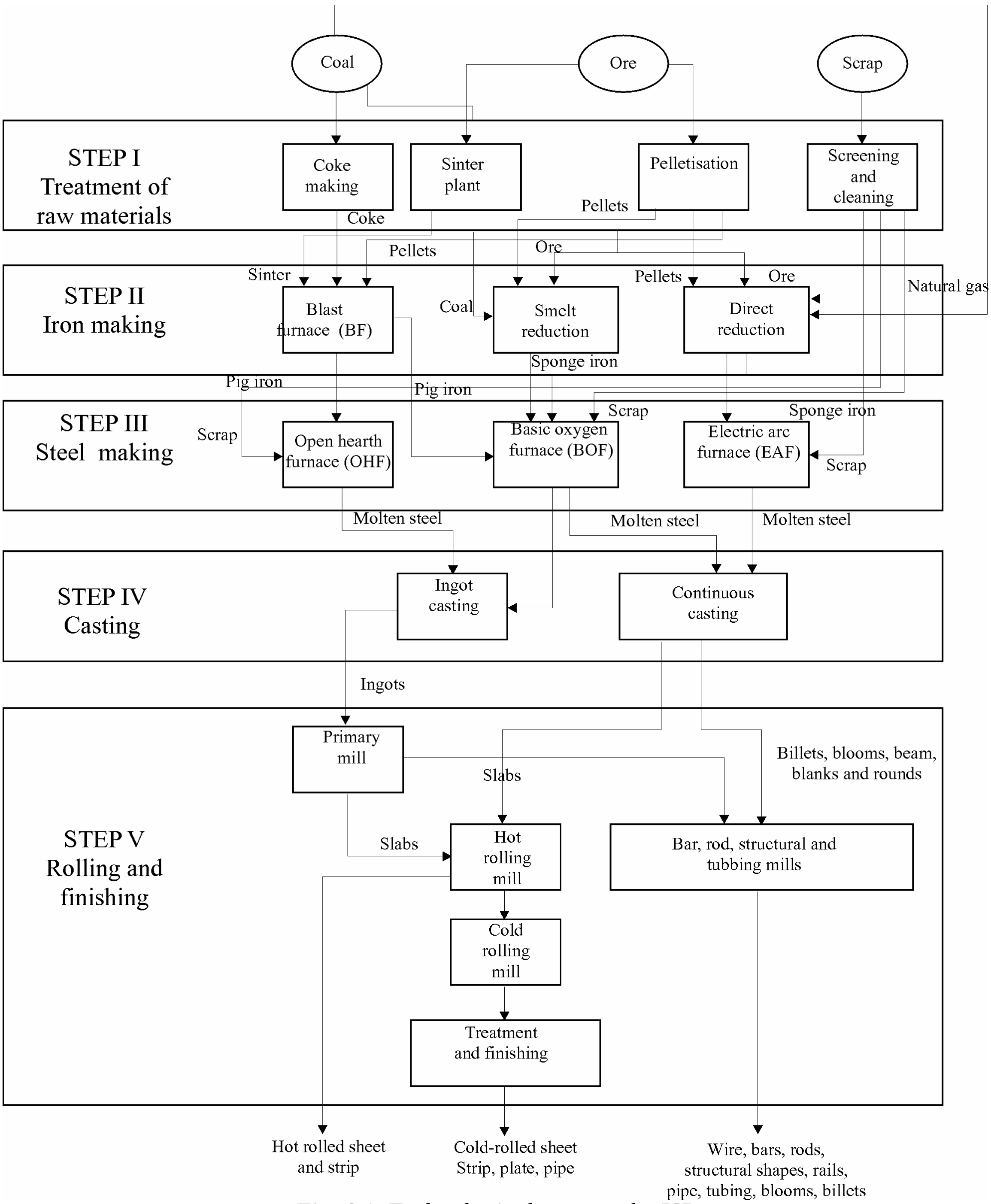


Fig. 6.1. Technological steps at the ISP

It is to be mentioned that energy consumption at stage 3 significantly depends on the iron content in row material. In the Table 6.2.2 the differences are shown between the consumption of fuel and electricity for hot rolling and cold rolling per 1 ton of shaped steel.

Table 6.2.2. Fuel and electricity consumption for the production of 1 t of rolled steel

N	Process	Fuel consumption (GJ / t shaped steel)	Electricity consumption (GJ / t shaped steel)
1	Hot rolling	1.53	0.35
2	Cold rolling	1.10	0.53

In the Table 6.2.3 different methods of steel casting at the integrated steel plant are given along with the possibilities of energy saving.

Table 6.2.3. Energy saving possibility in the framework of CDM project implementation

N	Technology to be implemented	Energy saving per ton of produce, GJ
1	Ingot casting	-
2	Continuous casting	2
3	Thin slab casting	2?4
4	Strip casting	2?4+X

As the fourth method is quite new and as far it is introduced only at 3 plants, the energy saving is not yet estimated and consequently this is indicated by X in the Table.

At the same time it is important to take into account how depreciated is the machinery used, by what means is obtained consumed electricity and what kind of fuel is burned.

Below is given a list of essential measures, well known in the international practice, by the introduction of which it is possible to reduce GHG emissions from the iron and steel module. This branch of industry is the largest emitter of GHGs in the industry sector. Its energy consumption makes 10-15% of total industrial consumption, and the amount of associated CO_2 emissions from this branch equals to about 7% of global anthropogenic CO_2 emissions.

- The replacement of open hearth furnaces by electric arc furnaces is saving from 1 to 3 GJ of energy in the production of 1t of cast steel, that corresponds to 5-15 % of the value presently adopted in OECD practice;
- Making steel from the scrap;
- Application of continuous casting of steel that at the mean time is replacing the ingot casting. The last one requires the repeated thermal treatment of produce in the primary mill to manufacture rolled and finished steel commodities. Continuous casting provides necessary shaping of metal before its cooling.

From the listed above measures in our pilot project the adoption of electric arc furnace instead of open hearth furnace is proposed.

6.2.2. Cement Production

The energy intensity of cement production is essentially dependent on the kind of cement, that is determined by the quantity of clinker in it, and on the chemical characteristics of the row material. The energy consumption constitutes 30-40% of the cost of produced material. In 1994 the CO_2 emissions from the cement production made 5% of global emissions associated with energy consumption. The highest quality cement is Portland cement, which contains up to 95% of clinker. In other kinds (composite pozzolanic, blast furnace or Portland composite) the content of clinker varies between 20 and 94%.

The technology of cement production, which contains 3 main rings, is given on the Fig. 6.2.

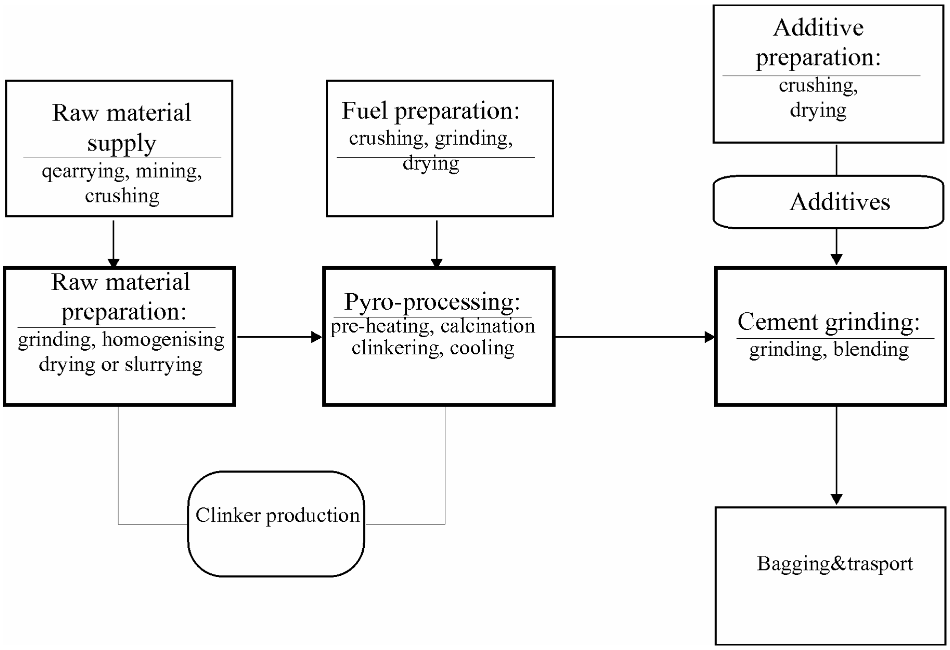


Fig 6.2. Steps of cement production

In the Table 6.2.4 the energy intensity features of cement production technological steps are presented (according to [8]).

Table 6.2.4. Energy intensities of cement manufacturing technological steps

N	Manufacturing steps	Lowest specific energy consumption (per unit)
1	Preparation of row materials	16 KWhe / t row material or 27 KWhe / t clinker[1]
2	Pyro-processes [2]	3.0 GJ /t clinker +26 KWhe
3	Cement grinding (new plant)	28.2 KWh / t cement [3]
4	Cement grinding (capacity upgrades)	36.8 KWh / t cement [4]
5	Additive grinding	32.8 KWh / t

1. It is assumed that 1.65 t of row materials are needed to produce 1 t of clinker. This value does not include the energy for drying the row materials;
2. Does not include energy for grinding the fuel;
3. Data corresponds to the use of roller press, 1-4% moisture content and ground to 3500 Blane. In other cases the value will differ;
4. Assuming 2-stage grinder with roller press, 1-4% moisture content and ground to 3500 Blane.

The reduction of GHGs emissions in the production of cement could be achieved by the introduction of following basic measures:

- Transition from the “wet” process to the ”dry” process of cement production;
- Improvement of row materials preparation, the application of boiling layer dryer in the use of low quality fuel, application of dryer operating on the unused heat, differentiated grinding of gypsum and clay;
- Modification of kiln burning system to reduce heat losses, the recovery and utilization of heat released in the process of cooling of manufactured produce, application of boiling layer, only electricity consuming or hybrid kilns;
- Blending of cement by less energy consuming way;
- Improvement of grinding devices, including the perfection of particle size control.

From the above listed measures most important for the provision of CO_2 saving is the replacement of “wet” process, in which for the clinker production is consumed 5.7 MJ/kg, by the “dry” process with pre-heating, which requires 3.3 MJ for the production of 1kg of clinker. At present the wet process is gradually withdrawn from the use is most developing countries and it remains in few of them, including Georgia.

List of technologies reviewed in the framework of current project is given in the Table 6.2.5.

Table 6.2.5. Technologies reviewed in the project and their main features

	Technology	**Essence of technology**	**Technology efficiency**	**Note**
1	***2***	***3***	***4***	***5***
1. UNDERGROUND PIPELINES				
1.1	Leak detectors and pipeline repair	Reduces methane emission from the natural gas transmission and distribution pipelines	Emission reduction by 60-80%	
2.1	Replacement of high-pressure exhausters with low-pressure ones	Provides catching of emitted gas while pipelines cleaning	Emission reduction by 80%	
2. PRE-TREATMENT OF COAL				
2.1	Application of pulverized coal in TESs	Technology means pre-cleaning, grinding and drying of coal before entering in combustion chamber	Efficiency reaches 30-35%	
2.2	Underground gasification of coal bed			Prospective for the Tkibuli deposit. 7 billion m^3 of gas with 5MJ/m^3 heat content could be got from outbalance reserve of the Tkibuli deposit (3.5-4 million t)
2.3	Gasificator operating on incoming flow principle	Coal is pressed like flour and is gasified at high temperature		Could be used in the Georgian conditions, but requires briquetting
2.4	Coal gasification by the fixed layer	Production of low heat content gas from coal for making use in the industry and energy generation		
2.5	Liquid (boiling) layer gasificator	Produces fuel gas of low heat content (4-4.5 MJ/m^3)		Quite effective in the Georgian conditions, as high ash content is acceptable
3. METHANE EXTRACTION FROM COAL DEPOSITS				
3.1.	Gob Well technology	Methane recovery technology from worked out coal mines	Methane emission in the atmosphere is reduced by 30-35%.	
3.2	Pre-mining degasificatation of coal beds	Drilling of degasification wells 2-10 years before layer treatment by the traditional approach	Reduction of gas content in the deposit by 50-70% (95% methane)	
4. CO-GENERATION SYSTEMS				
4.1	ROLLS-ROYCE INDUSTRIAL POWER SYSTEMS LTD RB211 type air-turbine unit	27-30 MW	Efficiency 50-60%	
4.2	GENERAL ELECTRIC MS 6001 B type air-turbine unit	39, 62 MW	Efficiency 50-60%	
4.3	MAN GHH BORSIG FT-30 type air-turbine unit	25 MW	Efficiency up to 60%	Considerable reduction of hazardous emissions and noise level
4.4	MAN GHH BORSIG, steam boiler-utilizer	25 MW	Efficiency up to 50%	
4.5	Air-turbine of Ukraine made			
5. ELEGAS SWITCHES				
5.1	SIEMENS ZAT2-FI-500	500 kV transmission lines		Increase of reliability of lines operation, saving of electricity consumption by relevant reduction of GHG emission
5.2	SIEMENS AAP1-F1-220	220 kV transmission lines		
5.3	ALSTHOM SI-245 F3-220	220 kV transmission lines		
6. ENERGY EFFICIENT STARTING DEVICES				

1	2	3	4	5
6.1	OSRAM (Germany, Turkey, Italy)			Efficiency equals to 0.98 Power factor is 0.98 Operating frequency 40 KHz
6.2	TOPSTAR, (China)			
6.3	PHILIPS (the Netherlands, Poland)			
7. AUTONOMOUS LIGHTERS OPERATING ON SOLAR ENERGY				
7.1	PHOTOWATT Inc. (France)		Solar panel capacity is 0.5-1.2 W. Capacity of energy saving lamps is 18 W. Accumulator capacity is 75-150 ah Operating time 6-14 h	
7.2	SIEMENS SOLAR (Germany)		Similar parameters	
7.3	SOLITTE (Austria)			
8. ENERGY SAVING LAMPS FOR INDOOR LIGHTING				
8.1	OSRAM (Germany, Turkey)		Power factor 0.50	
8.2	PHILIPS (the Netherlands, Poland)		Power factor 0.50	
8.3	TOPSTAR, JIA MEI (China)		Power factor 0.45. It could be increased up to 0.95-0.96 and loading on electric networks could be reduced 5 times.	
8.4	PROLITE (Germany)		Power factor 0.60	
9. STEEL PRODUCTION				
9.1	ISP	22		
9.2	Scrap-EAF	7.7		
9.3	DRI-EAF (gas)	22		
9.4	DRI-EAF (coal)	25		
9.5	Corex	19		
	Rolling	Energy consumption, GJ/t		
9.6	Hot rolling	1.88		
9.7	Cold rolling	1.63		
10. CEMENT PRODUCTION				
10.1	Cement production by the “dry” method	3.3 GJ/t energy consumption instead of 5.7 GJ/t for clinker production using “wet” method		
10.2	Raw material crushing	Use of rolling and hydro-grinders (0.3-0.7 kWh e./t) instead of hummer grinders (1.5-1.6 kWh e./t)		
10.3	Raw material grinding	Making use of rolling press (12 kWh e./t) instead of ball mill (22 kWh e./t)		
10.4	Calcination in Kiln (consuming only electricity)	Application of 5-stage pre-heater with pre-calcination (26 kWh e./t) instead of semi-dry method (30 kWh e./t)		
10.5	Calcination in Kiln (by direct consumption of fuel)	Short furnace, application of 5-stage pre-heater for calcination (2.9-3.2 kWh e./t) instead of wet furnace (5.9 kWh e./t)		
10.6	Clinker grinding	Application of rolling press (24.5 kWh e./t) instead of ball mill (55 kWh e./t)		
11. BREAD INDUSTRY				
11.1	Flour transportation at the first stage of technological process	Application of screw elevator (3 kWh) instead of aerosol-transport (75 kWh)		
11.2	Bread baking	Installation of advanced energy efficient furnaces. Reduction of electricity consumption by 30%.		
11.3	Steam supply	Installation of advanced steam boilers. Reduction of natural gas consumption by 30%.		

Energy consumption to produce 1 ton of cast steel, GJ/t (the best parameter)

7. RAISING OF PUBLIC AWARENESS

The raising of public awareness on the issues of the currently applied technologies` energy efficiency increase and associated reduction of GHG emissions is directly linked with the growth of interest to the global problem of climate change. The growing tendency in recent years towards the increase of climate warming and of dangerous hydrometeorological phenomena intencity has promoted the sharpening of public attention to this problem.

In the framework of the current project the activities on the raising of public awareness on the above mentioned subject, that began during the implementation of the initial phase of the project, were continued. As a result of these activities the wide circles of society-policymakers, leaders of separate sub-sectors of economy, representatives of the private sector, academic and educational institutions were informed on the works being carried out worldwide on the subject of climate change and the participation of Georgia in these activities. At this time, during the focused on the necessity of energy efficiency raise of technologies currently applied in the energy and industry sectors, and on the possibility of corresponding reduction of GHG emissions.

From the very beginning of the project implementation the PMT established close contacts with the experts representing different governmental structures related to the problem. A group of experts has been hired from the Department of Science and Technologies, but after a short period of time it became evident that the Department does not possess the information of the necessary extent on technologies currently applied in the energy and industry sectors. In spite of this, these experts became aware on the principles of the UNFCCC that will be used by them in their future activities relevant to the selection of environmentally sound technologies to be applied in different sectors of Georgian economy. Highly fruitful turned to be the cooperation with the experts from the Georgian Technical University. That became possible because most experts from this group took part in the implementation of preceding project GEO/98/G42, aimed at the removing of barriers to the restoration of Georgia’s municipal heating system. The group, consisting of 8 experts and led by Prof. M. Kipshidze, managed to collect highly valuable information on the state of country's energy sector in 1990 and 1999, and to thoroughly analyze the obtained database. The analysis has been carried out from the standpoint of the correspondence of applied technologies to the modern standards of energy efficiency and environmental protection. This helped the group to select technologies compatible with the requirements of the UNFCCC and adoptable in the real conditions of Georgia. A variety of currently applied technologies have been reviewed in the generation, transmission, distribution and consumption segments of energy sector. The efficiency of these technologies has been assessed and the possibility of their improvement or substitution by the advanced technologies has been estimated.

Individual experts have been invited also for the solution of a number of problems, connected with the reviewing of energy efficiency and estimation of GHGs emission reduction potential in some sub-sectors of industry and with the projection of energy sector development in the nearest 10-20-year period. These experts represented the Georgian Parliament, Ministry of Environment, Ministry of Economics, Industry and Trade, Ministry of Healthcare, National Agency on Climate Change, different design institutes and some large enterprises of the industry sector. In all, about 20 national experts have been trained in identifying the compliance of currently applied technologies to the principles of the UNFCCC and the benefits of the introduction of advanced technologies in the energy and industry sectors.

Owing to the necessity of getting information to create the technology database, the members of PMT and national experts established close contacts with the managers and leading specialists of a number of large industrial enterprises, involved in the inventory of applied technologies. These contacts were used to raise the awareness of leading personnel in the energy and industry sectors on the principles of the UNFCCC, the main objectives of the current project, the goals of technology transfer process and the possibilities to use this process for the advancement of Georgian energy and industry sectors on the environmentally sound basis.

During the implementation of the project the project Manager Ms. M. Shvangiradze has met several times with the managers of Rustavi Metallurgical Plant and discussed with them the proposals to modernize the production of steel pipes at the plant. With the late Project Manager Mr. T. Gzirishvili she made a number of visits to the Zestafoni Plant of Ferroalloys as well, trying to involve the managers of the plant in the preparation to the technology transfer process. Under the initiative of the Governor of Imereti Region Mr. T. Shashiashvili in the end of September 2001 she took part at the special meeting of the economic managers of the Region. She has used this opportunity to raise their awareness on the economic and environmental benefits of technology transfer process. Different forms of possible financial support for these measures using the confessional loans from foreign investors have been discussed. Ms. M. Shvangiradze together with project expert Ms. L. Inasaridze established contacts with the managers of Tbilisi bread-baking plant No4 and during their visits to the plant explained the objectives of the project to them. As a result, valuable data have been gathered, illustrating the potential for raising energy efficiency and renovation of technologies in the enterprises of this kind. Ms. M. Shvangiradze also made a number of visits to the Tbilisi Analytical Instruments Enterprise “Orion”, aiming to involve this enterprise in the process of technology transfer. During the meeting with the leading experts of the plant the idea has been suggested on the utilization of sawdust, produced by the local timber industry, for the manufacturing of pallets.

The Assistant Manager of the project Mr. B. Beritashvili established close contacts with the managers of Rustavi Cement Plant and Chemical Enterprise "Azot". They were informed on the objectives of the project and opportunities for their plants which could be obtained by the participation in the technology transfer process. As a result on the interesting material has been gathered to be used for the preparation of project proposals.

In the process of collecting data for the energy sector the head of this group Prof. M. Kipshidze had several meetings with the managers of separate energy enterprises who collaborated with the project by providing project experts with the necessary data. The same work has been performed by the National Expert Prof. T. Gochitashvili, who made several visits to Tkibuli mines, oil and gas transporting companies, informing their leaders and experts on goals of the current project and gathering the primary data. The project expert Ms. M. Basilashvili has worked in close cooperation with the managers of Tbilisi gas distributing company "Tbilgazi" while preparing grounds for the project proposal on the modernization of Tbilisi gas distributing network.

One of the major events in raising public awareness on the problems of energy efficiency and technology transfer was the project concluding workshop, held in mid-December 2001 at the UN Georgian Office in Tbilisi. The theme of the workshop was "Energy efficiency in Georgia, barriers to energy efficient technology transfer and ways to remove them". Representatives from the following governmental bodies, academic institutions and NGOs took parts in the workshop:

? Georgian Parliament
? Ministry of Environment and Natural Resources Protection
? Ministry for Fuel and Energy
? Ministry of Agriculture and Food
? Ministry of Economics, Industry and Trade
? United Nations Development Programme (UNDP)
? National Agency on Climate Change (NACC)
? Georgian Technical University (GTU)
? Institute of Hydrometeorology of the Georgian Academy of Sciences (IHM)
? Energy Efficiency Centre of Georgia
? JSC Chemical Enterprise "Azoti"
? JSC "Energogeneratsia"
? NGO "Movement of Georgian Greens"
? NGO "The Green Alternative"
? NGO "Partnership for Social Initiatives"

Along with general reviews of the problem and policy statements, the papers presented at the workshop included the results of examinations on specific aspects of the current project, in particular:

? Main objectives and preliminary results of the project GEO/96/G31 (phase 2) (M. Shvangiradze)
? Analisys of Georgian energy sector status in 1990 and 1999 concerning the adoption of energy-efficient technologies in the:
? Generation and transmission (M. Kipshidze),
? Consumption (D. Dvali).
? Energy efficiency assessment of technologies applied in extraction and transportation of energy resources in Georgia (T. Gochitashvili)
? Tentative scenarios for the development of energy sector in Georgia (I. Shekriladze)
? Possible directions of the Georgian energy sector development (M. Kipshidze)
? General features of the functioning of Georgian industry sector in the period of 1990-2000 and prospective for its development (B.Beritashvili, G. Dadiani)

The workshop gave the possibility to experts engaged in the energy efficiency activities to discuss a number of urgent problems and coordinate their efforts in achieving the common goal- revitalization of Georgian economy on the basis of modern energy-efficient technologies. Papers presented at the workshop are planned to be published in No 11 issue of Bulletin of the National Agency on Climate Change in 2002.

Like in previous projects, the raising of public awareness on climate change-related issues was one of the priorities of current project as well. Though is this case the emphasis was made on the necessity to transfer modern technologies to the Georgian energy and industry sectors and to increase the energy efficiency of currently used technologies. In this respect the publication of extensive interview by the late Project Manager the Director of the National Agency on Climate Change Dr. T. Gzirishvili in the daily newspaper "Gza" (08.02.2001) is to be mentioned under the title "Georgia is given a chance for the accelerated development". A number of his TV-appearances on the subject of necessity to transfer to modern technologies in Georgian energy and industry sectors are to be noted as well. The Assistant Manager of the project Dr. B. Beritashvili also published an interview on the same subject in another newspaper "Akhali Epoka" (28-30.08.2001.)

The proposed project on the reconstruction of Tbilisi gas supply network and joint efforts by the NACC and USAID were discussed in the article "National Agency on Climate Change is elaborating project for the survival of Tbilgazi" (Monthly magazine "Economics", No 5, 2001).

Significant contribution to the subject of our project was made by the publication in Georgian and English of No 10 issue of Bulletin of the National Agency on Climate Change, in which 2 papers relevant to the current project were placed:

- "Environmental problem in cement production" by T. Gzirishvili, B. Beritashvili and J. Karchava and
- "Estimation of gas leakage from Tbilisi natural gas distributing network and ways to improve the condition of the network" by T. Gzirishvili, O. Giorgobiani, Sh. Mestvirishvili and M. Basilashvili.

The issue was widely distributed among the concerned organizations both in Georgia and abroad.

8. CONCLUSIONS

The current programme of assessment the technology needs in non-Annex I countries has the special importance for the countries with economy in transition, like Georgia. It is well known that the energy policy and energy consumption in the Soviet period was very squandering. Introduction of the advanced energy efficient and correspondingly economically efficient technologies at the initial stage of the sustainable development of the energy and industry sectors being under the rehabilitation and restructuring is the essential condition for successful progress.

It has to be noted that out of these two sectors (energy and industry) considered in the project especially remarkable results are obtained for the energy sector. 1345 units operating in the generation and transmission sectors were described in detail and their energy efficiency was assessed by the state of 1990 and 1999. Collected data were archived into the computer data base. The railway transport, subway, trams and trolleybuses were thoroughly described in the consumer sector. The electric appliances and street and indoor lighting were not assessed at the desirable level because of the lack of initial data.

Along with the low energy efficiency the amount of extra GHG emissions was estimated. Estimated extra emissions of GHGs could be reduced by recovering the designed efficiency of the operating technologies and also under the adoption of the modern energy efficient technologies. As a result, at least 1.46 million ton of CO_2 could be reduced annually from the energy sector (generation, transmission-distribution and consumption) including the low efficiency of Hydro Power Plants.

As the heating systems in Georgia have not been operating since 1993 the assessment of energy efficiency in the sector was performed only for 1990.

Based upon the obtained results, the low efficient units that will give the considerable economic and environmental effect as a result of increasing their efficiency were estimated: Tbilisi CHP, from the generation units, advanced elegas switches in the electricity transmission sector and energy efficient lamps of street and indoor lighting in the consumer sector.

Obtained results have attracted the great interest of the different Ministries and Departments in Georgia related to the energy sector and to the problem of energy efficiency. According to the existing information the database of Georgian energy sector comprising detail inventory of energy objects and their efficiency was created first time.

With regard the industry sector the performed work is the first serious step for assessment the state of the sector under the principles of the UN Framework Convention on Climate Change. Several large enterprises were surveyed at this point: Rustavi Metallurgical Plant, Rustavi Cement Plant, Chemical Plant "Azoti", two medium sized bakery plants. Energy efficiency of each technological step was assessed at the above listed enterprises and some proposals on increasing the energy efficiency were elaborated. Respectively, amount of GHG which could be reduced implementing the measures presented in the proposals was estimated.

As a result of the project implementation it became evident that effective realization of the Convention principles in the country is almost impossible without carrying out of such kind of works. Continuation of activities in the industry sector would be necessary at the subsequent stage in order to reach the same level that has been achieved in the energy sector. Also the first steps should be done in the transport sector.

The main barriers to the problem considered in current project are low environmental public awareness and intricate coordination among the different departments.

Project implementation team hopes that the results acquired within the project would be applied to the activities planned for the modernization and improvement of energy efficiency of technologies utilized in the Georgian energy and industry sectors. At the same time they should play a significant role in the preparation of the second national communication of Georgia to the UNFCCC and the designing of the National Climate Change Action Plan.

PART II

ENERGY SECTOR

1. PROPOSAL ON GHG EMISSIONS REDUCTION IN POWER GENERATION SECTOR (TBILISI CHP MODERNIZATION APPLYING ADVANCED ENERGY EFFICIENT TECHNOLOGIES)

1.1. Introduction

The main function of Tbilisi Combined Heat and Power plant (CHP) operating since 1939 is provision of the central part of the city with electric and thermal energies. CHP is an important object providing city with electricity. In case of electricity deficit it autonomously supplies primary importance consumers, disconnected from the system

By 1946, power capacity of Tbilisi CHP was equal to about 8 MW. As a result of development and reconstruction conducted in 1966 its installed capacity reached 18 MW and design thermal capacity – 110 MW. Out of this 70 MW was considered to be generated by steam turbines and the rest – from the peak boilers.

Till 1960, mazut was used as a main fuel in Tbilisi CHP. By the same year, natural gas was used as a main fuel and mazut – as a reserve fuel.

At present, Tbilisi CHP could not meet the demands of important objects situated in the center of Tbilisi and requires reconstruction and modernization using the advanced energy efficient technologies.

1.2. Main Units of the Tbilisi CHP, Their State and Reconstruction Needs

At present, the following main devices are installed at the Tbilisi CHP:

? Four energy boiler installations – 2 x ? ? -50, 1 x TM-35 and 1 x ? ? -35. Their function is generation of necessary amount of super heated steam for turbines with relevant parameters. The parameters of boilers are as follows:
- Steam generation capacity of No1 and No2 boilers (? ? -50) equals to 50 t/h, super heated steam pressure – 40 ata, and temperature – 440^0C. They have been put into operation since 1975 and 1977, correspondingly;
- Steam generation capacity of No3 and No4 boilers (TM-35 and B? -35) equals to 35 t/h, super heated steam pressure – 43 ata and temperature – 450^0C. Both of them have been operating since 1958.

Three turbo-generators 1 x A? -6 and 2 x AT-6 with steam extractions. Their parameters are as follows:
- Nominal electric capacity of No1 turbo-generator (1 x A? -6) is 6 MW and thermal capacity – 25 MW. Parameters of steam obtained from the turbine pipe are as follows: pressure – 5 ata, temperature – $230\div244^0$C and mass consumption – 40 t/h. Thermal energy of steam obtained from this turbo-generator is for industrial consumers. It has been operating since 1966;
- Nominal electric capacity of No2 and No3 turbo-generators (2 x A? -6) stands at 6 MW and thermal capacity – 22 MW. Pressure of steam obtained from these turbo-generators is 1.2 ata and temperature – 132^0C. They have been operating since 1966 and 1958, correspondingly.

? Two basic boilers (2 x ?? -200), two peak boilers (2 x ?? -115) and one delivery water peak heater (1 x ? ? ? -315-3-23), for heating of heat and hot water supply network water:
- Delivery water in the base boilers should be heated up to 103^0C;
- Water temperature in peak boilers and delivery water heater should be up to 151^0C.

? Two hot-water boilers – 2 x ? ? ? ? – 50, which should generate thermal energy required for heat and hot water supply in the coldest period of season. Thermal capacity of Tbilisi CHP was sizably increased in 1968 after their installation.

As it is evident from the presented information, almost all above listed main installations of Tbilisi CHP have passed a depreciation period and so they are not energy efficient. For the present time, actual efficiency of thermal power plant is low – 23.43%. Despite the fact that at present some of units are in an operating status, their reliability and characteristics are considerably decreased reasoning from the technical condition. Some equipment needs replacement at all. For example, No3 turbo-generator is not in operating condition, one main boiler (?? – 200) and two peak boilers (?? – 115) of thermal system should be replaced, both of hot-water boilers are out of order, etc.

Simplified thermal scheme of Tbilisi CHP (before reconstruction and modernization) is presented on the Figure 1.1. Steam from boiler installation (1) is delivered to turbo-generators (2) through the general collector and in case of necessity to reductive-cooling devices (3). The tangible amount of steam is extracted from the turbine and is delivered through the collectors (5 at and 1.2-2 at) to the main boilers (6) preparing the delivery water and to the peak boilers (7, 8) during the thermal regime. Waste steam, which volume is changing according to the turbines operational conditions, runs to the condensers (4). Circulating system of process water required for the condensers is directly feeding from the R. Mtkvari. Thermal device is linked with the heat network by the double-pipeline system.

Water returned from the heat network is delivered through the network pump (5) to the boilers and water route of hot-water boilers (9) and then passes in the heat network "supply" line. To composite water loses in the network, the process water as well as delivery water from the routes passing through chemical treatment devices is added (10).

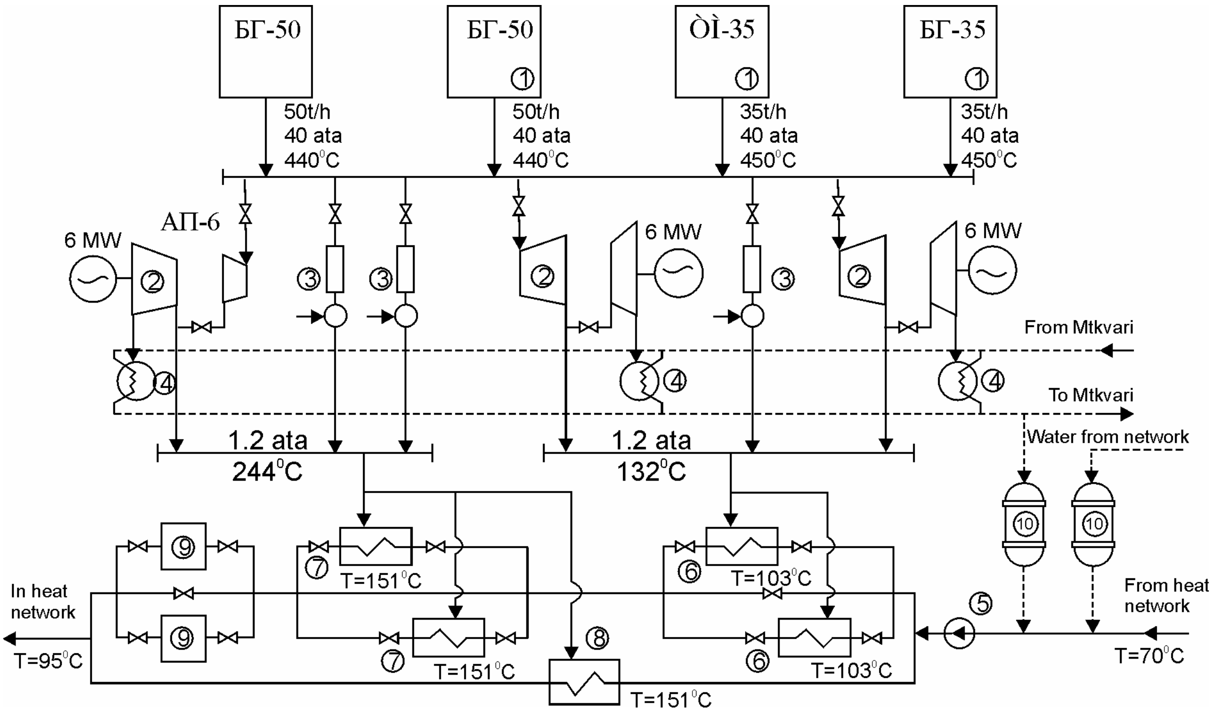


Fig.1.1. Simplified thermal scheme of Tbilisi CHP

As it has been already mentioned, the main function of Tbilisi CHP is provision of basic objects located in the center of Tbilisi (schools, hospitals, communication centers, theatres, State Chancellery, Parliament, etc.) with electric and thermal energies. CHP is important during the blackout, when country is entirely or partially without electricity. The part of the city is automatically disconnected from the unified energy system and Tbilisi CHP provides the above-listed objects with electricity. For the present time, Tbilisi CHP of such a great importance is physically and morally depreciated. The fact that conventional fuel for generation per kWh electricity raised from 412 to 525 gcf/kWh within 1990-1999 indicates its low efficiency. Reasoning from all above-stated, it is clear that reconstruction and re-equipment of Tbilisi CHP, so as to improve the baseline capacity source, is urgently needed.

1.3. Modernization of Tbilisi CHP by Installing of the Steam and Gas Combined-Cycle

At present, wide adoption of steam and gas combined-cycle in the existing thermal power plants is the best way to restore baseline capacities. This approach corresponds to the latest international practice and is based on high efficiency of steam and gas combined devices. In particular, thermal power plants operating on the steam and gas combined-cycle are characterized by the following features:

- high efficiency that varies within 50-60% (conventional fuel specific consumption changes correspondingly from 240 to 200 gcf/kWh);
- high flexibility;
- environmental safety;
- reliability of operation;
- suitable hardware;
- installed capacity low price (400-500 *US*$/kW);

- short period of time for installation (1.5-2 years);
- short payback period (5÷6 years), etc.

At present, tens of thermal power plants are realized on the basis of steam and gas combined devices and intensive construction of similar plants and renovation of the existing ones is going on in numerous developed or developing countries. It should be separately mentioned that transfer to steam and gas combined-cycle gives opportunity to apply existing at the thermal power plants morally depreciated steam-turbines with maximum efficiency and to increase significantly the installed capacity of the plant.

Hence, reconstruction and modernization in Tbilisi CHP should be realized by shifting to the steam and gas combined-cycle using new gas-turbines, steam boiler-utilizers and existing steam turbines (as after the capital repair, bringing of the existing steam turbines to the design condition is not difficult).

Correct selection of thermal scheme and equipment for effective reconstruction and modernization of Tbilisi CHP should be based on the following requirements:

- Installed electric capacity of the plant should be significantly increased, thermal efficiency should be raised, maneuverability of devices and environmental safety should be improved;
- Modernization should be performed by minimum rebuilding of the existing thermal scheme and by minimizing the reconstruction and installation activities;
- Technical capacity of devices existing at the Tbilisi CHP should be applied at most;
- Reconstruction and modernization should be carried out as soon as possible in the short period of time;
- From the financial and economic standpoint, modernization proposal should meet the current demands on investments effective use (minimum expenses and maximum recovery).

At present, Tbilisi CHP owner – joint stock company "Sakgazi" is negotiating with the different international companies on modernization of CHP and the increasing of its capacity.

Taking into account numerous factors, it is necessary to make an optimal decision. Although, at this stage we would analyze only technical and economic parameters of gas-turbines and steam boiler-utilizers manufactured by the companies of different countries.

1.3.1. Selection of Basic Units for the Modernization

Modernization of Tbilisi CHP, agreed with its present owner – JSC "Sakgazi", implies increasing of electric capacity of CHP up to 65-70 MW on the basis of two gas-turbines (capacity of each one equals to about 26 MW) and correspondingly two steam boiler-utilizers. Therefore, technical and economic parameters of gas-turbines (about 26 MW of power) and their corresponding steam boiler-utilizers manufactured in the different international companies were analyzed in course of selection of basic installations.

Gas-turbines of "RB211" type with 27-30 MW of nominal capacity manufactured by "ROLLS-ROYCE INDUSTRIAL POWER SYSTEMS LTD", 39.62 MW "MS 6001 B" type manufactured by "GENERAL ELECTRIC", 25 MW "FT-30" type manufactured by "MAN GHH BORSIG" and 25 MW gas-turbine produced in Ukraine were examined. On the basis of comparison of parameters and costs along with boiler-utilizers, energy efficient gas-turbines of "FT8-30" and steam boiler-utilizers of "HEAT RECOVERY STEAM GENERATOR" type both manufactured by the foreign holding company "MAN GHH BORSIG" were selected as the basic installations required for the reconstruction and modernization of the Tbilisi CHP plant.

1.3.2. Measures for Modernization of Tbilisi CHP

For reconstruction and modernization of Tbilisi CHP plant, the following key issues should be assessed in advance: the provision of CHP with fuel, compatibility of units, electric facility, supply with circulating and chemically treated potable water and environmental safety. Let's analyze these issues one by one.

1.3.2.1. Fuel Supply

After the reconstruction and modernization of Tbilisi CHP plant, natural gas should be used as a main fuel and liquid oil products – as reserve fuel. Therefore, capacity of the existing gas pipeline and its technical condition should be assessed in advance so as to guarantee the supply of thermal power plant with fuel. Relying on the analyses based upon the findings of JSC "Sakgasi", it could be concluded that both the capacity of the existing pipeline and its technical condition do not meet the requirement necessary for reconstruction of CHP. Thus, the new pipeline with higher capacity should be constructed meanwhile the reconstruction and modernization of CHP.

1.3.2.2. Compatibility of Units

Overall dimensions of gas-turbines and steam boiler-utilizers are the most important criteria during the selection of equipment for the reconstruction and modernization of Tbilisi CHP. Compatibility of units and specification of their configuration at the existing territory of Tbilisi CHP should be performed at the stage of project design.

1.3.2.3. Facilities for Electricity Delivery

Existing scheme of Tbilisi CHP gives possibility to deliver 80-90 MW of capacity by 6 kV of feeders passing through the city network and 6/35 kV and 25 000 kVA two transformers linked with the energy system that actually satisfies the modernization purposes.

Despite the above-stated fact, existing installations are morally depreciated and require rehabilitation, because of planned changes in heat-mechanic section by the reconstruction and modernization project will cause the increase of electricity amount and capacity on self-consumption (e.g. on compressor driven, etc.).

1.3.2.4. Provision with Chemically Treated Potable Water

The use of existing repair shop for potable water chemical treatment is foreseen by the project. Addition of brightening units would become necessary. Presumably, capital expenditure on the rehabilitation and modernization of this repair shop would not exceed 0.6-1% of project total cost. This issue would be finally refined at the stage of project preparatory work.

1.3.2.5. Environmental Safety

Environmental safety of energy objects burning an organic fuel considers the protection of environment against the hazardous emissions, thermal pollution, vigorous magnetic field, leakage of toxic and carcinogenic substances, etc.

Among the above-listed factors harmful emissions, thermal pollution and noise factors are topical for the Tbilisi CHP.

Application of modern equipment (units manufactured by MAN GHH BORSIG) foreseen by the present project proposal will reduce amount of hazardous emissions, but the noise factor will be kept at the same level. Aforementioned is caused by the following:

- Share of noxious gases (SO_2, CO_2, NO_2, H_2S, C_nH_m, V_2P_5) in emission, according to the certificate norms of FT8-30 gas-turbines would be rather less than the permissible norms being in force in Georgia, i.e. the amount of hazardous emissions would be decreased. Above-stated is proved by the fact that the degree of complete combustion in the combustion chambers of modern gas-turbines is apparently higher than the same features of traditional boilers.
- FT8-30 gas-turbine muffling system is designed according to the ENISO 3746 and ISO 6190 international norms. It provides not more than 85 db of noise background at a height of 1m above the equipment and 1.5 m above the ground.
- Thermal pollution of environment preconditioned by heat emitted by circulating water from the steam turbines condensate of Tbilisi CHP will be same, as reconstruction and modernization of Tbilisi CHP does not envisage increasing of turbines capacity.

1.3.3. Principle Thermal Scheme of Tbilisi CHP after the Modernization

Principle thermal scheme of Tbilisi CHP after the reconstruction and modernization is presented on the Fig 1.2.

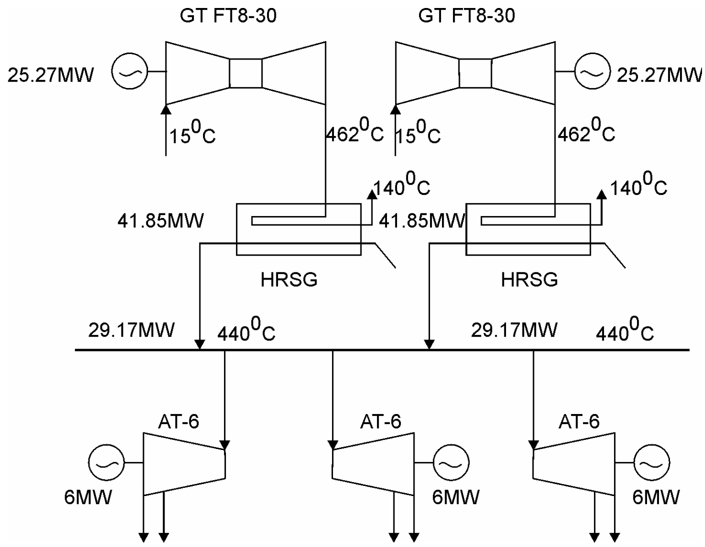
In compliance with the task of reconstruction and modernization of Tbilisi CHP, FT8-30 gas turbine and HRSG steam boiler-utilizer were selected as the basic installations.

Dismantling of the existing hot-water boilers and their replacement with gas-turbine (FT8-30) and boiler-utilizer is foreseen at the first stage of modernization. At the second stage, another gas-turbine and steam boiler-utilizer will be installed after dismantling one or two boiler. Thus, by the end of modernization the following basic equipment will be installed at the Tbilisi CHP: two gas-turbines, two boiler-utilzers and three existing steam turbines. Their total electric capacity will be equal to 2x25.27+3x6=68.58 MW and total thermal capacity – approximately 23.4 MW.

According to this scheme, heating system along with the steam turbo-generators will be kept.

Above given order of reconstruction of Tbilisi CHP is preliminary and should be defined more exactly before project implementation, at the stage of preparatory works.

It has to be mentioned that in course of reconstruction and modernization the complete rehabilitation of the existing steam turbo-generators should be considered along with their preservation.



Note: Total electric capacity is 2x25.27+3x6=68.58 MW;
Total thermal capacity – 23.33 MW.

Fig.1.2. Principle thermal scheme of modernized Tbilisi CHP:
HRSG – steam boiler-utilizer

1.3.4. Specific Consumption of Conventional and Natural Fuel after the Reconstruction of Tbilisi CHP

Based on the principle thermal scheme of Tbilisi CHP it is evidence that:

- Total installed capacity of gas-turbines equals to: N_{GT} = 2 x 25,27 = 50,54 MW;
- Total installed capacity of steam turbines makes: N_{GT} = 3 x 16 = 18 MW;
- Total thermal capacity delivered for heat and hot water supply consists: Q_{th} = 23,33 MW;
- Efficiency of gas turbines is: $?_{GT}$ = 0,37.

  Total generated thermal energy equals to:

Operation under the combined-cycle for generation only electricity:

- Efficiency of combined-cycle will be equal to:

$$?_{cc.el} = \frac{N_{GT} ? N}{Q_?} ? \frac{50,54 ? 18}{136,6} ? 0,50;$$

- Specific consumption of conventional fuel will make:

$$b_{cc.el} = \frac{0,123}{?_{cc.el}} ? \frac{0,123}{0,5} ? 0,246 \text{ kgcf/kWh};$$

- Specific consumption of natural fuel or natural gas imported from Russia with thermal capacity 32657 kJ/m^3 will be equal to:

$$b_{cc.el} = \frac{b_{cc.el} ? Q_{pir}}{Q^{nat}} ? \frac{0,246 ? 29330}{32657} ? 0,220 \text{ m}^3\text{/kWh.}$$

Operation under the combined-cycle for combined generation of electric and thermal energies:

- Efficiency of combined-cycle consists:

$$?_{cc.el.th} = \frac{N_{GT} ? N}{Q_? ? Q_{th}} ? \frac{50,54 ? 18}{136,6 ? 23,33} ? \frac{68}{113,27} ? 0,605;$$

- Specific consumption of conventional fuel makes:

$$b_{cc.el.th} = \frac{0,123}{? _{cc.el.th}} ? \frac{0,123}{0,605} ? 0,203 \text{ kgcf/kWh;}$$

- Specific consumption of natural fuel or natural gas imported from Russia with combustion heat capacity 32657 kJ/m^3 equals to:

$$b^{nat}_{cc.el.th} = \frac{b_{cc.el.th} ? Q_{pir}}{Q^{nat}} ? \frac{0,203 ? 29330}{32657} ? 0,182 \text{ m}^3\text{/kWh.}$$

1.4. Economic Calculation for the Modernization of Tbilisi CHP

The present tentative economic calculation for the reconstruction and modernization of Tbilisi CHP should be specified before the project implementation.

1.4.1. Technical and Economic Parameters

The basis for technical and economic calculation of reconstruction and modernization of Tbilisi CHP are the following:

? Fuel – natural gas Q =48000 kJ/kg = 48000x0.741 = 35568 kJ/m^3;
? Fuel price by the state of 2001 – 0.06 *US*$/nm^3;
? Electricity selling price (tariff) – 6 tetri/kWh; (about 0.03 *US*$/kWh)
? Baseline operational regime – 7 000 hours per annum;
? Share of fuel in the prime cost – 80%;
? Share of operational expenses – 20%;
? Duration of invested project – 5/10 years;
? Construction duration – 1.5-2 years;
? Cost of 1 kW of installed capacity – $ 420-450.

1.4.2. Economic Calculation of Tbilisi CHP

Total income of CHP

1. Amount of electricity delivered by CHP per year after the reconstruction:
- Total installed electric capacity of the plant will be equal to:
  SN_{Inst} =(2 x 25,27)+(3 x 6)=68,54 MW=68540 kW;
- Electricity annual generation by the plant during 7000 hours operation in baseline regime will make:
  $?_Y$ =SN_{Inst} x 7000=68540 x 7000=479 780 000 kWh;
- If assume that plant's self-consumption after the reconstruction is 8% of generated electricity, electricity delivered per year will be equal to:
  $?_Y^{Del}$= $?_y$-0,08$?_Y$ =0,92 $?_Y$=0,92 x 479 780 000 = 441 397 600 kWh/y.

2. Annual income of the CHP as a result of electricity selling:
- Assuming that after CHP reconstruction electricity selling price will be the same (6 tetri/kWh=0.03 *US*$/kWh), plant's annual income from selling of electricity will equal to:
  U_{el}=$?_y^{del}$ x 0,03=441397600 x 0,03 = $ 13 241 928.

3. Amount of thermal energy generated by CHP per year after the rehabilitation and modernization:
- Amount of heat obtained from the FT8-30 gas turbine and delivered to the HRSG steam boiler-utilizer will be:
  Q_1=m x Cpm x T_1 = 83,1 x 1,09 x 462=41847 kJ/sec =41,85 MW,
  where, m is mass of gas combustion product from the gas turbine (kg/sec);
  Cpm – mass thermal capacity of gas combustion product (kJ/kg ^{0}C);
  T_1 – temperature of gas combustion product obtained from the gas turbine and delivered to the steam boiler-utilizer (^{0}C).
- Heat taken away from two steam boiler-utilizers will be:
  Q_{HRSG}=2 x [m x Cpm x (T_1-T_2)]=2 x [83,1 x 1,09 (462-140)]=
  = 2 x 29166 =58334 kJ/sec =58,334 MW,
  where T_2 is temperature (^{0}C) of gas combustion product obtained from the steam boiler-utilizer.
- Thermal capacity of one ÀÏ-6 and two ÀÒ-6 steam turbo-generators during their exploitation under the nominal regime is about 35 MW and that's why N_{Th} = 58,334 – 35 = 23,334 MW thermal capacity could be delivered from the station.

- For 5 months of heat and hot water supply season, amount of thermal energy delivered from the CHP in a year makes:

$Q_{Heat} = N_{Ther}$ x 5 x 30 x 24 =84 002 400 kWh/y.

4. CHP annual income by selling of thermal energy constitutes:

- According to SEMEK, tariff on thermal energy delivered from the CHP is 5Tetri/kWh=0.025$/kWh, and so plant income after thermal energy selling will be:

$U_{Ther} = Q_{Ther}$ x 0,025 = 84002400 x 0,025 = $ 2 100 060.

5. CHP combined income by selling of electric and thermal energies makes:

$U = U_{El} + U_{Ther}$ = 13 241 928 + 2 100 060 = $ 15 341 988.

CHP expenses

1. Expenses on fuel purchases:

- fuel annual consumption (based on FT8-30 gas-turbine data), if natural gas thermal capacity is 48 000 kJ/kg=35 568 kJ/m^3 for two turbines will be:

$$V_{Fuel} = 2 ? 5130 ? 7000 ? 71820000 \, {}^{kg}\!/_{y}$$

or

$$G_{Fuel} = 71820000 : 0,741 = 96\,923\,077 \text{ m}^3/\text{y},$$

where, 5130 is natural gas consumed by one gas turbine (kg/h) and 0.741 – natural gas density (kg/m^3).

- As the thermal capacity of natural gas imported from Russia consists 32657 kJ/m^3, its annual consumption will be:

$$G^{R}_{Fuel} ? 96923077 ? \frac{35568}{32657} ? 105562667 \text{ m}^3/\text{y};$$

- Considering that 1000 m^3 of natural gas costs $ 60 investment necessary for fuel purchase will equal to:

U_{Fuel} =105562,667 ? 60= *US*$ 6 333 760;

2. Expenses on water, salaries and taxes on them, suplimentory materials and maintanence approximately equals to 8% of expenses on fuel, i.e.

$U_1 = U_{Fuel}$ x 0,08 = 6333760 x 0,08 = *US*$ 506 700.

3. Tentative expenses make 1% of investment necessary for CHP reconstruction and modernization, i.e.

U_{Des} = 35000000 x 0,01 = *US*$ 350 000.

4. Property tax equals to 1 % of CHP total cost, i.e.

U_{Prop} = (35000000 + 100000) x 0,01 = *US*$ 351 000.

5. Land tax is obtained by multiplication of area belong to the CHP (50mx50m=25 000m^2) by tax on 1m^2 of non-agricultural land (tax on 1m^2 of area is 0.24 GEL/m^2 = 0.12$/m^2), i.e.
6.

U_{Land} = 2500 x 0,12 = *US*$ 300.

6. Depreciation expenses are determined by the relevant norm from the balance cost (Reference [18], Article 54, paragraph 10). Depreciation norm on the average is considered to be 11 % for all types of fixed assets. Depreciation expenses for the first year are:

U_{Depr} = (35000000 + 100000) x 0,11 = *US*$ 3 861 000.

CHP residual value and depreciation expenses according to the years are given in the Table 1.1.

Table 1.1. Changes of residual values and depreciation expenses by the years

Years	Residual value, *US* $	Depreciation average norm, %	Depreciation expenses, *US* $
1	35 100 000	11	3 861 000
2	31 239 000	11	3 436 290
3	27 802 710	11	3 058 298
4	24 744 412	11	2 721 885
5	22 022 527	11	2 422 477
6	19 600 050	11	2 156 005

7. Business tax is determined as 1 % of total income excluding expenses on fuel, i.e.

$U_{Ind} = (U – U_{Fuel}) \times 0,01 = (29\ 466\ 711 – 6333760) \times 0,01 =$ *US*$ 231 330.

8. Road tax is 1 % of total income, i.e.

$U_{Road} = U \times 0,01 = 29\ 466\ 711 \times 0,01 =$ *US*$ 294 667.

9. Taxable profit equals to difference between total income and annual expenses, i.e.

$U_{Taxable} = U – U_{Exp.} = 29\ 466\ 711 – 13\ 396\ 261 =$ *US*$ 28 082 714.

10. Profit tax is determined to be 20 % of taxable profit, i.e.

$U_{Prof.Tax} = U_{Taxable} \times 0,2 = 28\ 082\ 714 \times 0,2 =$ *US*$ 5 616 543.

1.4.3. Assessment of GHG Emissions Reduction

As it was mentioned above, Tbilisi CHP efficiency is 23.4% and consumption of conventional fuel reaches 525 gcf/kWh. As a result of reconstruction, CHP efficiency should be reach 60% and conventional fuel specific consumption for electricity generation should be decreased to 0.246 gcf/kWh in the combined cycle. Thus, after modernization fuel specific consumption would be reduced by 61-53%.

After modernization total value of annually consumed Russian natural gas by the CHP would be equal to 105 562 667 m^3, i.e. 78,222 thousand ton. In terms of current efficiency, gas annual amount consumed for generation of only electricity equals to 78,222:0,61=128,233 thousand t. Assuming that 1t of natural gas emits 1.96 t CO_2 during combustion the reduction of CO_2 emission after modernization of the plant will make (128,233 – 78,222) X1,96=98,022 thousand t.CO_2/y.

Table 1.2. CHP rehabilitation financial assessment

(in thousand US$)

10-year period

	Investment	Expenses									Generated energy cost	Generated energy	
		Project expenses	Expenses on fuel	Expenses on water	Property tax	Land tax	samewarmeo tax	Road tax	Profit tax	Total		Electricity (kWh)	Thermal energy (kWh)
	-35000000,00	-350000,00											
1			-6333760,00	-506700,00	-351000,00	-300,00	-231330,00	-294667,00	-5616543,00	-13334300,00	29466711,20	441397600,00	84002400,00
2			-6333760,00	-506700,00	-351000,00	-300,00	-231330,00	-294667,00	-5616543,00	-13334300,00	29466711,20	441397600,00	84002400,00
3			-6333760,00	-506700,00	-351000,00	-300,00	-231330,00	-294667,00	-5616543,00	-13334300,00	29466711,20	441397600,00	84002400,00
4			-6333760,00	-506700,00	-351000,00	-300,00	-231330,00	-294667,00	-5616543,00	-13334300,00	29466711,20	441397600,00	84002400,00
5			-6333760,00	-506700,00	-351000,00	-300,00	-231330,00	-294667,00	-5616543,00	-13334300,00	29466711,20	441397600,00	84002400,00
6			-6333760,00	-506700,00	-351000,00	-300,00	-231330,00	-294667,00	-5616543,00	-13334300,00	29466711,20	441397600,00	84002400,00
7			-6333760,00	-506700,00	-351000,00	-300,00	-231330,00	-294667,00	-5616543,00	-13334300,00	29466711,20	441397600,00	84002400,00
8			-6333760,00	-506700,00	-351000,00	-300,00	-231330,00	-294667,00	-5616543,00	-13334300,00	29466711,20	441397600,00	84002400,00
9			-6333760,00	-506700,00	-351000,00	-300,00	-231330,00	-294667,00	-5616543,00	-13334300,00	29466711,20	441397600,00	84002400,00
10			-6333760,00	-506700,00	-351000,00	-300,00	-231330,00	-294667,00	-5616543,00	-13334300,00	29466711,20	441397600,00	84002400,00

NPV(10%)= 22 405 658 **IRR= 17%**

6-year period

	Investment	Expenses									Generated energy cost	Generated energy	
		Project expenses	Expenses on fuel	Expenses on water	Property tax	Land tax	samewarmeo tax	Road tax	Profit tax	Total		Electricity (kWh)	Thermal energy (kWh)
	-35000000,00	-350000,00								-35350000,00			
1			-6333760,00	-506700,00	-351000,00	-300,00	-231330,00	-294667,00	-5616543,00	-13334300,00	29466711,20	441397600,00	84002400,00
2			-6333760,00	-506700,00	-351000,00	-300,00	-231330,00	-294667,00	-5616543,00	-13334300,00	29466711,20	441397600,00	84002400,00
3			-6333760,00	-506700,00	-351000,00	-300,00	-231330,00	-294667,00	-5616543,00	-13334300,00	29466711,20	441397600,00	84002400,00
4			-6333760,00	-506700,00	-351000,00	-300,00	-231330,00	-294667,00	-5616543,00	-13334300,00	29466711,20	441397600,00	84002400,00
5			-6333760,00	-506700,00	-351000,00	-300,00	-231330,00	-294667,00	-5616543,00	-13334300,00	29466711,20	441397600,00	84002400,00
6			-6333760,00	-506700,00	-351000,00	-300,00	-231330,00	-294667,00	-5616543,00	-13334300,00	29466711,20	441397600,00	84002400,00

NPV(10%)= 11 515 453 **IRR= 15%**

2. PROPOSAL ON GHG EMISSIONS REDUCTION IN ELECTRICITY TRANSMISSION SECTOR (ADOPTION OF ADVANCED COMMUTATION TECHNOLOGIES FOR HIGH VOLTAGE (500 KV, 220 KV) TRANSMISSION LINES)

2.1. Introduction

Proper functioning of Georgia's energy sector much more depends on the reliability of electricity transmission systems and commutative devices of power substations which guarantee security and efficiency of the system.

Commutative device turns electricity on and off (commutation). It includes automatic power switches, electromechanical and tiristor contactors, safety fuses, etc.

Switches (electromechanical commutative apparatus) are usually equipped with mobile contact parts, special compartments, drivers, etc. As a rule, preventive maintenance is required after the definite number of "turnings on and off". Timely maintenance guarantees correct operation of switches for a long time or within its warranty period.

111 automatic switches are installed in the high voltage transmission system of Georgia, out of those only 25 switches are modern and 86 ones – outdated. Among the old-fashioned switches 40 are gas-switches and 46 – oil-switches. Besides, these last ones are morally and physically depreciated due to incorrect operation (often and unreasonable "turning on and off") and delays in rehabilitation and repairing works because of lack of finances. Planned repairs were not performed for a long time due to the absence of spare parts along with the shortage of finance. Actually, only the emergency repairs requiring more expenses were conducted.

Due to the impossibility of normal exploitation of switches and ineffectiveness of their further operation the selection and adoption of new advanced commutative equipment – automatic switches for the high voltage electricity transmission system of the country is the main goal of the work.

2.2. Existing Switches

As it has been already mentioned, at the present time only 25 modern switches are operating in the energy system of Georgia, out of that 24 are installed in power substations and 1 – in the 500 kV outdoor switchgear of Gardabani TES. The rest 86 switches are old-fashioned. It should be indicated that these switches are depreciated physically and morally, as well. Age of commutative equipment demonstrating their physical conditions are presented in the Table 2.1.

Table 2.1. Age of switches operating in high voltage transmission sector of Georgia

Type of switches	Quantity	Age (year)							
		10	15	20	25	30	35	40	50
Gas	40	-	-	7	17	-	6	4	6
Oil	46	-	20	8	4	9	5	-	-

Lifetime of gas and oil-switches is about 12 years [2], which depends on the number of turnings on and off determined by the producer. Within the last period the number of turnings a lot more exceeds the standard that causes the grave condition of switches – the main component of power substations of energy system.

Situation is extremely alarming in substations equipped with the gas switches. They require the urgent replacement. Even the better technical state of compressor services (the majority of which are installed in 1997-98), that facilitates the operation of gas switches, could not improve existing condition.

Owing to the fact that the gas switches are worldwide being gradually replaced by oil switches and recently – by electric-gas switches the factories are producing neither new gas switches nor spare parts necessary for their repairing.

Poor condition of outdated switches existing in the system causes permanent increase of expenses on repairs. For instance, switches have to be overhaul repaired once in 1.5-2 years. However, thorough repair of one 500 kV gas or oil switch costs about US$ 17-20 thousand, and major repairs of one 220 kV gas or oil switch – about US$ 10-13 thousand. Expenses on current repairs of one gas or oil switch make approximately US$ 3 000 per year. Thus, based upon the given data it could be concluded that annual expenses on repairs are rather considerable, particularly:

- Expenses on overhaul repairs 86/2 ? 13000 = US$ 559000;
- Expenses on maintenance 86/2 ? 3000 = US$ 129000.

Annual expenses on the production of compressed gas as well as on the recovery and filling up of oil for switches are also significant:

? Electricity expenses to provide the gas switches with compressed gas equal to:

15 ? 45 ? 24 ? 365 ? 0,7 ? 0,045 = US$ 186260,

where, 15 is number of compressors; 45 kW – capacity of compressor driven;
0.7 – factor of active days per year; 0.045 cent/kWh – electricity tariff.

? Among 46 oil switches 16 are of BMT type, which require 0.084 t of oil per switch. There are 20 switches of Y-220-1000/2.5 type, which need 27 t of oil per unit. Number of Y-220-10/1000-I type oil switches is 10 and 46 t of oil is necessary per unit. Thus, total cost of oil used by oil switches amounts to:

(16 ? 0,084 + 20 ? 27 + 10 ? 46) ? 750 = US$ 751008,

where, US$ 750 is tentative cost of 1 t of oil.

Thus, US$ 751 008 is totally spent on oil used by oil switches and annual expenses on oil recovery and filling up are equal to 751008 ? 0,15 = US$ 112651, where 0.15 out of total cost of used oil is share of annual expenses on oil recovery and filling up.

Annual expenses for operation for old-fashioned gas and oil switches are presented in the Table 2.2.

Table 2.2. Operational expenses for out of date gas and oil switches

No	Types of annual expenses	US$
1	Overhaul repair	559000
2	Maintenance	129000
3	Oil recovery and filling up	112651
4	Electricity	186260
	Total expenses	986911

Hence, annual exploitation expenses on out of date (existing) switches are estimated at about US$ 987 thousand.

2.3. Characteristics of Modern Switches and Basic Concept of the Project

At present, modern, reliable and energy efficient electric-gas switches are successfully applied in the energy systems all over the world. Positive and negative characteristics of these switches are discussed below.

Electric-gas switches

Electric-gas switches are manufactured in various countries: Germany, France, USA, Russia, etc. In these switches the arc-extinguishing and insulating environment is represented by six-fluorine sulphur (SF_6) or so-called electric gas (elegas). Transportation and preservation of the last one is possible only in a liquid form. Elegas belongs to the class of especially heavy gases. The following parameters of elegas stipulate the priority of its usage in the commutative equipment as compared with oil and compressed air:

? Higher ionization energy, high thermal conductivity and heat content (more effective cooling of arc);
? Voltage decrease on the arc (hard mechanical work takes place while communication);
? Lower temperature of ionization that causes less hazard on breaching and braking of arc;
? Crossing the zero point, electric conductivity in elegas decreases faster then that of air that causes reduction of arc section and it disappears in a rather short space of time;
? Less noise; gas is not emitted into the atmosphere during the commutation.

Due to the listed advantages 3-5 times stronger current could be switched off by electric-gas switches in comparison with the standard gas or oil switches. Some disadvantages of elegas switches are given below:

? High initial investment;
? Circulation of elegas in closed circuit and application of Al_2O_3 filters are required because elegas decay products (SF_4; HF; Cu_2; Cu_2S) under the influence of the voltaic arc are corrosive and poisonous substances;
? Application of narrow and large cross section canals in arc arrester chamber is necessary due to insufficient speed of gas flow;
? Liquidation of gas needs low pressure (about 10 bar and 10^0C).

Despite the above listed disadvantages, electric-gas equipment is still effective in comparison with oil and gas switches. Especially, within last 20 years, constructions of such switches (intended for outdoor installation) are equipped with simple, durable and protected mechanisms that need no special maintenance and control.

Chemical, physical and electric parameters of elegas make it as incomparable insulation substance. The main contact wires of power switch are operating almost without depreciation, because throughout the switch operation they are not under the arc influence. As concerns the arc breaking mechanisms, they are protected against the arc influence by fireproof material.

Hence, inner facility of device practically does not require periodic control and repair. It is aimed for outdoor (open) location. General view of three-phase (A, B, C) elegas switch is presented on the Figure 2.1.

As it is evident from the Figure, columns of all three poles of power elegas switch are installed on the bearing (1). Driven gear is connected with a side of the bearing (3). Switchboard is additionally connected with B pole (2). Column of each pole that consists of bearing insulators (4) and arc arrester closed chamber (5) is placed upon them. This chamber is filled up with elegas – (SF_6) that is used as arc arrester and insulating environment.

Switchboard connected with B pole consists of all necessary equipment to manage and control power switches.

The function of connecting cable (6) is to connect the control system with three drivers. As it is shown from the Figure, all three pole columns (A, B, C) of power switches have the same configuration.

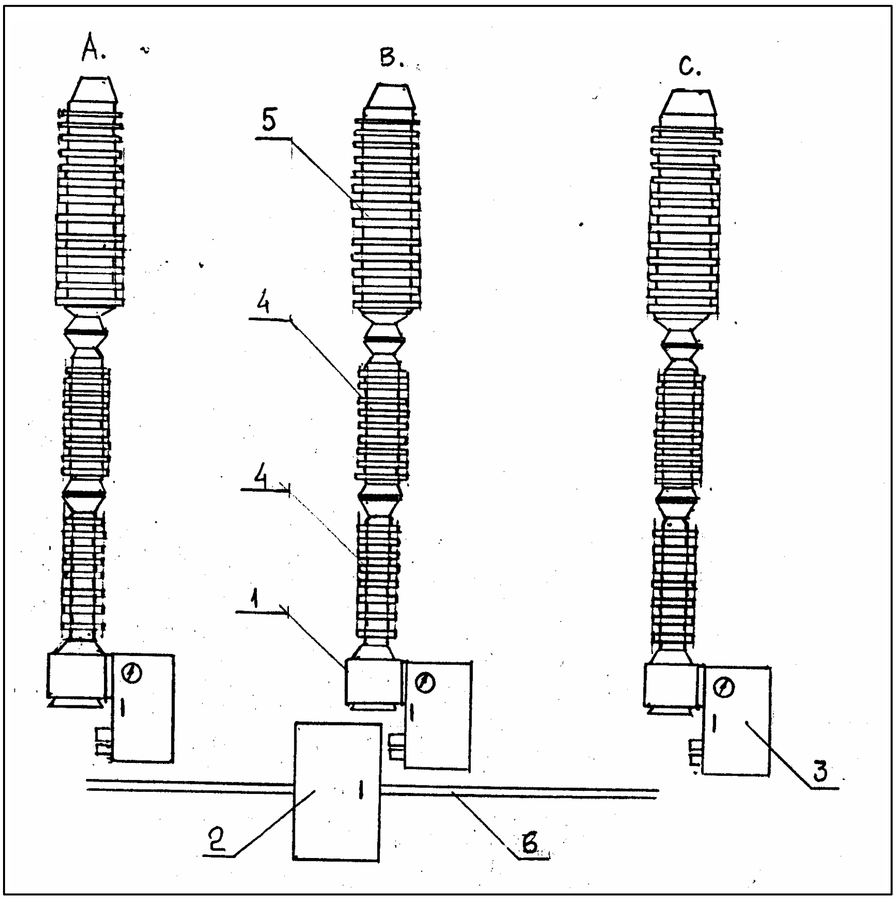


Fig.2.1. Three-phase electric-gas switch:
1 - Bearing; 2 - Switchboard; 3 – Driven gear; 4 – Bearing insulators;
5 – Arc arrester chamber; 6 – Connecting cable

Electric-gas switches used by the energy system of Georgia

The following defects in the functioning of 25 electric-gas switches installed and operating in the energy system of Georgia have been noted:

- Damage of one phase of 500 kV switch installed at the outdoor switchgear of Tbilsresi (installation default);
- Insignificant leakage of elegas in AT-2 and 220 kV switches of 500 kV substation – “Ksani”;
- Inconsiderable damage in kinematic system of elegas switches installed at the substations - “Ksani” and “Didi Zestaponi”.

Despite the above listed failures, the exploitation of electric-gas switches installed in the Georgian energy system clearly demonstrates those preferences that will appear in energy system as a result of large-scale application of advanced elegas switches.

Selection of switches

As it has been already mentioned, elgas switches are manufactured in the various countries: Germany (SIEMENS), France (ALSTHOM), USA (General Electric), Russia, etc. According to the conclusions made after review and analysis of parameters and data on the exploitation of elegas switches used by the energy system of Georgia the priority was given to the following switches:

- 500 kV 3AT2 E1 type and 220 kV 3AP1FI type switches produced by SIEMENS;
- 220 kV SL 245F3 type switches produced by ALSTHOM.

Main parameters of these elegas switches are presented in the Table 2.3.

Table 2.3. Main parameters of selected electric-gas switches

Parameters		Type of selected electric-gas switch		
		?? T2-FI-500kV (SIEMENS)	? ? ?1F1- kV (SIEMENS)	SI-245F3-220 kV (ALSTHOM)
U_{nom} (kV)		550	252	245
$?_{nom}$ (Hz)		50	50	50
I_{nom} (A)		4000	4000	3150
$I_{m.S}$ (ka)		40	40	40
Electric-gas mass in single phase (kg)		15	27	12
Initial control	Years	12	12	6
	Number of cutting-off	3000	3000	-
Maintenance	Years	25	25	12 and 24
	Number of cutting-off	6000	6000	2000

2.4. Economic Evaluation

Numerous commutative equipment (especially gas switches) operating in Georgia has not been functioning any more and needs urgent replacement. Moreover, some of switches are at the brink of their possibility.

Purchasing price of commutative equipment and installation costs depend on various factors and it could be changed not only by the variation of the market conditions, but also according to the volume of purchase.

<u>I Version</u>

For the tentative evaluation it could be assumed that the cost of 500 kV elegas switch equals to US$ 70 000 and cost of 200 kV switch – US$ 60 000. About US$ 40 000 is necessary to install a switches set. Thus, US$ 100 000 – 110 000 is required to purchase and install one switch.

Among the out-of-date switches 5 units are 500 kV switches and 81 units – 200 kV. Hence, the following amount of investments is necessary to replace old-fashioned switches:

? Expenses for replacing 5 switches of 500 kV:
5 X 110000 = US$ 550 000;

? Expenses for replacing 81 switches of 200 kV:
81 X 100000 = US$ 8 100 000;

? Total investment to replace old-fashioned switches:
550000 + 8100000 = US$ 8 650 000.

Table 2.4. Economic estimation for installation of new commutative technologies for 500 and 220 kV transmission lines

For 10-year period			For 15-year period		
No	Investment	Income (Saving on repairs)	No	Investment	Income (Saving on repairs)
	-8 650 000			-8 650 000	
1		986 911	1		986 911
2		986 911	2		986 911
3		986 911	3		986 911
4		986 911	4		986 911
5		986 911	5		986 911
6		986 911	6		986 911
7		986 911	7		986 911
8		986 911	8		986 911
9		986 911	9		986 911
10		986 911	10		986 911
			11		986 911
			12		986 911
			13		986 911
			14		986 911
			15		986 911
NPV(10%)=-2 350 781 IRR=2%			NPV(10%)=-1 039 524 IRR=8%		

II Version

Replacement of old switches with new ones should be performed step by step because of high initial capital investment required for the replacement. If assume that only old-fashioned gas switches are replaced at the first stage:

? Expenses to replace 40 units of gas switches, out of which 5 units are of 500 kV and 35 ones – of 220 kV, amounts to:

5 X 110 000 = US$ 550 000;
35 X 100 000 = US$ 3 500 000;

S = US$ 4 050 000;

Savings should be determined in the following way:

? Savings on overhaul repair:

5 X 20 000 = US$ 100 000;
15 X 13 000 = US$ 195 000;

S = US$ 2 950 000;

- Savings on maintenance:

20 X 3 000 = US$ 60 000;

- Savings on reduction of electricity consumption (compressors should not be necessary):

15 X 45 X 24 X 365 X 0,7 X 0,045 = US$ 186 260.

Total savings due to the replacement of 40 units of existing gas switches:

295 000 + 60 000 + 186 260 = US$ 541 260.

Table 2.5. Economic calculation to adopt new commutative technologies for 500 and 220 kV transmission lines

For 10-year period			For 15-year period		
No	Investment	Income (Saving on repairs)	No	Investment	Income (Saving on repairs)
	-4 050 000			-4 050 000	
1		541 260	1		541 260
2		541 260	2		541 260
3		541 260	3		541 260
4		541 260	4		541 260
5		541 260	5		541 260
6		541 260	6		541 260
7		541 260	7		541 260
8		541 260	8		541 260
9		541 260	9		541 260
10		541 260	10		541 260
			11		986 911
			12		986 911
			13		986 911
			14		986 911
			15		986 911
NPV(10%)=-658 356 IRR=6%			NPV(10%)=-60 788 IRR=-10%		

Electricity saving resulted by replacement of compressors makes 15X45kWX24hX365dayX0.7=4.139 million kWh. Estimated emission in CO_2 equivalent while the generation of 1 million kWh electricity is 238 ton. Hence, implementation of elegas switches will reduce 1.07 thousand ton CO_2 equivalent emission per year.

3. PROPOSAL ON GHG EMISSIONS REDUCTION FOR ELECTRICITY CONSUMPTION SECTOR (ADOPTION OF ENERGY EFFICIENT TECHNOLOGIES FOR STREET AND INDOOR LIGHTING)

3.1. STREET LIGHTING

Getting over the energy crisis is vitally important for the sustainable development of Georgia's economy, social and energy sectors. Governmental programs elaborated in order to solve the problem foresee rehabilitation of electricity generation and transmission objects and construction of new ones applying modern energy efficient technologies. Along the long term and high investment projects so needed for country it is necessary to prepare the proposals on implementation of energy-saving technologies in the electricity consumer sub-sector.

The proposals could comprise:

- Import and installation of energy-saving lamps and the starting devices for outdoor lighting (streets, gardens, squares). Also arrangement of local manufacture is planned for future;
- Import and distribution of solar autonomous lighting equipment.

The implementation of energy-saving projects is caused by over consumption of electricity by the existing street lighting systems. It has to be mentioned that replacement of existing systems with modern energy efficient technologies will seemingly decrease the electricity consumption and the consequent GHG emissions.

3.1.1. Street Lighting Technologies

Tangible amount of electricity is consumed for street lighting, in particular: for the lighting of streets, gardens, squares, etc. Characteristics of street lighting systems – consumed electricity, losses in the starting devices, endurance of street lighting lamps and their number by the state of 1990 and 1999 are presented in the Table 3.1.1.

Table 3.1.1. Characteristics of street lighting system by the state of 1990 and 1999

Consumer	Year	Operating hours per day, hr	Consumed electricity, mln. kWh	Energy losses in starting devices, mln. kWh	Average capacity of street lighting unit, kW	Number of lamps, (1000 pieces)
Tbilisi	1990	10-14	78,5	23,55	0,32	56,0
	1999	4-6	6,6	1,96	0,32	11,7
All the rest of Georgia	1990	10-14	35,1	10,6	0,32	25,0
	1999	4-6	2,9	0,89	0,32	5,0

As it seems from the Table 3.1.1. low efficient equipment are used for street lighting. The result is 30% loses in consumed electricity.

Mercury gas discharge and Sodium arc-discharge luminous lamps, with the approximate efficiency 50 lumens per consumed watt, are being basically used for the street lighting though hundreds of incandescent lamps were introduced for last period (due to the absence of other types of lamps).

The disadvantage of existing lighting systems (technology) is lamps' switching on device (starting device). Out of date starting devices used in Georgia have rather low energy parameters:

? Low efficiency varying within 0.7-0.75;
? Low capacity factor that approximately equals to 0.5;
? Operation at low frequency that equals to 50 Hz.

As it has been already mentioned, low energy parameters of starting devices of street lighting cause 30% losses of consumed electricity and high wattage up to 0.32 kW per lamp. The high wattage is conditioned by the low efficiency of starting device and its operation at the low frequency. As it is known the increase of electricity frequency inside the lamp improves the light output up to 60-70 lumen per watt. The lamp operation at 50 Hz causes the pulsation of current at 100 Hz and stroboscopic effect as ensuing consequence. The overstraining of eyes could be also resulted as a side effect.

The low efficiency of starting devices stipulates 1.8 times more distortion reactive capacity than the active capacity that results in the additional active energy losses and other undesirable phenomena such as: supper high voltage, damage of insulation, additional voltage drops, etc.

Thus, it is evident that replacement of applied starting devices with new modern and energy efficient ones is very important for saving the electricity consumed by the street illumination.

Project Concept and Proposed New Technologies

Proposal consists of two phases:

? The first phase considers the import and installation of widespread energy efficient starting devic es for street lighting;

? The second phase envisages import and installation of autonomous lighting devices operating on the solar energy.

In both cases the project will be implemented in two stages. New technologies should be imported and installed at the first stage. The development of local manufacture should be performed at the second stage (in future).

3.1.2. Import and Application of Energy efficient Starting Equipment of Street Lighting Energy Saving Lamps

The mentioned starting devices have high energy parameters:

- High efficiency, that equals to 0.98;
- High power factor, that constitutes approximately 0.98;
- High frequency up to 40 000 Hz.

The following companies are producing starting devices for street lighting: “OSRAM” (Germany, Turkey, Italy), “TOPSTAR” (China), “PHILIPS” (Holland, Poland), etc. Estimated costs of components of street lighting energy-saving technologies are given in Table 3.1.2.

Table 3.1.2. Estimated cost of components of street lighting technology

Lamp		Starting device		Lighter’s total cost, US $
Wattage, W	Cost, US $	Capacity, W	Cost, US $	
125	15	125	20	35
250	30	250	100	130
600	50	600	150	200
1000	80	1000	250	330

Power factors of outdoor lighting starting devices produced by the “OSRAM” are high and vary between 0.98 and 0.99.

On the basis of findings on the street lighting existing systems, it could be concluded that nowadays street lighting system of Georgia needs approximately 60 000 pieces of modern energy efficient starting devices and 3 000 pieces of energy-saving lamps.

3.1.3. Import and Application of Autonomous Solar Lighters

As it is known, Georgia is located in the subtropical zone that is characterized by moderate cloudiness and ability to receive the significant value of solar energy per m^2. In particula r, the value of the solar energy available per m^2 of area through the year is approximately 2.5 times more than in Europe. Therefore, there are suitable conditions in Georgia for import of lighters operating on the solar energy. That sort of lighters is widely adopted in Europe, China and India. Solar radiation intensity factor, according to the regions of Georgia, varies insignificantly (K=1.12-0.86).

The autonomous solar lighters could be used in Georgia for lighting of streets, gardens and squares. These micro solar power plants are charged during a day-time by solar panels.

They automatically switch on at night and operating before the daylight comes.

Autonomous Solar lighters consist of four units:

? Solar panel;

? Rechargeable battery (chemical source);

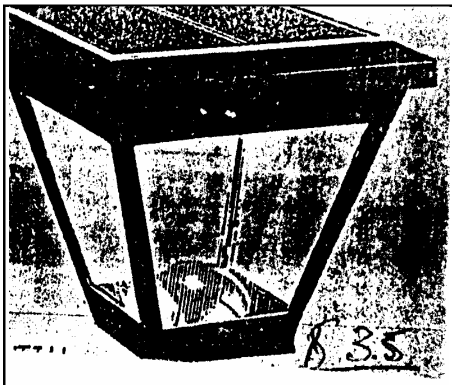
? Battery charger;

? Energy-saving lamp.

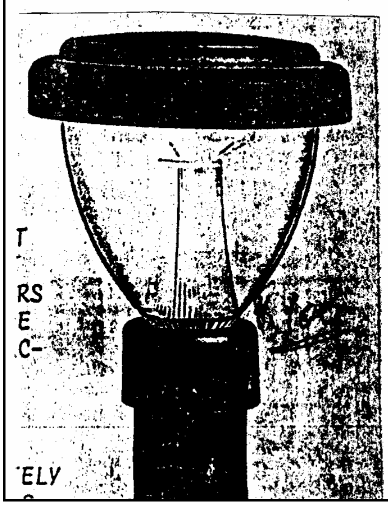
For low capacity solar lighters (1-7 W) all units are placed in one block but for relatively high-power illuminators (20-40 W) they are separatly located from each other.

Low capacity solar lighters are basically used for lighting of gardens and squares. These types of lighters are placed on low towers, on decorative pedestals made of special concrete or other material. There are solar autonomous lighters of different design, from which two types are presented on the Fig.3.1. Solar panel capacity of these autonomous solar lighters varies within 0.5 and 1.2 W and light power of energy-saving lamp changes from 7 to 15 candelas. Lighters illuminate 3-4 m radius area for 6-7 hours in winter and 10-14 hours – in summer.

There are different options of placing the solar lighter units at the street lighting tower. Solar panel and energy efficient lamp, as a rule, are installed on the upper part of a tower, but battery and charger might be placed both on the lower or upper part of a tower. Options of disposition of solar lighter units at the tower are presented on the Fig. 3.1.

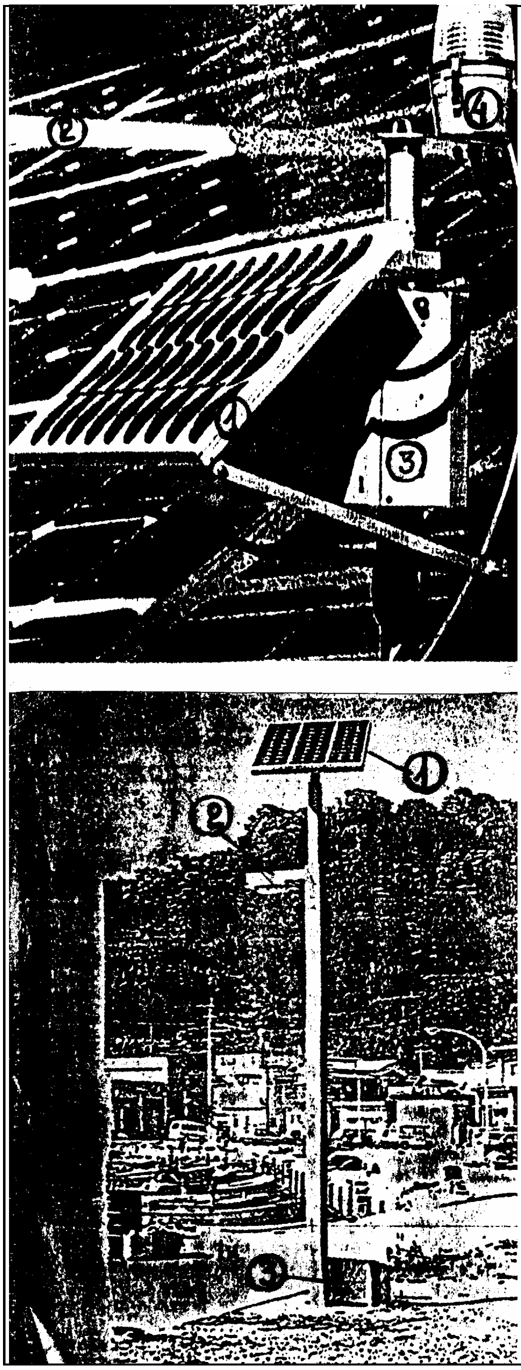


a.
Parameters of solar autonomous lighter (option a) placed in one block:
- solar panel capacity – 0.5W
- battery capacity – 1 A/h
- light power – 1 candela



b.
Parameters of solar autonomous lighter (option b) placed in one block:
- solar panel capacity – 1.2W
- battery capacity – 2 A/h
- light power – 10 candela

Fig. 3.1. Different types of low capacity solar autonomous lighters



a.
Disposition of battery and its charger at the upper section of lighter tower:
1. solar panel; 2. energy saving lamp; 3. battery; 4. charger

b.
Disposition of battery and its charging device at the lower part of lighter tower:
1. solar panel; 2. energy saving lamp; 3. battery and charging device in one block

Fig. 3.2. Layout of solar lighters' units at the tower

In the option (a) on the Fig. 3.2, battery and its charger are placed separately in the upper part of lighter tower and in the option (b) they are placed inside one block in the lower section of tower.

The autonomous solar lighters are manufactured by different companies: "Photowatt Inc." (France), "Siemens Solar" (Germany), "Solitte" (Australia), etc. Parameters of solar lighters produced by these companies are presented in the Table 3.1.3.

Table 3.1.3. Parameters of solar lighters

Name of company	Lamp wattage, W	Battery capacity, A/h	Panel peak capacity, W	Cost (approximate), US$
PHOTOWATT Inc	18; 2x18;35	75;150	35-160	250-600
SIEMENS SOLAR	7	-	30	150
SOLITTE	1;26(for street)	1-75	1-150	30-500

Designed versions of street lighting by autonomous solar illuminators of different capacity manufactured by "PHOTOWATT Inc." are presented on the Fig. 3.3 Solar autonomous lighter of 18 W is Version 1 presented on the Figure, lighter with 2x18 W is Version 2 and lighter of 35 W – Version 3.

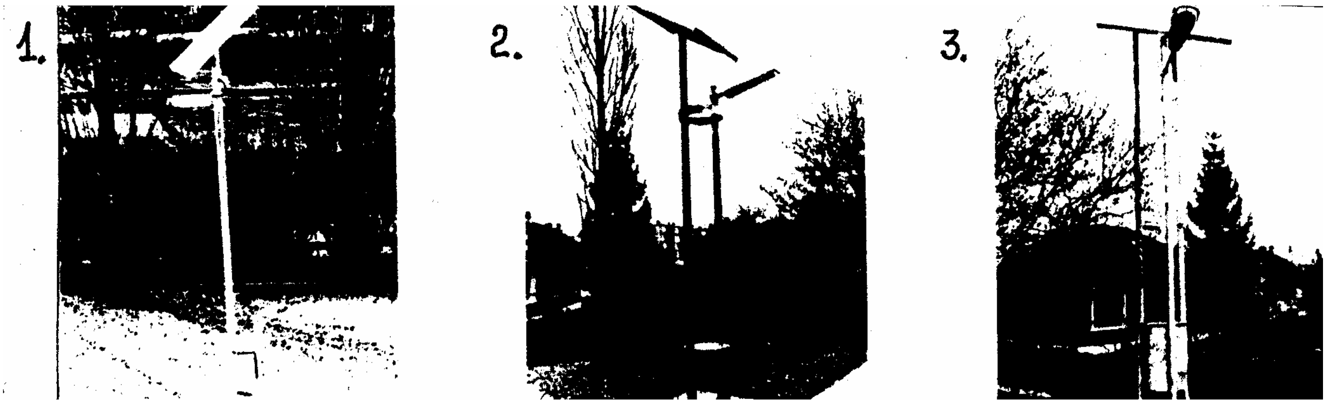


Figure 3.3. Designed versions of autonomous solar lighters of different capacity manufactured by "PHOTOWATT Inc."

Autonomous solar illuminators used for street lighting are equipped with energy-saving lamps of 20-40W, luminous flux of which reaches approximately 4 000-10 000 lumen. Sodium lamps are mainly used in these kinds of autonomous solar lighters.

On the basis of conducted analysis it could be assumed that replacement of approximately 10 % (6000 pieces) of existing lighting points with autonomous solar lighters is possible in Georgia (at the initial stage, in Tbilisi and Batumi).

3.1.4. Economic Calculation

(a) Economic calculations have been carried for each phases of both cases.

Economic Analysis of Import and implementation of Energy Efficient Starting Devices

The initial stage of the project envisages modernization of 10 000 starting devices out of 60 000. Furthermore, Russian made DĐË type energy-saving lamps will be used. Definite number of such lamps (approximately 30 000) are under operation. Purchasing price of this kind of lamps is in the ranges of *US*$ 15-20.

High efficiency and high operational frequency (this last one increases the light output of a lamp) of modern energy efficient starting devices decreases average wattage of one point of street lighting from 0.32 kW to 0.22 kW. The average price of this kind of starting device is *US*$ 100 and expenditures on the modernization of existing illuminates are *US* $ 10.

Hence, after the implementation of the first phase of the project the following results could be obtained:

1. Electricity annual saving that will be reached as a result of application of energy efficient starting devices for street lighting is:

$Ý_1 = N_1$ x ?t x n x ?P = 10 000 x 10 x 365 x 0.1 = 3 650 000 kWh,

where N_1 is the number (pieces) of energy efficient starting devices;

?t – average operating period (hr) per day;

n – number of days in a year;

?P – decrease of illuminator capacity using the energy efficient starting device (kW).

2. Annual income from electricity saving makes:

$U_1 = Ý_1$ x 0.045 = 3 650 000 x 0.045 = *US*$ 164 250,

where 0.045 US$/kWh is current electricity tariff.

3. Expenditures:

- on the purchase of the starting devices equal to 10 000 x 100 = *US*$ 1 000 000;
- on the installation of the starting devices - 10 000 x 10 = *US*$ 100 000; and
- unforeseen expenses – 10 000 x 3 = *US*$ 30 000.

Total - *US*$ 1 130 000.

Table 3.1.4 Economic analysis to adopt street lighting solar autonomous lighters

For 10-year period			For 15-year period		
No	Investment	Income (Saving on repairs)	No	Investment	Income (Saving on repairs)
	-1130 000			-1130 000	
1		164 250	1		164 250
2		164 250	2		164 250
3		164 250	3		164 250
4		164 250	4		164 250
5		164 250	5		164 250
6		164 250	6		164 250
7		164 250	7		164 250
8		164 250	8		164 250
9		164 250	9		164 250
10		164 250	10		164 250
			11		164 250
			12		164 250
			13		164 250
			14		164 250
			15		164 250
NPV(10%)=-109 777 IRR=7%			NPV(10%)=108 453 IRR=12%		

(b) Economic Analysis of the Import and Distribution of Solar Autonomous Lighters for Street Lighting

The second phase of the project foresees the import and replacement of 1000 pieces from 6000 of street lighters. If the average operational time of autonomous solar illuminators for street lighting is 10 hours per day, the wattage of imported lighters is 35 W and the least cost of unit is approximately *US*$ 250 the following calculations have to take place:

1. Electricity annual generation will make:

$$?_2 = N_2 ? ?t ? n ? P = 1000 ? 10 ? 365 ? 0,035 = 127\ 750 \text{ kWh},$$

where N_2 is number of autonomous solar lighters;
P – capacity of each autonomous solar lighter;

2. Income as a result of electricity sales will be equal to:

$$U_2 = ?_2 ? 0,3 = 127750 ? 0,3 = US\$\ 38\ 325,$$

where 0,3 *US*$/kWh is average mean of the world tariff on electricity generated by solar lighters. For example, tariff on electricity generated by TESs and HPPs in Japan at present equals to 0.25 *US*$/kWh.

3. The expenses are to be as follows:
   - expenses on purchase of autonomous solar lighters
     $U_{Lighter} = 1000 ? 250 =$ *US*$ 250 000;
   - expenses on installation
     $U_{Inst} = 1000 ? 35 =$ *US*$ 35 000;
   - contingencies
     $U_{Contr} = 1000 ? 15 =$ *US*$ 15 000;
   - Total expenses
     $U = U_{Lighter} + U_{Mount} + U_{Contr} = 250\ 000 + 35\ 000 + 15\ 000 =$ *US*$ 300 000.

Table 3.1.5. Economic analysis for implementation the autonomous solar lighters

For 10 years period			For 15 years period		
No	Investment	Income (saving on repairing)	No	Investment	Income (saving on repairing)
	-300 000			-300 000	
1		38 325	1		38 325
2		38 325	2		38 325
3		38 325	3		38 325
4		38 325	4		38 325
5		38 325	5		38 325
6		38 325	6		38 325
7		38 325	7		38 325
8		38 325	8		38 325
9		38 325	9		38 325
10		38 325	10		38 325
			11		38 325
			12		38 325
			13		38 325
			14		38 325
			15		38 325
NPV(10%)= -58 645 IRR=5%			NPV(10%)= -7 725 IRR=10%		

3.2. INDOOR LIGHTING

3.2.1. Development of Energy-Saving Lamps Local Manufacturing

Objective of the project is to produce and apply the energy-saving lamps that will save approximately one billion kWh of energy annually for Georgia; to mitigate social problems (expenditures of population at lighting will decrease almost five times); to increase the export capacity of the country. It should be stressed that it is faster and cheaper to carry out the energy saving measures than to create the new energy sources.

It would be mentioned that all types of energy-saving lamps have the same imperfection – low power factor and high reactive power of distortion. The high capacity electricity grids more or less endure this defect but large-scale distribution of these lamps in Georgia will destroy the country's energy system (distortion of voltage forms, emergency and resonance resistance events, high failure rate of insulation, short-circuits in cables, etc.).

The project is planned to be implemented stage-by-stage:

<u>The first stage</u> includes import of the lamps spare parts and their improvement during the assembling using the indigenous know-how (the know-how is patented and it will significantly improve the technical parameters of the lamp).

At the same time, lamps service centers should be organized in Tbilisi and other regions of Georgia. The purpose of the service centers is selling of the lamps, reception and repair of the defective ones.

Description of Know-How:

The energy-saving lamps switch on by force of high frequency alternating voltage which is generated by starting devices. The alternating voltage received from the grid is transformed by the starting device into the direct voltage which is later transformed to high frequency alternating voltage. High capacity condenser, which is charged in 2-4 m/s (millisecond), is used as fillers in the transformer of network alternating voltage into direct voltage. Therefore, current supplied by the grid (due to the short charging time of condenser) has an impulsive form and significantly differs from sinusoidal current. The consumed impulsive current provokes in the system the distorted reactive power that reduces power factor of a lamp up to 0.4-0.5.

In order to increase the power factor (k), we have elaborated three know-how (patented as No 1171930; No 553, No 603). At present new know-how is submitted for receiving the patent. The last one is devoted to making changes in the electronic circuit/scheme of energy saving lamps so as to increase its power factor (up to 0.9-0.96). Innovation lies in new circuits, which are used at the plate of a lamp's electronic scheme that significantly increases power factor.

This know-how have been tested and introduced in serial production, particularly, in the power sources of direct current.

<u>The second stage</u> comprises the development of lamp spare parts production locally (tubule, body, cap).

Total investment required for the implementation of the first stage amounts to *US*$1 200 000.
The "STU-ENERGIA" Ltd. possesses the building costing *US*$400,000 and know-how.
Furthermore, it is necessary to conduct the following activities:

- Rehabilitation of existing building, purchase and installation of equipment and establishment of service centers require- *US*$ 580 000;
- Establishment of working assets – *US*$ 600 000;
- Research and design activities – *US*$ 20 000;

Thus, for starting the project it is necessary *US*$ 1 180 000 of technical credit and *US*$ 20 000 for research and design activities, that makes in total – *US*$ 1 200 000.

The credit will be covered in 5 years by 12 % of interest rate. Repayment of credit would begin in one year after borrowing.

Project beneficiary is "STU-ENERGIA" Ltd. Its contribution is *US*$ 400 000 equivalent in national currency. The company is located in Tbilisi and its legal address is 77 Kostava Str.

<u>Staff</u>: 9 managers, 5 scientists, 80 principal workers, 30 auxiliary workers (from the beginning of enterprise operation). There are highly qualified and experienced managers and scientists. Mostly, senior students of the Georgian Technical University (GTU) will perform as workers.

<u>Project realization</u> will serve as the drastic and rapid step to help the country's energy system to overcome the crisis. Decrease of taxes on lighting almost 5 times will mitigate social problems of population (expected increase of tariffs on electricity will become less painful); amount of electricity import, peak loads, expenses on rehabilitation of transmission lines and substations will decrease as well.

Data on electricity consumption for lighting is represented in the Table 3.2.1.

Table 3.2.1. Electricity consumption for lighting in Georgia in 1990 and 1999

Year	Electricity total consumption by the residential sector (million kWh)	Electricity consumption for lighting (million kWh)
1990	2,9	1,16
1999	3,5	0,33

3.2.2. Local Production of Energy-Saving Lamps

(a) Scope of Production

"STU-ENERGIA" Ltd (130 employees from the beginning) will produce energy-saving electronic lamps with 12 and 20 W of capacity equivalent to 60 and 100 W incandescent lamps and will sell them throughout Georgia and will export them outside the country. The company will provide warranty service for sold lamps and will purchase warranty overdue and damaged lamps from population and organizations.

Planned production of energy-saving lamps for the first 5 years are presented in the Table 3.2.2.

Table 3.2.2. Production of energy-saving lamps for the first 5 years

No	Lamp power (W)	2002	2003	2004	2005	2006
		Number of lamps				
1	12	180000	160000	320000	320000	500000
2	20	420000	640000	1280000	1280000	1500000
3	Total	600000	800000	1600000	1600000	200000

(b) Marketing and Production Plan

Existing Market

The following companies are producing energy-saving lamps at present: "PHILIPS" (Holland, Poland); "OSRAM" (Germany, Turkey); "PROLITE" (Germany); "TOPSTAR", "JIA MEI" (China), etc. Capacity consumed by the lamps varies from 3 to 30 W that is equivalent to 15-150W of incandescent lamps. Lifetime and estimated prices of energy-saving lamps according to the manufacturing companies are given below (see Table 3.2.3.).

Table 3.2.3. Some characteristics of energy-saving lamps

No	Company	Lifetime (thousand hours)	Price (US $)	Power Factor
1	"OSRAM"	8-15	6-8	0,5
2	"PROLITE"	10-15	8-9	0,6
3	"PHILIPS"	8-15	10-14	0,5
4	"TOPSTAR" "JIA MEI"	3-10	1-3	0,45

Energy-saving lamps produced by all companies have one and the same significant shortcoming – low power factor (H), which varies within 0.45-0.6. Therefore, energy-saving lamp in comparison with incandescent lamp (along with 5 times low active power (P)) requires from energy system so called reactive power of distortion (T) that is 1.73÷1.1 times more than active power. Full amount of power consumed by the energy system represents geometrical sum of active (P) and reactive (T) powers. Its value equals to $\sqrt{P^2 ? T^2}$? (2÷1,4)P that is (2.5÷3.5) times but not 5 times less. Consequently, the energy system load will be decreased only 2.5÷3.5 times in case of utilization of energy efficient lamps. The mentioned drawback will not be reflected at the meters and population will not "learn" on it though the existence of distortion capacity in the energy system will cause:

- Distortion of voltage form when the distortion capacity is adjustable to the installed capacity of energy source (e.g. power plant);
- Resonance effects (formation of overcurrent and supervoltage);
- Fast damage of insulation and short-circuits in cables;
- Increase of voltage drops and capacity losses in transmission lines and in the whole energy system;
- Breakdown of balancing devices and increase of losses in transformers;
- False operation of protective systems, hampering and damaging of communication and management equipment.

Reasoning from the aforementioned:

- It is impermissible to connect a lot of energy-saving lamps accessible at the world market to the weak and unsustainable energy system of Georgia.

"STU-ENERGIA" Ltd is capable to modernize existing energy-saving lamps on the basis of its know-how making relevant changes in the circuit of electric node. This will increase power factor of energy-saving lamp up to 0.95-0.96 and will provide unfailing operation within wide range (150-250 V) of voltage variations that is typical for the energy system of Georgia.

The development of offered know-how and the modernization of energy-saving lamps is possible and economically sound on the basis of energy-saving lamps spare parts imported from China. These spare parts are high quality and low price.

(c) Demand on Energy-saving Lamps

Market of energy-saving lamps in Georgia is in a state of formation and it looks as it spontaneously makes its way through. Volume and rates of imports and sales are low. For example, according to experts' evaluation, average annual extent of sales does not exceed 45 thousand, though, interest and demand on product seems to be rising. The low rate of present sales along with the high tariff of electricity and its growing tendency could be explained by different factors: novelty of produce, high price, poverty of majority of population and in addition rather low price of "traditional" incandescent lamps; lack of advertisement on energy-saving lamps and what's most important absence of warranty assurance and services after sale.

Removing of above-listed factors is not difficult. The simple calculations made by the consumer will show them that the replacement of one 100 W lamp with its equivalent by illumination 20 W energy-saving lamp will save 146 kWh – [(100-20)/1000x365x5=146 kWh] for 5 hours operation per day. Hence, 14.3 (146x0.098) GEL will be saved annually that exceeds the selling price of energy-saving lamps. The consumer will surely consider one year warranty period and possibility of selling of damaged energy-saving lamps to the service centers expiring the guarantee period.

In summary, we have to suppose that at least 80% of Georgian population will become potential buyer of energy-saving lamps. Demand from non-residential sector has to be considered as well. According to experts' appraisal the total demand constitutes 7.5 million lamps. Taking into account the average lifetime of energy-saving lamps (7÷10 years) the annual demand should be in the range of one million lamps.

(d) Arrangements to Meet Demand

In spite of the high quality of lamps and service it is anticipated that 3÷5% of demand on produce will be covered through the export. The percentage could be increased in case if the country doesn't adopt a ban on import of energy-saving lamps with the low power factor. All mentioned determine the annual production and realization plan of factory producing domestic energy-saving lamps.

According the proposal the enterprise will be established in two stages:

I stage includes import and modernization of existing at the market lamps that will provide an opportunity to cover the demand in a shortest time-period. Selection of the acceptable for country's market effective lamp is based on the prices of spare parts and transportation expenses because the invisible qualitative differences between them will be removed after modernization. In this regard, considering established price and transportation expenses, application of Chinese lamps is expedient for Georgia.

II stage foresees replacement of damaged lamps and joining to the international market with competitive products. Significant increase of power factor of lamps will make them competitive. This stage considers local production of no transportable and low specific weight spare parts (tubule, socle, body) that will reduce the product prime cost. And what is not less important, it will give an opportunity to use local resources and create new jobs in the country.

"STU-ENERGIA" Ltd.

(e) Fixed assets:

1. Existing building (2000 m^2) is estimated at *US*$ 400 000. Investment in amount of *US*$ 180 000 is required for building rehabilitation.
2. Equipments at the enterprise and their prices are given in the Table 3.2.4.

Table 3.2.4. Equipment and Their prices

No	Equipment	Quantity (number)	Unit Price (US$)	Total (US$)
1	2	3	4	5
1	Editor	100	100	10000
2	Supervisory equipment	5	10000	50000
3	Investigating equipment	10	1000	10000
4	Galvanic installations	1	50000	50000
5	Thermoplastic automatic equipment	10	1000	10000
6	Photocopiers	1	20000	20000
7	Dyeing machine	1	10000	10000
8	Produce packaging line	1	50000	50000
9	Equipment for mechanical processing	20	1000	20000
10	Expenditures on transportation and installation	-	-	70000
11	Total	-	-	300000

Research activities would be carried out continuously. The initial activity will focus on the rising of power factor of energy-saving lamps. 0.5 year from the start-up moment and *US*$ 20 000 investment are required for these activities.

Arrangement of warranty service centers will require also 0.5 year and *US*$ 100 000 investment. Thus, *US$* 600 000 would be required to carry out research and repairing works, purchase necessary technologies.

3.2.3. Financial Plan

(a) Prime Cost of Product

Material and spare parts have a decisive role in the formation of prime cost. Their list of spare parts and their prices are given in the Table 3.2.5.

Table 3.2.5. Expenses On The Production Of One Energy-Saving Lamp

N	Material	Price (US $)
1	Radio components	0,8
2	Plate	0,05
3	Body	0,1
4	Tubule	0,25
5	Packaging material	0,3
6	Total	1,5

Spare parts and their prices presented in the Table 3.2.5 correspond to the Chinese production.

Complete prime cost of one 20 W capacity energy-saving lamp considering non-productive outlays much more depends on the volume of production. The results of relevant calculations made by "STU-ENERGIA" are given in the Table 3.2.6.

Table 3.2.6. Prime cost of 20 W lamps

N	Annual program, (number)	Prime cost of unit production, (US $)	Nonproductive expenditures, (US $)	Total prime cost, (US $)
1	600 000	2,515	0,395	2,91
2	800 000	2,45	0,368	2,818
3	1 600 000	2,36	0,203	2,562
4	2 000 000	2,34	0,179	2,519

Prime cost of produce gives us an opportunity to offer the cheapest and the high-quality lamps not only to the Georgian market but also to the neighboring countries' markets (Armenia, Azerbaijan, Turkey and Iran) as well.

US$ 4 could be set up as selling price including the VAT *US*$ 0.66, but selling price for company is *US*$ 3.34 that provides fair net profit and timely repayment of credit.

(b) Investment components

The loan of *US*$ 1 200 000 would be necessary to implement the above-mentioned project. This sum will be distributed as follows (see Table 3.2.7):

Table 3.2.7. Investment Components

N	Works	Expenses, (US $)
1	Research activities	20000
2	Rehabilitation of building	150000
3	Import, transportation and installation of equipment	300000
4	establishment of service-centers	100000
5	Working Assets	600000
6	Total	1200000

Significant share of working assets in the investment structure can be explained by the fact that, at the first stage of production we intend to import from China all spare parts for the final produce. Replenishment of stocks will take place once in a month. Revenue from realization of products in the first months (on the initial stage of market development) will rise at a slow pace.

Table 3.2.8. Economic analysis for distribution of indoor lighting energy efficient lamps, US$ (The rate of 1US$ is assumed by 2001)

	2001	2002	2003	2004	2005	2006
Sale, pcs.	-	600 000	800 000	1 600 000	1 600 000	2 000 000
Loan (credit)	1 200 000	-	-	-	-	-
Production expenses	-	1 509 240	1 963 040	3 778 080	3 778 080	4 685 600
Non-production expenses	-	237 500	294 700	324 200	324 200	358 400
Total income (sale)	-	2 004 000	2 672 000	5 344 000	5 344 000	6 680 000
Cash flow	-	257 260	414 260	1 241 720	1 241 720	1 636 000

IRR=2%NPV(1%)=1 458 029

Overall report on production activity (US $)

	Profit – Loss	**2002**	**2003**	**2004**	**2005**	**2006**
Expenses	Production surcharge expenses	228 000	304 000	608 000	608 000	760 000
	Maintenance and service (3 %)	15 000	15 000	15 000	15 000	15 000
	Amortization of industrial building (7 %)	42 000	42 000	42 000	42 000	42 000
	Amortization of equipment (15 %)	75 000	75 000	75 000	75 000	75 000
	Enterprise insurance expenses	5 000	5 000	5 000	5 000	5 000
	Property tax	11 000	11 000	11 000	11 000	11 000
	Land tax	-	-	-	-	-
	Business tax	20 040	26 720	53 440	53 440	66 800
	Road tax	20 040	26 720	53 440	53 440	66 800
	Production expenses	1 509 280	1 963 040	3 778 080	3 778 080	3 956 800
	Non-production expenses	237 500	294 700	324 200	324 200	358 400
	Other expenses	486 600	617 600	663 400	663 400	676 800
	Total sale (profit)	2 004 000	2 672 000	5 344 000	5 344 000	6 680 000
	Cash flow	257 220	414 260	1 241 720	1 241 720	2 364 800

IRR=1% NPV (0.5%)=978 479

3.2.4. Estimation of GHG Emission Reduction

As it was cited above, 3.65 million kWh of electricity could be saved annually as a result of adoption of advanced energy efficient starting devices in the street lighting system. It was assessed that 258 t of CO_2 is emitted generating 1 million kWh of electricity. Hence, 942 t CO_2 will be saved annually after placing starting devices into operation. 127.8 thousand kWh of electricity saving at the initial stage of implementation of autonomous solar lighters corresponds to GHG annual emission reduction equivalent to 45 t of CO_2.

As to adoption of energy saving lamps for indoor lighting, replacement of 1 million of 100 V lamps with 20 V annually all over the country will give 146 million kWh electricity saving that corresponds to GHG emission reduction equivalent to 37.7 thousand t of CO_2.

INDUSTRY SECTOR

4. RUSTAVI JSC "AZOTI"

In 1990 the chemical industry of Georgia included many enterprises of different range, the largest of them being Rustavi Chemical Enterprise "Azoti". At that time it produced about 80% of all the production in the sub-sector [9]. Nowadays, it keeps reflecting the state of this sub-sector of industry. That's why this enterprise was chosen to evaluate the chemical industry of Georgia.

This enterprise had an over-republican range and its produce was exported to all the Soviet Union and abroad. After the collapse of the USSR most of the large enterprises in Georgia stopped functioning or were disintegrated into small ones resulting from the lack of raw materials and high prices on energy carriers. This process slightly affected "Azoti" which was transformed in a state-owned joint-stock company (JSC) and kept functioning on a smaller scale. By the year 2000 it was the main enterprise in the chemical industry of Georgia producing about 99,9% of all the goods manufactured in this sub-sector. (According to the statistical data [33, 16, 38] the production of other enterprises being insignificant). Changes in this sub-sector of industry are reflected in the Table 4.1.

Table 4.1. Changes in the number of chemical enterprises and their staff in for 1990-2000

Characteristics	Years	
	1990	2000
Number of industrial enterprises in Georgia, total	1 365	2 840
Among them:		
in chemical and oil processing industry	56	NA
in chemical industry	44	58
Number of employees in the whole industry	458 900	99 600
Among them:		
in chemical and oil processing industry	20 600	4 120

Note: The data of 1990 are taken according to the old Soviet classification, and those of 2000 – according to the new national classification harmonized with the European one (the two being not in the absolute accordance).

The list of major production activities and substances emitted by them are given in Table 4.2. In the Tables 4.3, 4.5 and 4.6 the emission quantities in 1990 and 2000 are given for GHGs appropriate groups. The data on the total CO_2 emission related with the electricity use, the fuel consumed and the production-making processes are given in the Table 4.6 as well.

Table 4.2. Rustavi JSC "Azoti" main production activities and emitted GHGs

No	Production Activity	Aggregate	Aggregates in Operation (Number)	Industry Emission
1	Ammonia production	AM – 600	2	CO_2, CO, SO_2, NO_2, NH_3
2	Weak nitric acid production	AM – 72	1	NO_X, CO, N_2O
3	Nitramine production	AG – 72	1	NH_3, NH_4NO_3
4	Kaprolactam production	-	-	NO3, CO, NO_X, SO_2, Oxime, ammonia, kaprolactam dust
5	Cyclohexanon shop	-	-	-
6	Hydroxylamine sulphate producing shop	-	-	NO_X
7	Raw lactam and kaprolactam producing shop	-	-	kaprolactam dust
8	Ammonium sulphate production	-	-	Ammonium sulphate dust
9	Sodium cyanic hydrogen acid production	-	-	NaCN, HCN, CO
10	Electrochemical manganese dioxide production	-	-	MnO_2, CO, SO_2, NO_X

Note: At present electrochemical manganese dioxide and Kaprolactam production is ceased

General environmental and economic features of JSC "Azoti" are given in the Table 4.3. The data show that in 2000 four types of major products (from the five being produced in 1990) were kept being manufactured and the quantity of nitramine – the main produce of "Azoti" –had not been reduced much, making 94.8% of the product in 1990. There are 14 types of products in the complete list and among them many small-scale enterprises manufacturing cosmetic pencils, paper bags, etc.

The Table 4.3 reflecting the energy consumption per ton of the produce shows these parameters being not greatly changed for the last decade and tend to be increased for all 4 major types of produce.

It is seen from the Table that in 2000 the amount of production has decreased compared with 1990, while the specific energy consumption per unit of produce has increased, that resulted in the corresponding raise of produce prime cost and the selling price as well.

The main reason for this is the operation of practically depreciated equipment after their major repair that made it impossible to run the production processes in an optimal mode.

Table 4.3. Main characteristics of Rustavi JSC "Azoti" in 1990 and 2000

No	Characteristics	Designed	Actual	
			1990	2000
1	2	3	4	5
1	Name of the enterprise		Rustavi JSC"Azoti"	Rustavi JSC "Azoti"
2	Year of founding/changing of the property form		1956	1993
3	Form of property		State	State Joint-Stock company
4	Territory area, ha		213	213
5	Number of employees		?10 000	3 200
6	Number of types (among them main) of the annually manufactured products		13 (5)	14 (4)
7	Electricity annual consumption, kWh		361 307 410	213 796 000
8	Natural gas annual consumption, mln.m^3		431 589 800	247 140 000
9	Mazut annual consumption, thousand tons		15	-
10	Main products manufactured annually, ton			
	10.1 Ammonia (evaluated in 100%)	400 000	219 210	136 256
	10.2 Nitric acid (evaluated in 100%)	372 000	237 933	226 206
	10.3 Nitramine	450 000	301 371	285 662
	10.4 Sodium Cyanide	10 000	7245.6	3947.8
	10.5 Kaprolactam	50 000	40 114	--
11	Consumption of energy for manufacturing 1 ton of product and GHGs' aggregated specific emission (CO_2 eq. t/t)			
	a) Electricity, kWh; (GJ):			
	11.1. ammonia		1100; (3.960GJ); 283.8	968;(3.485GJ); 249.7;
	11.2. nitric acid		60; (0.216 GJ); 15.48;	61.22;(0.220 GJ);15.8;
	11.3. nitramine		20.3; (0.073 GJ); 5.24;	20.3; (0.073 GJ); 8.514;
	11.4. sodium cyanide		810; (2.916 GJ); 208.9;	811; (2.920 GJ); 209.25.
	11.5. kaprolactam		840; (3.024 GJ); 216.7.	---------
	b) Natural gas, mln.m^3; (t); GJ			
	11.1.1. ammonia	1390	1058.5;(37.68 GJ);78.4814	1137.34;(40.4893 GJ);84.327
	11.2.2. nitric acid	85	65.7; (2,339 GJ); 4.8713	66.065; (2.3519 GJ);4.898
	11.3.3. nitramine	---	----------	------------
	11.4.4. sodium cyanide	1427	1043.9;(37.163 GJ);77.3989	1061.42;(37.78655 GJ);78.69
	11.5.5. kaprolactam	---	182.5;(6.497 GJ);13.53128	----------

1	2	3	4	5
12	Process emission values for 1 ton of product manufactured t/t:			
	12.1. from ammonia manufacturing process: a) carbon dioxide CO_2 b) NMOVCs c) carbon oxide CO d) sulphur dioxide SO_2 Total in CO_2-eq. 12.2. from nitric acid manufacturing process: a) N_2O-nitric suboxide b) NO_X-nitric oxides Total in CO_2-eq. 12.3. from nitramine NH_4NO_3 manufacturing process: a) NH_4NO_3.-dust b) NH_3-ammonia Total in CO_2-eq. (because of electricity consumption) 12.4. from sodiume cyanide manufacturing process: a) NaCN – dust b) CO- carbon oxide Total in CO_2-eq. 12.5.from kaprolactam manufacturing process: a) NO_X-nitric oxides b) CO carbon oxide c) NH_3 ammonia d) SO_2 sulphur dioxide Total in CO_2-eq.		1.55 0,00375 0,0075 0,00035 1.614 0,0075 0,00113 2.3702 0,00053 0,000055 0,012 0.0000003 0,13 0,39 0.000075 0.0085 0.00018 0.000008 0.0285	1.58 0,00382 0,00765 0,000355 1.645 0,0077 0,00114 2.4326 0,00054 0,000058 0,013 0.0000003 0,1281 0,3843 Not produced
13	1 t product cost price : 12.1. ammonia 12.2. nitric acid 12.3. nitramine 12.4. sodium cyanide 12.5. kaprolactam		 96.15 roubles 40.47 roubles 69.52 roubles 861.34 roubles 1196.52 roubles	 239.15 lari 90.83 lari 132.98 lari 1001.41 lari -
14	1 t product market price: 13.1 ammonia 13.2 nitric acid 13.3 nitramine 13.4 sodium cyanide 13.5 kaprolactam		 125 roubles 41.14 roubles 70 roubles 1000 roubles 1250 roubles	 400 lari 266 lari 210.0 lari 1320 lari -
15	1 t product export price: 14.1. ammonia 14.2. nitric acid 14.3. nitramine 14.4. sodiume cyanide 14.5. kaprolactam		 125 roubles 41.14 roubles 69.52 roubles 861.34 roubles 1196.52 roubles	 $ 200 $ 133 $ 100 $ 660 -
16	Quality of manufactured product exported, t: 15.1. ammonia 15.2. nitric acid 15.3. nitramine 15.4. sodium cyanide 15.5. kaprolactam		 28613 102 240480 7245.6 -	 1399 241 2470580 3624 -
17	Product was not imported on the local market			

The technical state of equipment also affected the patterns of GHGs and dust emission which generally has increased in the period of 1990-2000, but not more than by 2%. Meanwhile, the actual emissions cited in this Table significantly (by 2-14%) exceed relevant values recommended for the same processes by the IPCC, CORINAIR and other methodologies [10, 7] (see Table 4.4).

Table 4.4. Recommended and actual values of emission from 1 ton of product and the "extra" emission

N	Products and emissions	Recommended t/t	Actual t/t		Difference t.		Extra emission, t	
			1990	2000	1990	2000	1990	2000
1	Ammonia:							
	a) CO_2	1.5 CO_2/t	1.55	1.73385	0.05	0.23285	10960.5	31863
	b) NMVOCs	0.0036 t/t	0.00375	0.00382	0.00015	0.00022	32.8815	29.97632
	c) CO	0.0069 t/t	0.0075	0.008235	0.0006	0.001335	131.526	181.90176
	d) NOx	NA	0.00027	0.000325	-	-	-	-
	e) NH_4 dust	NA	0.011	0.0133	-	-	-	-
	f) SO_2	0.00003	0.000035	0.0000355	0.000005	0.0000055	1.09605	0.749408
	Total in CO_2-eq.	1.5603	1.62455	1.813575	0.05345	0.240275	11716.774	32738.909
2	Nitric acid:							
	a) N_2O	0.00675	0.0075	0.0077	0.00075	0.00095	178.44975	214.8957
	b) NO_X	0.001	0.00113	0.00114	0.00013	0.00014	30.93129	31.66884
	c) CO	NA	0.000234	0.00024	-	-	-	-
	Total inCO_2-eq.	2.1325	2.370902	2.43332	0.2377	0.3001	56556.673	67884.42
3	Ammonia nitrate NH_4NO_3:							
	a) NH_4NO_3-dust	0.000504	0.00053	0.00054	0.000026	0.000036	7.835646	10.283832
	b) NH_3	0.000052	0.000055	0.000058	0.000003	0.000006	0.904113	1.713972
4	Sodium cyanide:							
	a) NaCN –dust	0.0000001	0.0000003	0.0000003	0.0000002	0.0000002	0.0014491	0.0007895
	b)CO	0.1t/t	0.13	0.1281	0.03	0.0281	217.368	110.93318
	Total CO_2-eq.	0.3	0.39	0.03	0.09	0.0843	652.104	332.79954
5	kaprolactam:							
	a)NOX	0.00006	0.000075	-	0.000015	-	0.60171	-
	b)CO	0.00826	0.0085	-	0.00024	-	9.62736	-
	c)NH3	0.00015	0.00018	-	0.00003	-	1.20342	-
	d) SO2	0.000006	0.000008	-	0.000002	-	0.080228	-
	Total in CO_2-eq.	0.002718	0.0285	-	0.00672	-	52.95048	-
	Total CO_2 from 1 t of produce	4.01998	4.413952	4.631195	0.38787	0.624675	68978.501	100956.11

As it is clear from the Table 4.3, the technologies used in "Azoti" are rather energy-consuming that especially applies to the ammonia production.

Hence, it causes additional increase already high technological emissions. New technologies or measures should provide the decrease of both the process emissions and the energy intensity emission.

Among the technological processes at JSC "Azoti" have been estimated those which arise the significant environmental problems and are most energy intensive. The implementation of new technologies and energy efficiency measures at the individual stages of processes is much more realistic and economically more efficient rather than the reconstruction and reorganization of entire technological processes, especially under the present conditions in Georgia.

The technological processes at "Azoti" with the corresponding shares in energy consumption and GHGs emissions are given in Annex B.

As it was mentioned above, the main product to be exported is nitramine intermediate products of which are ammonia and nitric acid.

The initial product – ammonia is obtained by 2-step catalytic conversion of: natural gas with air and steam, (carbon monoxide) 2-step catalytic conversion with steam of CO, cleaning the converted air off carbon dioxide (CO_2), cleaning the synthetic gas from CO and CO_2, and the ammonia synthesis at the pressure P=320 atm and t=500^{0}C using a catalyst.

The second important product – nitric acid is obtained by oxidation of synthetic ammonia with air on P=3 atm and t=850^{0}C, oxidation of produced NO into NO_2 and N_2O_4, by absorption of these oxides by distilled water or steam condensate giving at last a 58-60% nitric acid.

The main product – nitramine is obtained through neutralization of nitric acid by ammonia, concentration of the produced nitramine solution up to 99,9% or more, granulating this solution and cooling it using a granulating column and a so called "boiling layer", adding some anti-agglutination substance. Nitramine is used generally in agriculture as a fertilizer.

Applied technologies were elaborated in the USSR and the enterprise started functioning in 1979-80 with a 20-year amortization period. The ammonia producing technology cost 56,5 mln. rubles, those of nitric acid and nitramine – 30 and 20 mln. rubles respectively.

Besides nitramine "Azoti" produces also sodium cyanide being obtained by catalytic oxidation of natural gas and ammonia with air at $t=1000^0C$ temperature, concentration of the received cyanic acid (HCN) and its condensation into liquid, neutralization of HCN with caustic sodium NaOH, concentration of sodium cyanide liquid into crystals. The technology was designed in the USSR and Japan and it got into exploitation in 1972 with 20-year period of amortization. It cost 25 mln. rubles.

Table 4.5. Annual emission of GHGs from main technological processes in Rustavi JSC "AZOTI" in CO_2-eq., thousand tons

No	Production category	Years	
		1990	2000
1	Ammonia production	353, 805 (339, 776)	224, 141 (215, 285)
2	Nitric acid production	563, 948	550,268
3	Nitramine production	3,616	3, 714
4	Sodium cyanide production	2,826	1,517
Total in CO_2-eq.		924, 195	779,64

Note: In brackets is the amount of CO_2 emitted during amonia process. Other processes, presented in the Table, have no CO_2-emission (their aggregated emissions of GHGs are given in CO_2-eq.).

One of the important fields of sodium cyanide utilization is a process of gold extraction off ore, containing it.

In 1990 the chemicals plant also produced kaprolactam being used by the Rustavi Enterprise of Chemical Fiber and other enterprises for producing different kinds of goods. Regardless the efficiency and high profitability of this production, it had been retarded in further years and stopped by 2000.

The charts of the technologies mentioned above with the descriptions of individual steps from environmental point of view (energy consumption and GHGs emission) are given in Annex B.

According the existing data the technologies applied at the JSC "Azoti" have passed their amortization period by 2000. Thus, the enterprise faces the necessity of technical and technological re-equipment. In this process the problem of raising environmental efficiency have an important role. Selecting the appropriate measures we have to use differentiated approach to the concrete processes and individual stages, proceeding from their energy intensity and environmental importance. At the same time we have to follow recommendations concerning specific measures to raise energy efficiency in the chemical industry:

- Use of improved catalysts for key chemical reaction;
- Improvements in distillation equipment;
- Improvements in gas turbine efficiency;
- Expanded the heat recovering process;
- Use of membrane technologies for the separation of reactants.

The analysis of technological processes taking place at the JSC "Azoti"(see Tables 4.3, 4.4, 4.5 and Annex B) shows that the main product of the enterprise is ammonia nitrate (nitramine), for the production of which major share have the medial products – ammonia and nitric acid. Their production characterizes with high energy intensity and the largest part of emissions, among which the most impressive is the share of nitric gases having the great global warming potential (GWP). From this standpoint it seems obvious that the main target for the technological perfection at the enterprise must be ammonia and nitric acid production processes.

From the foregoing it follows that it is essential to consider a plan of modernization of individual stages of production making process worked out by the "Azoti" management team. In particular, the plan considers capital repairs of the unit No 2 in the ammonia synthesis shop requiring 3 mln. GEL or 1,5 mln. USD. At the same shop the platinum nettings in the contact installation are planned to have changed, requiring US$ 1 million. Other additional measures in this and other shops are planned to be carried out, costing in total 60 000 Lari. The characteristics estimating the financial and environmental effectiveness of these measures are given in the Table 4.7. While analyzing this Table the following circumstances must be considered:

1. In ammonia producing process – after repairing the No 2 unit it will be possible to increase the process pressure in working mode up to 350 atm, resulting in increase of productivity or volume of production by 5% and in decrease of losses at the same time. At present the pressure is below 280 atm;
2. In nitric acid producing process - the renewal of catalyst and platinum nettings in the contact installation (where the main process of generating NO and NO2 takes place) brings the productivity increase; the capital

repairs of K-31 absorbing column improves its absorbing power. The productivity is increased also in result of adding a catalyst in P-40; the total effect of these measures is the increase of productivity by about 30% (or the decrease of losses by the same value);

3. In ammonia production – in a cooling shop the losses of NH_3, caused by desorption, will be decreased by about 98,4% after deeper cooling of ammonia water-solution;
4. In ammonia production – the overheating of water steam by 20-30% in the ammonia synthesis unit No2 makes CO_2, CO and NO_2 residues, left in the reaction area, to react completely, reducing the emissions to zero.

As the presented in Annex B Table 4.7 shows the modernization measures planned at the "Azoti" enterprise have important financial, economic and environmental efficiency, therefore being in a whole accordance with the principles of sustainable development. In particular, it is obvious that regardless the high costs of the planned measures (US$ 1,5 and 1,0 million), the profit after their realization is also considerable (US$ 2,4 and 1,2 million per year respectively), the main cause of this being such optimization of the technological process which results directly in the increase of productivity, providing US$ 5,7096 million income annually, reimbursing all the costs in 5,3 months.

The Table shows also the abatement of GHGs emission causing the reduction of fine for them as well. In the considered case its total value is US$ 16243 per year, making only 0,28% of the total profit.

It seems that the efficiency of the discussed above measures is conditioned by selecting for the modernization of most important and basic processes in ammonia and nitric acid production which are connected with the greatest energy inputs and GHG emissions. In particular, the measures related to the last cycle of ammonia production technological process – the ammonia synthesis, which is most energy-consuming ring in that process chain. At the same time, significant amount of gases is being emitted at this stage (see Annex B). The above mentioned measures will substantially increase the environmental efficiency of this process as it is shown in the Table 4.7 (Annex B). As a result of these measures only in the ammonia production the annual offset of CO_2 will reach more than 31 thousand tons, 88.323 tons of CO, 37.57 tons of NO_2 and 178.15 tons of ammonia that will save more than US$ 16062.46 annually.

Turning to the nitric acid production process the most important technological steps from the standpoint of nitrous oxides emission and energy consumption is the ammonia catalytic oxidation cycle, during which nitrous gases are emitted mainly. The cycle of absorption of these gases and the cycle of catalytic cleaning of residual emitted gases from nitrous oxides are highly energy-consuming (see Appendix B). In view of these circumstances it seems appropriate to select the mentioned stages for the technological perfection, as it will provide significant economic and environmental effect. Namely, in the issue of implemented measures, 2.47 t of NO_2 and 0.523 t of CO will be saved only in nitric acid production that gives US$ 181.13 saving per year.

In summary, it has to be mentioned that the modernization plan worked out by the JSC "Azoti" management team is in agreement with the energy efficiency and environmental protection standards and each of these activities is kept in the frames of specific energy saving measures, recommended for the chemical industry. In particular, the restoration and re-enforcement of catalyst in the nitric acid shop, the superheating of steam and the increase of process pressure in operating conditions at the ammonia synthesis unit is indirectly linked with the heat conservation measures.

Along with discussed above plan, it would be appropriate to work out other projects too, if the proposed technologies will complement the already presented measures and/or contain better financial-economic and environmental features. In searching for such technologies we are to be aimed, on the one hand, at the maximum conservation of electric and heat energy by universal means (as it is directly linked with the reduction of CO_2 and CO emissions) and on another – at the use of specific means, reducing nitrous oxides emission.

5. RUSTAVI METALLURGICAL PLANT (RMP)

The present proposal represents the economic and environmental prospectiveness for US$ 30-32 million investment to reconstruct OHF shop of RMP. The project envisages installation of electric-arc furnace, steel continuous casting device (CCD), steel without furnace processing unit ("furnace-bucket") in the steel smelting shop, and new package-press and press-clipper in the rolling shop.

Measure aims improvement of molten steel quality, expansion of range of goods, (including highly alloyed and rust-proof steel), reduction of steel losses in the form of cuttings and abatement of GHG emissions.

Project envisages production of 400-500 thousand t continuous casting product per year. Final product of steel makting shop will be round (110-120mm) and square (100X 100 and 200X200mm) articles.

In case of project realization the following will take place:

? Raising of steel making unit capacity by 250%;

- ? Improvement of molten steel quality and expansion of produced goods' range;
- ? Reduction of steel specific consumption on produce output by 15-20%;
- ? Product prime cost reduction by 30-40%;
- ? Possibility for making use of the existing buildings, cranes, machinery devices for the preparation of furnace charge of energy (oxygen, air, technical and chemically treated water, steam, etc.) and transport communications;
- ? Meeting the increased demand on round and square steel products and pipes at the market;
- ? Making use of vast amount of steel scrap existing in Georgia and in the south Caucasus. Besides, RMP possesses slag dumps, where 15 million m^3 of slag with 5-7 % of metal content is stored. After its processing 1 million t of scrap could be obtained;
- ? Significant decrease of GHG emissions (approximately by 25%).

On the Figures 5.1 and 5.2 the steps of old and new technologies and energy resources consumption are given.

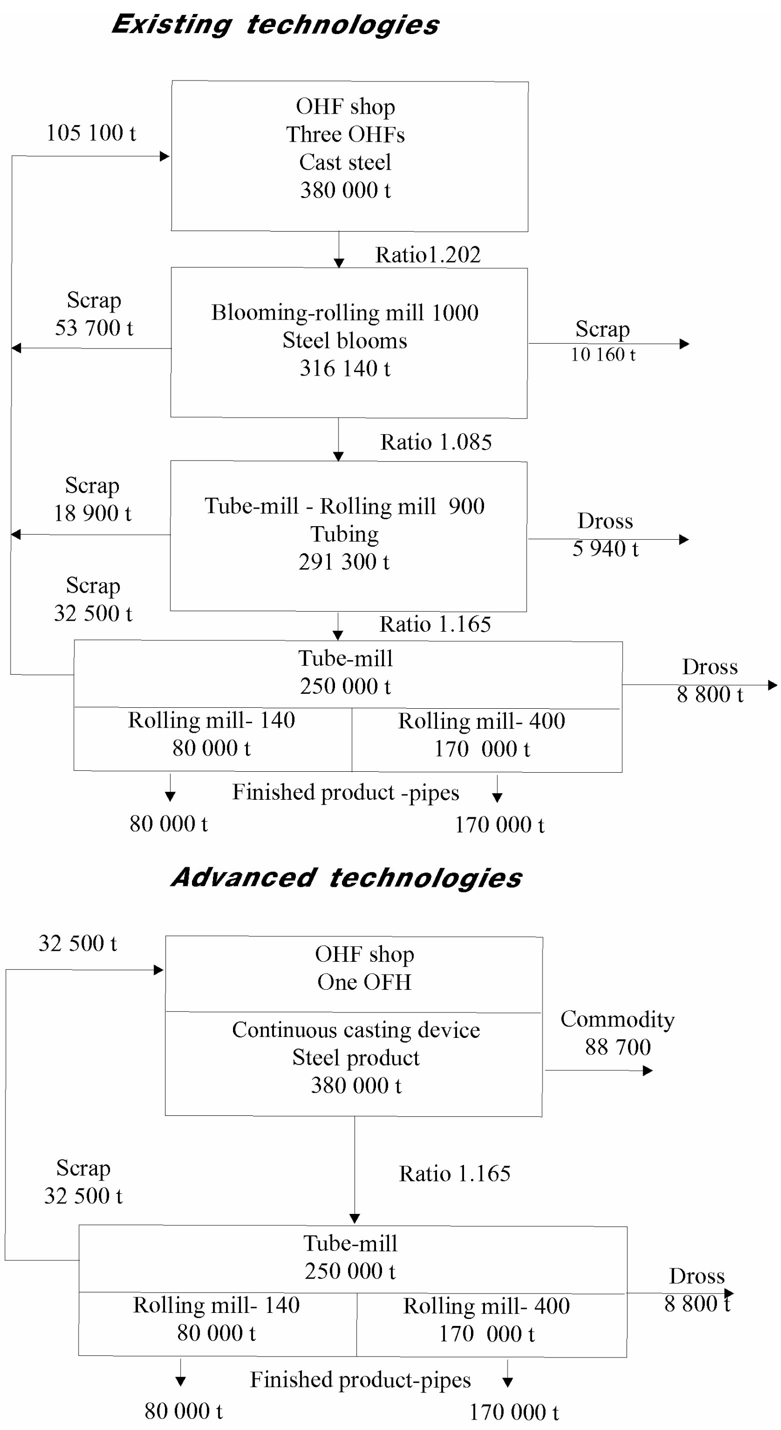


Fig. 5.1. Operation scheme of RMP principal shops by means of existing and proposed new technologies

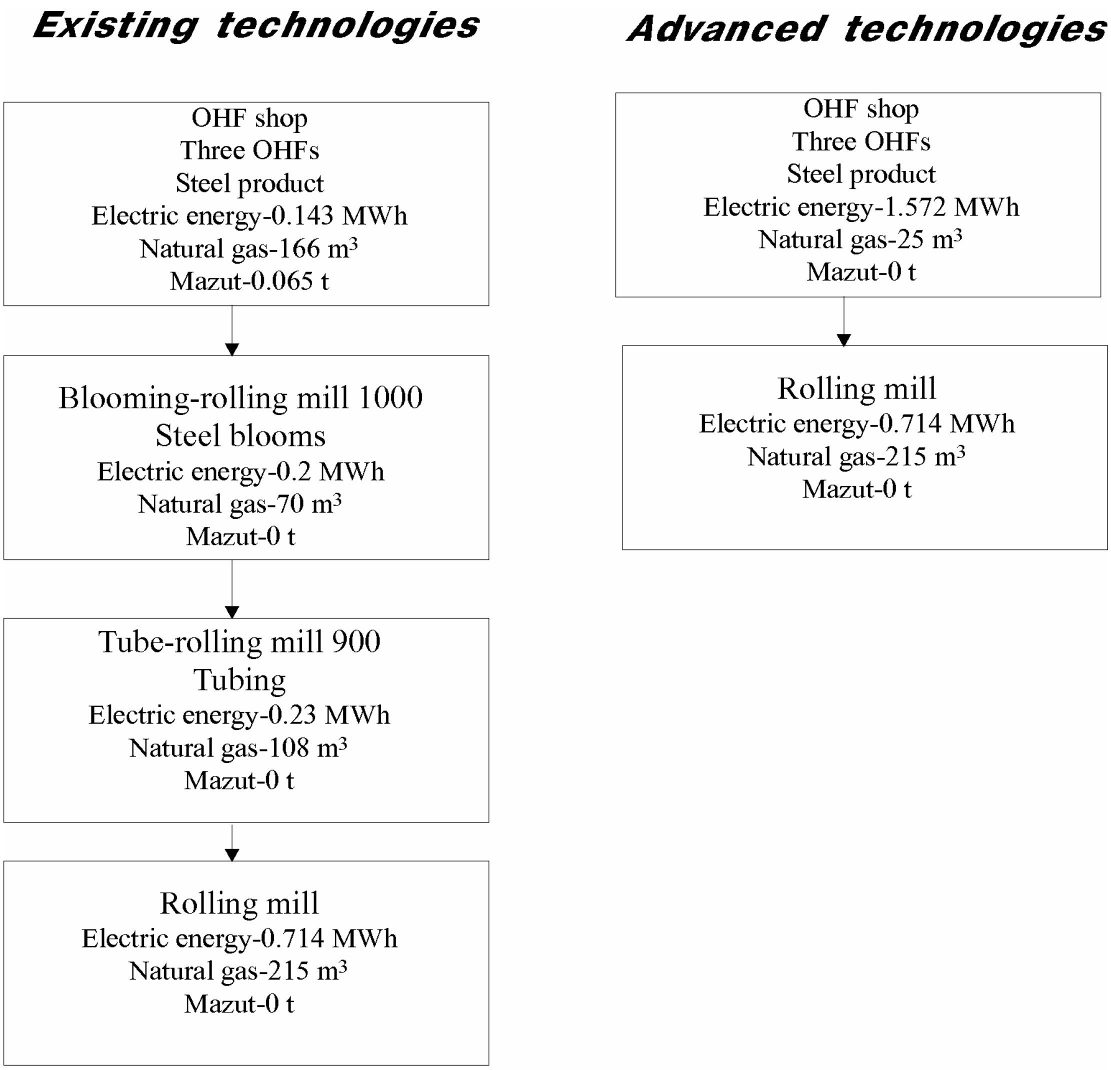


Fig. 5.2. Energy resources consumed by RMP main shops

Financial and economic features of project implementation and their comparison with the current state are given in the following tables.

Investment components required for project implementation are given in the Table 5.1.

Table 5.1. Investment components for implementation of advanced technology

Investment components	Cost, US$ 1000				
	Device	Spare part	Transport	Installation	Total
CCD	10000	300	700	2500	13500
Electric arc furnace	4500	135	315	1125	6075
Transformer	500	15	35	125	675
Furnace-bucket	2000	60	140	500	2700
Air-cleaner	3000	90	210	750	4050
Package-press	1400	42	98	350	1890
Press-clipper	1200	36	84	300	1620
Design activities	500	0	0	0	500
Total	23100	678	1582	5650	31010

Comparison of each step of new and old technological cycles is presented in the Tables 5.2 and 5.3.

Table 5.2. Expenses per ton of steel production

Categories	Price	OHF	t.c.f/t	$/t	Electric furnace		$/t
	$/unit	1 t product			1 t product	t.c.f/t	
Steel part, t	42,75	1,2		51,3	1,12		47,88
Electricity, MWh/t	60	0,14	0,05	8,57	1,571	0,55	94,3
Natural gas, thousand m^3/t	80	0,17	0,2	13,23	0,025	0,03	2,0
Mazut, t	100	0,065	0,085	6,5	0	0	0
Expenses on energy carriers				28,29			96,3
Energy expenses, t.c.f.			0,335			0,58	
Other expenses				54,1			35,3
Total				133,69			179,5

Table 5.3. Expenses per ton of steel product output

|Categories	Price	Rolling mill-1000			Rolling mill-900			Pipe rolling		
	$/unit	energy/t	t.c.f/t	$/t	energy/t	t.c.f/t	$/t	energy/t	t.c.f/t	$/t
Electricity, MWh	60	0,2	0,07	12	0,23	0,08	13,7	0,714	0,25	42,9
Natural gas, thousand m^3	80	0,07	0,08	5,3	0,11	0,13	8,6	0,215	0,26	17,2
Mazut, t	100	0	0	0	0	0	0	0	0	0
Total energy expenses				17,3			22,3			60,1
Energy expenses, t.c.f.			0,15			0,21			0,51	
Other expenses				7,10			11,7			52,7
Total				24,39			34,0			112,8

In the Tables 5.4 and 5.5 are cited annual expenses and profits.

Table 5.4. Financial indices of RMP activity (annual expenses)

List of categories	Existing technology			New technology		
	$/t	t/y	$ 1000	$/t	t/y	$ 1000
Steel production	129,4	380000	49172	179,5	380000	68210
Rolling-mill 1000	14,8	316140	4679	0	0	0
Rolling-mill 900	23,2	291300	6758	0	0	0
Pipes working	78,4	250000	19600	78,4	250000	19600
Total expenses			80209			87810

Table 5.5. RMP annual expenses and profits applying existing and new technologies

List of categories	Existing technology			New technology		
	$/t	t/y	1000 $	$/t	t/y	1000 $
Commodity rolled metal	150	0	0	150	88700	13305
Pipes	350	270000	94500	350	270000	94500
Scraps	35	105100	3679	35	32500	1138
Total			98179			108943
Taxes+VAT			-5391			-15203
Expenses			-80209			-87810
Net profit			12578			5930

In the Table 5.6 financial indices are presented, from this data it is evident that project is profitable if credit interest rate does not exceed 10%. (IRR=13%).

Table 5.6. Financial estimation of RMP activity in terms of adoption of advanced technologies

Investment	1	2	3	4	5	6	NPV	
	-15505	-15505	0	0	0	0	-28 426,75	-31010
Credit % of the first year		-930,3	0	0	0	0	-877,64	-930,3
Net profit			35475	35475	35475	35475	122 924,62?.	141900
Annual expense			-58265	-58265	-58265	-58265	-201 894,38	-233060
VAT+other taxes			-15203	-15203	-15203	-15203	-52 680,00	-113492
Sale			108943	108943	108943	108943	377 499,00	435772
			NPV 6%		35 709,70			
			IRR		13%			

The results of calculation of GHG emissions in CO_2 equivalent per ton of product and annual emissions for existing and advanced technologies are given in the Tables 5.7 and 5.8.

Table 5.7. CO_2 emission per t of steel production (including pipes)
(a) Existing technology

Name of unit	ELECTRICITY		NATURAL GAS		MAZUT		Total GHG emission in CO_2 equivalent, t
	Consumption, MWh/t	Emission in CO_2 eq, t	Consumption, thousand m^3/t	Emission in CO_2 eq, t	Consumption, t/t	Emission in CO_2 eq, t	
OHF	0,143	0,00022737	0,166000	0,289338	0,065000	0,222698	0,512263
Rolling-mill-1000	0,2	0,000318	0,070000	0,239140	0,000000	0,000000	0,239458
Rolling-mill-900	0,23	0,0003657	0,108000	0,188244	0,000000	0,000000	0,188610
Pipe rolling mill	0,714	0,00113526	0,215000	0,374745	0,000000	0,000000	0,375880
Total	1,287	0,00204633	0,559	1,0914666	0,065	0,2226978	1,31621073

(b) Using advanced technology

Name of unit	ELECTRICITY		NATURAL GAS		MAZUT		GHG emission equivalent to CO_2, t
	Consumption, MWh/t	Emission in CO_2 eqv., t	Consumption, thousand m^3/t	Emission in CO_2 eqv., t	Consumption t/t	Emission in CO_2 eqv., t	Total
Electric furnace	1,572	0,00249948	0,025000	0,043575	0,000000	0,000000	0,046074
Pipe rolling mill	0,714	0,00113526	0,215000	0,374745	0,000000	0,000000	0,375880
Total	2,286	0,00363474	0,24	0,41832	0	0	0,42195474

Table 5.8. GHG annual emission from steel production (including pipes)
(a) Existing technology

Name of unit	GHGs total emission equivalent to CO_2, t/t	Annual output, t	GHG total annual emission equivalent to CO_2, t
OHF	0,512263	380000	194660,0046
Rolling-mill-1000	0,239458	316140	75702,12566
Rolling-mill-900	0,188610	291300	54942,00561
Pipe rolling	0,375880	250000	93970,065
Total	1,31621073		419274,20

(b) Advanced technology

Name of unit	GHG total emission equivalent to CO_2, t/t	Annual output, t	GHG total annual emission equivalent to CO_2, t
Electric furnace	0,046074	380000	17508,3024
Pipe rolling	0,375880	250000	93970,065
Total	0,42195474		111478,37

From the difference of the sums presented in the last two (a) and (b) Tables, annual saving of CO_2 emissions in case of introduction of advanced technologies would be equal to 307796 t. and for the last four years (for which the project is destined) the total CO_2 saving will equal to 1231184 t.

6. BREAD INDUSTRY

6.1. General Review

Bread industry is one of the most important sub-sectors of the Georgian industry sector. Its faultless operation greatly promotes the stable situation in the country, influencing its political and economic orientation as well. Current state of the sub-sector and its transformation process, within the last 10 years, are examined in detail in the work published by UNDP (V. Melikidze. "Georgian bread industry within the economic reform". Discussion paper series, No7. UNDP, Tbilisi, 1998).

Analyzing this work from the standpoint of objectives set up in our project, we will find that since 1990, when the Georgian bread industry was mainly in hands of two giant monopolies (Tsekavshiri – 51.7% of production and Ministry of Bakery Foods - 43.3%), sub-sector experienced the considerable transformation as a result of privatization of majority of enterprises that commenced from 1995. In particular, by 1998, the great parts of enterprises (63.6%) were transformed into the privatized enterprises of the former state sector, 29.9% was represented by new private enterprises and only 6.5% remained in Tsekavshiri system. In 1990, the sub-sector comprised 63 large-scale units, in which 665 bakeries were united. By the year 1991, sub-sector accounted capacity has reached its maximum and consisted 1005 thousand ton of bread and bakery produce. In 1998 number of bread baking enterprises reached 1400, but production was reduced down to 193 thousand tons. Considering 450 g bread average daily norm per capita in Georgia, it is evident that the great portion of population (majority in villages and small towns) are baking bread at home that gives sizable economic profit. In addition, granting numerous other aspects, the share of "shadow sector" was significantly increased in bread industry within last 10 years that in its turn makes the statistics data unreliable. According to experts' estimation, at least 30% is the share of this sector within the last 5-6 years.

According to the present state, enterprises operating in the Georgian bread industry could be divided into three categories:

- Enterprises integrated in the Tsekavshiri system, almost under the state property, specific share of which, in compliance with economic reforms ongoing in the country, is gradually decreasing. Thus, it could be said that in line with the grave economic condition of the country, the most prevailing and ramified bread producing system in the Republic, which mainly served rural population, is about ruin, though some constituting enterprises are steel functioning.
- Enterprises of the former state sector, which represent large-scale bread producing joint stock companies functioning in the big cities. In 1990, 152 bread baking enterprises of state sector were operating in the Republic, in which were included large enterprises with more than 25 t/day capacity. After the privatization process, since 1995, fragmentation of these enterprises into small enterprises has began, the great part of which joined to the private sector. The rest of large enterprises were modified as joint stock companies, control stock of which was remained under the state possession. Presently, there are 35 such large enterprises, including Tbilisi No6 bakery plant, Kutaisi No4 bakery plant, Batumi, Poti, Zugdidi, Tkibuli, Chiatura, Zestaponi, Borjomi, Rustavi, Telavi, Marneuli bakery plants, Akhaltsikhe, Khashuri, Katschreti bread-baking plant and others. Large enterprises have more preferential terms than private ones that is expressed in continuous energy supply and possible support from the government and local authorities. During last years, profitability of these enterprises ranges within 5-7%. Capacities of the enterprises are loaded by ⅔ because of massive competition from the small-scale private enterprises.
- A lot of small enterprises of the private sector formed after 1995, estimated number of which exceeds 1400. In this category is included wide spectrum of the enterprises, beginning from home-grown thone (Georgian bakery) with 150kg/day capacity and ending with new mini plants equipped with modern devices equipment, the capacity which reaches 2000 kg per day.

At the present time, Georgian population is quite well supplied with bread and bakery foods as a result of effective activities of last two types of above mentioned enterprises. Moreover, acute competition among the enterprises along with flour massive import creates the terms for sub-sector viability and development that gives possibility to conclude that present bread industry is very flexible sub-sector in Georgia having quick adaptation possibility to any variability of the market terms. Except 3 or 4 largest cities of the Republic new small bakeries became the leading or single producers of bread, while in large cities they provide at least half of bread production.

Control on bakery foods production is mainly implemented by the tax administration. Unfortunately, the state policy in the sub-sector is not steel formed.

As for technologies applied in the bread industry, by the state of 1998, the following picture can be drawn.

- Large-scale enterprises (bakery plants and bread-baking plants) are using outdated, depreciated equipment of soviet period, are applying old-fashioned technologies and because of numerous motivations could not introduce new technologies. Along with economic reasons (absence of financial resources to purchase new equipment and transfer advanced technology), staff conservatism and what is most important, features of local market play the significant role. According to the traditions, bread is the main food in Georgia. Therefore, its caloric content is most valuable and bread made by the soviet technology in spite of its low quality meets this demand. Attempt to introduce the advanced technology (to make white, dry and light bread) has failed. As against the western developed countries, where the food is rich in proteins and bread is only less important food, for us bread is main source of albumen, and factory bread is more useful.
- Mechanization level in small-scale enterprises is minimum. The most of enterprises are equipped with the old soviet technique, energy efficiency of which is very low. Traditional Georgian bread is mainly home-made. Owing to the absence of bread quality control system, baking standard technology is followed as far as possible. Marketing examinations are not carried out. Existence of storage building, continuous energy supply and sale market are the main conditions for small enterprises activities. Regardless the heavy operation conditions, enterprises of this sector are steel competing with large ones (have rather better conditions). To determine the possibility of operation of large-scale enterprises and adoption of the latest energy efficient technologies at them, specific data of some enterprises of this sub-sector are examined below.

6.2. TBILISI BAKERY PLANT No. 4

Tbilisi bakery plant No 4, was founded in 1940. After the reconstruction it renewed operation in 1968. Until 1996 it was acting as the state enterprise and in 1996 its legal position was changed to the Joint Stock Company. Staff possesses 100% of shares. It represents a middle-sized enterprise.

The plant has been producing 4 types of produce by 1990: three different kinds of bread and some bakery. Bread is the main product. By 1990 the object has been operating under 85% of design capacity and 17 250 tons of bread was produced annually. Use of 85% of its actual capacity, accounting on various types of technological lay-outs, it is recognized as a good result. After the disintegration of the Soviet Union, and transfer to the market economy, small private bakeries have gained large part of market. Hence, plant produce realization indices were significantly reduced. Presently, the object utilizes only 24% of the main capacities, therefore product output is dropped down to 4 380 tons annually.

Present low competitiveness of factory produce is mainly conditioned by high prime cost. The last one is conditioned by old-fashioned equipment and technological processes. The fact that already by 1991 almost all equipment has been depreciated, is to be taken into account.

Due to the same reason the factory could not meet the environmental norms.

Main stages of bread (basic product) baking technology are cited in the Table 6.1. Energy consumption norms are given for one day. During this period the factory produces about 12 tons of bread while consuming 10 tons of flour.

The first two processes are implemented by aerozol transport using the compressed air, that requires air with 2 atm of pressure and 20 m^3/h capacity. It consumes about 243 kWh of electricity (8 hour-cycle).

301 kWh of electricity is consumed during the third and the forth stages.

The last three stages – arresting¸ baking and final processing are going using the steam boiler contineously around the day. 276 kWh of electricity and 2500-3000 m^3 of natural gas are consumed throughout these last three stages, out of its 60% is consumed by the boilers. In total, 821 kWh of electricity and 2750 m^3 of natural gas in a day, and about 300000 kWh of electricity and 1 million m^3 of natural gas annually are consumed.

Table 6.1.Main parameters of technologies applied at the Tbilisi Bakery Plant No. 4

Stages of main technology process	Equipment parameters		Consumed electricity, kWh/day	Equipment's operation duration per day, h	Natural gas daily consumption, m^3
	Quantity, pcs	Capacity, kW			
1	2	3	4	5	6
1. Getting of flour without packing	2	75	150	1	
2. Flour sifting and transportation to the industrial bins		4.8	93		
a) Sieve	2	2.8	39	7	
b) Bin (Dosage and removal)	2	1	14	7	
c) Industrial bin (Delivery to knead dough)	5	1	40	8	
3. Production of semi-manufactured articles		8	186		
a) Phase preparator	2	3	36	6	
b) Kneader	5	5	150	6	
4. Dough processing (using dough cutter and pelletizer)		4.8	115		
a) Dough cutter	4	3	72	6	
b) Pelletizer	4	1.8	43	6	
5. Final processing by steam boiler		6.1	276		
a) Boiler	2			24	1650
b) Delayer and over (baking)	5	1.8	216	24	1100
c) Transporter	1	2.8	39	14	
d) Table	1	1.5	21	14	
TOTAL			821		2750

The fact that due to the energy crisis of Georgia, the plant often is not supplied with electricity and natural gas, should be also taken into account. In such cases diesel fuel (in diesel generator) and mazut (in boiler) are used; their hourly consumption are 60 l/h and 3 t/dü respectively.

Electricity consumption in some phases of the cycle is quite high as compared with the modern technologies. Therefore, introduction of advanced technologies will significantly improve the situation and consequently, the GHG emissions will be reduced.

In particular, first stage of this process consumes a lot of energy. 75 kWh of electricity is consumed to get 10 ton of flour (dayly norm) without packing, while only 3 kWh of electricity is required for this process in terms of new technology (by means of screw conveyor). Consequently 72*2(kWh)*0,258kg (National Emission Factor for electricity production) =37.2 kg of CO_2 will be saved in a day that corresponds to 13.6 ton of CO_2 annually. Installation of new advanced furnaces will save 30% of dayly electricity consumption in the baking process. Electricity dayly consumption will be reduced by 64.8 kWh, and emmision will be decreased by 64.8 kWh*0,258 kg=16¸7 kg CO_2, that gives 6.1 ton annually. As to boilers, which are basic natural gas conumers (approximately 1650m^3 of natural gas per day), replacement of only one of them by a new Italian boiler will save 1/3 and more of consumed natural gas (approximately 550m^3 per day and 200750 m^3 per year), i.e. 550m^3*1,96 kg=1078 kg of CO_2 will be saved dayly that equals to 393¸5 ton of CO_2 in a year.

Thus, saving of 208¸8 kWh of electricity and 550m^3 of natural gas per day will be posible after replacement of all depreciated equipment with new ones, i.e. 208¸8kWh*0¸258kg +550m^3*1¸96kg=1131¸9kg of CO_2 emission will be avoided¸ that makes 413 t of CO_2 per annum.

6.3. JSC „TEMKIS PURI“

JSC „Temkis Puri“ (former bakery foods experimental plant) was founded in 1980. Legal position (state enterprise) of the plant was changed in 1996 and it became Joint Stock Company.

In 1990, plant produced verious types of bakery foods, but presently is producing only bread. By the year 1990, plant's load factor was 85-90% and bread daily output was equal to 100 tons, but on holidays it amounted to 120 tons. After transferring to the market economy, the production indices of plant were significantly reduced. At present, produce daily output is decreased to 19 tons, that makes day round operaion regime unneccessary, and so there are two eight-hour shifts.

Bread making technology process is continious; liquid-salt phase is used. 6 lines are installed at the JSC „Temkis Puri“, out of which 5 ones are operating. Furnaces of BN-150 type of German (former GDR) production and manufactured in 1978-1979 are used. Part of them are depreciated. All other equipment used in the technology perocess (except furnaces) are Soviet made.

Main stages of bread baking technology are presented in Tab. 6.2.

Table 6.2. Main parameters of technologies applyied at the JSC „Temkis Puri“

Stages of technology process	Equipment parameters			Operation duration per day		Consumed electricity per day, kWh		Natural gas dayly consumpt. * m^3
	Quantity, pcs		Capacity, kW					
	Main	Reserve		Unit	Total	Unit	Total	
1. Getting of flour without packing	2	4	126	8	16	1008	2016	
2. Flour sift and transportation to the industrial bins							272,8	
Among them:								
a. Sieve	1	1	2,8	8	8	22,4	22,4	
b. Bin	2		2,2	16	32	35,2	70,4	
	3		2,2	10	30	22	66	
						Total	136,4	
c. Industrial bin	2		2,2	16	32	35,2	70,4	
	3		2,2	10	30	22	66	
						Total	136,4	
3. Manufacture of semi-manufactured articles							382	
Among them:								
a. Phase preparatory	2		3	12	24	36	72	
b. Kneader	2		5	16	32	80	160	
	3		5	10	30	50	150	
						Total	310	
4. Knead processing	2		4,8	16	32	76,8	153,6	
	3		4,8	10	30	48	144	
						Total	297,6	
5. Final processing							1269,6	
Among them:								
a. Boiler								
a.1. Steam boiler	1	1		16	16			
a.2. Exhaust ventilators			22		16		352	
b. Arresting board	2		1,8	16	32	28,8	57,6	
	3		1,8	10	30	18	54	
						Total	111,6	
c. Furnace	2		7	16	32	112	224	
	3		7	10	30	70	210	
						Total	434	
d. Transporter and table (one set - 4 pcs)	2		6	16	32	96	192	
	3		6	10	30	60	180	
						Total	372	
Total per day							4238	5200
On produce unit, kWh/t							223	274

* January 2002 data. Contains total consumption of boiler and furnaces (their separation was impossible)

Capacities of devices listed in the Table are taken from passport data, and operation hours are averaged.

Natural gas is consumed by boilers and baking furnaces. Soviet made two boilers of ? ? ? ? -4-13 type are installed in the boiler house. They are functioning one by one. One natural gas meter is installed in the enterprise, that does not give a possibility to differ amount of natural gas consumed by boiler and furnaces in total natural gas consumption.

Diesel-generator is used as the emergency source of electricity. JSC „Temkis Puri“ has three generators, 500 kW capacity each. Two of them are in reserve. Diesel fuel consumption equals to 70 l/h.

As it is clear from the Table, electricity consumption is rather high at the enterprise, especially per produce unit. The main reason is not only the fact that Soviet made devices and eqiupment are characterised by quite high energy consumption, but the fact that due to present low demand on the product, the enterprise uses only small part of its capacity. Before solving the issue related to the unregistered goods output in the country, JSC „Temkis Puri" could not determine long-range strategy and estimate production volume for the future. As yet (1-2 year prospect) ensuing from the financial and economic conditions of the enterprise and considering banking and credit terms (very high interest rates) of the country, its technical modernization issue is not discussed. Though, JSC „Temkis Puri" is much interested in compliance of real demand on product with industrial capacities by force of adoption of new technologies, that as a result of energy consumption reduction will cause GHG emission saving along with direct economic effect. Namely, if the specific consumption of electricity would be reduced from the existing 223 kWh down to 68 kWh (parameters of Tbilisi bakery plant No 4), it will save about 2950 kWh per day and about 1 077 000 kWh of energy annually. Moreover, in terms of advanced technology intoduction, at least 1 200 000 kWh of energy will be saved annually in the long run. 309.6 t of CO_2 emission will be avoided annually in Georgian energy sector considering GHG emission factor (0.258 kg CO_2/kWh).

As for natural gas consumption, here is huge reserve for replacement of boilers as well as installation of the modern furnaces, though qualitative apprisal is complicated because of lack of initial data (natural gas actual consumption, equipment efficiency).

6.4. JSC "SPAGETI-94"

The Joint Stock Company "Spageti-94" was founded in 1991 on the basis of No 8 Bakery Foods Plant and in 1994 was transformed into Joint Stock Company. 100% of shares are in the possession of individual stockholders, among them the staff members.

The line producing long-pipe macaroni manufactured by Buhler Company is installed at the JSC. The plant outputs spaghetti and 2 types of macaroni. Line capacity is: spaghetti - 2 t/h, macaroni - 1.5 t/h. In 2000-2001, the average annual produce volume made only 3-5% of total capacity. The reason is following:

After the gaining of independence together with transferring to the market economy, import of food articles and especially, macaroni articles was widely practiced. Macaroni and spaghetti imported from Turkey and Iran are of rather low grade. They are cheaper then the local produce and therefore, they have occupied the considerable segment at market during last years. Considerable parts of imported produce are smuggled or carried under the bargain with customs that causes its low price. Consequently they appear at fairs and in street trading network and are not rated by tax. Indeed, "Spageti-94" consumes raw material manufactured in Georgia, but its producers themselves make initial raw material (wheat) import. Thus, price of produce output by "Spageti-94", in prime cost of which the significant share comes on taxes, is higher then the price of untaxed imported ones. Besides, there are the facts of home-made production of macaroni, including the use of "Spageti-94" title. Because of all earlier mentioned, "Spageti-94" was forced to decrease its production level to the minimum. Though, it has to also denote that "Spageti-94" management is seeking for the best solution of the created situation. For this purpose, it provides constantly high quality of product, it reorganized the staff, purchased the cars and itself supplies the trading centers, enlarged contacts outside the capital. According to indicative calculations it is assumed that within two years production present level will be doubled and if produce illegal import all over the country is suppressed, the volume of output will increase even more. Though, to reach the full capacity is less assumable, as from the beginning the plant was designed for meeting the demand of all South Caucasus republics since it was designed during the Soviet period.

The plant consumes high quality flour, or cereals (delivery from the local milling grinding plants) and water as raw material. Cereals give better quality, but it makes produce expensive.

Technology line is 10-12 years old and needs modernization. Line power capacity is 550 kW.

Technology process is going under the following sequence:

At the outset, the flour is powdered into the receiving bins, from here it transferred into two interim bins and then it is delivered to scales for the determination of relevant water volume according to the formula. Water of 36^0C temperature is delivered to four mixers and then to the press, afterwards finished product (uninterrupted spaghetti/macaroni pipes) comes from there. From press the product is put up on drying rods (aluminum narrow cross-cut bars) and enters in the dryer that consists of 11 zones. Steam, produced in the line, is delivered to five of them. Temperature in the drying lines is kept through water heated by the steam entered from the boiler. The finished product from dryer is delivered to 7-storied collector and from there to the cutting machine, where it is cut into 250 mm length of sticks. Manufactured produce is collected in the paper bags or is packed in plastic packets. Technological cycle lasts 24 hours in a day.

Table 6.3. Energy consumption and GHG emission at JSC "Spageti-94" comparing existing and modern technologies

Stem boiler	Parameters of steam				Fuel **	Daily consump., m3		Working days				Annual fuel consumption, 1000 m3						Annual CO2 emissions, t						Annual emission reduction, t	
	Required		Provided by boiler *					At present		In future		At present production			In future			At present production			In future				
	Amount t/h	Pressure bar	Amount t/h	Pressure bar		Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Total	Winter	Summer	Total	Winter	Summer	Total	Winter	Summer	Total	At present prod.	In future
Existing	1,35	6	4	13	Nat gas	3500	2000	15	15	30	30	52,5	30	82,5	105	60	165	209	119	328	209	119	328		
										75	75				263	150	413				522	298	820		
										150	150				525	300	825				1044	1641	2685		
New	1,35	6	1,5	8	Nat gas	2450	1400	15	15	30	30	36,8	21	57,8	73,5	42	116	73,1	41,8	115	146	83,5	230	25	98
										75	75				184	105	289				365	209	574		246
										150	150				368	210	578				731	1149	1879		805
						2100	1200			30	30	31,5	18	49,5	63	36	99	62,6	35,8	98,4	125	71,6	197	33	131
										75	75				158	90	248				313	179	492		328
										150	150				315	180	495				626	358	984		1700
						1750	1000			30	30	26,3	15	41,3	52,5	30	82,5	52,2	29,8	82	104	59,7	164	41	164
										75	75				131	75	206				261	149	410		410
										150	150				263	150	413				522	298	820		1864
																		Annual CH4 emissions, kg						Reduction, kg	
																		5,58	3,19	8,77	11	18	29		
																					28	44	72		
Assumptions:																					56	88	144		
		Increase of production in future					2			Decrease of fuel consumption						30		3,91	2,23	6,14	8	12	20	1,68	9
		by					5			by new steam boiler,						40					20	31	50		22
							10			% in comparisson with old one						50					39	61	101		43
																		3,35	1,91	5,26	7	11	17	2,23	11
																					17	26	43		29
*	Pasport data, not actual for existing																				34	53	86		57
	Approximate for new																	2,79	1,60	4,39	6	9	14	2,79	14
																					14	22	36		36
**	Parameters of natural gas:																				28	44	72		72
	Calorific value				35,45	MJ/m3												Annual N2O emissions, kg						Reduction, kg	
																		1,12	0,45	1,56	2	4	6		
																					6	9	14		
	Emission factor			CO2	15,3	tC/TJ		56,1	tCO2/TJ		0,542	kgC/m3		1,99	kgCO2/m3						11	18	29		
				CH4	3	kgCH4/TJ					0,106	kgCH4/1000m3						0,78	0,45	1,23	2	2	4	0,34	2
				N20	0,6	kgN2O/TJ					0,021	kgN2O/1000m3									4	6	10		4
																					8	12	20		9
																		0,67	0,38	1,05	1	2	3	0,45	2
																					3	5	9		6
																					7	11	17		11
																		0,56	0,32	0,88	1	2	3	0,56	3
																					3	4	7		7
																					6	9	14		14

Steam required to heat water used in the technological process (required amount - 1350 kg/h, pressure - 6 bar) is got from the Soviet made boilers of ? ? -4-14 ? ? type. Boiler design parameters (capacity – 4 t/h, pressure - 14 bar) does not meet the requirements, moreover the boiler is depreciated. Besides, boiler is installed at the JSC "Temka Puri" (that represents legal successor of No 8 bakery foods plant, on the basis of which "Spageti-94" was formed) boiler and steam is delivered through 100 m pipe that is not insulated and therefore there are a lot of losses. In winter boiler could not provide required pressure and fuel consumption is rather high.

Natural gas of medium pressure is used as a fuel, and its consumption is equal to about 3500 m^3/day in winter and about 2000 m^3/day in summer. In winter steam is used for shop heating as well, because at the low temperature the product is got of low quality. Heating system is functioning only during the line operation.

The line has operated only 9 days from November 2001 to February 2002.

The managers of JSC "Spageti-94" wish to purchase and install new, effective boilers, but at present there are no investment. Therefore, corresponding financial and technical calculations were not performed.

Calculations of energy supply and GHG emission of JSC "Spageti-94" are carried out for the following assumptions:

1. Increase of production volume a) 2 times; b) 5 times; c) 10 times;
2. Efficiency of new boiler reduces fuel consumption a) by 30%; b) by 40%; c) by 50%;
3. Emission factors for greenhouse gases (CO_2, CH_4, N_2O) are taken from IPCC Guidelines [25, 26, 27].

The result of calculation is presented in Tab. 6.3. From the presented Table is evident that 1864 t of CO_2 emission, 72 kg of CH_4 emission or 1.5 t of CO_2 equivalent, 14 kg of N_2O emission or 4.3 t of CO_2 equivalent will be reduced annually in case of transferring to the modern technologies. In total, 1869.8 t emission of CO_2 equivalent will be abated.

7. RUSTAVI CEMENT PLANT

For the Rustavi plant limestone is extracted at the Dedoplistskaro open-cast mine which is 180 km away from the enterprise. After being crushed it is delivered by railway to the plant, where it is grinded and mixed with clay silt. Clay is mined at the local open-cast pit, distanced 3 km from the plant. The consumption of row materials and energy resources for the production of 1t of cement at the Rustavi plant in the period of 1990-2000 is given in the Tab.7.1. Till 1994 the plant has no detailed information on row materials consumption, while in 1997 the relatively low consumption of materials was conditioned by the partial import of clinker from Armenia (1990 data were reconstructed using the existing information).

Table 7.1. Row materials and energy resources consumption for the production of 1t of cement at the Rustavi plant

Year	Row materials consumption, t						Use of energy resources		
	Total	Including					Electricity, kWh	Natural gas, m^3	Total, kWh
		Limestone	Clay	Gypsum	Fly-ash	Slag, basalt			
1990	1.758	1.267	-	-	-	-	130.7	250	158.9
1994	1.933	1.151	0.503	0.039	0.035	0.205	425.5	232	451.7
1995	2.098	1.354	0.561	0.036	0.030	0.117	304.7	304	339.0
1996	1.700	1.184	0.258	0.046	0.029	0.183	228.6	213	252.6
1997	1.513	1.017	0.228	0.061	0.061	0.191	244.8	187	265.9
1998	1.830	1.335	0.460	0.054	0.035	0.182	179.0	276.2	210.2
1999	1.830	1.339	0.438	0.054	0.033	0.281	158.1	300.0	192.0
2000	1.818	1.379	0.397	0.031	0.042	0.203	111.2	279.6	142.8

Similar to the Kaspi plant, the main pollutants of the atmosphere in Rustavi plant are the kiln sector, clinker and additives store-houses, grinding sector and cement producing sector.

The kiln (pyroprocesses) sector consists of 3 kilns each of 25-28t/hr capacity, equipped with electric filters. The actual efficiency of them did not exceed 10%. Due to the absence of dust-catching equipment sufficient large quantities of kiln-dust were dispersed from the clinker and additives store-houses and from the crushing sector. Meanwhile, in the cement production sector, where 7 grinding mills were working, all of them were equipped with the sleeve-filters, the efficiency of which amounted to 99.99%. This fact caused relatively small dispersion of dust into the atmosphere from the Rustavi plant compared with the Kaspi plant.

During last decade of past century the technical condition of Rustavi plant's dust-catching system underwent some changes. Fig.7.1 illustrates close relationship between the GHG emission factor and the efficiency of dust-catching system. The correlation is clearly defined by the negative regression coefficient and high value of correlation coefficient.

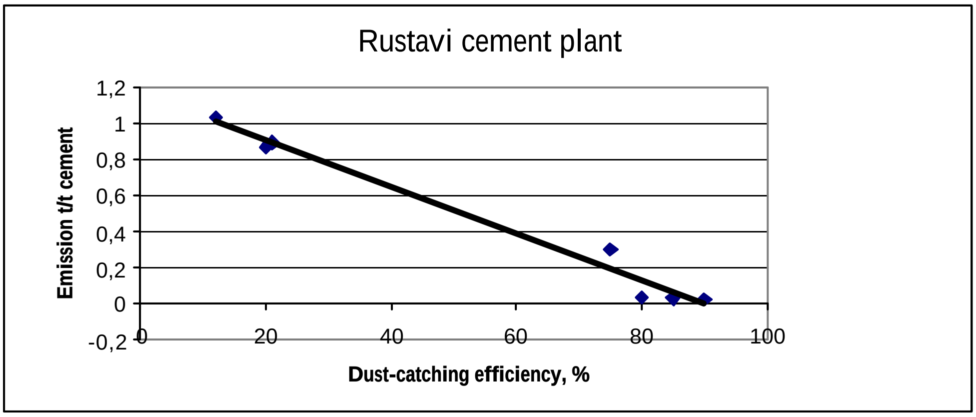


Fig. 7.1. Correlation between the GHG emission factor and dust-catching efficiency

The differing picture has been revealed in the relationship between the total energy consumed for the production of 1t cement and the efficiency of dust-catching equipment (Fig.7.2).

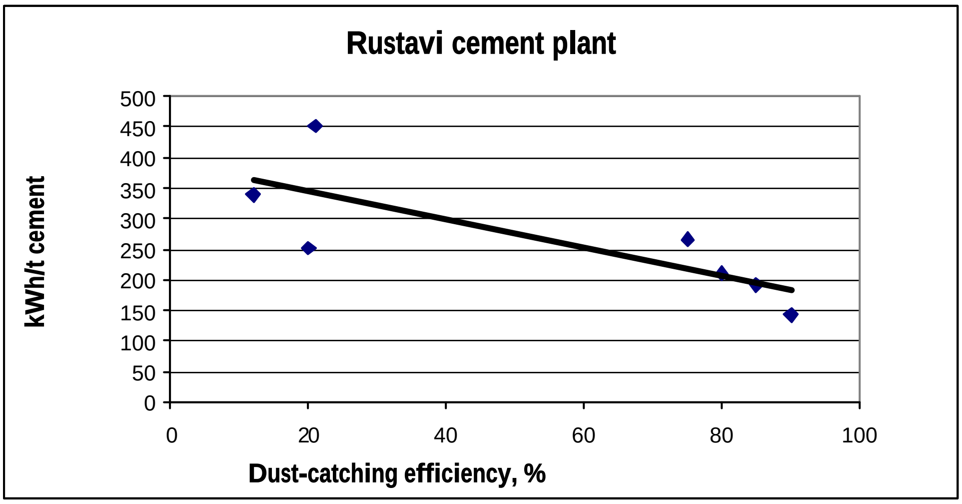


Fig. 7.2. Correlation between the specific consumption of energy and the dust-catching efficiency

It is to be supposed that the low correlation in this case is due to the fact the consumption regime of the most part of components of total energy consumed is not dependent on the functioning of dust-catching system.

The general, technological and environmental features of functioning of Kaspi and Rustavi plants for the year 1990 are given in the Table 7.2. Due to the fact that the functioning of dust-catching systems is these enterprises was significantly lagging behind the world standards, it has been assumed that the priority problem for both plants consists of the raising of the efficiency of these systems up to at least 99%. Along with the actual data the Table contains the results of calc ulations of the major parameters of plant, relevant to the functioning of dust-catching systems at that level.

Table 7.2. Main features of the functioning and efficiency of Georgian cement industry in 1990

No	Characteristic features	Kaspi plant		Rustavi plant	
		Actual	99% dust-catching	Actual	99% dust-catching
1	2	3	4	5	6
1	Year of foundation	1930		1956	
2	Area of territory	30		25.6	
3	Number of personnel	876		451	
4	Rated capacity				
	Cement, 10^3 t	865		864	
	Roofing slate, 10^3 conditional slates	40.0		-	
5	Manufacturing technology	wet		wet	
6	Type of cement produced	“300” and “400”		“400”	
7	Quantity of cement manufactured, 10^3 t	583.5	693.0 (616.3) *	706.5	811.6 (741.2) *
8	Fuel used	Natural gas		Natural gas	

1	2	3	4	5	6
9	Consumption of energy resources for the production of 1t of cement (specific energy consumption)				
	- Electricity, kWh (MJ)/t	140.5 (505.8)	117.3 (422.3)	130.7 (470.5)	113.8 (409.7)
	- Natural gas, m^3 (MJ)/t	224.1 (5728.3)	187.1 (4780.9)	250.0 (6387.5)	217.6 (5560.4)
	- Black oil (mazut), kg (MJ)/t	2.9 (130.9)	2.5 (111.2)	-	-
	Total, GJ/t	6.365	5.314	6.858	5.970
	Saved specific energy consumption, GJ/t		1.051		0.888
10	Total consumption of row materials for the production of 1t of cement, t	1.715	1.605	1.758	1.754
11	Total quantity of generated kiln-dust, 10^3 t	110.6	110.6	105.1	105.1
12	Total quantity of kiln-dust, picked up by the dust-catching system, 10^3 t	46.1	109.5	76.9	104.0
13	Quantity of kiln-dust dispersed into the atmosphere, 10^3 t	64.5	1.1	28.2	1.1
14	Dust-catching efficiency, %	41.7	99.0	73.2	99.0
15	Concominant emissions to the production of 1t of cement (specific emissions)				
	- kiln-dust, t/t	0.11	0.0016	0.04	0.0013
	- total greenhouse gases, CO_2 equivalent, t/t	0.9917	0.8365	1.0297	0.8962
	- including CO_2, t/t	0.9471	0.7990	0.9832	0.8557
	- other GHGs, CO_2 equivalent, t/t	0.0446	0.0375	0.0465	0.0405
	Among them CO_2:				
	- technological, t/t	0.5438	0.4579	0.5574	0.4852
	- from fuel consumption, t/t	0.3303	0.2781	0.3578	0.3115
	- from electricity consumption, t/t	0.0730	0.0630	0.0680	0.0590

** In the case of 30% efficiency of transformation of kiln-dust into cement*

The data presented shows that one of the major features of production – the energy consumption is somewhat higher for the Rustavi plant, that is conditioned by the introduction of more complete cycle of grinding processes (in case of Kaspi some of them are missed). In particular, for the production of 1t cement in the Rustavi plant in 1990 6.858 GJ of energy was consumed while for the Kaspi plant this index equals to 6.365 GJ.

Despite the fact that both enterprises are of similar type and used “wet” technology of production, yet there are some differences among them in the consumption of row materials, and in the characteristics of technological emissions. In particular, such indices are the specific emissions of dust, carbon dioxide and other greenhouse gases. Namely, the specific emission of kiln-dust in Kaspi plant (0.11t per t of cement produced) is 2,75 times more than in Rustavi plant (0.04 CO_2 t/t). But on the other hand, due to the higher specific energy consumption, related with the production of higher quality cement, the CO_2 specific emissions are s little bit higher (by 4%) than the emissions from the Kaspi plant.

It can be seen from the data presented that the dominant part in GHG emissions belongs to CO_2, the share of which for both plants amounts to 95.5%. In the CO_2 emissions themselves technological emissions portion in the Kaspi plant is equal to 57.4%, and in Rustavi plant –56,7%. The shares of emissions from fuel consumption appeared to be respectively 34,9% and 36.4%.

While examining the economic features of both enterprises’ functioning, due to the aforementioned circumstances, the attention has been focused again on the dust-catching problem in view of its environmental and economic significance.

As it is known [35], the normal regime of the functioning of cement enterprises implies the kiln-dust catching at the 99.99% efficiency level. In plants examined by us this efficiency in 1990 was equal to 41.7% (Kaspi) and 73.2% (Rustavi). Thus, the most urgent and potential-bearing measure for the raise of general efficiency is, undoubtedly, the provision of dust-catching efficiency at the level of international standards.

Since this paper is not aimed at the economic and financial analysis of the functioning of Kaspi and Rustavi plants, we made approximate economic estimation of the modernization of their dust-catching equipment. The results of estimations are presented in the Table 7.3.

According to the Law on the protection of atmospheric air the Taxation Codex, now in force in Georgia, the normative tax on the dispersion of 1 ton of cement dust in the atmospheric air amounts to 90 Lari, and the environmental coefficient for the examined region equals to 1.3. The environmental taxation value and other economic parameters given in the Table 7.3 were calculated on the basis of these circumstances.

The values that represent expenses for the enterprise are given by negative numbers, while those which represent revenues - by positive ones. For the simplification of comparisons with the data presented in contemporary literature [36, 8], the resulting financial indices of the activity of plants are given in USD. While assuming the costs of dust-catching equipment and its maintenance the present prices on the world market were considered. The value of the kiln-dust transformation coefficient into the final produce was taken in calculations equal to 0.3.

Despite of aforementioned important restrictions, in the case of 99% efficiency of dust-catching system only as a result of the utilization of cement dust, it becomes possible to reduce the prime cost of cement production by 12.8% at the Kaspi plant and by 1,6% at the Rustavi plant. Owing to this the annual income of Kaspi plant could be increased by about 35% and that of Rustavi plant - by 7-8%.

Taking into consideration as well, that the raise of dust-catching systems' efficiency leads to the decrease of specific energy consumed by the plant, that results in a related abatement of CO_2 emissions, from the Table 7.3 it can be derived that this factor could be used as an additional source of revenue by the enterprise. In particular, if we admit that the price of 1 ton of CO_2 saved emission equals to 10USD, as it traded now at the international market, then we will get that each plant would be able to take annually extra income of about 0,9 million USD for the abatement of CO_2. That would increase of Kaspi plant's total revenue by 45% and that of Rustavi plant by 13-14%.

A comparison between the indices of the consumption of different components, fuel and electricity for the production of cement in Georgia with the features, given in literature and describing state of cement manufacturing in various countries shows that these figures are within the range of numbers, characterizing the international practice.

Table 7.3. Indices of expenses and economic efficiency of the installation of 99%-effective dust-catching equipment at the Georgian cement manufacturing enterprises

No	Characteristic features	Kaspi plant		Rustavi plant	
		Actual	99% dust-catching	Actual	99% dust-catching
1	Taxation on the pollution of atmospheric air by the dispersed kiln-dust, Lari/yr	- 7 546 500	- 129 402	- 3 299 400	- 122 967
	- Saving for the case of 99% dust-catching, Lari/yr		- 7 417 098		- 3 176 433
2	Approximate cost of cement, picked up by the dust-catching system, Lari/yr	1 021 000	2 430 900	1 571 000	2 121 600
	- Saved sum, Lari/yr		1 409 900		550 600
3	Difference between the environmental tax on kiln-dust emission and cost of picked-up cement dust, Lari/yr	- 6 525 500	2 331 900	-1 728 400	2 111 700
	- Economic efficiency of 99%-effective dust-catching, Lari/yr		8 857 400		3 840 100
4	Conditional cost of dust-catching system with the 5-year complete amortization, Lari/yr		1 000 000		1 000 000
5	Total annual conditional expences on the performance of dust-catching system, Lari/yr		2 000 000		2 000 000
6	Total efficiency of the increase of dust-catching effectiveness up to 99% considering relevant expences, Lari/yr		5 857 400		840 100
7	Prime cost of manufacturing 1t of cement, USD/t	37	32.25	34	33.43
	- Selling price, USD/t	54		56	
8	Reduction in the prime cost of manufacturing 1t of cement in case of 99% dust-catching, USD/t (%)		4.75 (12.8)		0.57 (1.6)
9	Revenue of enterprise in case of 99% dust-catching				
	- As a result of additional produce manufacturing, million USD/yr (%)		3.485 (35.1)		1.186 (7.6)
	- As a result of abatement of CO_2 emission, million USD/yr		0.947		0.944
	- Total, million USD/yr (%)		4.459 (45.0)		2.130 (13.7)

The examined above problem raising efficiency of dust-catching system does not represent a subject for consideration in the leading cement manufacturing countries – for them this problem is solved in general terms and realized in practice. At present their efforts are directed to the improvement of economic features of the functioning of their enterprises. For achieving this goal in the developed and developing countries the following steps are being taken:

- Transformation of processes from "wet" technology to the "dry" one;
- Increase of the share of additives, in particular of blast-furnace slag in the range of maximum possibility, related to the specific kind of cement produced;
- Since the crushing and grinding processes are taking up much (up to 90%) of electricity, consumed in cement production process, the main problem in this sphere is the adoption of energy-saving systems (choosing of energy-efficient electric motors, etc.);
- Transition from higher intensity technology equipment to the lower intensity technology and machinery (roller and gyratory crushers, roller press, 5-stage pre-heater, precalciner, short kiln, etc.), which provide more effective use of energy and less harmful impact on the environment.

The managing team of Rustavi cement enterprise has submitted to the National Agency on Climate Change an official document in which a list of measures is given proposed by the team for the improvement of environmental efficiency of the enterprise. It includes:

1. Installation of dust-catching filters of three rotating kilns (4x127-128m) (purchasing and installation) – US$ 8 million;
2. Installation of new type burners of the rotating kilns (3 pieces) – US$ 150 000;
3. Transition of rotating kilns from "wet" technology of production to the "dry" technology. The re-equipment is required and the cost to re-equip each kiln is about US$ 30-50 million. Three kilns are installed in the plant. – US$ 120 million;
4. Purchase of installation of four new turbo-compressors – US$ 250 000.

Thus, the total expense is approximately US$ 128,4 million.

According data cited in the Table 5.2.2.1. (book I of the report), from 3.7 to 7.2 GJ/t of energy is consumed on production of the main component of cement – clinker, out of which from 2.9 to 5.9 GJ/t is consumed on burning process that should take into consideration to assess CO_2 reduction potential while transferring from the wet to the dry method. It could be saved up to 35% of energy consumed on burning in the dry method as a result to avoid energy expenses on evaporation from wet silt [3]. That promotes to decrease energy expenses on clinker production by 27-29%.

If assume that least 25% of energy and corresponding CO_2 emission is reduced in the RMP through adoption of new technology, we get that according to the Table 7.2 in case of 95% of dust catching. CO_2 specific emission could be reduced from 0.86 t/t to 0.64 t/t. In terms of preserving of annual capacity of the plant at the existing level (by 99% of dust catching – 800 000 t) this specific saving (0.22 t/t) gives possibility to reduce 176 000 t of CO_2 emission per year. At the contemporary international market of emission trading, considering 1t saved CO_2 price (10$/t), it gives additional incomes in the range of US$ 1.76 million.

REFERENCES

1. Basin G. L., Bragin M. I., Basin V. G., Gavazova T. V. Resourse-saving Heating Techniques Abroad. Moscow, Energia, 1985 (in Russian).
2. Biomass-Fired Power Generation. IPCC, March 2001.
3. Butt U. M. Technology of Cement and Other Binding Materials. Stroyizdat, Moscow, 1976.
4. Coal Mining Tehnologies: Pre-mining degasification. IPCC, March 2001.
5. Coal Mining Technologies: Enhanced Gob Well Recovery. IPCC, March 2001.
6. "Dich-Wich"- Underground Construction Equipment. Charles Machine Works, Inc., Oclahoma, USA,2000.
7. Economopulos A. P. Metchodology of Accelerated Inventory of Environmental Pollution Sources, v.1. WHO, Geneva, 1993 (in Russian).
8. Emission Baselines. Cement Case Study. OECD/IEA, Paris, 2000.
9. Emission Baselines. Iron and Steel Case Study. OECD/IEA, Paris, 2000.
10. Environmental Data Collection and Processing in NIS Countries. Inventory Reporting Instructions, vol.3. OECD/TACIS, Kiev, 1999.
11. Eristavi E., Chomakhidze D., Tsintsadze P. Fudamentals of Energy Regulation, v.1. Georgian Proffessional Accounters and Auditors Federation Publishers, Tbilisi, 2000 (in Georgian).
12. Furfari S., Variali G. EU Coal-Fired Thermoelectric Power Plants. Boiler efficiency and environmental performances. DG XVII and University, Rome, 1999.
13. Gas from the Coal. "Thermo" Type Device for the Production of Gas from the Coal. Moscow, 1993.
    Gazprom approves financing for Metan Kuzbassa project. FSU Oil and Gas Monitor, 12 February, 2002.
14. Georgian Energy Market Support Project. Restoration of Transmission Grid, No. 33 318. Company "Fiechtner", Schtutgart, 1998 (in German and in Georgian)
15. Georgian Industry in 1985-1996. Georgiann State Dept. on Statistics. Tbilisi, 1997 (in Georgian)
16. Georgia`s Initial National Communication Under the United Nations Framework Convention on Climate Change. Nat. Clim. Res. Centre, Tbilisi, 1999.
18. Georgia`s Taxation Codex. Tbilisi, 2000 (in Georgian).
19. Greenhouse Gas Inventory Reporting Instructions, Revised 1996. IPCC Guidelines for National Greenhouse Gas Inventories. V.1, OECD, OCDE and IEA,1997.
20. Greenhouse Gas Inventory Workbook. IPCC Guidelines for National Greenhouse Gas Inventories. V.2, OECD, OCDE and IEA, 1997.
21. Greenhouse Gas Inventory Reference Manual. IPCC Guidelines for National Greenhouse Gas Inventories. V.3, OECD, OCDE and IEA, 1997.
22. Industrial Cogeneration. IPCC, March 2001.
23. Kipshidze M., Jamarjiashvili V. Assessment and Analysis of the Technical State of Tbilisi TES Equipment. Magazine "Energia", 1997, ½4 (in Georgian).
24. Management Information. Module 6. International version. Tbilisi, 1999 (in Russian).
25. Materials of International Conference on the Ecological Use of Coal in the Energy Sector. "Clean Coal, 2000". Praha, 1999.
26. Metan Kuzbassa project to begin in Kemerovo region next year. FSU Oil and Gas Monitor, 30 October, 2001.
27. National Inventory of GHG Emissions and Sinks. Energy Module. UNDP/GEF-Government of Georgia project GEO/96/G31. Nat. Clim. Res. Centre, Tbilisi, 1998 (in Georgian).
28. National Inventory Of GHG Emissions and Sinks. Industry Module. UNDP/GEF-Government of Georgia project GEO/96/G31. Nat. Clim. Res. Centre, Tbilisi, 1998 (in Georgian).
29. Oil and Natural Gas Technologies: Low-Emission Technologies and Practices, IPCC, March 2001.
30. Oil and Natural Gas Technologies: Improved Leak Detection and Pipeline Repair. IPCC, March 2001.
31. Per-Aarslef A/S Pipe Technologies, Insituf, RM, 2000.
32. Plan for the Optimal Development of Georgian Energy Sector. Burns and Row Enterprises INC., ICF Keizer, Tbilisi, 1998. (in Georgian)
33. Production Potential of Georgian Industry. Georgian Social and Economic Information Committee, Tbilisi, 1992 (in Georgian).
34. Provisional Assessment of Distribution Sector for the Privatization. Hagler Bailly Consulting, Inc. Tbilisi, 1997 (in Georgian).
35. Pulverised Coal-Fired Power Plant. IPCC, March 2001.
36. Reference Document on Best Available Techniques in the Cement and Lime Manufacturing Industries. IPCC, Europian Comission, Seville, 1999.
37. Regulations for Technical Operation of Electric Power Plants and Grids. Georgian

Ministry for Fuel and Energy / Georgian Energy Research Institute, Tbilisi, 1999 (in Georgian).
38. Social and Economic State of Georgia, 2000. Georgian State Dept. on Statistics, Tbilisi, 2001.
39. Stride to the Sustainable Energy. Practical Recommendations for Europe. Europian Comission, Brussels, 1998.
40. Tri Generation: Intergrated gas and steam generation. Gamos Ltd, ODA, 1997.
41. Tsintsadze I. Scientific Foundations for Gas Emission Projection and Technological Management in the Thick Coal Seams Processing (At the Example of Georgian Deposits). Tbilisi, 1997 (in Georgian).