TECHNOLOGY NEEDS ASSESSMENT

TO ADDRESS CLIMATE CHANGE

ENABLING THE ISLAMIC REPUBLIC OF IRAN TO PREPARE ITS FIRST NATIONAL COMMUNICATION TO UNFCCC (Top-Up Phase)

ISLAMIC REPUBLIC OF IRAN

DEPARTMENT OF THE ENVIRONMENT

NATIONAL CLIMATE CHANGE OFFICE

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Table of Contents

Introduction
Chapter I: Transportation, Industry, Power Generation, Commercial and Domestic Sectors
Chapter II: Oil, Gas and Petrochemical Industries
Chapter III: Water Sector
Chapter IV: Agricultural Sector

Introduction

The Islamic Republic of Iran has submitted its First National Communication (FNC) to UNFCCC in March 2003. The top-up or Phase II of the Enabling Activity was started following submission of FNC. The Technology Needs Assessment (TNA) to address climate change was part of the Phase II (Top-UP) of the Enabling Activity which was carried out in 2004. The TNA report was not communicated to the UNFCCC at the time that it was prepared because it was not mandated by the Conference of Parties (COP).

Although this report has been prepared based on the data and information that were available up to 2004, to the extent possible, it also reflects to some extent the current status because the technology diffusion to Iran for mitigation of and adaptation to climate change has been limited in recent years. In addition, a comparison has been made between the existing technologies that are used in Iran with the modern technologies that are available in the world. It is predicted that with the current trend of privatization of major industries in Iran, the demand for financial resources and technologies will increase sharply.

It should be noted that, as a part of Iran's Second National Communication (SNC) to UNFCCC, TNA will be undertaken and therefore an updated version of this report will be included in the SNC.

The population growth and young population of the country have increased the demand for energy which has resulted in sharp increase in greenhouse gas emissions. In electricity sector alone there has been an increase of about 10% annually and the consumption of transportation fuels has doubled in a decade. The demand for food for this young population has also increased the water demand for agriculture and other uses which has exerted intensive stress on water resources. In order to adapt to these new conditions and to achieve sustainable development, it is necessary to increase the efficiency in energy production and consumption which require new and advanced technologies. On the other hand, fluctuations in the price of oil have resulted in further constraints for investment in energy technologies. Furthermore, Iran has some limitations in acquiring the necessary cleaner technologies to produce and conserve energy.

The focus of this report is on TNA for mitigation especially for the energy sector, with less emphasis on TNA for adaptation, whereas the latter is extremely important for Iran since the country is highly vulnerable to the adverse impacts of climate change as well as to the impacts of response measures.

The Islamic Republic of Iran has cooperated and could enhance its cooperation in the context of sustainable development with the international community to address climate change provided that sound and safe technologies and new and additional financial resources become available.

CHAPTER I:

Transportation, Industry, Power Generation, Commercial and Domestic Sectors

Table of Contents

1. Data Acquisition and Analysis ... 1
1.1. Transportation ... 1
1.1.1.A review on data ... 1
1.1.2.A Review of Technologies of Iranian Car Manufacturing Industries ... 5
1.1.3.Environmental standards requirements ... 7
1.1.4.Transport and energy consumption relationship ... 9
1.1.5.Review of transport sector's infrastructure ... 11
1.2. Industry ... 14
1.2.1.Classification of industries on the basis of process and energy consumption: ... 14
1.2.2.Fuel consumption, energy intensity and energy efficiency in industries: ... 15
1.2.3.GHGs emissions from industries: ... 18
1.2.4.Investigation on appropriate methods for reduction of GHGs in industries: ... 22
1.2.5.Role of research and development in GHGs emissions of industries: ... 22
1.3. Power generation, Residential and Commercial sectors ... 23
1.3.1.Classification of power plants (based on energy consumption and process) ... 23
1.3.2.Data Collection on utilization, intensity and efficiency of energy in various power plants and in the domestic-commercial sector ... 23
1.3.3.Determining the potentials for energy efficiency improvement, change in design, replacement of materials and equipment, new processes, etc. to reduce GHGs emission in each type of power plants and in domestic appliances and buildings material ... 26
1.3.4.Cost of reducing CO2 emission by 1 ton in the domestic appliances of the country ... 37
1.3.5.Potential for energy saving in buildings sector ... 37
2. Technology Needs Assessment ... 39
2.1. Transportation ... 39
2.1.1.Development of new materials and reduction of weight of vehicle: ... 39
2.1.2.Aerodynamic development of vehicle's body: ... 39
2.1.3.Development of system and components of motors: ... 39
2.1.4.Fuel consumption of different substituting technologies ... 42
2.1.5.Advantages of fuel cell vehicles ... 43
2.1.6.Determination of criteria: ... 43
2.1.7.Determination of priority for each sub-sector of transport sector ... 44
2.1.8.Prioritization of technologies to combat the impacts of climate change ... 45
2.1.9.Investigation on constraints for technology transfer ... 46
2.2. Industry ... 47
2.2.1.Potential for GHGs emission reduction in Iran's industrial sector ... 47
2.2.2.Determination of criteria for prioritization of technologies for proper selection and transfer of technologies considering climate change objectives ... 48
2.2.3.Prioritization of technologies for industrial sector ... 49
2.2.4.Collection and compilation of information for substituting technologies ... 49
2.2.5.Technology prioritization considering the objectives of drastic changes ... 50
2.2.6.Barriers and obstacles for GHG emission reduction ... 50
2.2.7.Some actions for overcoming the obstacles of technology transfer ... 51
2.3. Power generation, Residential and Commercial ... 51
2.3.1.Programs and polices of technology transfer ... 51
2.3.2.The essential needs in technology transfer in power sector and in residential - commercial sectors of Iran 52
2.3.3.The essential needs in technology transfer in the residential - commercial sector ... 55
3. Technology transfer policy making for mitigation of GHGs ... 59
3.1. Transportation ... 59
3.1.1.Determining factors for planning of technology transfer in order to mitigate GHGs emissions in transport sector ... 59

3.2. Industry 63
3.2.2.Executive approaches for achieving GHGs emission reduction's objectives 64
3.2.3.Conclusions 66
3.3.Constraints and gaps in technology transfer in power generation, domestic and commercial sector 66
3.3.1.Main constraints and gaps of technology transfer 66
3.3.2.Review of the actions carried out by the public sector aimed at reducing GHGs emission 69
3.3.3.Comparison of proposals of section 3.3.2. with the country's Third Five-Year Development Plan 70

List of Figures

Figure 1.1: Energy trend in recent years 1
Figure 1.2: Share of energy consumption by different sub-sectors of transport system in 2000 2
Figure 1.3.: GHG emission of different sub-sectors of transport system IN 2002 3
Figure 1.4: Relationship between the number of vehicles and gasoline consumption in recent years 10
Figure 1.5 : Number of heavy-duty vehicles and energy consumption in Iran in recent years 11
Figure 1.6: Age distribution of vehicles in Iran 12
Figure 1.7.: Age distribution of heavy and semi -duty vehicles in Iran 12
Figure 1.8.: Age distribution of cargo vehicle in Iran 13
Figure 2.1: Comparison of substituting technologies and their fuel consumptions 43

List of Tables

Table 1.1: Energy consumed by transport sector in recent years (x1000lit) 1
Table 1.2.: Trend of energy consumption in transport sector 2
Table 1.3: Energy consumption in transport sector per type of fuel in 2002 2
Table 1.4.: Environmental pollution induced by sub-sectors of transport system in 2002 (ton) 3
Table 1.5.: Pollution of light – duty vehicles 4
Table 1.6.: Energy consumption by light-duty vehicles in transport system 4
Table 1.7: Energy consumption of transport sector in 2001 5
Table 1.8: Environmental pollution of marine transport 5
Table 1.9. Energy consumption of different vehicles produced in the country 6
Table 1.10: Targeted environmental standards for some Iran-made vehicle 6
Table 1.11.: Schedule of ICMC's for achieving the environmental standards 8
Table 1.12.: Comparison environmental standards between Iran and Singapore 9
Table 1.13.: Data on light-duty vehicles in three recent years 9
Table 1.14.: Gas and petrol consumption by transport sector (x1000lit) 9
Table 1.15 Data on heavy-duty vehicles in three recent years 10
Table 1.16.: Energy consumption by heavy-duty vehicles (x1000lit) 10
Table 1.17.: GHG's emission from the transport sector 10
Table 1.18.: number of light-duty vehicles and taxi 11
Table 1.19.: Age distribution of cargo vehicles in Iran 13
Table1.20: Data for large industries workshops in Iran 14
Table 1.21: The fuel consumption in industries in 1994 15
Table 1.22: Fuel consumption in industries in Iran 16
Table 1.23: The amount of energy consumed per unit of produced goods 17
Table 1.24: Comparison of energy efficiency between Iran and world 18
Table 1.25: The amount of GHGs emission related to consumed natural gas in 2000 (ton/yr) 19
Table 1.26: The amount of GHGs emission related to consumed petrol in 2000 (ton/yr) 19
Table 1.27: The amount of GHGs emission related to consumed kerosene in 2000 (ton/yr) 20
Table 1.28: The amount of GHGs emission related to consumed gas oil in 2000 (ton/yr) 20
Table 1.29: The amount of GHGs emission related to consumed naphtha in 2000 (ton/yr) 21
Table 1.32: The value of savings potentials in six industrial categories in 2000 22
Table 1.33.: The amount of fuel consumption by the power plants under the control of MOE 23
Table 1.34.: The amount of fuel consumption by the large industries 23
Table 1.35: Internal utilization and the country's power networks between 1967 and 2001 24
Table1.36: Gross generated electric energy of MOE between 1967-2001 (Million kWh) 24

Table 1.37: Consumption of energy carriers in the country's domestic-commercial sectors (2001).........25
Table 1.38: Share of electricity consumption in various sectors in 1996-2001 (%) 26
Table 1.39: Cost of turbine efficiency improvement (for one unit) in 1999 in power stations (US$).......27
Table 1.40: The number of units and the amount of consumed fuel for the types of power plants in 1999 27
Table 1.41: Cost of optimizing energy consumption and the amount of fuel saving in the power plants of the country 27
Table 1.42: The amount of reduction in CO2 emission from the energy saving in the country's power plants in 1999 (ton)...28
Table 1.43: Price of energy carriers in the world markets in year 1999 and possible saving amount in the country's power plants 28
Table 1.44: The amount of capital investment and income resulting from 3% saving in energy for the three types of power plants in the country...29
Table 1.45: The capital return year and the cost of eliminating each ton of CO2 for different types of the country's power plants in 1999 29
Table 1.46: Classification of the methods for reduction of the low-tension network 30
Table 1.47: Capacity and total value of the capacity releasable through substituting filament bulbs in the country...31
Table 1.48: Cost of replacement and the value of the unconsumed energy in the country in 2000...........31
Table 1.49: Potential for reducing emission of CO2, NOx and SO2 as a result of using low energy consumption light bulbs in the country in year 2000...31
Table 1.50: Potential for reducing the social-economical costs as a result of using low energy consumption light bulbs in the country in year 2000...32
Table 1.51: Prediction of saving in energy consumption through employing energy labels for fridge and freezers (1998 –2004)...32
Table 1.52: Prediction of percentage share of different power plants in the country till year 2004 32
Table 1.53: Potential for reduction of CO2 emission by implementing energy labeling in fridges and freezers used in the country for the period 2000 - 2004)..33
Table 1.54: Prediction of average electricity sale price in domestic sector during the country's Third National Socio-economic Five-Year Development Plan 33
Table 1.55: Potentials for energy saving in fridges and freezers in Iran (2000 - 2004)........................... 33
Table 1.56.: Prediction of potential for saving in energy consumption resulting from use of energy labeling standard in washing machines in the country (2000-2004) 34
Table 1.57: Prediction of potential for reduction of CO2 emission resulting from use of energy label in washing machines used in the country (2000-2004)..34
Table 1.58: Potential for financial saving as a result of energy labels in fridges and freezers in Iran (2000-2004)...34
Table 1.59: Prediction of energy saving resulting from use of energy labels standard in the country's air-conditioners (2000-2004) 34
Table 1.60: Prediction of potential for reduction of CO2 emission resulting from use of energy labels standard in the country's air-conditioners (2000-2004)...35
Table 1.61: Prediction of potential for financial saving resulting from energy saving in the country's air-conditioners (2000-2004) 35
Table 1.62: Prediction of potential for technical energy saving resulting from using energy label standard in domestic pumps, compressors, samovars and irons in the country (2000-2004) 35
Table 1.63: Prediction of potential for reduction of CO2 emission resulting from using energy label standard in domestic pumps, compressors, samovars and irons in the country (2000-2004) 36
Table 1.64: Prediction of potential for financial saving resulting from using energy label standard) in pumps, compressors, samovars and irons (2000-2004) 36
Table 1.65: Total potential for reduction of CO2 emission and possibility for financial saving in some domestic appliances in the country (2000-2004) 36
Table 1.66: Cost of reduction of CO2 emission in domestic sector resulting from the use of energy label standard (2000)...37
Table 1.67 Classification of buildings from the point of view of need for energy saving in the country..37
Table 1.68: Prioritizing various divisions of the country's energy sectors for implementing energy saving techniques...38

Table 2.1: Organization and technologies for improvement of efficiency in transport sector 40
Table 2.2: Constraints of technology transfer 46
Table 2.3: Fundamental obstacles and policies needed in technology transfer in Iran's power sector 55
Table 3.1: Existing constraints and gaps in all aspects versus technology transfer in the country 67
Table 3.2: Predicting of CO2 emission by use of MGCP model for Iran 72

1. Data Acquisition and Analysis

1.1. Transportation

1.1.1. A review on data

The energy consumption in transportation sector has increased by over 30% in the past 6 years which is due to heavy investment and sharp increase in developing heavy and light-duty vehicles in order to remove the obsolete fleet from the roads. In this regard, some sub-sectors were developed to different extents. About 97% of the total energy is consumed in transport sector used by light, semi-heavy and heavy-duty vehicles with significant environmental pollution. Table 1.1 and Figure 1.1 show the energy consumed in different sub-sectors of transport sector during recent years.
Contribution of air transport is negligible with no significant effect on general trend of energy consumption in the country.

Table 1.1: Energy consumed by transport sector in recent years (x1000lit) [MOE 2002 & IFCO 2003]

Year	1996	1997	1998	1999	2000
Light-duty vehicles	11717955	12228371	13615760	14232436	15596733
Heavy-duty vehicles and Rail Road	12033862	12076426	11774715	12422808	13297063
Marine Transport	315733	502969	829665	1021801	947609
Total	24069546	24809763	26222138	27679044	29843405

Note that, as Liquefied Petroleum Gas (LPG) is used mostly by light duty vehicles such as taxis, a smaller portion of LPG is used by heavy-duty vehicles, although no exact data are available in this regard. Figure 1.2 shows the share of different sub-sectors of transport system in energy consumption.

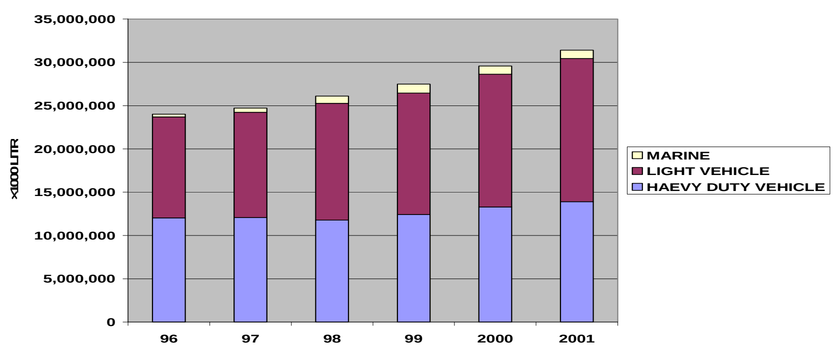

Figure 1.1: Energy trend in recent years [Ref: generated from data of Energy Balance 2000 & IFCO]

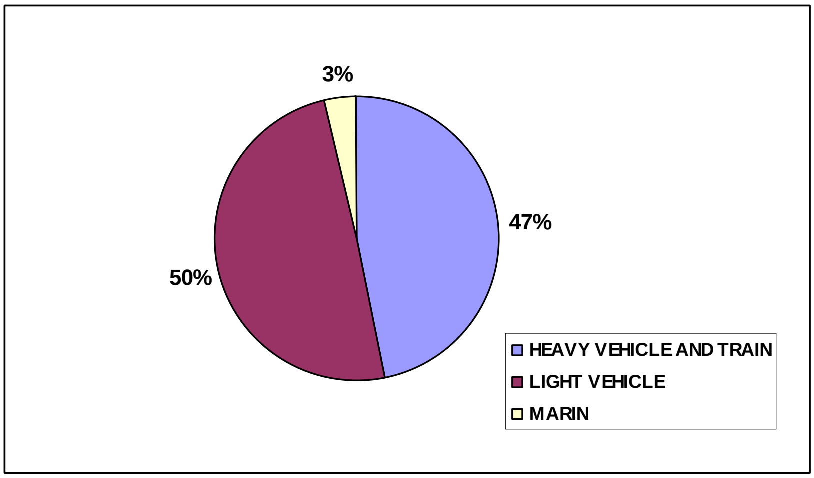

Figure 1.2: Share of energy consumption by different sub-sectors of transport system in 2000 [MOE 2002 & IFCO 2003]

Table 1.2 shows the increasing trend in energy consumption in transport sector. It reveals that the energy consumption has an increasing trend up to 1998 but it shows that a declining trend has begun since 2001. Table 1.3 shows the energy consumed in transport sector in terms of the fuel type.

Table 1.2.: Trend of energy consumption in transport sector [MOE 2002]

Year	1996	1997	1998	1999	2000
Growth Rate (%)	-	3	5.6	5.5	7.2

Table1.3: Energy consumption in transport sector per type of fuel in 2002 [MOE2004]

Year	Gas Oil	Petrol	Naphtha	Gas	Total
Diesel vehicles	13675060	0	0	0	13675060
Light-duty vehicles	0	16540862	0	298205	16839067
Marine transport	260661	18275	682524	0	961460
Rail transport	216962	0	0	0	216962

Table1.3 shows that light-duty vehicles have the contribution of 53% to fuel consumption, whereas heavy duty diesel vehicles, semi-heavy-duty vehicles, marine transport and railway transport have the share of 43%, 3% and 1% of the total energy consumed, respectively. In this regard and on the basis of studies that have been carried out by MOE, through consumption of 31692549 (10^3 liter) of energy by transport sector, about 79327575 tons of GHG's have been emitted (Fig 1.3). Also, Table 1.4 shows environmental pollution induced by transport sector in the country in 2002.

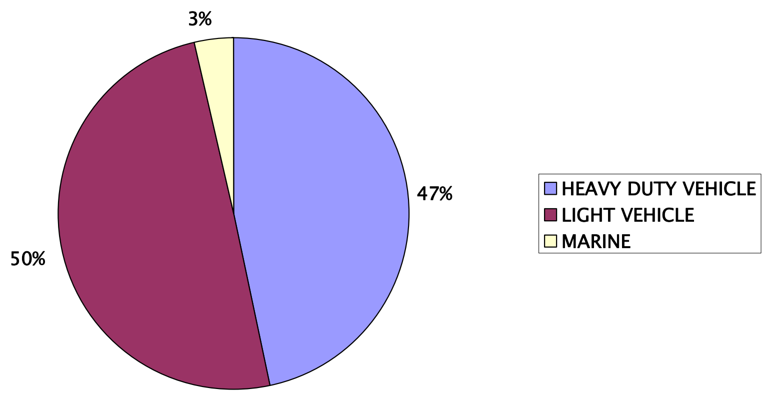

Figure 1.3.: GHG emission of different sub-sectors of transport system IN 2002 [MOE 2004]

Table 1.4.: Environmental pollution induced by sub-sectors of transport system in 2002 (ton) [MOE 2004]

Year	NOx	SO2	CO2	SO3	CO	CH	SPM	GHG
Diesel vehicles	375085	233386	36786074	2778	100023	305625	183375	37091699
Light-duty vehicles	223301	24811	38424422	0	5789302	1042074	21503	39466496
Marine transport	14110	36441	2765239	541	8276	7159	4147	2772398
Total	612496	294638	77975735	3319	5897601	1354858	209025	79327575

It can be seen from Table 1.4 that over 79 million tons of environmental pollutions are emitted by energy consumption in transport sector and the contribution of light-duty, heavy-duty vehicles and railway and marine transport are 50%, 47% and 3%, respectively. Heavy-duty vehicle, with a share of 11% of the whole fleet, has the second rank in emission of GHGs.

1.1.1.1. Light-duty vehicles

The major contributions of GHG emissions are due to light-duty vehicles which are used for different personal and administrative purposes. Most of the light-duty vehicles consume petrol and are made in the country. These vehicles include personal light-duty vehicles, taxis and vans which consume significant part of energy and emit significant amounts of pollutants and GHGs. Unfortunately, because of weakness of information system in the country and lack of exact information and of recognition of fate of vehicles in transport system, there is no exact data and statistics available. In this regard, the data of existing vehicles, the domestically produced cars and the imported vehicles should be accounted for, although the exported vehicles are not significant.

These vehicles consume petrol and only minor percent of the fleet use natural gas. It should be mentioned that natural gas is recently being presented in fleet's fuel consumption by the Government. Only a minor contribution of light-duty vehicles consumes LPG which is estimated to be approximately 1500 vehicles. Liquefied Natural Gas (LNG) has recently been considered due to economic justification and level of environmental pollutions of this fuel. It could not find the required priority, so application of this fuel has been stagnated. At present, the national policy has been directed into development of compressed natural gas (CNG) vehicles, although exact statistics in this regard is not available. Tables 1.5 and 1.6 show petrol consumption and pollution emissions including GHGs induced by energy consumption by light duty vehicles, respectively.

Table 1.5.: Pollution of light – duty vehicles [MOE 2004]

Year	NOx	SO2	CO2	SO3	CO	CH	SPM	GHG
Light-duty vehicles	222301	24811	38424422	0	5789302	1042074	21503	39466496

Table 1.6.: Energy consumption by light-duty vehicles in transport system [IFCO 2003]

Item	Petrol (10^3 lit)	Gas (ton)	Total
Energy Consumption	16540862	298205	16839067
Share of total consumption (%)	52	1	53

In 2002, the daily mean consumption of petrol in transport system was 45.8 million liter and the gas consumed (mainly by taxi), was 298205 tons, which indicates the small share (only one percent) of CNG consumed in transport sector. GHG's (39466496 tons) emitted by light-duty vehicles are equal to 49.7% of whole GHG's emission in transport section.

1.1.1.2. Heavy and semi-heavy-duty vehicles

This sub-sector of transportation includes minibus, bus, mini truck and truck which consume gas oil. The country needs to develop this sub-sector in order to compensate the lack of development of railway and air transportation services for passenger and cargo.

Active vehicles in this sub-sector for translocation of passenger and cargo might be divided into intra- and inter-city. There is no data on intra-city kind of these vehicles. In this regard, inter-city kind of diesel vehicles has a clearer picture than the intra-city ones. The National Terminals Organization supervises the inter-city fleet and the required data and information of these kinds of vehicles are easily accessible. The intra-city diesel vehicles are mainly under supervision of the municipalities or are privately owned for which data are not easily accessible. Data on gas oil consumption of road transport (including heavy, semi-heavy, bus and minibus are accessible but are not classified based on the fuel type.

1.1.1.3. Rail Road Transport

Rail transport does not have significant role in Iran's transportation system. The length of railroad was about 7156 Km in 2001 with 7% growth rate compared to 2000. The railroad system has contributed to transportation of about 13111000 passengers and 26392000 tons of cargo. The total net cargo-distance was 14,613 million tons-km. Electric locomotives have not been developed to significant extent and of the total of 34,550 million tons-km, only 18.9 million tons of gross cargo have been transported by them. The energy consumption of this sub-sector was 216,963 (x1000lit) in 2001, which is about 1% of the total energy consumption in the energy sector. This figure shows 1.29% growth rate in comparison with the previous year. Environmental pollution induced by the sub-sector is integrated with road transport. [Ref: Islamic Republic of Iran Railways]

1.1.1.4. Marine transports

Iran's marine transport activities might be summarized by two main sub-sectors. These are cargo and petrochemical products. The Caspian Sea, in the north between Iran and the Persian Gulf and the Sea of Oman Sea might be considered as the most important waterways for marine transport. The required fuel of the sub-sector is naphtha with 961,460 (10^liter) consumption (Ref: Energy Balance 2001), contributing to about 3% of the total energy consumed by transport system in 2001. Table 1.7 shows the energy consumed by transport sector in 2001.

Table1.7: Energy consumption of transport sector in 2001 [MOE 2003]

Item	Petrol	Gas Oil	Naphtha	Total
Energy Consumption	18275	260661	682524	961460

Based on data [Ref: MOE], the GHG's emission from the sub-sector is about 2,772,348 tons and about 3.5% of the total GHG's emitted by transport sector. Table 1.8 shows the environmental pollution induced by marine transport in Iran.

Table 1.8: Environmental pollution of marine transport [MOE 2004]

Pollutant	NOx	SO2	CO2	SO3	CO	CH	SPM	GHGs
Marine transport	14110	36441	2765239	541	8276	7159	4147	2772398

1.1.2. A Review of Technologies of Iranian Car Manufacturing Industries

1.1.2.1. Fuel technology and its improvement

The most important action taken by the government was the removal of lead from gasoline; starting with Tehran and then extending to the whole country.

1.1.2.2. Efficiency of fuel conversion in vehicles

Light-duty vehicles consume large amounts of fuel due to out-dated technology, high vehicle age and the lack of proper maintenance. Table 1.9 shows the fuel consumption of different vehicles models produced in Iran.

Table1.9. Energy consumption of different vehicles produced in the country [MIM 2003]

No	Type of vehicle	Engine volume (cc)	Consumption in urban areas (lit/100 km)	Consumption at speed of 90 km/h (lit/100 km)	Ratio of the fuel consumption in urban areas to engine volume
1	Peykan	1598	14.5	8.3	9.07
2	Sepand 2	1108	12	9	10.83
3	Peugeot RD	1598	14.4	8.1	9.01
4	Peugeot Pars	1761	5.5	7.5	6.7
5	Sinad	1598	5.1	5.1	5.19
6	Peugeot 206	1360	9.6	5.6	5.6
7	Citroen	1998	12.9	6.9	6.45
8	Pride	1323	9.6	5.95	7.25
9	Pride (injector-equipped)	1323	8.95	5.6	6.76
10	Peugeot 405	1905	9.7	7.5	5.09

From Table 9 it can be seen that Peykan (with 14.5 liter/100 km fuel consumption) constitutes 53% of vehicle fleet in Iran.

1.1.2.3. Environmental pollutions of Iran-made vehicles

In the past years, there was no legal obligation to meet environmental pollution standards for Iranian car manufacturing companies (ICMC’s) and their products penetrated into national fleet without any environmental considerations. Recently ECE-1504 was the first environmental standard that most ICMC's products should meet. Since some European brands of cars are assembled in Iran, a stricter standard R83 has been designated by the Department of the Environment for the ICMC. Table 1.10 shows the environmental standards for some Iran-made vehicles.

Table 1.10: Targeted environmental standards for some Iran-made vehicle [ARES 2003]

Item	Type of vehicle	The targeted environmental standards
1	Peykan	ECE-1504
2	Pride	R83-01
3	Peugeot	R83-03
4	Samand	R83-01

1.1.2.4. The required technology for fuel consumption reduction

- ***Light-duty vehicles***

- ***Motor efficiency improvement***

- The main objective might be summarized as follows:
- Increase of power per fuel unit consumed due to combustion system improvement
- Increase of number of valves
- Application of electronically control methods of motor

- ***Weight Reductions***

Application of light and resistant materials instead of heavy ones has being performed.

- ***Appearances***

Appearances of vehicles influences on fuel consumption due to resistance to air. Aerodynamic appearances and angle removal could decrease fuel consumption up to 5% at high speed.

- ***Power transmission system improvements***

Optimization of proportion and number of gears in power transmission system could reduce fuel consumption through control on energy loss and utilization of the best round in motor of vehicles.

- ***Heavy-duty vehicles***

Most approaches have been described before are also applicable to heavy-duty vehicles which have been implemented for heavy-duty vehicles in the past years. Now manufacturer are to introduce new and modern techniques like super charger and inter cooling cylinder- inflow air, optimization of the system would be increased and in turn, fuel consumption might be reduced.

1.1.3. Environmental standards requirements

In this section the environmental standards that should be met by Iran Car Manufacturing Companies (ICMC) are described and compared with some developing countries.

1.1.3.1. Environmental standards of vehicle manufacturer

The required standards might be considered in two separate parts: light and heavy-duty vehicles as described below.

- ***Light-duty vehicles***

Considering the increasing environmental pollution of the cities in the country, the car manufacturers are committed to meet environmental standards (ECE-1504) which has been decided based on some studies that have been carried out on driving pattern and driving cycle.

At present, the majority of ICMCs has committed themselves with the standards. The following standards have been designated for emission of light-duty vehicles:

- Pollution standard for Iran-made petrol consuming cars is R83-00 or ECE-83-01. Based on their classification, ICMCs are bound to install fuel injector and catalytic converter in their products.

- Pollution standards for petrol-consuming injector–equipped cars are ECE-R83-01 or ECE-R83-03. On the basis of classification of ECE-R83-01, ICMCs are bound to obtain environmental compatibilities certificate of their products up to 2003.

- All new cars that are produced in the country or imported, should meet ECE-R83-03.

- All cars before obtaining the above-mentioned standards should meet the requirements of ECE-1504.

- From early 2005, the minimum allowable standard of vehicle is ECE-R83-03.

- All vehicles that are produced from early 2002, should meet ECE-R83-03.

- All imported vehicles should meet ECE-R83-03.

Table 1.11 shows the required regulations for different vehicles that are produced in Iran.

Table1.11: Schedule of ICMC's for achieving the environmental standards [ARES 2003]

<table>
<tr><th>No.</th><th></th><th>Vehicle</th><th>Company</th><th>Standard Certificate to August 2002</th><th>Standard Certificate to March 2003</th><th>Standard Certificate to late 2002</th></tr>
<tr><td>1</td><td>A</td><td>Pride</td><td>SAIPA</td><td rowspan="3">R83-00
or
R83-01</td><td rowspan="3">R83-00
or
R83-01</td><td rowspan="3"></td></tr>
<tr><td>1</td><td>A</td><td>Sepand, Sepand PK</td><td>PARS KHODRO</td></tr>
<tr><td>1</td><td>A</td><td>Peykan and Peugeot RD</td><td>IRAN KHODRO</td></tr>
<tr><td>1</td><td>B</td><td>Mazda</td><td>Bahman Group</td><td rowspan="3">R83-01</td><td rowspan="3">R83-01</td><td rowspan="3"></td></tr>
<tr><td>1</td><td>B</td><td>Sahra Jeep</td><td>Pars Khodro</td></tr>
<tr><td>1</td><td>B</td><td>Alvand-Sahand</td><td>Fath</td></tr>
<tr><td>2</td><td>A</td><td>Peugeot Pars-Samand</td><td>Iran Khodro</td><td>R83-01</td><td>R83-01</td><td>R83-03</td></tr>
<tr><td>2</td><td>A</td><td>Daewoo Matiz and Cielo</td><td>Kerman Motor</td><td rowspan="8">R83-03</td><td rowspan="8">R83-03</td><td rowspan="8"></td></tr>
<tr><td>2</td><td>A</td><td>Peugeot 206</td><td>Iran Khodro</td></tr>
<tr><td>2</td><td>B</td><td>Mazda323</td><td>Bahman Group</td></tr>
<tr><td>2</td><td>B</td><td>Sinad</td><td>Kish Khodro</td></tr>
<tr><td>2</td><td>B</td><td>Citroen</td><td>SAIPA</td></tr>
<tr><td>2</td><td>B</td><td>Nissan Maxima and Pickup</td><td>Pars Khodro</td></tr>
<tr><td>2</td><td>B</td><td>Ana</td><td>Renos</td></tr>
</table>

- ***Heavy-duty vehicles***

At present, heavy-duty vehicle manufacturing companies are bound to meet EURO1. The EURO2 standard has been proposed in near future. There is no environmental standard for heavy and semi-heavy-duty vehicle fleet.

1.1.3.2. Comparison of environmental standards with some developing countries

Table 1.12 shows comparison between Singapore and Iran from the standpoint of vehicle type, type of regulation and date of applicability, which were about 2001 for Iran

Table 1.12.: Comparison environmental standards between Iran and Singapore

Type of vehicle	ECE regulation	Date of applicability
Passenger Cars	93/59/EEC	July 1995
Light Duty Vehicles	93/59/EEC	October 1993
Heavy Duty Vehicles	91/542/EEC	November

The comparison reveals that acceptance and implementation of environmental standards for vehicles in Iran are far behind Singapore. Note that for motorcycles, at present there are no environmental standards.

1.1.4. Transport and energy consumption relationship

As energy consumption has recently been increased. Outdated vehicle fleet in transport sub-sectors and lack of integrated management are the main reasons for high-energy intensity in this sector. Figure 1.4 shows the relation between the number of vehicles and energy consumption in recent years.

1.1.4.1. Light-duty vehicles

The number of light-duty vehicle in fleet has increased significantly in recent years and it is estimated to increase further in the future. In spite of the Act on ban for importing the passenger cars, light-duty vehicles have quadrupled during the past 10 years. Table 1.13 shows the data of light-duty vehicles during recent years. Table 1.14 shows fuel consumption in this sector

Table 1.13.: Data on light-duty vehicles in recent years [MIM 2003]

Year	1996	1997	1998	1999	2000	2001
Light-duty vehicles	2,909,464	3,076,428	3,274,858	3,505,922	3,793,376	4,163,976

Table 1.14.: Gas and petrol consumption by transport sector (x1000lit) [MIM 2003]

Year	1996	1997	1998	1999	2000	2001
Energy consumption	11717955	12228371	13615760	14232436	15596733	18839067

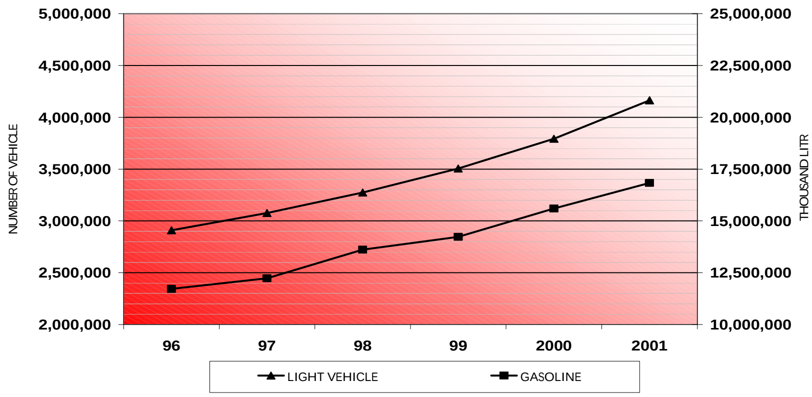

Figure 1.4: Relationship between the number of vehicles and gasoline consumption in recent years [MIM 2003]

1.1.4.2. Heavy and semi-heavy duty vehicles and rail transport

Review of production and import of heavy and semi-vehicles reveals that the numbers of these kinds of vehicles have not experienced significant growth in national fleet. This sub-sector consumed about 13,675,060 (10^liter) of gas oil in 2001 with more than 43% of energy consumption by transport sector. Energy consumption of rail transport is estimated to reach 216,962,000 liters which accounts for less than 1% of energy consumption in transport sector. This sector does not seem to have any significant increase in energy consumption in the future. Table 1.15 shows the number of heavy and semi-heavy-duty vehicles in recent years.

Table 1.15 Number of heavy-duty vehicles in three recent years [MIM 2003]

Year	1996	1997	1998	1999	2000	2001
Heavy-duty vehicles	475,447	482,554	490,822	499,908	509,724	518,858

The data of Table 1.15 show that this sector has not experienced significant changes: the number of production and import of the sub-sector is about 10,000 vehicles annually. High age of these vehicles and the low technologies are of the main reasons for high-energy consumption in the sub-sector. Energy consumption and GHGs emissions from this sub-sector are shown in Tables 1.16 and 1.17, respectively.

Table 1.16.: Energy consumption by heavy-duty vehicles (x1000lit) [MIM 2003]

Year	1996	1997	1998	1999	2000	2001
Energy consumption	12,033,862	12,0767,642	11,774,715	12,422,808	13,297,063	13,892,022

Table 1.17.: GHG's emission from the transport sector [MOE 2003]

Year	1996	1997	1998	1999	2000	2001
GHGs	59,956,207	612,25,000	63,639,136	66,658,550	72,081,674	76,558,195

It is necessary to be noted that heavy and semi-heavy-duty vehicles are about 11% of the total active vehicles in transport sector of the country.
Figure 1.5 depicts the number of heavy-duty vehicles and energy consumption in transport sector.

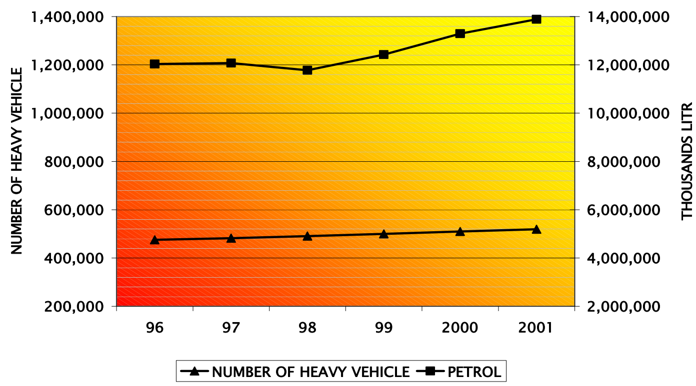

Figure 1.5: Number of heavy-duty vehicles and energy consumption in Iran in recent years [MIM 2003]

1.1.5. Review of transport sector's infrastructure

1.1.5.1. Urban and road transport

- **Urban Transports**

Import of vehicle that has been stagnated after Islamic Revolution in 1979, was de-regulated in 1999 resulting in import of 56,601 cars which is about 48% of the total vehicles entering into fleet annually in that year. Import of cars has again reached to null due to legal limitations in 2001. It is estimated that the number of light-duty vehicles was around 4,163,978 in March 2001, which considering the 65 million population in that year, it is not very a significant figure. It should be noted that in this statistic the vehicles registered before 1968 were excluded. Table 1.18 shows the number of light-duty vehicles and taxis in recent years.Table 1.18.: number of light-duty vehicles and taxi [MIM 2003]

Year	1992	1993	1994	1995	1996
Number of vehicles	2564611	2632796	2699880	2788519	2909464
Year	1997	1998	1999	2000	2001
Number of vehicles	3076428	3274858	3505922	3793376	4163978

At present, the mean age of vehicle fleet is about 14.5 years old in the country as shown in Figure 1.6. In this Figure, 2000, 1999, 9998, 1997 … is equal to 1, 2, 3, 4 years old.

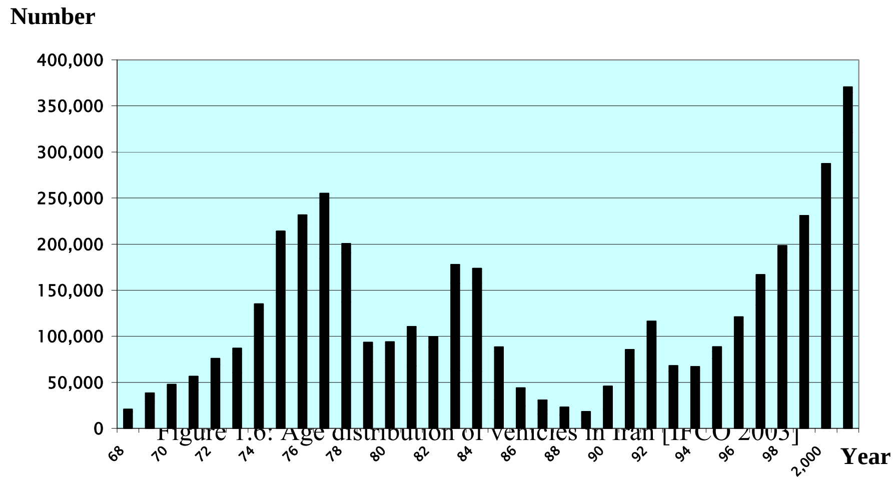

Figure 1.6: Age distribution of vehicles in Iran [IFCO 2003]

Tehran which is the capital city and the center for socio-economic activities of the country contains more than half of the vehicles in Iran. At present (2002), the numbers of modern vehicles are very low and Peykan, the domestic made old model car with high fuel consumption, has a significant contribution to the fleet. Share of injector-equipped car is about 2% of the national fleet. Public transport is very inconvenient and people prefer to use their own car instead of public transport. Among cities, only Tehran has underground which has not been properly developed.

- ## Road transport

Road transport includes two main sectors in the country i.e. cargo and passenger transport. The number of heavy, semi-heavy vehicles including buses and mini buses is about 518,000 which will be described below separately. Figure 1.7 shows age distribution of heavy and semi-heavy-duty vehicles in Iran.

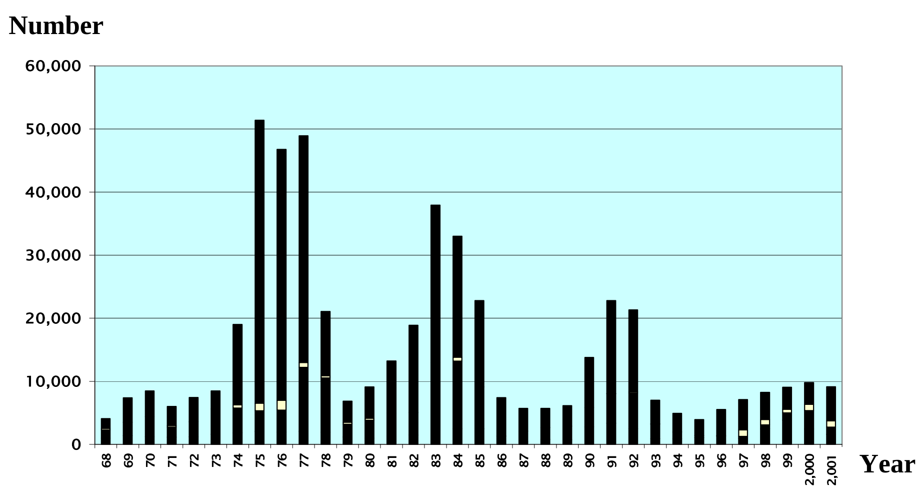

Figure 1.7.: Age distribution of heavy and semi -duty vehicles in Iran [IFCO 2003]

- **Cargo vehicles**

There are about 196,000 cargo vehicles in the national fleet. In 2002, the total amount of transported cargo was 78,702 million-ton-km. The mean age of vehicles of the sub-sector is about 21 years old which is shown in Table 1.20 and Figure 1.8.

Table 1.19.: Age distribution of cargo vehicles in Iran [IFCO 2003]

Less than 6 years	6 to 10	11 to 15	16 to 20	21 to 25	More than 26	Total
13,338	21,052	12,178	46,291	40,100	633,229	196,188
6%	10%	6%	23%	20%	35%	100%

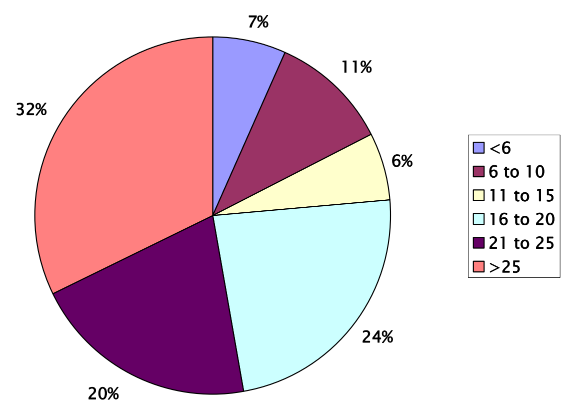

Figure 1.8.: Age distribution of cargo vehicle in Iran [IFCO 2003].

- **Passenger vehicles**

The number of buses and mini buses are estimated at 56,400 and 116,000, respectively. Mean age of passenger vehicles is 17 years old.

- **Rail transport**

The first railway of the country 148 km long has been constructed in 1920. In 2003 the railway length has reached to 7156 km. The mean number of cargo wagons of this fleet is 13,363 with 20 years old as their mean age. The number of passenger wagons is about 813 with an average age of 22. Which are run by about 193 Diesel locomotives with an average age of 22. Majority of these locomotives had been purchased from General Motors. In 2001 approximately 1,311,000 passengers have been transported by this sub-sector which is equivalent to 8,043 million-passengers-km. About 26,393,000 tons of cargo equivalent to 14,613 million tons-km have been transported by rail transport. Overall, the age of the equipments is high, technologies of the sub-sector are outdated and electrical locomotives are not developed.

1.2. Industry

1.2.1. Classification of industries on the basis of process and energy consumption:

Iran Statistical Centre (ISC) has taken census of large industrial workshops (from 10 workers or more) since 1972 for which the statistics is available, except for 1977 and 1978. Those industries under supervision of the Ministry of Industries and Mines (MIM) which have been classified according to the third version of the International Standards of Industrial classification -ISIC- (the third version- United Nations publication) are summarized in Table 1.20.

Table1.20: Data for large industries industrial units in Iran [Statistic Yearbook, 2001]

Activities	**Total**	**Total of workshop**		
		10-49 persons	**50-99 persons**	**100 persons and more**
Food & Beverage Industry	1954	1525	197	232
Tobacco& Cigarette Industry	1	0	0	1
Textile Industry	1543	1136	158	249
Clothing & Fire Processing Industry	132	111	13	8
Tanning, Leather Processing and Shoes	190	146	14	30
Wood &Wooden Goods	133	107	7	19
Paper Industry	180	127	28	25
Press, Printing of the Recorded Media	182	148	16	18
Cock, Oil Refining, Nuclear Fuel	60	39	7	14
Chemical industry	658	445	87	126
Plastic Industry	548	422	69	57
Basic Metal industry	322	205	40	77
Machinery& non-classified equipments	851	595	106	150
Business Machines	36	27	6	3
Power Generator& power transmitter and other non-classified electrical devices	326	185	64	77
Radio and T.V. and Mass Media	59	31	7	21
Medicine Instruments	117	70	25	22
Motored Vehicles	293	153	59	81
Other transportation Equipments	88	49	15	24
Furniture and other non-classified goods	226	180	27	9

Tanle1.20 Cont.

1.2.2. Fuel consumption, energy intensity and energy efficiency in industries:

Considering the importance of energy and its increasing demands in industries, recognition of energy structure in industry sector, planning for supply, consumption and energy efficiency are of high significance so that improving energy consumption in industries would result in decline of price of goods and air pollution.

1.2.2.1. Energy consumption in industries:

In order to optimize the fuel consumption for energy management, it is necessary to collect and process the relevant data on fuel consumption. Table 1.21 shows the fuel consumption in nine industrial categories during 1994 and Table 1.22 shows the fuel consumption in industries during 1996 to 2001 and their contribution to the fuel consumption in the country. The data of these tables reveal that through optimization of fuel consumption, significant economic and environmental effects might be expected.

Table 1.21: The fuel consumption in industries in 1994 [IOT 1994]

Type of Industry	Fuel Consumption							Electricity (1000 Kwh)	Water (1000 cubic meter)
	Kerosene (1000lit)	Gas oil (1000lit)	Natural Gas (1000 cubic meter)	Liquid Gas (Ton)	Petrol (1000lit)	Naphtha (1000lit)	Coal, Charcoal (ton)		
Food, Beverage and Smoking	6359	258075	263846	13872	29140	531590	25399	971083	40319
Textile, Clothing and Leather	21214	186646	148209	4645	21949	144558	7	1294590	32386
Wood and Wooden Products	1289	25290	5094	387	3026	24031	4	76783	2821
Paper, Broad Paper, Press and Publication	1143	31275	122221	4393	5796	71227	0	275127	8057
Chemical, Oil and Coal	47156	195883	2011334	5277	35417	147371	150	1038805	233866
Mineral and Non-metallic Products except Oil and Coal	25673	433688	1307193	36489	41513	2430434	236	2620064	31598
Basic Metallic Production	8789	233500	2132059	13317	22815	203637	13	6472691	65593
Machineries, Equipments and Instruments	8246	466178	187398	9827	35376	33909	47	1462187	30081
Miscellaneous	1319	24080	47092	3835	2796	7619	1715	60154	18954
Total	121188	1854615	6224446	92042	197828	3594376	27571	14271484	463675

Table 1.21. Cont.

Table 1.22: Fuel consumption in industries in Iran [MOE 2003]

Year	**Gas oil (1000lit)**	**Gasoline (1000lit)**	**Naphtha (1000lit)**	**Natural Gas (1000 cubic meter)**	**Kerosene (1000lit)**
1996	2118327	51809	5203040	9287	-----
1997	3152920	44830	5672645	9300	-----
1998	2163150	51573	6144679	9365	76200
1999	2060883	41875	5838700	9933	41300
2000	2195028	52706	5784214	11761	38700
2001	2303028	51488	6156828	-----	-----

1.2.2.2. Energy intensity and industries:

Although energy consumption per capita and energy intensity are indicators of the level of social welfare in developed countries, due to illegal traffic of fuels to neighbouring countries, high level of fuels losses in supply and demand side, it is very difficult to relate the level of energy consumption to the social welfare and improvement of daily life of people in Iran. Energy intensity that can be calculated in term of primary energy supply or final energy consumption is normally very high. This is because energy-intensive industries overshadow the structure of industries in the country. At present, considering low fuel and energy prices, both government-owned and private-owned industries have no strong incentive for reduction of fuel consumption and investment in these fields. Iran Energy Efficiency Organization (IEEO) has calculated energy intensity of some industries in terms of their production units. Table 1.23 shows the amount of energy consumed in terms of production unit of goods. The data of this table do not imply production efficiency in industries.

Table 1.23: The amount of energy consumed per unit of produced goods

Industry	Products	Energy Intensity	Unit	Year	Ref.
Metal Industry	Aluminum Billets	19.8	MJ/kg	2000	SABA
	Aluminum Profiles	31.4	MJ/kg	2000	SABA
	Aluminum Rods	13.9	MJ/kg	2000	SABA
	Aluminum Flakes	25.2	MJ/kg	2000	SABA
	Aluminum Sheets	19	MJ/kg	2000	SABA
	Aluminum Foils	60.4	MJ/kg	2000	SABA
	Aluminum Tubes	38.4	MJ/kg	2001	SABA
	Aluminum Wires	2.6	MJ/kg	2000	SABA
	Raw Steel	37.62	GJ/ton	1998	SABA
	Raw Steel	36.93	GJ/ton	1995	JICA
	Forged Steel	19.7	GJ/ton	1999	SABA
	Cast Iron (Electric Furnace)	24.19	GJ/ton	2000	SABA
	Cast Iron (Thermal Furnace)	38.7	GJ/ton	2001	SABA
Mineral and Non-Metal Industries	Cement (clinker)	5.37	GJ/ton	1998	SABA
	Cement (clinker)	5.492	GJ/ton	1995	JICA
	Glass Sheets	27.027	GJ/ton	1995	JICA
	Floor Tile	173.64	MJ/m^2	2001	SABA
	Wall Tile	173.32	MJ/m^2	2001	SABA
	Hygienic Chinaware	22.97	GJ/ton	2001	SABA
	Porcelain China	61.58	GJ/ton	2001	SABA
Chemical Industries	Synthetic Fiber (Nylon, Polyester, acrylic)	52.66	MJ/kg	1995	JICA
	Synthetic Fiber (Nylon)	91.15	MJ/kg	1995	JICA
	Synthetic Fiber (Polyester acrylic)	43.62	MJ/kg	1995	JICA
	Synthetic Fiber (Polyester)	16.5	MJ/kg	1999	SABA
	Synthetic Fiber (Acrylic)	30.8	MJ/kg	1999	SABA
	Synthetic Fiber (Polypropylene)	7.8	MJ/kg	1999	SABA
	Worsted thread	7.28	kWh/kg	1999	SABA
	Woolen Fabrics	7.49	MJ/m	1999	SABA
	Thread from Synthetic Fiber	3.26	KW/kg	1999	SABA
	Fabrics from Synthetic Fiber	4.94	MJ/m	1999	SABA
	Carpet Threads	1.69	KW/kg	2000	SABA
	Synthetic Fibers	20.16	MJ/kg	1999	SABA
	Powder	0.252	GJ/ton	2000	MIM

	Hand Washing Soap	17.9	GJ/ton	2000	MIM
	Cloth Washing Soap	42.5	GJ/ton	2000	MIM
	Dish Washing Liquid	0.33	GJ/ton	2000	MIM
	Cleansing Liquid	0.62	GJ/ton	2000	MIM
	Tooth Paste	0.83	GJ/ton	2000	MIM
	Hair Shampoo	0.97	GJ/ton	2000	MIM
	Fatty Acid	30.73	GJ/ton	2001	MIM
	Glycerin	96.39	GJ/ton	2000	MIM
Food Industries	Cube Sugar	3.628	GJ/ton. beet	2001	SABA
	Sugar	3.28	GJ/ton. beet	2002	SABA
	Sugar	32.028	GJ/ton. sugar	1995	JICA
	Beverage	1.8	MJ/lit	2000	SABA
	Vegetable Oil	12.45	GJ/ton	1995	JICA
	Bread	709-693-746	kJ/kg	1998	SABA

1.2.2.3. *Energy efficiency in industry:*

Basic and formulated works have not been carried out in the field of energy efficiency and fuel consumption optimisation because of low price of fuel and energy. Nevertheless, there are some actions, which have been taken by IEEO could be related to the recent years. Comparison of energy efficiency in certain industries in Iran with the same industries in other countries shows the current situation regarding energy efficiency and fuel consumption in Iran.

Comparison of energy efficiency of steel, cement, ceramics, glass, wood and paper, sugar and vegetable oil industries and their world means have been included in Table 1.24. For example, the ratio of energy efficiency of steel industries in Iran to the same industry in Canada was 2.2 times in 1998. It means that energy consumption in terms of one unit of steel produced in the country is 2.2 times that of Canada.

Table 1.24: Comparison of energy efficiency between Iran and world [IEEO]

Item	**Steel**	**Cement**	**Ceramics**	**Glass**	**Wood & Paper**	**Sugar**	**Vegetable Oil**
Iran	35.70	5.88	8.87	26.23	32.34	29.82	15.96
World Mean	21.00	4.62	6.52	13.42	14.62	19.74	10.08

1.2.3. GHGs emissions from industries:

The GHGs emissions and fuel consumptions estimated for industries based on ISIC classification are shown in Tables 1.25, 1.26, 1.27, 1.28 and 1.29. It is necessary to say that some emissions induced by petrol consumption (like CO2) have not been accounted. Tables 1.30 and 1.31 show the recent data on GHGs emissions induced by industry including (CO2, SO2, NOx, CO) during 1996 to 2001.

Table 1.25: The amount of GHGs emission related to consumed natural gas in 2000 (ton/yr) [SIC 2004]

No.	Type of Industry	Fuel Consumed (1000 lit)	Direct GHGs	Indirect GHGs	
			CO2	CO	SO2
1	Food, Beverage and Smoking	609830	1384683	2	2
2	Textile, Clothing and Leather	201110	44543	0	0
3	Wood and Wooden Products	19328	45053	0	0
4	Paper, Broad Paper, Press and Publication	192867	429525	0	0
5	Chemical, Oil and Coal	2708476	5795776	17	17
6	Mineral and Non-metallic Products except Oil and Coal	1459460	3219654	9	9
7	Basic Metallic Production	12739499	27381588	77	77
8	Machineries, Equipments and Instruments	239259	543168	1	1
9	Miscellaneous	5384	1262	0	0
Total	Total	18175213	38845252	99	106

Table 1.26: The amount of GHGs emission related to consumed petrol in 2000 (ton/yr) [SIC 2004]

No.	Type of Industry	Fuel Consumed (1000 lit)	Indirect GHGs	
			CO	NOx
1	Food, Beverage and Smoking	30511	10679	408
2	Textile, Clothing and Leather	13047	4566	175
3	Wood and Wooden Products	2852	988	35
4	Paper, Broad Paper, Press and Publication	5537	1937	72
5	Chemical, Oil and Coal	26159	9156	352
6	Mineral and Non-metallic Products except Oil and Coal	25806	9033	349
7	Basic Metallic Production	20052	7019	270
8	Machineries, Equipments and Instruments	32876	11506	440
9	Miscellaneous	1689	590	23
Total	Total	158529	55486	2124

Table 1.27: The amount of GHGs emission related to consumed kerosene in 2000 (ton/yr) [SIC 2004]

No.	Type of Industry	Fuel Consumed (1000 lit)	Direct GHGs		Indirect GHGs	
			CO2	N2O	CO	SO_2
1	Food, Beverage and Smoking	6801	16945	1	2	16
2	Textile, Clothing and Leather	13119	32687	5	10	30
3	Wood and Wooden Products	561	1397	0	0	1
4	Paper, Broad Paper, Press and Publication	786	1958	0	0	1
5	Chemical, Oil and Coal	5075	12644	1	4	12
6	Mineral and Non-metallic Products except Oil and Coal	12323	30703	4	8	28
7	Basic Metallic Production	6252	15577	1	4	13
8	Machineries, Equipments and Instruments	7926	19748	1	5	18
9	Miscellaneous	549	1367	0	0	1
Total	Total	53392	13303	13	32	120

Table 1.28: The amount of GHGs emission related to consumed gas oil in 2000 (ton/yr) [SIC2004]

No.	Type of Industry	Fuel Consumed (1000 lit)	Direct GHGs	Indirect GHGs		
			CO2	CO	SO_2	NMVOC
1	Food, Beverage and Smoking	303018	802393	30	2061	4757
2	Textile, Clothing and Leather	168651	446586	33	1216	2627
3	Wood and Wooden Products	24239	64172	4	172	380
4	Paper, Broad Paper, Press and Publication	30270	80155	5	218	415
5	Chemical, Oil and Coal	256541	679321	52	1846	4024
6	Mineral and Non-metallic Products except Oil and Coal	308719	1613273	122	4384	9568
7	Basic Metallic Production	179023	474051	34	1287	2810
8	Machineries, Equipments and Instruments	195926	518813	38	1411	3075
9	Miscellaneous	8074	21380	1	58	126
Total	Total	1474461	4700144	319	1265 3	27782

Table 1.29: The amount of GHGs emission related to consumed naphtha in 2000 (ton/yr) [SIC 2004]

No.	Type of Industry	Fuel Consumed (1000 lit)	Direct GHGs	Indirect GHGs	
			CO2	**CO**	**SO_2**
1	Food, Beverage and Smoking	702029	20914294	2	4724660
2	Textile, Clothing and Leather	167996	500291	0	7320
3	Wood and Wooden Products	18020	53664	0	845
4	Paper, Broad Paper, Press and Publication	41923	124847	0	1967
5	Chemical, Oil and Coal	766302	2282053	0	35972
6	Mineral and Non-metallic Products except Oil and Coal	3270069	9738267	15	153479
7	Basic Metallic Production	124216	369914	0	5830
8	Machineries, Equipments and Instruments	36709	109320	0	1723
9	Miscellaneous	420	1250	0	19
Total	Total	5127684	15271099	17	4931815

Table 1.30: The amount of GHGs emissions from industry section related to consumed fuel in 2001 (ton) [MOE 2003]

Fuel	**NOx**	**SO2**	**CO2**	**SO3**	**CO**	**CH**	**SPM**
Naphtha	61568	388971	18335034	4454	23	2463	6157
Gas oil	11515	36157	6098418	461	461	461	3455
Oil	15	72	72042	---	23	---	---
Petrol	731	81	125823	---	18957	3412	70
Natural Gas	48095	98	30501869	---	1981	834	4141
Total	121924	32579	5513379	4875	21445	7170	13823

Table 1.31: The amount of GHGs emission from industry section 1996-2001 [MOE 2003]

Fuel	**NOx**	**SO2**	**CO2**	**SO3**	**CO**	**CH**	**SPM**
1996	97969	277961	43067348	4154	21665	6647	11330
1997	111071	316235	49755989	4698	19451	6630	13622
1998	108295	322711	46503723	4838	22809	7250	12468
1999	110562	306641	48726566	4599	17413	6234	12399
2000	121007	306225	55005116	4586	22287	7208	13429
2001	121924	325379	55133186	4875	21445	7170	13823

1.2.4. Investigation on appropriate methods for reduction of GHGs in industries:

As mentioned above, to reduce emissions of GHGs it is necessary to carry out different projects on transfer of clean technologies, energy management, energy efficiency and application of renewable energies. .Nevertheless, pricing policies of fuels might play a significant role in rationalization of energy consumption in industries. Since 1997 some actions have been taken in the field of energy management and up to 2000 energy management studies have been carried out for aluminium, metallurgy and textile industries by IEEO. The same organization carried out energy auditing for tile, ceramics and sugar industries in 2001. The results of the current investigations show that through investment and implementation of different projects in the studied industries significant savings in fuel and electricity consumption would be expected. Table 1.32 reveals savings potentials in six industrial categories.

Table 1.32: The value of savings potentials in six industrial categories in 2000 [IEEO]

Industry	**Number of investigated plants**	**Saving potential (tera Joule)**
Cement	29	3900
Textile	38	2280
Aluminum	35	6872
Metallurgy	45	1200
Sugar	34	2570
Ceramics & Tile	62	2040
Total	243	18862

1.2.5. Role of research and development in GHGs emissions of industries:

Considering the crucial fact that a properly run energy management in industry should be based on the results of investigation and measurements, the role of research and development becomes clear. R&D units need to be established in industries in order to formulate a comprehensive and continuous plan in field of energy management which will result in reduction of energy consumption and GHGs emissions. For small –scale industries common R&D units are proposed. Monitoring should not be neglected by responsible organizations such as the Ministry of Industries and Mines, Ministry of Energy and the Department of the Environment.

1.3. Power generation, Residential and Commercial Sectors

1.3.1. Classification of power plants (based on energy consumption and process)

In 2001, of the total capacity of the Ministry of Energy's (MOE) installed power stations, 51.4% were steam power plants, 14.5% combined cycle, 25.1% gas turbines, 7.1% hydro and 1.9% diesel fuelled power stations. In comparison with the year 2000, the share of hydro, steam and diesel are seen to have reduced while that of gas and combined cycle has been increased.

1.3.2. Data collection on utilization, intensity and efficiency of energy in various power plants and in the domestic-commercial sector

Choice of fuel for power stations depends upon factors such as cost of each fuel, geographical position of the power station, accessibility especially in fall and winter, measure of pollution of each fuel to the environment, and even the medium and long term policies governing the energy sector. The amount of consumed gas oil in the MOE power stations in 2001 compared to 2000 has been increased by about 26.11%, which of furnace oil by 4.7% and natural gas by 4.9%. The amount of fuel consumption by the power stations under the control of MOE is given separately in Table 1.33.
In Iran, large industries are responsible for their own power generation. Table 1.34 shows the amount of fuel consumption from 1996 to 2001 in large industries.

Table 1.33.: The amount of fuel consumption by the power plants under the control of MOE [MOE 2003]

Year	**Fuel Consumption**			**Heating Value of the Consumed Fuels (billion kcal)**
	Gas oil (M lit)	**Fuel oil (M lit)**	**Gas (M cu m)**	
1967	136	311	13	4358
1968	118	420	33	5431
1969	128	496	21	6150
1970	165	672	22	8192
1980	983	1473	2278	43494
1990	1143	4810	8316	135951
2000	1283	6492	22883	271082
2001	1618	6799	24012	286167

Table 1.34.: The amount of fuel consumption by the large industries [MOE 2003]

Year	**Fuel Consumption**	
	Gas oil (M lit)	**Natural Gas (M cu m)**
1996	96.8	753.6
1997	40.7	970.7
1998	32.6	934.0
1999	51.4	883.3
2000	22.7	959.8
2001	48.9	989.0

1.3.2.1. Domestic consumption and power stations losses

In 2001, the internal consumption of the MOE power stations was 4.8% of the gross generation. In this year, part of the electricity generated has been lost as heat in the network and auxiliary distribution networks. The share of losses of transmission power sources and distribution networks has been about 17.32% of the gross power generated in 2001. Fuel and energy consumption of power plants under control of MOE between 1967 and 2001 are shown in Table 1.35.

Table 1.35: Internal utilization and the country's power networks between 1967 and 2001 [MOE 2003]

Year	**Share of internal utilization of total net generation (%)**	**Share of losses of power transmission network (%)**	**Share of losses of distribution network (%)**	**Total internal utilization and the networks losses (M kWh)**
1967	5.5	1.2	14	381
1977	4.8	3.0	9.7	2041
1987	4.8	3.3	9.3	7628
1997	5	3.8	11.2	17719
2001	4.8	5.0	14.42	326756

1.3.2.2. Thermal efficiency of power stations

The average thermal efficiency of the MOE's power stations has decreased slightly from 36.65% in 2000 to 35.63% in 2001. The thermal efficiency of the MOE steam power stations reached 36.88% in 2001, that of as gas turbines was 26.97% and for combined cycle was 44.87%, respectively.

1.3.2.3. Electric energy generation

The country's electric energy generation in 2001 was more than 130 Tera Watt-hour, 95% of which has been generated by MOE and the remainder by other organizations. Electric energy generation by MOE in 2001 has been 124,275 million kWh with a rise of 7.4% compared with the previous year. In 2001, the share of hydro has been 4.1%, steam 65.2%, gas 16%, combined cycle 14.4% and that of diesel fuelled power stations 0.3%, respectively (Table 1.36).

Table1.36: Gross generated electric energy of MOE between 1967-2001 (Million kWh) [MOE 2003]

Year	**Hydro**	**Steam**	**Gas**	**Combined cycle**	**Diesel**	**Sum**
1967	658	732	56	--	396	1842
1977	6249	6316	3928	--	893	17386
1987	8390	25360	7305	--	1499	42554
1997	6908	65628	19298	--	476	92310
2000	3650	78332	20510	12855	361	115708
2001	5057	81103	19888	17899	328	124275

1.3.2.4. Energy consumption of domestic-commercial sector

The energy consumption of country’s domestic-commercial sector in 2001 is shown in Table 1.37.

Table 1.37: Consumption of energy carriers in the country’s domestic-commercial sectors (2001) [MOE 2003]

Sector	Petrol (1000 lit)	Kerosene (1000 lit)	Furnace oil (1000 lit)	Gas oil (M cu m)	Natural Gas (M cu m)	Liquid gas(ton)	Engine oil (1000 lit)
Domestic	0	8,363,770	0	1,578,790	22,959	1,754,555	0
Public	109,391	323,340	102,147	1,205,713			32,012
Commercial	625	78,148	1,502,030	577,462			25,452

In 2001, the domestic sector with a consumption of 32,891 million kWh has utilized the most electric energy among the economic sectors accounting for more than 33.9% of the total final electricity consumption. The average rate of increase of consumption of this sector has been over 6.5% in the period 1996 to 2001.

The consumption of electricity by the commercial and public sectors in 2001 was 18.9% of the total final power consumption. The share of the commercial sector and public sector has respectively been 6.6% and 12.3% (Table 1.38). In 2001, the total sale of electric energy for the country’s different consumers was as follows:

Domestic-Urban: 28,028,907 (x1000 kWh), rural: 4,845,568 (x1000 kWh), miscellaneous: 116,224 (x1000 kWh), Total: 32,890,699 (x1000 kWh).

Public-Urban: 11,698,937 (x1000 kWh), rural: 231,119 (x1000 kWh), miscellaneous: 21,000 (x1000 kWh), Total: 11,951,056 (x1000 kWh).

Commercial-Urban: 6,094,304 (x1000 kWh), rural: 203,858 (x1000 kWh), miscellaneous: 95,603 (x1000 kWh), Total: 6,393,765 (x1000 kWh).

Streets lighting: 4,116,795 (x1000 kWh).

Consumption of natural gas (cu m per yr) for cooking, heating and hot water of each household in the country’s provincial capitals, summed up as follows:

Volume for cooking usage (8,830), volume for hot water usage (21,950), volume for heating usage (52,200) and volume for annual usage (78,830).

Table 1.38: Share of electricity consumption in various sectors in 1996-2001 (%) [MOE 2003]

Year	Domestic	Public and commercial	Industrial	Transport	Agricultural	Others	Total
1996	34.5	20.4	32.9	--	8.2	4	100
1997	36.2	20.3	32.3	--	8.1	3.1	100
1998	36.9	20.0	31.0	0.05	8.8	3.2	100
1999	35.1	19.1	31.1	0.2	9.5	5.0	100
2000	34.6	19.1	31.8	0.2	10.1	4.2	100
2001	33.9	18.9	31.4	0.2	11.4	4.2	100

1.3.3. Determining the potentials for energy efficiency improvement, change in design, replacement of materials and equipment, new processes, etc. to reduce GHGs emission in each type of power plants and in domestic appliances and buildings material

1.3.3.1. Potential for technical saving in the country's electricity sector

Technical potentials for reduction of GHGs emission include change in design, new management and change in processes and apparatus used in power stations, the descriptive explanation of which is as follows:
MOE-environmental group and Japan International Cooperation Agency (JICA) carried out studies in a joint project in 4 years (1995-1999) on 2 outstanding power stations in Tabriz and Esfahan. It was found that there would be a 3% potential for saving energy in these two power stations through increasing the turbine efficiency. To do so, it is necessary to determine the principal indicators for high-pressure HP turbines and intermediate pressure (IP) turbines. Efficient power generation shall be achieved through replacement of diaphragm component and also its axes sector by new parts to reduce the circulation area of steam mixture in HP and IP turbines, as well as replacement of rotating blades in HP turbines by new ones. Approximate cost for improvement of turbine efficiency is provided in Table 1.39.

Based on the studies by the JICA programme, considering the 3% efficiency improvement, taking into account the reduction of the fossil fuel consumption resulting from efficiency improvement, the necessary capital investment, and expenses already carried out, capital return and also the cost of eliminating a ton of CO2 have thus been calculated. In these calculations, the software program of environment studies group of MOE has been used for estimation of the rate of CO2 emission. Table 1.40 provides the number of units and also the amount of consumed fuel for the types of power stations in year 1999.

Table 1.39: Cost of turbine efficiency improvement (for one unit) in 1999 in power stations (US$) [MOE 2002]

Replacement	**Materials and equipment**		**Overhead costs**	**Field work**	**Commissioning time**
Packing	Axis and diaphragm	400,000	200,000	60 days	6 months
Rotors	For HP	4,200,000	200,000	60 days	1 year
Total		50,000 US $		80 to 100 days	

Table 1.40: The number of units and the amount of consumed fuel for the types of power plants in 1999 [Ref: EER 2004]

The types of power stations	**Number of units**	**Consumed fuel (x 1000)**		
		Gas oil (lit)	Furnace oil (lit)	Gas (cu m)
Steam turbines: Power stations inside and outside the network	65	27,701	5,945,605	12,310,537
Gas turbines: Power stations inside and outside the network	126	662,025	0	2,338,338
Combined cycle Power stations inside and outside the network	46	245597	0	6584766

In the JICA program the cost of improving the power station efficiency was estimated to be at 5,000,000 $ per unit. The cost of energy consumption improvement per unit for the different types of power stations and the amount of fuel saving in power stations of the country is given in Table 1.41.

Table 1.41: Cost of optimizing energy consumption and the amount of fuel saving in the power plants of the country [EER 2004]

Power station	**Cost of energy consumption improvement (US$)**	**Saving in fuel consumption (x1000)**		
		Gas oil (lit)	**Furnace oil (lit)**	**Gas (cu m)**
Steam	325,000,000	831	178,368	36,9316
Gas	630,000,000	19,860	0	70,150
Combined cycle	230,000,000	7,367	0	19,7542

Based on the data in Table 1.41, the amount of reduction in CO_2 emission for the different power stations resulting from the potential for energy saving in the country is provided in Table 1.42.

Table 1.42: The amount of reduction in CO2 emission from the energy saving in the country's power plants in 1999 (ton) [EER 2004]

Power station	**Fuel Consumption (M lit)**			**Total**
	Gas oil	**Furnace oil**	**Gas**	
Steam	2,200	531,537	787	534,525
Gas	52,591	0	149	52,741
Combined cycle	19,410	0	421	19,932
Total				607,198

With reference to the prices provided in US Gulf for gas oil and furnace oil and also bpamoco price in the case natural gas in the year 1999 (after calculating the average) the price of the 3 mentioned energy carriers are as in Table 1.43.

Table 1.43: Price of energy carriers in the world markets in year 1999 and possible saving amount in the country's power plants

Energy carrier	**Price**	**Selling price of the saved energy carriers (US$/barrel) 3**
Gas oil	18.26 (1)	3,182,530
Furnace oil	13.74 (1)	15,935,410
Gas	2.2 US$/MBTU (2)	25,480,369

Note: Refs:
1) Average US Gulf price – source: OPEC Bulletin, Aug 1999
2) Average selling price of Iran gas to neighboring countries
3) Based on the Table 1.41 results

Table 1.44 shows the amount of capital investment and the income that result fro 3% saving in energy in power plants in the country. In this table Scenario 1, in order to calculate the net profit or the net income, 50% of this price has been taken off for the cost of transmission pipeline, refining and getting the gas to the borders (Turkey and Pakistan- if 3% of gas consumption of power plants is saved and transported to neighboring countries). In Scenario 2, no percentage has been taken away from the selling amount of gas. This assumes that if a pipeline has been constructed on the borders (Turkey and Pakistan) beforehand, these expenses will not be accounted and spent for developing appropriate infrastructures for further exports. The negligible cost of carriage of gas oil and furnace oil by tanker has been ignored. With these assumptions, the amount of capital investment and income resulting from 3% saving in energy, for the 3 power station types in the country, are calculated and shown in Table 1.44.

Table 1.44: The amount of capital investment and income resulting from 3% saving in energy for the three types of power plants in the country [EER 2004]

Power plant type	**Cost of energy consumption optimization in power plants (US $)**	**Income from selling the saved energy carriers (US $)**		**Total cost for capital investment (US$)**	
		Scenario 1	**Scenario 2**	**Scenario 1**	**Scenario 2**
Steam	325,000,000	30,802,310	45,574,954	294,197,689	279,425,045
Gas	630,000,000	5,058,611	7,864,617	624,941,288	622,135,382
Combined cycle	230,000,000	8,737,387	16,639,106	221,262,612	213,360,893

Considering the data in Table 1.44., the capital return year and the cost of eliminating each ton of CO_2 (in US$) for different types of the power plants are given in Table 1.45.

Table 1.45: The capital return year and the cost of eliminating each ton of CO_2 for different types of the country's power plants in 1999 [EER 2004]

Power station	**The capital return (year)**		**Cost of eliminating each ton of CO2 (US$)**	
	Scenario 1	**Scenario 2**	**Scenario 1**	**Scenario 2**
Steam	10.5	7.1	28.1	49.7
Gas	124	80.1	47.9	74.2
Combined cycle	26.3	13.8	216	297

Based on the forecast of energy supply till the year 2005, the share of combined cycle power plants will have increased by 42%, share of gas turbine power plants will remain constant and that of steam power plants will be reduced on the account of nuclear, renewable and large hydro power plants.

In the year 1999, the share of gas, steam and combined cycle power stations have respectively been 66%, 30% and 9% of the total power generation. On one hand, as a result of 3% saving in fuel, a total of 607,199 ton CO_2 is reduced. Of this reduction, 88.3%, 8.69% and 3.28% are respectively designated to steam, gas and combined cycle power stations. On the other hand, noting Scenario 1, the sum to be spent based on the results in Table 1.45 for steam, gas and combined cycle power plants, will be a total of 36,399,148.07 US dollars for reduction of CO_2 emission. Therefore, for reduction of 1 ton CO_2, an equivalent of average 59.95 US$ should be spent for the 3 power stations.

To reduce power losses in the country, there are various methods including the following that explain the available and possible potentials (Table 1.46).

Table 1.46: Classification of the methods for reduction of the low-tension network [EER 2004]

Option Order	Order of priorities	Name of method	Manner of loss reduction	Capital return	Approximate percentage of loss reduction	CO2 emission from loss reduction in 2000 (tons)
1	4	Balance 3 phase load	2 current power	1-2 months	20-40%	12,211,311 to 9,158,480
2	1	Displacement of load	3 current power	Less than 1 month	20-75%	12,211,311 to 3,815,985
3	2	Capacitors installing	2 current power reduce generation	4-7 months	15-75%	12,974,518 to 3,815,985
4	3	Transformers displacement	3 current power	2-4 years	75%	3,815,985
5	6	Neutral section refit	1 neutral resistance power	10-20 year	1-4%	14,203,959 to 13,773,536
6	5	3 phase section refit	1 neutral resistance power	2-4 years	25-50%	11,469,270 to 763,207
7	7	Earthing	Less than 1 neutral resistance power	More than 120 years	0.1-0.3%	14,333,086 to 14,304,394

1.3.3.2. Potential of technical saving in the country's domestic-commercial sector

- ***Potential of technical saving by using low energy consumption bulbs***

Reduction of consumed power in the network is possible to achieve by various methods. One of these methods is the increase of the electrical equipment power factor, especially those with widespread usage in the society. The sale statistics of electrical goods in recent years show that between 30-40% of the power generated is sold to domestic consumers. Domestic consumers use 30% of their electricity consumption for lighting which accounts for nearly 10% of the net electricity in the network. This indicates the importance of improvement of domestic lighting in consumption of electric power. One of the ways to improve lighting situation is to use low energy bulbs instead of filament bulbs that can reduce power consumption by 75%.

For domestic and public uses of the country, filament bulbs provide 85% of lighting and the remainder is mostly of fluorescent type. Table 1.47 shows the released capacities and their total value (billion dollars) for the percentage of the peak load likely to replace. (Capacity of network and that of generation are reckoned as 18,500 MW and 28,000 MW respectively.

Table 1.47: Capacity and total value of the capacity releasable through substituting filament bulbs in the country [EER 2004]

Percentage of replaceable peak load	Percentage of peak load reduction	Nominal generating capacity released (MW)	Released capacity of network (MW)	Total value of released capacity (US$ Billion)
16	12.8	3584	2368	2.7
20	16	4480	2960	3.3
25	20	5600	3700	4.2
30	24	6720	4440	5

Table 1.48 shows the number of bulbs, cost of replacing in each case (assuming coefficient of 0.6 for simultaneous use) and also the value of the unconsummated energy per year including reduction in losses (on average 0.2 kWh for each 1 kWh consumption drop in the whole year). Usage of the bulb is assumed 2000 hours per year and cost of electric energy is considered to be 0.04 $ / kWh.

Table 1.48: Cost of replacement and the value of the unconsumed energy in the country in 2000 [EER 2004]

Percentage of replaceable peak load	Number of bulbs (million)	Cost of replacement (M $)	Value of energy (M $)
16	44.9	127	344
20	56.1	159	431
25	70.1	199	538
30	84.1	239	646

Noting the values in Table 1.47 concerning nominal generating capacity (MW) that has been released, the related amount of emission of CO2, NOx, and SO_2 and the potential for reducing the social-economical costs have been respectively calculated and shown in Tables 1.49 and 1.50.

Table 1.49: Potential for reducing emission of CO2, NOx and SO_2 as a result of using low energy consumption light bulbs in the country in year 2000 [EER 2004]

Nominal generating capacity released (MW)	Percentage of replaceable peak load	CO2 (ton)	NOx (ton)	SO2 (ton)
3,584	16	10,709,053	16,405	49,740
4,480	20	13,335,239	20,428	61,938
5,600	25	167,330	25,634	77,720
6,820	30	2,037,860	31,218	94,652

Table 1.50: Potential for reducing the social-economical costs as a result of using low energy consumption light bulbs in the country in year 2000 [EER 2004]

Nominal generating capacity released (MW)	CO_2 (ton)	NOx (ton)	SO_2 (ton)	Total (million Rials)
3,584	779,619	317,256	131,763	1,228,639
4,480	970,805	395,054	164,075	1,529,935
5,600	1218,197	495,713	205,881	1,919,791
6,820	1483,562	603,708	250,733	2,338,004

- ***Potential for saving in electric domestic appliances***

Prediction of saving in energy consumption through employing energy labels for fridges and freezers until year 2004 is given in Table 1.51. The energy demand forecast during 2000 to 2004, based on EFOM (a French software) and ESAM (Energy Saving and Management) models for capacity of power generation for different types of power plants, is shown in Table 1.52 and the potential of CO_2 reduction in manufacturing of energy-labeled fridges and freezers is estimated based on this forecast which is shown in Table 1.53.

Table 1.51: Prediction of saving in energy consumption through employing energy labels for fridge and freezers (1998 –2004) [MOE 2000]

Year	Demand (GWh)	Saving in energy consumption (GWh)
1998	1,295,488	236
2000	1,504,072	765
2002	1,575,312	1,328
2004	1,708,253	1,935

Table 1.52: Prediction of percentage share of different power plants in the country till year 2004 [www.tavanir.org.ir]

Plant Type / Year	2000	2001	2002	2003	2004
Steam	65.8	57.4	48.9	40.1	32.2
Combined cycle	22.3	30.1	39.1	47.5	55.9
Gas	6.9	6.8	6.8	6.8	6.7
Nuclear	0	0.3	0.6	0.9	1.2
Large hydro	4.6	4.4	4.1	3.8	3.6
Renewable	0.3	0.3	0.4	0.5	0.5

Table 1.53: Potential for reduction of CO2 emission by implementing energy labeling in fridges and freezers used in the country for the period 2000 - 2004) [MOE 2000]

Year of saving in energy consumption	**Reduction of CO2 emission (ton)**
2000	435139
2001	578343
2002	719691
2003	859006
2004	995465

In Table 1.54, the average tariff of electricity sale price in the domestic sector has been calculated assuming a 10% annual increase in sale of electricity in that sector.

Table 1.54: Prediction of average electricity sale price in domestic sector during the country's Third National Socio-economic Five-Year Development Plan [MOE 2000]

Domestic sector	**Average electricity sale price (Rial/kWh)**
2000	89.36
2001	98.52
2002	114.10
2003	131.76
2004	151.06

Considering the data in the above tables, the potentials for energy saving in fridges and freezers can be calculated for the period 2000 - 2004 (Table 1.55).

Table 1.55: Potentials for energy saving in fridges and freezers in Iran (2000 - 2004) [MOE 2000]

Year of saving in energy consumption	**Potential for saving**	
	Rials *	**Dollars**
2000	4,980,900,0000	6,226,125
2001	75,920,000,000	9,488,250
2002	104,100,000,000	13,012,500
2003	178,860,000,000	22,357,500
2004	234,135,000,000	29,266,875

*Assuming constant exchange rate of 1 US$ = 8000 Rials

The prediction of energy saving in washing machines resulting from the use of energy label standard during 2000 - 2004 has been carried out by the Office of Energy Optimization of the MOE (Table 1.56). Based on these findings, the potential for reduction of CO2 emission (Table 1.57) and potential for financial saving (Table 1.58) have been calculated.

Table 1.56.: Prediction of potential for saving in energy consumption resulting from use of energy labeling standard in washing machines in the country (2000-2004) [MOE 2000]

Year	Demand (GWh)	Energy saving (GWh)
2000	304855	14.3
2001	309228	28.8
2002	316352	43.5
2003	323464	58.2
2004	329839	73.7

Table 1.57: Prediction of potential for reduction of CO2 emission resulting from use of energy label in washing machines used in the country (2000-2004) [MOE 2000]

Year of saving energy consumption	Reduction of CO2 emission (ton)
2000	7764
2001	15600
2002	23162
2003	30337
2004	37472

Table 1.58: Potential for financial saving as a result of energy labels in fridges and freezers in Iran (2000-2004) [MOE 2000]

Year	Potential for financial saving	
	Rials *	Dollars
2000	931,000,000	116375
2001	2,100,000,000	262500
2002	4,350,000,000	543750
2003	6,402,000,000	800,250
2004	8,917,000,000	1114625

*Assuming constant exchange rate of 1 US$ @ 8000 Rials

Prediction of energy saving in the country's air-conditioners resulting from use of energy label standard for the period 2000 – 2004 is provided in Table 1.59. On this basis, the potentials for reduction of CO2 emission and financial saving in this sector are calculated and shown in Tables 1.60 and 1.61.

Table 1.59: Prediction of energy saving resulting from use of energy labels standard in the country's air-conditioners (2000-2004) [MOE 2000]

Year	Demand (GWh)	Energy saving (GWh)
2000	479,790	57
2001	531,926	120.2
2002	582,432	189.4
2003	631,653	264.3
2004	695,621	347

Table 1.60: Prediction of potential for reduction of CO_2 emission resulting from use of energy labels standard in the country's air-conditioners (2000-2004) [MOE 2000]

Year	Reduction of CO2 emission (ton)
2000	32,073
2001	66,276
2002	102,112
2003	139,365
2004	177,830

Table 1.61: Prediction of potential for financial saving resulting from energy saving in the country's air-conditioners (2000-2004) [MOE 2000]

Year	Potential for financial saving	
	Rials *	Dollars
2000	3,711,000,000	463875
2001	8,766,000,000	1095750
2002	18,940,000,000	2367500
2003	29,084,000,000	3635500
2004	41,987,000,000	5248375

*Assuming constant exchange rate of 1 US$ = 8000 Rials.

- **Pumps**

Potential for electric energy saving in pumps, compressors, samovars and irons, as a result of using energy label standard, has been assessed by the Office of Energy Optimization of the MOE (Table 1.62). Based on these findings, potential for reduction of CO_2 emission (Table 1.63) and potential for financial saving (Table 1.64) have been calculated.

Table 1.62: Prediction of potential for technical energy saving resulting from using energy label standard in domestic pumps, compressors, samovars and irons in the country (2000-2004) [MOE 2000]

Year	Energy saving (GWh)
2000	60.8
2001	108.7
2002	159.9
2003	214.6
2004	246.0

Table 1.63: Prediction of potential for reduction of CO_2 emission resulting from using energy label standard in domestic pumps, compressors, samovars and irons in the country (2000-2004) [MOE 2002]

Year	**Potential for reduction of CO2 emission (ton)**
2000	35,070
2001	59,830
2002	86,165
2003	103,024
2004	126,139

Table 1.64: Prediction of potential for financial saving resulting from using energy label standard) in pumps, compressors, samovars and irons (2000-2004) [MOE 2002]

Year	**Potential for financial saving**	
	Rials *	**Dollars**
2000	3,911,000,000	488,976
2001	7,929,000,000	991,208
2002	15,993,000,000	1,999,125
2003	23,603,000,000	2,950,475
2004	29,807,000,000	3,725,992

*Assuming constant exchange rate of 1 US$ = 8000 Rials

As such, the total potential for reduction of CO_2 emission and also potential for financial saving, in Rials and Dollars, in the domestic sector under discussion is calculable (Table 1.65).

Table 1.65: Total potential for reduction of CO_2 emission and possibility for financial saving in some domestic appliances in the country (2000-2004) [MOE 2002]

Year	**Potential for reduction of CO2 emission (ton)**	**Potential for financial saving**	
		Rials *	**Dollars**
2000	510,047	58,363,000,000	7295375
2001	720,050	94,716,000,000	11839500
2002	839,132	143,383,000,000	17922875
2003	1111,742	237,949,000,000	29743625
2004	1,336,907	314,847,000,000	39355875

*Assuming constant exchange rate of 1 US$= 8000 Rials.

** Domestic appliances include: fridges and freezers, washing mashies, air-conditioners, samovars, irons, pumps and compressors.

1.3.4. Cost of reducing CO2 emission in the domestic appliances of the country

By considering the results of the above tables for domestic fridges and freezers, washing machines, air-conditioners, samovars, irons, pumps and compressors, the total energy saving (GWh), reduction of CO2 emission (ton), and income gained from the sale of the saved electricity abroad are shown in Table 1.66 along with the cost of eliminating one ton of CO2.

Table 1.66: Cost of reduction of CO2 emission in domestic sector resulting from the use of energy label standard (2000) [MOE 2002]

Type of appliance	**Total energy saving (GWh)**	**Reduction of CO2 emission (ton)**	**Income from export electricity sale (US$)**	**Cost of eliminating each ton of CO2 (US$)**
domestic appliances	897.1	510,047.11	34,089.80	0.07

Note: 1. Domestic appliances include: fridges and freezers, washing machines, air-conditioners, samovars, irons, pumps and compressors.

2. Sale price of export electricity = 0.038 dollar for each kWh.

1.3.5. Potential for energy saving in buildings sector

Concerning the potential for energy saving in residential buildings, the following was established. By saving thermal and electrical energy in Scenarios 1 and 2 (selected for costs of export and transmission of gas), the cost of eliminating each ton of CO2 in Scenario 1 shall equal 0.027 dollar and in Scenario 2, 0.01 dollar. Classification of buildings from the point of view of need for energy saving is given in Table 1.67.

Table 1.67 Classification of buildings from the point of view of need for energy saving in the country [MOE 2002]

Classification of various usage of buildings (P-3-2	**Geographical classification as regards energy needs (P-3-1)**	**Large towns**		**Small towns**	
		Construction area less than 1000 sq. m	**Construction area more than 1000 sq. m**	**Construction area less than 1000 sq. m**	**Construction area more than 1000 sq. m**
Type A	high	1	1	2	2
	average	2	2	3	3
	low	3	3	4	4
Type B	high	2	1	2	2
	average	3	2	3	3
	low	4	3	4	4
Type C	high	2	2	2	2
	average	3	3	3	3
	low	4	4	4	4
Type D	high	4	4	4	4
	average	4	4	4	4
	low	4	4	4	4

Prioritizing of various energy sectors for implementing energy saving techniques is provided in Table 1.68.

Table 1.68: Prioritizing various divisions of the country's energy sectors for implementing energy saving techniques [MOE 2001 & MOE 2002]

Prioritizing Order	**Name of energy subsection**	**Saved cost for energy saving (MUS$)**	**Cost of eliminating each ton of CO_2 (US$)**	**Potential of reducing CO_2 emission (ton)**	**Year**
1	Domestic-lighting	---	-20.3	10,709,053	2000
2	Domestic-appliances	---	0.07	510,047	2000
3	Power-steam plant	294.19	28.1	534,525	1999
4	Power-combined cycle plant	221.26	216	19,932	1999

Note: Gas turbine power plants are not included in this table because of long capital return time and high cost of eliminating each ton of CO_2

2. Technology Needs Assessment

2.1. Transportation

2.1.1. Development of new materials and reduction of weight of vehicle:

Contribution of application of low-density materials in light vehicles has increased significantly in the world. These materials constitute a minimum of 12% of the vehicle weight. Applying resistant plastic materials in vehicle body can lead to reduction of vehicle weight up to 10% and it would cause to decrease fuel consumption up to 5%. In recent years, imported cars and also those which are assembled in Iran are less heavier than the old ones.

The most important action in reducing weight of vehicle in Iran is as follows:

- Use of aluminum (Al) in producing cylinder and its different parts would result in reduction of weigh of this part of engine up to 30% in comparison with cast iron cylinders.
- Application of lighter thin plate in production of vehicle's body through substitution of steel thin plates with Al – thin plates.
- Use of light materials like polymers and plastics in producing different parts of vehicles.

2.1.2. Aerodynamic development of vehicle's body:

In recent years car manufacturing companies in Iran have noticed to the aerodynamic improvement of vehicle's body as an effective way for reduction in fuel consumption. About 15% reduction in air friction factor might increase 2.3% in distance mileage per given fuel consumption unit.

2.1.3. Development of system and components of motors:

Improvement in efficiency of engine combustion for reduction of energy use that is resulted from friction and also power transmission system is among actions that major car manufacturing companies have already followed. Also, Iran has imported these achievements in recent years. Improvement of moving – power's efficiency, reduction of power and acceleration of motor, increase of compression ratio, direct injection of fuel, increase of number of valves, etc. could decrease the amount of consumed fuel. Table 2.1 shows the responsible organizations and various kinds of technologies for improvement of efficiency in transport sector of the country.

Table 2.1: Organization and technologies for improvement of efficiency in transport sector.

Responsible organization	Technology	
Ministry of Industry & Mines (MIM)	Application of fiberglass and aluminum (Al) thin plat in body of vehicles	Technologies for reducing weight
MIM	Use of Al in chassis	
MIM	Use of profiles & suitable thickness- thin plates	
MIM	Use of board springs and parabolic	
MIM	Reduction of weight of cast parts using advanced metallurgic methods	
MIM and Car – Manufacturing Companies (CMC)	Use of Al and Mg alloys	
MIM & CMC	Use of two stage turbo-charger	Technologies for improving system and component of engines for heavy – vehicles
MIM & CMC	Use of turbo-charger with geometrical modification of inlet nozzles	
MIM & CMC	Use of hybrid diesel engine	
MIM & CMC	Increase of compression ratio up to 18–24%	
CMC	Use of injector instead of carburetor, turbo-chargers and super-charger in gas burning vehicles.	Technologies for improving system and component of engine for light vehicles
MIM & CMC	Use of heating system of manifold in vehicles	
CMC	Improvement of compression ratio in existing engines	
MIM & CMC	Use of electronic control units	
MIM & CMC	Modification of compression ratio in existing engines	
MIM & CMC	Use of low capacity engine	
CMC	Use of gearbox with continuous velocity change	Reduction of aerodynamic forces
CMC	Use of power transmission with FWD (Four Wheel Drive) system	
MIM & Tire Producing Companies	Substitution of radial tires with bias ones	
MIM&CMC	Advanced vehicle body designing	**Improvement of quality of fuel and oil**
M. of Oil (MO)	Use of new additives in petrol for reducing evaporative loss & improvement of fuel efficiency	
MO & CMC	Use of sensors for use of high octane petrol	
Municipality	Improvement of current traffic control system	**Improvement of inner-city transport system**

2.1.3.1. Technology of M.F Heavy vehicles (MFHV)

MFHV are Lorries and buses equipped with CIE (Compression Ignition Engine). The MFHVs consume 100% methanol (M100) and some lubricant additives. In these systems, fuel is being injected in combustion chamber and air would be flamed by high temperature. Use of methanol would reduce NOx emission of diesel motors. It should be pointed out that MFHVs has been certified by EPA (Environmental Protection Agency).

FFVs (Flexible Fueled Vehicles), which have been specially designed to run on gasoline or any blend of up to 85% ethanol (E85), possess advanced technologies, acceptable efficiency, low emissions and its price is as much as petrol-fueled vehicles. The only limiting factor for FFVs is higher price than diesel-fueled vehicles.

While use of MFHVs would reduce NOx and particle emission up to 12% in cities, high price resulted in halting production of MFHVs. Methanol is a suitable liquid fuel for changing into hydrogen fuel cells, however, to use methanol as main energy resources in new generation of fuel cells, extensive research has to be carried out.

2.1.3.2. Different options for use of hydrogen fuel in vehicles:

There are three main methods for use of hydrogen in vehicles. First, the combustion of H_2 in engines, second generating electrical energy using fuel cells and finally the third option is to use hybrid electric vehicles (HEV). For commercialization of fuel cells in small vehicles, cost and size of fuel cells should be reduced.

- ***Traditional Internal Combustion Motors (ICM)***

While many attempts have been made to convert ICMs to use hydrogen as fuel, but in spite of many achievements, use of H_2 in ICMs is very expensive. This is partly justified by the fact that efficiency of engines and power transmission systems is very low and huge amount of H_2 is required for long distances. Estimations show that for a 300 mile distances about 10 kg of H_2 is required. If H_2 has been stored in the liquid form, it would have a volume equal to 37 gallons. Storage of H_2 in gas condition needs a space more than two times compared with liquid storage.

To store H_2 in the form of compressed gas double amount of space is needed compared with the liquid state. However, hydrogen can be stored in metallic hybrid. The lightest form of metallic hybrid (MgH_2) has 130 kg of weight and its price is more than 2000 US.

- ***Fuel cell electrical vehicle***

The second option is an electrical vehicle with fuel cells which has high efficiency. This system possesses high cost for use in public transport system and therefore is being used for space programs. However, nowadays fuel cells have found new and extensive applications. Electrical buses using fuel cells for public transport are becoming promising; though expensive when compared with other modes of transport.

- ***HEVs***

Various generations of HEVs are under development by CMCs. Some Prototypes have already been made in Germany. Recently a hybrid vehicle is designed that uses H_2. Net weight of the vehicle is about 1140 kg and it can gain acceleration of zero to 96 km per hour within 8 seconds. Using a high electrical capacity system, this vehicle can burn H_2 in a small engine to drive a generator to charge an electrical reserving system. This system will drive an electrical motor to drive the wheels.
Hydrogen as a substitutive fuel has good potential for application in internal combustion engines. Considering the adverse effects of fossil fuels and the high efficiency of hydrogen driven motors, a bright future can be predicted for further development of hydrogen applications.

2.1.3.3. Technology of electrical vehicles:

From the standpoint of conservation of fuel consumption, electrical vehicles are comparable to internal combustion motors. For comparison of efficiency of electrical vehicle with internal combustion vehicle, the overall fuel cycle should be considered. It means that the energy used for extraction, production and transport of petrol to gas station should also be taken into account. With this consideration the estimation shows that electrical vehicles are more economical (approximately up to 25%) when compared with petrol–fueled vehicles. It should be pointed out that diesel vehicles are 10 to 30 percent more economical than electrical vehicles. If efficiency is to be merely considered, electrical vehicles use 66% of the electricity input while internal combustion engines use only 22 to 33% of the energy input.

2.1.3.4. Technology of CNG – fueled vehicles (CNGFV)

CNG or compressed natural gas is a suitable substitution for other fuels. While it reduces fuel cost, it can result in reduction of pollution up to 20%. Main differences amongst gas – fueled vehicles and traditional vehicles can be justified in their fueling system. CNGFVs may have a dual fueling system using both petrol and gas.

2.1.4. Fuel consumption of different substituting technologies

Figure 2.1 compares the substituting technologies and their fuel consumptions. They show that using light materials in production of cars and direct injection of fuel result in significant improvement compared to the current car models. Higher improvement might be achieved through modification of driving system into electrical or hybrid one. The most important aspect is with regard to fuel cells if it could be supplied with reasonable price. HEVs are the best option since they owe many advantages over the present cars.

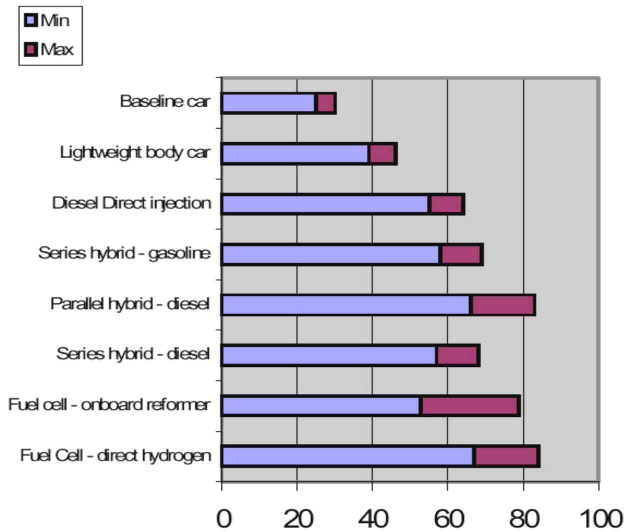

Figure 2.1: Comparison of substituting technologies and their fuel consumptions

2.1.5. Advantages of fuel cell vehicles

To summarize the advantages of fuel cell car are as follows:

- **Energy density:** The power and Energy density of Fuel cells are two to three times more than electric vehicles. More density means more distance. Fuel cells have very suitable fuel efficiency.

-Zero – pollution: As pure H_2 is used in fuel cells, final combustion product will be water. In comparison with fuel cell vehicles which use methanol they have less pollution and they should easily meet LEV and ZEV standards.

-Ability to fueling: There are some arguments for reducing charging time of electrical vehicles to 15 or 20 minutes. Fuel cell vehicle take less time in comparison with traditional vehicles in petrol stations.

-Efficiency: One of the important reasons for approaching to fuel cell technology in vehicles is its good potential to achieve higher efficiency in energy transmission in comparison with combustion engines.

2.1.6. Determination of criteria:

Appropriation of a given technology for a country is a function of some criteria and indicators. As it should be imported, technology transfer should follow given criteria to avoid resources, time and capital losses. Selection of criteria for this technology varies from region to region and country by country. If technology is harmonized with socio-economic security objectives, it would be considered as suitable one. Technology should be selected based on the national macro developmental policies. In this regard, a series of factors like complexity of technology, ability of adoption, regional advantage laws & regulation, cultural and socio economic issues are of considerable importance.

Iran intends to formulate some criteria for technology transfer considering its special geographic conditions and political and economic circumstances. Determination of such criteria has been introduced by the Deputy Minister for Technology of MIM and a draft for it has been prepared. These criteria are of five main groups that can be presented as follows:

2.1.6.1. Abilities, Possibilities and current Advantages of the Technology:
This main group of criteria is to be accounted as departure point of country to reach it. In this regard, natural resources, equipment and expertise man – powers are being considered.

2.1.6.2. Possible opportunity for access to technology
Assessment of opportunities and threats and the required time for access to and absorption of technology affect the selection of technology and these are the most important criteria for selection of the technology by decision makers. On the other hand existence of suitable market at national, regional and global levels will also facilitate technology transfer.

2.1.6.3. Effects on competitive abilities of the country
Since one of the important objectives of each country is to find high position in science and technology and to be pioneer in one or more fields of science and technology for ease of trade with developed countries. Some kind special technologies would have higher priority.

2.1.6.4. Effects on socio-economic and cultural development of the country
In this regard, first group of criteria is related to economic impacts including promotion of GNP, employment and export and in some cases considerations of waste minimization, conservation of energy and resources. Other group of criteria is related to quality of life, social and cultural impacts including welfare, health and environmental improvement.

2.1.6.5. Effects on national Security
Improvement of national defense ability and increase of national security are being considered in technology transfer. In addition to the above mentioned criteria, additional criteria include: (a) importance of national defense abilities and (b) food security and (c) optimum use of rare resources.

2.1.7. Determination of priority for each sub-sector of transport sector
Iran's transport sector consumes a significant portion of energy at national level (almost one third of the overall energy), producing large amount of air pollutants and greenhouse gases. Within transport sector, light and semi-heavy vehicles have the highest share of energy consumption. The other modes of transport such as air, international bunkers and rail transport stand in the next ranks, respectively. Transport sector is suffering from inadequate technologies compatible with energy saving as well as with the environment. Considering high-energy consumption in the transport sector and sever air pollution in at least seven major cities of the country, higher priority must

be given to this sector. In summary, the priorities of transport sector can be grouped as follows:

- Road transport including light duty vehicles and public passenger buses
- Rail transport, which is a suitable substitution for road transport
- Air transport that due to some political problems has old vessels
- Marine transport that is active in goods transport or oil.

Considering the aforementioned points and the significant contribution of road transport in GHGs emission, it seems that investment in this field will have reasonable results and positive impacts both on natural resources as well as on the environment.

2.1.8. Prioritization of technologies to combat the impacts of climate change

Based on I.R of Iran's policies, ten criteria have been identified for selection of technologies as follows:

- Gap and lack of expert manpower,
- Improved social welfare, health and environment,
- Existence of natural resources and equipment,
- Ability to ensure food security, provide basic goods and use rare resources properly,
- Extent to which the technology is diffused,
- Short term access to technology,
- Opportunities and threats of global markets,
- Improvement of defense capability, and
- Possibility of reduction the gap with developed countries by focusing on some certain industries.

Considering the above mentioned criteria, some of the most important technologies for GHGs emission reduction have been identified as:

1. Technologies (Tech) in relation with optimization of combustion efficiency in CIE.
2. Tech in relation with optimization of combustion efficiency in hybrid transport.
3. Tech in relation with optimization of combustion efficiency in fuel cells
4. Tech in relation with optimization of combustion efficiency modification and substitution of combustion system in vehicles
5. Use of more advanced systems in traffic control
6. Application of substituting fuels in combustion engines to reduce fuel consumption and pollutants
7. Application of modern energies in vehicles
8. Application of train with modern technology

2.1.9. Investigation on Constraints for technology transfer

At present, proper technology transfer is essential for the country and in order to achieve this goal and localize the technology research and scientific activities should be enhanced. Although in recent years, more attention has been paid to technology transfer the results of which have been rather successful, studies in the country reveal that many hard and software are being lavishly imported into the country but not much attention has been paid to other factors such as management or organizational skill of manpower.

Therefore, some constraints of technology transfer are as follows:
1. Shortages of expert manpower
2. Shortages of research facilities at the universities, educational and research institutions.
3. Shortages of capital and financial resources
4. Cultural and social problems
5. Resistance of some developed countries to export some high technologies
6. Lack of R & D units in many industrial plants
7. Financial resources shortages
8. Lack of well-established and modern infrastructures
9. Inefficient laws and regulations

Table 2.2 shows a list of required technologies and available constraints.

Table 2.2: Constraints of technology transfer

Technology	**Constraint**	Priority
Tech related to optimization of combustion efficiency in CIE	1. Existence of bans and situation on global market 2. Relatively long time in technology trades	1
Tech related to hybrid transport	1. Lack of allocation of sufficient funds 2. Lack of the required other resources 3. Lack of expertise manpower 4. Long time to achieve technology transfer 5. Imposing bans on foreign trade	2
Tech related to fuel cells	1. Lack of skillful man powers 2. Relatively long time in technology transfer	3
Tech related to modification and substitution of combustion systems in vehicles	1. Lack of sufficient investment 2. Lack of advanced equipment 3. Existence of some bans 4. Lack of skillful manpower	4
Application of substituting fuels in vehicles aiming at improved fuel combustion and pollution reduction	As the some as Item 4	5
Modification of fuel & use of modern fuel in vehicles	As the some as Item 4	6
Train with new tech	As the some as Item 3	7
Light materials	As the some as Item 4	8

2.2. Industry

2.2.1. Potential for GHGs emission reduction in Iran's industrial sector

Different countries apply different criteria for selection of technology considering their national objectives and development plans for different sectors of their economy. Therefore, selection of appropriate technology is carried out on the basis of objectives of development such as employment, access, efficient utilization of resources and materials. Appropriate technology is determined considering the degree of development and different approaches in country. Criteria for selection of technology would change with consideration of social, cultural, economic infrastructure and industrial and economic development strategy.

In I.R. Iran considering the socio-economic, regional circumstances and development plans, it is necessary to pay attention to find an appropriate technology. The deputy minister for technology of the Ministry of Science, Research and Technology lists the following indicators and criteria for prioritization of technology transfer,

A. Capabilities, possibilities and advantages in relation with the technology. This group of indicators would consider natural resources, equipment and expert manpower.

B. Possibilities to access the technology. This group of indicators is dealing with the time required to access the technology considering development objectives which are threatened by international bans and existence of keen competition in this field.

C. Effectiveness in increasing competitive abilities. This group of indicators would pay attention to access the high levels of Science, technology and global economy. Using appropriate technologies the country could reduce its technological gap with developed countries.

D. Effectiveness in socio-economic and cultural development of country. This group of indicators would take into account the socio-economic and cultural effects including increase of gross national product (GNP), employment and export as well as waste reduction and conservation in consumption of materials and energy. The social effects include cultural changes, public health, welfare and level of life, in addition to the effects on the environment.

E. Effect on national security. This indicator includes improvement of defense ability of country, increase of national security, food security and effective use of rare resources.

Regarding GHGs emission reduction technologies, it needs short and long - term planning. The application of current technologies that are used in developed countries would be effective because majority of industries in the country are old and therefore. Some methods for reduction of GHG emission are as follows:

- Substitution of fossil fuels by renewable energies
- Substitution of natural gas with liquid fossil fuels
- Increase of efficiency of fuel consumption
- Upgrading the high energy intensive industries.

Application of some of the technologies mentioned above have certain limitations with respect to economic and political circumstances of the country. In addition, the current laws and regulations should be revised.

2.2.2. Determination of criteria for prioritization of technologies for proper selection and transfer of technologies considering climate change objectives

Technology transfer can be carried out by different ways as follows:

2.2.2.1 Foreign Investment

One or more foreign companies do the investment either directly or jointly with the host country. In this case appropriate actions should be taken for transfer of technology through negotiations.

2.2.2.2 License

The required technology is being purchased from technology-owner which is a suitable means for technology transfer.

2.2.2.3 Turn- key contract

Technology owner is being committed to carry out the whole managerial and engineering services and deliver the technology.

2.2.2.4 Engineering technical services contract

A series of expertise and technical services are being at disposal of the client.

2.2.2.5 Know-how contract

The contract is sometimes called *"technical knowledge"* contract. Important information would not be at disposal of the client and only the data for construction and operation of a production unit with a given capacity would be accessible for the client.

2.2.2.6 Franchise contract

Some part of income as the result of the implementation of the project would be at disposal of licenser. This type of contract usually leads to higher quality of product and suitable marketing.

2.2.2.7 Inverse engineering contract

Technology transfer is being carried out through duplication of machinery. It is highly depended on experienced engineers and various hardware. This approach is applicable when the technology-owner refuses to deliver the requested technology.

2.2.2.8 Importation of machinery

Through importation of machinery, a kind of technology transfer is being carried out. Local technological capabilities and technical management might affect on the success of this approach.

2.2.2.9 Buyback contract

Technology-owner would provide the required goods for production of materials and it buys back the produced goods as well. Technology-owner supplies the technology and the host country supplies natural resource and energy.

In the First National Five-Year Socio, Economic and Cultural Development Plan (1990-1994), the industry sector had been considered as one of important economic poles. In this plan self-reliance in industrial sector through application of interior resources and development of technological capabilities had been focused. In Second Plan (1995-1999) technology transfer was considered which was accompanied by foreign investment promotion and development of industrial good's market at international scale.

During the First and Second Five-Year Plans no particular strategy was followed with regard to technology transfer. Thus, wide spectra of technologies from simple to complex ones have been imported into the country with no specific plans for technology transfer. In the Third Plan (2000-2004), preparation of the required circumstances for development of foreign investment, incentives, optimized utilization of technology developments and establishment was taken into consideration. Considering the prevailing international bans-on the country, implementation of technology transfer had some obstacles and therefore only the most simple technology transfers were used. This included engineering services contracts, inverse engineering contracts and import of machinery where the experience of other developing countries was valuable. The criteria for selection of technologies to reduce GHGs emissions are yet to be developed.

2.2.3. Prioritization of technologies for industrial sector

Considering the outdated industries in the country and the fact that industrial renovation is in the agenda of the government, modern technologies with less air pollutants and greenhouse gas emissions should be considered in development of industrial sector in the Fourth and Fifth Five-Year National Development Plans. According to Iran's Initial National Communication (INC) to UNFCCC, the energy sector contributed to more than 75% of GHG emissions which reflects the importance of technology transfer in that sector. In industrial processes sector, metal producing industries had the highest share in GHG emissions whereas the pulp and paper industries contributed the least (see the following paragraph for more details).

It seems reasonable to prioritize technology transfer as follows:

A. Technology transfer for newly constructing industries
B. Technology transfer for existing industries on the basis of their GHGs emission

It should be noted that considering privatization of industries in Iran along with some financial incentives that have been recently provided by the government for energy efficiency activities have made private sector more interested in this field.

2.2.4. Collection and compilation of information for substituting technologies

Establishing a data bank on the existing industries with respect to their technology and collection of data and information on modern technologies that are available in the world, the planning process for substitution of current technology with modern technologies would be facilitated. In this regard, it is very useful to collect data on the consumption of water, electricity, fuel, material; type and amount of emissions; energy intensity; energy efficiency, current pollution control devices; etc.

2.2.5. Technology prioritization considering the objectives of drastic changes

Generally technology prioritization in industry might be as follows:

- Clean technologies
- Pollution control technologies
- Energy consumption optimization technologies
- Waste minimization technologies
- Fuel substitution technologies

Another prioritization may be used based on the level of GHG emissions. According to INC the contribution of industrial processes to GHGs emission in the country are:

- Basic metals producing industries
- Chemical, petrochemical and coal industries
- Food beverage and tobacco industries
- Machinery and equipment industries
- Paper, paperboard and press industries
- Textile, clothes and leather industries
- Non-metallic industries
- Wood and wooden products industries

2.2.6. Barriers and obstacles for GHG emission reduction

2.2.6.1 Financial and investment obstacles

– Shortage of cash and capital of industry owners and of foreign currency as well as the unstable foreign currency.

2.2.6.2 Shortage of expert manpower

– Lack of information on the needs of industrial sectors to the skilled manpower, inefficient training and problem of employment of expert man power due to the low wage.

2.2.6.3 Limits to utilization of energy resources and materials

– Limitations on the production and distribution of energy resources and materials.

2.2.6.4 Lack of consistency within technologies of different sub-sectors of industry

– Lack of harmonization within available technologies has been caused chaos, as there are some modern technologies as well as very old ones. This is the reason of non-traditional growth of industry in Iran.

2.3.6.5 International bans

– Iran has been banned by technology-owners causing critical problem to access modern technologies.

2.2.7. Some actions for overcoming the obstacles of technology transfer

To overcome technology transfer obstacles, proper planning is needed and preparation of an action plan is required. It is necessary to note that some factors like cheap manpower, low price of energy, lack of transparency in laws and regulations in industry sector have caused foreigners to invest in Iran. Practical approaches to overcome technology transfer obstacles are as follows:

- Formulate appropriate and transparent laws and regulations,
- Remove administrative bureaucracies and establish appropriates managerial structure,
- Provide the funding needs and appropriate exchange-currencies policies,
- Train manpower and establish the relevant courses at the universities,
- Plan for application and utilization of renewable energies,
- Establish of R & D programs,
- Support local consulting companies which work on technology transfer,
- Document the technology information,
- Rationalize the energy prices.

2.3. Power generation, Residential and Commercial

2.3.1. Programs and polices of technology transfer

2.3.1.1 Introduction

Assessment of the most efficient technology requiring least cost for reduction of GHGs emission is considered as one of the main policies and programs. The role of government regarding information, regulations and standards and predicting of market situation is very important. Government should also prepare programs to raise public awareness about accessibility of investments in line with climate change. This also encourages experts who have been trained about stages of technology transfer. With regard to the alternative sources of energy, the transfer of technology should be associated with maximizing the level of information and know-how in the relevant technologies. Legislation for setting a minimum efficiency requirement for power sector, aimed at employing efficient technology, is useful and necessary.

These alternative energy sources include: technologies for small hydro-electric plants, making use of existing natural flare gas, combustion (incineration), aerated digestion of solid municipal waste, bio-fuels, solar heating, combustion of biomass, use of biological digestion apparatus, conversion of coal and biomass to gas, cogeneration (combined heat and power) and construction of wind farms.

2.3.1.2 Assessment, confirmation and implementation

In order to assess different technologies for selection and implementation, we need to set up relevant criteria. These criteria can be the capabilities and advantages of the technology; accessibility of technology; effectiveness of the technology to enhance competitive abilities; competitiveness in science, technology and global economy; utilization of appropriate technologies to reduce technological gap between the developing countries and developed countries; economic, social and cultural development of the country; increase in gross national product (GNP); new job opportunities; higher exports; waste reduction and conservation in consumption of material and energy; cultural up-grade; better hygiene; enhancement of social welfare; protection and preservation of the environment; higher national security; improvement of defensive capabilities of the country; increase of national security; food security; and effective use of rare resources.

Once assessment of the technology is complete, it is important to test it to see how it can lead to the opening of the next stage. Market accessibility is an important condition for the success of new technology. Share of market will be important until private potential partners with short-term interests can invest in new technologies (available and certain market).
Technology implementation along with job creation in local societies is bound to succeed. In such circumstances, use of renewable energy sources to reduce GHGs emission, can be considered as a sound activity. Another way for assurance of implementation of a technology is use of legal systems obviously; a positive bond exists between energy access, electricity services and teaching activities.

2.3.1.3. Obstacles of technology transfer between countries

The following obstacles may be encountered when transferring technologies among countries:

a) *Access to capital*: The necessary capital costs for technology transfer is generally more than conventional technologies.
b) *Tariff:* Although the country is revising its trade policies to promote free marketing, but tariff obstacles have remained for import of foreign technology including energy supply equipment.
c) *Role of stakeholders:* Certain stakeholders with strong lobbying influence at national level such as oil and gas companies, or manufacturers of equipments are able to influence the selection of technologies.
d) *Institutional arrangement:* There are organizational and operational difficulties for making contracts for technology transfer, especially the constraints that exist in the international contracts.
e) *Information and networking:* There is limited access to the relevant information in the country. It is therefore necessary to strengthen information technology in order to develop communication both within the country and with other countries.
f) *Legal regulations:* A basic need for fruitful agreement in technology transfer is to make sure of the existence of the legal regulations without which there shall be little tendency by private firms in transfer of technology.
g) *Tendency for well-established technologies:* Generally, the emphasis in the country is on large capacities of power generation with low price with high reliability and low technical risk. Thus there are little priorities for modern technologies in the power sector. An important reason for the tendency of not giving priority to modern technologies is that there are numerous obstacles arising from international sanctions against Iran.
h) *Financial incentives:* At present there are little financial incentives for those who need technologies. This matter is essentially observed in conditions like Iran, in which energy price is still low and at the same time ability for financing new investment is not so high enough.

2.3.2. The essential needs in technology transfer in power sector and in residential - commercial sectors of Iran

2.3.2.1 Power sector

The power sector of the country requires technology transfer and investment in the following areas:

- Improvement of combustion equipment on the basis of fuel quality, fuel injection system and other attachments of boilers. The approximate cost of complete system of combustion apparatus is between 100,000 and 500,000 US dollars depending on the boiler size and other conditions.
- Improvement of boilers and its accessories including heat exchangers, problems associated with the amount of carbon volume in ash, higher temperature of exit gas from stack, difficulties associated with acid dew point of the gas passing through air heaters and corrosion, manual control of boilers and exact measurement of fuel.
- Upgrading the turbine cycle: The associated cost of this improvement for natural gas fueled turbines is about 480 to 570 dollars per kW (120 - 440 MWe) and for turbines fueled with furnace oil is about 540 to 580 dollars per kW (120 – 210 MWe).
- Diminishing disturbing loads from auxiliary and supplementary apparatus.
- Heat recovery systems at a cost of about 1,000 US dollars per kW of the recovered energy from exhaust heat or process hot streams.
- Installing co-generation systems (heat & power) with the cost of about 1,000 dollars per kW (for industrial systems
- Increasing the achievable capacity by improving maintenance system, regular overhaul and modern control systems.
- Energy management systems: The cost for one unit with a 100 million kWh load per year is about 750,000 US dollars with energy saving to be 10%.
- Optimization of conductor and phase current with a cost of about 20 to 25% of total expenses of the transmission lines.
- Installing more efficient transformers with a cost of about 5 US dollars per MVA plus 4,100 up to 6,000 US dollars per each kW for the load losses. Approximately 750 US dollar per kVA plus 3,000 to 6,000 dollars per each kW for losses on load.
- Raising and stabilizing transmission line voltage with cost of 50,000 to 750,000 US dollars per km depending on the line voltage.
- Installing new and more efficient transmission lines.
- Establishing new technologies and standards for power transmission and distribution systems.
- Reducing the electricity losses, active: with cost of about 12 to 20 dollars per kVA.
- Upgrading and automation of distribution equipment.
- Reduce losses on conductor with the cost from 15,000 to 50,000 US dollars per one km.
- Establishing the measurement and monitoring the greenhouse gas emissions in the power sector.

- Revision of the emission factors of greenhouse gases in the energy and power sectors.
- Reduction of the environmental risks and hazards in the generation, transmission and distribution of electricity.

2.3.2.2 Determining the requirements of technology and financing methods for renewable energies used as a mitigation option for GHGs emission

- *Biomass:* For a unit 2 to 100 MWe with an average cost of about 530 to 600 US dollars per kW for industrial units and 300 US dollars per kW under conditions when energy sources are accessible geographically.
- *Geothermal Energy:* With size of 1 to 110 MW and cost of 840 to 2,500 US dollars per kW.
- *Small hydro:* With size of 1 to 20 MW and cost of 1,000 to 3,000 US dollars per kW.
- *Waste burning power plant.*
- Training programs and workshops for policy makers and experts.
- *Photovoltaic:* For generation of 5 to 10 MWe electricity by this method the cost is from 600 to 2,000 US dollars per kW in systems whose module costs are about 5,000 dollars per kW.
- *Solar thermal:* For generation of 30 to 80 MWe to 1,600 MWe the cost is about 3000 US dollars per kWe, central receiving systems 3,300 US dollars per kWe to 100 MWe or 2,800 US dollars per each kWe up to 200 MWe, parabolic receiver: approximately 1,700 to 3,000 US dollars per kWe.
- *Biogas:* Fuels obtained from waste: with capacities of 1 to 5 MWe or 30 to 100 MWe (they come in two ranges) with an approximate cost of 91,000 US dollars per Mt from daily capacity MSW (Municipal Solid Waste), 4,750 US dollars per kWe for biological gas.
- *Wind energy:* For capacity of 100 to 1000 kWe or 1 to 50 kWe with a cost of 1,000 to 1,200 US dollars per kWe plus the cost of 1,900 to 2,200 US dollars per each kWe for distribution and network connection and the cost of 2,400 to 5,600 US dollars per kWe for battery storage.

Table 2.3 summarizes the fundamental obstacles and policies needed in technology transfer in power sector.

Table 2.3: Fundamental obstacles and policies needed in technology transfer in Iran's power sector

Technology transfer	Main users	Key routes	Main obstacles	International obstacles	International policies
Efficiency improvement Power generation, transmission and distribution	Regional organizations, equipment manufacturers	Private sector (very little) and public sector	Local technology and managerial expertise	Restrictions in import of the equipments and spare parts of power plants	Capacity building and promotion of FDI
Replace fuels with lower carbon volume Biomass: Biomass sources: Biomass conversion	Oil and gas companies Power utilities Food producing centers and… Power utilities, equipment manufacturers	Private manufacturers and public societies - - - -	Economic cost Logistic infrastructures Land use competition Economic costs Fuel standards	Economic cost	Legal policies Monetary policies

2.3.3. The essential needs in technology transfer in the residential - commercial sector

Introduction

Article 4 of the UN Climate Change Convention is regarding technology transfer from developed to developing countries for mitigation and adaptation. In particular, the Clean Development Mechanism of the Kyoto Protocol emphasizes the transfer of technology from Annex I parties to Non-Annex I parties.

2.3.3.1 Limitations on determining effective technology transfer

Assessing technology transfer necessarily requires clear knowledge of limitations such as:

- Environmental limitations for emission of GHGs and other pollutants
- Economic and social limitations
- Operational, organizational and political limitations.
- Expense and geographical extent of technology transfer
- Organizational capacity building in long term
- Priorities in monitoring and evaluation
- Obstacles that reduce the effectiveness of the program.

2.3.3.2 Residential, commercial and buildings sectors

Investment in this area, in addition to reduction of GHGs, can have the following advantages:

- Reduction of future fuel cost
- Creation of healthier and comfortable indoor environment

- Production of more efficient work places
- Achieving environmental improvements
- Long-term investment

The most effective approach that has been successful in Iran is fuel switching to natural gas which has resulted in significant reduction of GHGs emission.

2.3.3.3 Technology needs for mitigation of climate change effects in the residential sector

There are three strategies that can reduce energy consumption in the residential sector:

A) Strategies for building insulation
B) Strategies for building appliances
C) Strategies for use of renewable energies

A- The required technologies include better insulation of walls and floors, double glazed windows, improved ceiling insulation, and more efficient cooling/heating systems.
B- Based on several studies that have been carried out in the country for energy saving in home appliances, technologies are needed for improving cooling, heating, lighting and cooking systems; raising efficiency of fridge, water heaters, washing machines and dryers, air conditioners and other appliances used in homes.
C- The needed technologies for renewable energies include the design of solar passive buildings and active systems for heating of water and space using solar energy, heat pumps, strategies for using natural light during the day and photovoltaic systems. In residential sector it is important to take into account the climate and geographical conditions of the building. It is also important to differentiate the buildings that are in the cities or rural areas, or whether the building is a house or a multi-apartment high rise. Making use of computer models commonly used in the world is another part of Iran's technologic needs in the residential, commercial and office type buildings.

2.3.3.4 Commercial and office buildings

This subsection comprises a variety of buildings: such as offices, shops, schools, hospitals, hotels, stores, theatres, holy religious places, etc. Since many similarities exist between the office buildings around either it is in developing country or it is in developed countries, essentially the same saving strategies can be applied similar climatic conditions. These include:

- Strategies for building insulation which depend on building size and type as well as the climate.
- Strategies for building utilities and appliances including heating, cooling, efficient lighting, control systems of energy management and office equipment efficiency.
- Strategy for application of renewable energies includes photovoltaic, active and passive systems and day lighting.
- In the near future, increased use of information and communication systems based on the Internet, may cause drastic changes in the form of work place such as working at home.

2.3.3.5 Constraints and gaps in technology transfer in residential sector

The existing obstacles in technology transfer in the building sector are summarized as:

- Lack of sufficient knowledge about new technologies available
- Initial high price of technology

- Existence of subsides for electricity and fuel
- Lack of proper services for maintenance and repair
- Variety in buildings codes and the utility equipments
- Current limitations in residential building materials

2.3.3.6 Role of government, private sector and NGOs in technology transfer

The government has a very important role in technology transfer including public awareness and program, energy pricing policies, development of energy and environment labels and standards, development of energy codes for buildings, home appliances and utilities' efficiency standards and its support for R&D. The government has a strategic role in transfer of "safe and climate friendly" technologies that are responsible for mitigation of climate change and reducing the vulnerability to climate change such as policies for land use and infrastructure development. Government policies influence market situation by way of proper subsides, incentives and tax programs. These policies will then affect tariff rules, import and export controls and other regulations.

The primary role of the private sector owners is to respond to the user demand by providing the necessary services to the building sector.

The role of social groups such as NGOs is also important in building sector. The can influence the public to change their habits of daily life for conserving the environment, by developing manuals for environmental friendly buildings even at lower costs.

2.3.3.7 Awareness and training programs

In the country, the most principal obstacles in technology transfer for increasing energy efficiency and operations compatible with environment are:

- Lack of information about the effects of decisions on technology transfer and the means of improving and rendering them effectively
- Lack of sufficient information for the public on how to reduce energy losses at their homes
- Lack of information for building owners and for operators on the performance and maintenance of equipments in order to reduce costs
- Lack of information at schools and other public places and limited access to guidelines and manuals

Trend of transfer of technologies compatible with the environment depends on the activity and performance of many sectors in the country.

2.3.3.8 Technological needs in the building sector

We need to consider the following issues in building sector:

- Energy consumption in the process of producing building materials
- Transfer of building materials to the building site
- Re-use of the building rubble
- Physical durability of building materials (materials lifetime of the time during which the structural parts of a building maintain their chief physical capabilities)

- Proper building maintenance
- Adaptation of building units with modern needs
- Tradable licenses of emission in building sector
- Building design standard
- Energy audit program.

The municipalities, the engineering code of practice and standards have a very important role in the implementation of mitigation options in this sector.

3. Technology transfer policy making for mitigation of GHGs

3.1. Transportation

3.1.1. Determining factors for planning of technology transfer in order to mitigate GHGs emissions in transport sector

Iranian industries in general and Iran's Car Manufacturing Industry (CMI) in particular do need foreign investment for improvement its product and achievement of global standards. Since foreign investment may create more possibilities for obtaining technical and managerial skills in the country's CMI, this sector seems suitable for technology transfer through foreign investment.
The required policy frameworks should be provided for foreign investors, i.e. there is a drastic need to revise the laws governing foreign investment, membership in international trade treaties. Business-facilitating factors (BFF) are absent but from the standpoint of financial incentives, car industry is supported by rules and regulations of Ministry of Industry. It seems that the Ministry of Industry should modify its industrial polices in the field of car manufacturing in order to modify the political frameworks sponsoring foreign investment.

3.1.1.1. Political frameworks

The policy framework for foreign investment must include:

- Political stability
- Economic stability
- Important requirements and activities of multi-national firms
- International treaties concerning foreign investments
- Trade and commercial policies

3.1.1.2. Determining economic factors in foreign investment

The determining economic factors in foreign investment are:

- Market - searching capital
- Finance - searching capital
- Productivity searching capital

3.1.1.3. Business facilitating factors (BFF)

The business facilitating factors are:

- Creation of mental imagination through propaganda
- Investment - creating activities
- Service after investment
- Financial incentives
- Social facilities

3.1.1.4. Policy framework for foreign investment in Iran's transport sector

The essence and core of these policies includes involvement and activity of multi-national firms in the country which require sponsoring acts and regulations. Other policies refer to the commercial and macro-organizational policies.

Core policies of Iran's foreign investment:

Based on constitutional law (Article 81) Registration of a foreign firm is prohibited. All Joint Investment contracts should interpret using alike legal acts. It could be legal acts of the third country. Majority of foreign investors does prefer to Judge and evaluate and then try to deal with their problems in accordance with ICC. Concerning with Iran, Public property claims would refer for Judgment upon cabinet's ratification. Nevertheless ratification of International Commerce Judgment act could be considered as significant steps towards facilitating international contracts. In Iran situation on international treaties is not clear and desirable. Since New York's convention on recognition and enforcement of International Judgment has not been recognized and the country is not a member of international center for settlement of investment disputes and multilateral investment guaranty agency (These two agencies are affiliated to the World Bank). Signature of an agreement for avoiding double taxation of multilateral firms with developed countries is necessary.
In other world, fair behavior of the host country is critical factor in determination of Investment site. In this regard existence of desirable circumstances for private sector would be the necessary requirements for fair behavior. Transparent polices might facilitate activities of multilateral firms in Iran's car manufacturing Industry. Purchase of government firms stock is prohibited. There is not any obvious in the current regulations for purchasing stock of governmental firms. Anyway if privatization process is properly carried out, it could enforce local firms.
Foreign Investment supports and Absorption Act is one of another law describing behavior with foreign firms. It has been rafted in 1955. Recently it has been revised in Iran. Foreign termed investments have been supported in framework of different finance methods. For example BOOT and buy-back methods provided that foreign investment lead to beneficial turn- over.

Free trade zone act:

Ample Incentives and special facilities for foreign investors have been included in such a way that foreign investors (FI) would gain more benefits for their respective countries.
Foreign Investors do not work law and social insurance provision FI are exempt of Tax for 15 years in free trade zone. FI could organize their activities with their desired stock contribution in Free Trade Zone.
Foreign Investment is allowed in Banking, Insurance and non-Banking credit institutes.

Iran's Commercial policies on foreign investments:

Commercial policies are supplementary ones that might effect on investment site. Costume tariff and quantity limitation on import of given goods would create a strong incentive for foreign investment aiming import substitution.
Export of industrial goods is one of strategic objectives that country should take proper steps toward foreign trade liberation membership in WTO and real Valuation of national currency to avoid discrimination against export.

Foreign Exchange Rate Policy could also affect on decisions of multilateral firms. It would influence on value of host country's properties; value of benefit transmitted abroad, competition potential of affiliated firms. Under high inflation in the country, foreign exchange rate would imply on high tax on foreign investors and exporters. Considering this fact Central Bank of Iran has allowed computation of exchange rate on basis special exchange rate. This act will lead the exchange rate to a more real price.

Economic stability

Financial, monetary and foreign currency determining economic stability would influence on all kind of investment. As these polices would leave implication tax, interest rate access to bank credits they would affect on cost of in the host-country, beneficiaries of investment, and risk of investment. Iran tax system is formulated on basis of Interior Industry support. Nevertheless attempts are going to be carried out for some modification in the system.

3.1.1.5. Determining economic factors for foreign investment in the process technology transfer

Recently, drastic new developments have occurred in the world with the strategy of multilateralism which has restructured the automotive industry. Recently a number of car manufacturing firms have been merged. For example, General Motors bought Vauxal and Opel companies. It also affiliated with SAAB through purchasing some part of its stocks. The effect of these merging initiatives is so significant on centralization of auto-manufacturing industry so that only 10 car manufacturing companies contribute about 69% of the global production of cars. The reason of these initiatives might be cost reduction. Nevertheless, situation in north - south countries is completely different.

Foreign firms seek cheap competitive markets where they can be assured of lowest cost and high security. In transportation industry the share of water, electricity and fuel is quite high, whilst the labor's share is just 14 to 20%. Thus, availability of cheap utilities is of high priority for automobile parts manufacturing companies, whereas manpower is of the second priority.

Although for the case of Iran the labor cost is relatively low, the complex acts for employment raises the labor costs. The site advantage still applies to Iran, but since car manufacturing is not an energy intensive industry, energy cost does not have an advantage in this industry.

3.1.1.6. Facilitating factors of foreign investment for technology transfer

Promotion of incentives, improvement of services after investment, reduction of administrative costs and providing social facilities are the items that would facilitate foreign investment. However, considering the national development plans in recent years with sustainable development objectives, it can be inferred that the reduction of environmental hazards should be taken more seriously.

3.1.1.7. General approaches for removing obstacles of technology transfer in the country

Consistency in plans, polices and activities of different organizations in process of selection, transmission, absorption, acceptance and development of the technology to specify extend fall within realm of duties realm and responsibility of management of transmission and development of technology in different macro-economic firms technology.

Establishment of Technology Information Bank

- Integration of comprehensive technology development in future economic development

- Application of political appropriate tools with regard to development of secret technologies in order to establish a stable relation within them.
- Promotion, research and development in private and governmental sectors, establishment of stable relation within R & D sections of industry, universities and establishment of suitable field for innovation
- Development of International and regional cooperation in fields of technological informational and experience of other countries in the region regarding technology transmission. Application of appropriate tools for direction of foreign investment for industrial-economic and technological objectives.

3.1.1.8. Creation of some possibilities for modification of manpower to human capital

- Revision of Organization and legal functions and responsibilities of the related organization with regard to developing scene both for in industry and technology.
- Evaluation of acts, control mechanisms, function of the related organizations, short and long-term, plans, policies of technological development for removing possible obstacles.
- The following should be noticed absorption of foreign investment despite of Positive effects in technology transmission and technical knowledge:
- existence of abilities to analysis information relating to international investment process
- Harmonization of interior institution development with industrial development strategy in foreign direct investment.
- Improvement of the level of interior institutions by government. Since, developing interior firms, possibilities for accessing to technology of multilateral firms would be facilitated.

3.1.1.9. Technology transfer Approaches Evaluation of the third Eco-socio-cultural development plan

The Third Socio-economic and Cultural Development Plan has been formulated with consideration of inter-sector development and with emphasis on structural and institutional, adjustments. The plan is basically structure – adjusting plan in national economy. The main objectives of the plan are structural and institutional adjustments in public sector for improving products of government, increase of national resources productivity and improvement of non-governmental organizations. In recent years, positive attempts such as tariff obstacle reduction, relatively trade liberation remove of unnecessary provisions; equalization of foreign currency has been carried out. Nevertheless, establishment of an industrial strategy does need an integrated and harmonized system constituting by macroeconomic policies, development of technology and skills, to organize industrial activities, finance and development of infrastructures. Therefore, formulation and implementation of Iran industrial polices need to pay attention to environmental factors in order to provide desired industrial development perspective. It needs to direct industrial activities through market-oriented interventions of the government. Therefore increase of competition ability of industry would be the main objectives of industrial development strategy considering the policies related to creation and transmission of technologies and R & D policies and increase of man-power skills.

3.1.1.10. Approaches for formulation of climate change-compatible technology transfer

- Domestic (or National) institutions can develop their planning for technology transfer through cooperation and supervision of international organizations.
- Expanding the information exchange and developing strategies for application of clean technologies.
- Conducting training workshops by cooperation of international development agencies for technology transfer emphasizing on formulation of action plans for clean technology transfer.
- Governmental support for developing active national centers and private companies in technology transfer, sustainable development and environmentally compatible technologies.
- Investigation and classification of information and projects on current policies in relation with climate change and reduction of fuel consumption.
- Enhancement of information capacities of interior institutions
- Firms and private-owned companies should be promoted to participate in commercialization of clean technologies through ensuring engineering services and technical assistance.
- International organizations should support the national networks aiming development of information and services technologies. This is the most convenient and effective method for ensuring technology transfer on basis of real needs of industry in the country.
- International institutions and bilateral cooperation agencies should provide the required information on trade and industry.

3.2. Industry

Iran's industrial sector does need technology transfer and participation of international investing companies for achievement of global standards. Therefore the political and economic frameworks should be modified to the extent that foreign investors would be interested to invest in the country. Effective political and economic framework for absorbing foreign investments in the field of technology transfer could briefly be categorized as followings:

- Political stability in country
- Adequate trade policies
- Ratification of transparent laws
- To enter into international treaties
- Appropriate propaganda
- Creative activities
- Services facility
- Reduction of bureaucracy
- Consequently, easy and suitable circumstances would cause to promote capital and technology owners to participate in investment in the country.
- Considering that other countries are competing to reduce their strike regulations for foreign investments, if the limiting factors are not removed and modified, the capital absorption and technology transfer can be stagnated.

3.2.1. Identification of the required resources and capital for action plan for GHGs emission reduction in industry

For technology transfer to the country it is necessary to identify the foreign lending institutions and the firms offering technology transfer. Based on Article 81 of the Constitutional Law, registration of any foreign company in the country is strictly prohibited and each joint investment contract has to be approved by the officials. As there is no possibility to purchase stocks of the national companies by foreigners, this would cause huge obstacles for easy technology transfer to the country. The limiting factors for foreign investor are as follows:

- Lack of official permission for purchasing stocks of the national companies by foreigners.
- Possibilities to illegal actions through the government in emergency situations
- Lack of membership of the country in ICSID
- Lack of transparency in economic policies and regulations.

Therefore, as a critical step in technology transfer, it is necessary to revise the current regulations. It is also important to identify the potential foreign investors once the legal barriers have been removed.

3.2.2. Executive approaches for achieving GHGs emission reduction's objectives

The executive approaches for technology transfer aiming at GHGs emission reduction might be summarized as follows:

3.2.2.1. Harmonization within organizations and responsible agencies and preparation of a common plan

Nomination of fully authorized representatives to participate at joint meetings in order to identify the main issues and become familiar with the abilities and common problems among sectors, this would avoid the possible parallel activities among different ministries and organizations and would help them to prepare a common coordinated plan.

3.2.2.2. Determination of different levels of technology transfer

Depending on the conditions of each industry with respect to its expertise, machinery, the investment needed, etc. different levels of technology transfer might be appropriate, otherwise technology transfer may lead to huge investment losses.

3.2.2.3. Harmonization with national development plans

Planning for transfer of technology needs careful harmonization with the existing official national development plans, otherwise technology transfer may interfere with such plans with adverse effects.

3.2.2.4. Establishment of Technology Information Bank (TIB)

Identification of technology owners and development of mutual cooperation with them is highly important in this field. It is therefore necessary that a Technology Information Bank (TIB) be developed as a reliable reference for planning a proper program for transfer of environmental technology.

3.2.2.5. Development of research centers

Establishment of research centers in different industrial sectors of the country would help to localize the technologies with consideration of circumstances of the industry. Localization of technology in a given industry would cause to create new movement in near future while it would help the manpower to become familiar with the new technologies. In this regard, relationship between the industry and universities can be highly beneficial.

3.2.2.6. Economic regulations

Enacting transparent regulations and modifying the current laws will lead to transparent situation where foreign investors and private sector could wisely take action. Modification of tax regulations and manpower employment laws is of significant importance in this field. For example, free trade zone regulation of the country could be considered as a desired prototype model that could absorb foreign investment and new technologies.

3.2.2.7. Exchange of regional and international experience

Establishment of bilateral relationships with the countries in the region in order to share experiences and technology information is of high importance since it helps to better understand the advantages and disadvantages of a given technology.

3.2.2.8. Development of culture of technology in country

Preparation of cultural grounds for adoption of technology is necessary through organizing seminars, training courses and mass media, because certain technologies may have a deep conflict with culture of people in hosting-countries.

3.2.2.9. Training of expertise manpower:

Training of expert manpower is of high significance for application of a new technology since this would facilitate the proper implementation of the technology at local level and also it would be able to propose possible modifications on the technology in order to localize it. Training of manpower might be carried out through formal education and short courses both abroad and within the country.

3.2.2.10. Capital and financial credits

For purchasing and transferring the technology, it is necessary to access sufficient financial resources. The required costs for purchasing land, plant construction, wages, foreign currency and other costs such as purchasing equipment and technical knowledge should be provided. Both interior and exterior financial resources should be specified.

3.2.2.11. Establishment and designation of consulting engineering companies

Establishment and designation of servicing and consulting engineering companies would provide the desired grounds for technology transfer to a country. These companies can offer some economic and engineering services for technology transfer.

3.2.2.12. Development of promotional policies for successfully technology transfer

Governmental supports of industrial sectors that have successfully transferred certain technologies could create incentives for other. These supports would be in different forms such as gratuitous loan, non-or low interest loan, technical and contract consulting.

3.2.3. Conclusions

Application and transfer of technology has desirable effects if properly implemented. The issues discussed in this report reveal that the industrial sector of Iran cannot meet its technological needs. Due to the fact that the sector is very old, some industries over 100 years old with outdated technologies. In addition, and the low energy price especially natural gas prices have lead to low productivity resulting in excessive use of energy which leads to GHGs emission. Solving these problems requires close attention of high ranking policy makers in order to reduce GHGs emissions.

Briefly, the following points should be considered in order to reduce GHGs emission by the country's industrial sector:

- Rationalization of energy price;
- Identification and transfer modern technologies;
- Financial support and promotion of industrial sector by government for substitution of outdated technologies with the state-of-the-art ones in different industrial sectors;
- Cooperation of international organizations for training and transfer of technologies;
- Establishment of technology information enter with assistance of the relevant organizations in the country and international agencies;
- Support of international organizations for technology transfer for mitigation of climate change.

It should be noticed that industrialized countries do not have the tendency to meet their obligations under the UNFCCC and the Kyoto Protocol in providing the technological needs of developing countries. They usually refuse to transfer the required and appropriate technology in order to sustain their political and economical benefits and superiorities. Instead, in most cases obsolete technologies are transferred to the developing countries.

3.3. Constraints and gaps in technology transfer in Electricity, Domestic and Commercial sectors

In order to assess the elements which are required for the technology transfer plans, the major constraints and gaps in the electricity and domestic-commercial sectors are described in this section.

3.3.1. Main constraints and gaps of technology transfer

The existing constraints in all sectors which hinder the transfer of technology in the country are shown in Table 3.1.

Table 3.1: Existing constraints and gaps in all aspects versus technology transfer in the country [MOE 2000]

Policy making tools	Existing constraints	Relevant factors
Infrastructure of systems for national innovation and technology 1- Systematic capabilities for innovation 2- Development of educational, scientific and technical organizations 3- Facilitate technological innovation by way of adjusting through technological networks performance including networks of finance, market, educational and links between consumers and suppliers.	-Lack of technology development and adaptation centers -Lack of educational development and skills organizations -Lack of access to science, engineering and tech findings for private and pub sectors -Lack of research -Lack of relevant knowledge for strategic planning and market development -Lack of framework for connecting and matching the governmental-industrial plans, and cooperation between these sectors	Routes taken by private sector (initially) All divisions
Social and diagnostic infrastructure 1- Increase capacity of social organizations and NGOs to facilitate selection of suitable technology 2- Create new social organizations and NGOs with technical expertise for protection of technology transfer 3- **C**onsultancy and adaptation procedures to facilitate and smooth networks acquire skill and know-how in NGOs.		
Frameworks for macro economics policies 1- Providing direct financial support by way of encouragements, subsides, provision of apparatus and tools, short and long term loans 2- Providing indirect financial support such as tax license/permits for investment 3- Increasing energy tariffs for financing long term economic costs 4- Altering the commercial and foreign investment policies such as trade agreements, tariffs and regulations 5- Altering regulations of finance	-Selection of unsuitable technology for development -Historical heritage of technology transfer in development -Difficulties in communications as well as cultural conflicts	None
Dynamic markets for environmentally friendly technologies 1- Demand side management must be improved 2- Capacity development for technology adaptation via small or medium scale economic systems (SMES) 3- Training consumers 4- Purposeful purchase of buildings by public sector and society	-Lack of access to capital -Lack of capital in long term -Subsidized prices or average cost (instead of final cost) for energy -Large custom tax on imports -High and varying inflation with many rates -Lack of trust to tax laws -Investment risk -Excess banking rules - Banks having poor investment - Danger of disownment	Routes guided by private sector yet connected to all methods and routes Foreign trade and investment policies especially concerning private sector participation Particularly stages of assessment and competition All divisions, energy tariffs for buildings, industry and energy sector
National legislative organizations 1- Authorize national frameworks to back intellectual regulations 2- Authorize operational and legal procedures to ensure clarity, participation in gratitude and independent revision 3- Authorize lawful organizations to reduce dangers		
Codes, Standards and Licenses 1- Development of codes and standards and organizations systems for their enhancement 2- Development of processes for issuing confirmation and ways for experiment and measurement	-High costs for trade deals -Insufficient power of auxiliary procurators -Distrust towards markets -Lack of awareness among consumers and technology users - Distrust to technology durability regarding economy and trade.	Guided routes by private sector Divisions of buildings, industry, energy All divisions and levels
Research and technology development 1- Development of scientific and educational foundations by way of building research laboratories, producing financial support, for the latter, and strengthening technical training 2- Direct investment in R&D.	-Lack of intellectual lawful support -Risk of signing contract. Existing dangers for wealth, danger of legislation -Diversion	All methods All sectors

		Especially, the agreement stage
	-Use of high interest rates shan't necessarily give most efficient tech -Lack of info -Lack of capability in public organizations for promulgate and adjusting technologies -Lack of tech standards and presence of organizations for protecting standards	All methods Divisions of buildings, transport, industry and energy Stage of assessment
	-Insufficient investment in R&D department - Inadequate foundation in science and teaching	Via government methods or societies Stages of assessment and response Divisions of b buildings, industry and energy

3.3.1.1. Obstacles of technology transfer in electricity supply

At present time, technically there is possibility of increasing power plants efficiency from 30% to 60%. Co-generation or CHP (combined heat and power) is considered to be a very efficient arrangement compared with generation of electricity alone. In Iran the main obstacles in implementation of co-generation are the shortage of capital, lack of legislative requirements and adjusting policies for commercializing the excess power generated and transmission to the present network.

Cogeneration and improving power plants efficiency face the following obstacles:

- Lack of incentive for major suppliers: Many utility sell their product through the existing adjusting procedures. This matter makes it possible for them to cover their operational expenses (including taxes and sums for capital return). This also brings about a rather undesirable incentive to improve power plants efficiency. It means that energy suppliers are governmental and due to low fund allocation, the suppliers would prefer to spend the fund for repair and other aspects. Nothing will be left for energy efficiency measures.
- Revision of regulations causes some distrusts in power industry. These revisions shall not necessarily bring about environmentally friendly outcomes (until sound policies are taken up). There is always resistance for implementation of new regulations.
- Limited expert human resource in Iran.
- The heavy subsidies for fuels and limited role of the private sector.
- Constraints due to imposing international sanctions.
- Limited access to small scale generators.

Fuel switching towards less carbon content fuels is considered as an important method of GHGs mitigation. Particularly, use of natural gas instead of oil and coal, is seen as an excellent solution, as natural gas has lower emissions of CO_2 almost 25% lower than fuel oil.

One of the other obstacles in technology transfer is the lack of continuous, consistent and comprehensive framework for evaluation of energy supply and cost from different sources. For such evaluation, it is necessary to analyze the complete the energy cycle. For example, for electricity generation from biomass; the required land cost of collection of biomass and competition among farmers for food production should be taken into account. As another example, for the case of natural gas, the pipeline infrastructure and security of supply in the cold seasons when the gas is shifted to domestic use should be taken into consideration..

Another obstacle is the lack of a system for reliable and continual supply of energy from renewable sources. This matter will either cause escalation of costs or reduced share of renewable energy in the supply system.

3.3.2. Review of the actions carried out by the public sector aimed at reducing GHGs emission

These actions briefly consist of:

- **Compiling energy management laws**

This law has prepared the required groundwork for a unified move in stable development of energy and GHGs reduction and has outlined the duties of suppliers and consumers of energy.

- **Creating the necessary organizations**

Within the Ministry of Energy, different activities of generation, transmission and distribution of eclectic power has been disaggregated into separate companies. In addition, separate organizations such as Iran Energy Efficiency Organization (SABA, abbreviation in Farsi), New Energy Organization (SANA, abbreviation in Farsi) and Energy Information Centre within the Ministry of Energy have been established. The Ministry of Oil has also established the Fuel Consumption Optimization Organization (IFCO, abbreviation in Farsi).

- **Training and informing schemes**

This activity includes training of engineers and managers of the electricity industry, providing students' grants and scholarships for Master and Ph.D. students at national universities, organizing specialized seminars, educational workshops, specialized round table discussions, compiling and distributing brochures, participation in specialized international expositions, preparing scientific films, television programs, specialized books, performing research as well as social and behavioral studies on consumers, creating contact network between those involved in energy utilization managers, launching internet sites, establishing training centers for energy consumption optimization and creation of centers for study of new and up to date technologies in the world.

- **Incentives and penalties**

Those who respect and observe fuel utilization optimization policies, receive bonuses such as financial facilities, reduction in energy tariffs, energy efficiency funds and subside for energy savers; and those who disregard the standards suffer from penalties such as higher tariffs.

- **Reforming the system of energy pricing and restructuring the energy sector**

These tasks are under study and still far from approval and implementation stage.

- **Setting up energy information centers**

These centers have made possible the exchange of energy between organizations especially at ministries of oil and energy and at national, regional and international levels.

- **Establishing SABA and IFCO**

These two companies have officially been designated by the government to reduce energy intensity in various energy sectors of the country.

- **Establishment of CDM Committee at the Ministry of Energy.**

3.3.3. Comparison of proposals of section 3.3.2. with the country's Third Five-Year Development Plan

Chapters 15 and 12 of Third Development Plan have addressed the environment and energy topics in 7 articles and several subdivisions. The following topics have been covered with detailed implementation directives:

- Pricing policies of the energy carriers,
- Restructuring of energy sector,
- Implementing energy saving programs,
- Rationalizing the energy consumption,
- Environmental protection,
- Compiling and observing standards,
- Establishing energy standards for construction of refineries, power plants and manufacturing units and home appliances,
- Optimizing the energy consumption in buildings sector (public and private).

In addition, in the mentioned Third Development Plan emphasis has been put on R&D which led to development of science and technology in the energy sector. Participation and investment of the private sector has been stressed.

Selecting policies for addressing global warming in the power and domestic-commercial sectors by making use of MGCP model [model on Global Warming Combat Policies in Energy Sector of Iran]. This model which has been developed at the Ministry of Energy can be used for policy making purposes. In this model 21 internal and external variables have been taken into account. The scenarios of this model are:

a) Desirable growth scenario
b) Medium growth scenario
c) Poor growth scenario
d) Business as usual scenario
e) Scenario of annual growth of 15% of nominal energy prices
f) Scenario of reduction of transmission and distribution losses to 10% level by year 2020
g) Scenario of increasing the power plants efficiency to 50% by year 2020.
h) Scenario of reduction of thermal power generation to 80% by year 2020.
i) Scenario of increase of share of natural gas in power plants to 99% by year 2020.

Results obtained from above scenarios for the objective function, which is the CO2 emission in the energy sector (limited to power plants and domestic-commercial sectors as mentioned above), show that the carbon dioxide in the sectors mentioned above was 255,900,987 tons which ac be reduced significantly according to the different scenarios described above as shown in Table 3.1.

By year 2020, this situation, in various scenarios, will reach the following respective values: Desirable growth scenario, 1626661020 ton; Medium growth scenario, 1997350889 ton; Poor growth scenario, 2248690143 ton; Business as usual scenario, 2816535410 ton; Scenario of Annual growth of 15% of nominal energy prices, 2375594349 ton; Scenario of reduction of transmission and distribution losses to 10% level by year 2020, 2620687733 ton; Scenario of increasing the power plants efficiency to 50% by year 2020, 2752002384 ton; Scenario of reduction of thermal power generation to 80% by year 2020, 2598871352 ton; and Scenario of increase of share of usage of natural gas in power plants to 99% by year 2020, 2622832452 ton.

In the prediction part of the model, predicted outcome of 2 choices for years 2001 till 2020, for individual years, for objective variables of energy sector, technical division and environment division has been carried out. In choice 1, economic variables of annual growth 4%; prices index annual growth 10%; energy prices that grow, annual growth 10%; internal variables of technical and environmental annual growth 15% are adjusted desirably. Rise of cars, till end of third five-year development plan will be 10% and consequently 4%. In choice 2, economic variables will have an annual growth rate of 6%, and techno-environment 30%. The number of vehicles and energy prices and price indicators are considered.

Results obtained from predictions, 21 objective variables in technical, energy and environment sectors, annually from 2001 to 2020 have been carried out. For example, in the event of assumptions of choic1 1, the amount of CO_2 emission in Iran energy sector in year 2020 will reach 1571307672 tons and the needed forest area for completely absorption of that equals 360684778 hectares. In the event of assumptions of choice 2, total, the amount of CO_2 emission in Iran energy sector in year 2020 will equal 4008104323 tons and needed forest area for completely absorption of that will equal 754964717 hectares.

3.3.4. Application of MGCP for mitigation of GHGs emission in the country’s energy sector

The following conclusions may be drawn from the application of the MGCP model:

1. If the present trend of energy consumption continues, the rate of CO_2 emission shall increase more rapidly in future years and economic policies alone will not be effective to control and reduce it.

2. Policy of fuel switching and increased usage of natural gas in power plants to 99% by year 2020 shall be the most effective approach for reduction of CO_2 emission.

3. In relation to environmental variables, reducing energy carriers CO_2 emission factor in the first place and increasing forest areas in the second place, shall have a noticeable role in reduction of this gas.

4. Regarding technical variables, reducing share of thermal generation of power to 80%, lowering transmission and distribution losses to 10%, and raising power plants efficiency to 50% by year 2020 are part of effective policies in the CO_2 reduction.

5. Increasing forest areas as an effective environmental measure, shall not on its own, reduce or absorb considerable amounts of CO_2.

6. By implementing the desirable growth scenario, namely, the 4.5% increase of economic growth, the 10% annual rise of energy carriers prices and inflation indicator, the 30% rise (positive or negative) of external technical and environmental variables by year 2020, best result for reducing CO2 emission will be accomplished.

7. Comparison of the prediction results shows that the 6% rate of economic growth versus the 4% rate shall to a large extent, increase emission of CO2. To achieve this economic growth, it is necessary to take advantage of the mentioned technical tools along with the environmental considerations.

In regard with power plants and their share of CO2 emission, the followings can be assumed:

a) Annual price rise of 15% for energy carriers till year 2020 would lead to reduction of CO2 emission by 204 million tons and decrease of the forest area required by 154 million hectares compared with business-as-usual scenario.

b) Increase of power plants efficiency to 50% (compared with the base year 2000) till year 2020 would lead to reduction of CO2 emission by 70 million tons and reduction of the required forest area as much as 23 million hectares compared with business as usual scenario

c) Decrease of thermally generated power to 80% level (compared with the base year 2000) till year 2020 would lead to reduction of CO2 emission by 217 million tons and reduction of required forest area as much as 76 million hectares compared with business as usual scenario

d) Increase of power plants share of natural gas utilization to 99% level (compared with the base year 2000) till year 2020 would lead to reduction of CO2 emission by 193 million tons and reduction of required forest area as much as 68 million hectares compared with business as usual scenario

e). Reducing the transmission and distribution losses to 10% level (compared with the base year 2000) till year 2020 would lead to reduction of CO2 emission by 196 million tons and reduction of required forest area as much as 68 million hectares compared with business as usual scenario

Prediction of objective variables and CO2 emission till year 2020 in Iran are provided in Table 3.2.

Table 3.2: Predicting of CO2 emission by use of MGCP* model for Iran

Group	**Description**	**1000 equivalent barrel of oil**			
		1999	**2010**	**2015**	**2020**
Target variables of energy	Petrol consumption	85,309	129,666	184,565	373,924
	Gas oil consumption	143,112	194,509	249,415	410,097
	Electricity consumption	52,030	81,721	119,051	252,659
	Kerosene consumption	65,754	83,522	101,878	151,581
	Liquid gas consumption	17,982	25,648	36,044	71,182
	Furnace oil consumption	56,285	62,127	68,391	82,880
	Natural gas consumption	217,384	482,710	938,429	3,546,758

Table 3.2. Cont.

Target technical variables of energy	Electricity generation	60,667	94,671	137,202	288,316
	Electro heat generation	58,725	87,489	121,986	237,272
	Fuel consumption in power sector	160,014	229,054	308,914	562,160
	Natural gas consumption in power sector	117,450	174978	243,972	474,544
	Liquid fuel consumption in power sector	42,564	54,076	64,942	87,616
Target variables of environment	Rate of CO2 emission of petrol (ton)	35,320,520	51,253,073	70,186,236	131,618,229
	Rate of CO2 emission of gas oil (ton)	60,981,643	79,126,448	97,615,548	148,564,022
	Rate of CO2 emission of kerosene (ton)	26,829,526	32,534,771	38,180,731	52,528,014
	Rate of CO2 emission of furnace oil (ton)	24,600,627	25,923,055	27,455,180	30,796,442
	Rate of emission of CO2 of liquid gas (ton)	6,052,764	8,241,887	11,143,314	20,369,940
	Rate of CO2 emission of natural gas (ton)	73,600,014	156,024,920	291,826,029	1,020,902,204
	Rate of CO2 emission of power plants (ton)	56,840,178	77,267,587	99,797,331	166,474,822
	Rate CO2 emission of energy sector (ton)	284,225,073	430,371,740	636,204,369	1,571,307,672
	Required forest area (ha)	76,740,770	110,934,201	157,773,230	360,684,778

*Model on Global Warming Combat Policies

CHAPTER II:

Oil, Gas and Petrochemical Industries

Table of Contents

1. An Overview of Oil, Gas and Petrochemical Industries 1
1.1. Oil Refineries 1
1.2. Gas Refineries 2
1.3. Petrochemical Industry 3
1.4. Upstream Sector 3
1.4.1.Drilling Towers and Offshore Platforms 3
1.4.2.Oil & Gas Transfer Facilities 3
1.4.3.Natural Gas Liquid (NGL) Plants 4
1.4.5.Crude Oil Desalting Units 4
1.4.6.Crude Oil Pumping Units 4
1.4.7.Storage and Loading Tanks 4
1.4.8.The Crude Oil Processing Units in Terrestrial Regions 4
1.4.9.Oil Wells 5
1.5. GHG Emission Model 5
1.6. Alternatives for Energy Efficiency and GHGs Mitigation in Oil, Gas and Petrochemical Industries 10
1.7. The Main Sources of Energy Loss in Iranian Oil, Gas & Petrochemical Industries 10
2. Transfer of Technology in Oil and Gas Sector 11
2.1. A Review of Plans and Policies for Transfer of Technology in Iranian Oil Industry 11
2.2 Government Activities for Transfer of Technology in Oil, Gas and Petrochemical Industries. 12
2.3.Technology Needs Assessment (TNA) for Mitigation of Greenhouse Gases in Oil, Gas and Petrochemical Industries 13

List of Figures

Figure 1.1 Model for GHGs emission computation 6
Figure 1.2. GHGs Emission of oil and gas industries in Iran 10

List of Tables

Table 1.1. Emission Factors used for calculation of GHGs in Oil & Gas Industries (gr/lit) 6
Table 1.2. Emission of GHGs due to the consumption of natural gas in oil and gas refineries and Compression stations 7
Table 1.3. GHGs emission of oil refineries in Iran 7

1. An Overview of Oil, Gas and Petrochemical Industries

In 2002, it was estimated that approximately 14.3% of the global reserves of oil and gas are in Iranian territories. Currently, Iran with 12% of the total oil reserves in the world (130.7 billion barrels) and 18% of the total oil reserves in the Middle East is ranked second only to Saudi Arabia in the world and in the Middle East. The oil and gas reserve basket of Iran consists of 44% crude oil and 56% natural gas. Although based on newly discovered oil reserves during 2001-2003 period, the National Iranian Oil Company (NIOC) is ranked 2nd in hydrocarbon reserves of the world, it is yet to find its appropriate role in the world energy market especially for supply of natural gas. This is mainly due to the current energy policy of the country to utilize other energy carriers instead of natural gas. Another important factor is the under-developed commercial role of Iran in international gas market.
The main components of this immensely important industries are the oil refineries, gas refineries, petrochemical industry, upstream sector including offshore and inland drilling platforms, oil and gas transfer facilities, Natural Gas Liquid (NGL) plants, crude oil desalting units, crude oil pumping units, storage and loading tanks, crude oil processing units and oil wells. The above-mentioned components are introduced briefly in the following paragraphs.

1.1. Oil Refineries

In the year 2000, Iran was the sixth largest oil refining country in Asia with a production capacity of 1.5 million barrels of oil per day. Most of the nine refining companies in the country have over the 25-year of operation time and are considered old by international standards. Abadan Oil Refining Company is the largest in the country with the daily capacity of 350 thousand barrels and Lavan Oil Refining Company is the smallest with the production of 20 thousand barrels per day. In the past 6 years, Iran has transformed from an importer of kerosene and gas oil to an exporter of these products. The replacement of natural gas with liquid fuels and improved consumption management are the main reasons for the halt in import of kerosene and gas oil since 1998. Only the import of gasoline is being continued due to the increase in the number of automobiles manufactured in the country, continuous utilization of old cars in the transport sector, availability of inexpensive gasoline and low technology. The export of petroleum products includes kerosene, gas oil and fuel oil, which are mainly exported from Bandar Abbas, Bandar Mahshahr and Lavan Terminals.

During 1997-2002, the consumption of petroleum products including kerosene, gas oil and fuel oil was controlled due to their replacement with natural gas due to the implementation of the policy for alteration of consumption patterns and energy conservation. Typical units in Iranian oil refineries are vacuum distillation unit, atmospheric distillation unit, liquid gas plant, kerosene treatment plant, heavy naphtha treatment plant, catalyst converter unit, hydrogen plant, hydro-cracker unit, tar plant, sulfur plant, sour gas treatment plant and water treatment plant.
Energy losses in refineries are divided into two groups namely, unavoidable and avoidable losses. Unavoidable losses are those which are considered as the indispensable parts of the regular process and could not be eliminated or reduced directly, or their elimination is not economically feasible. They include losses in separation of water and salt in crude oil, burning part of associated gas, purge gas in refineries and etc. On the other hand, avoidable losses are caused by the high age of the refineries and their equipments and improper maintenance of sensitive components like pumps, flanges steam traps and valves. Also, energy losses in oil & gas refineries as well as petrochemical processes which is due to low energy efficiencies, stack

losses, etc. are considered to be avoidable losses. Another major disadvantage of Iranian refineries is the production of low quality by-products like furnace oil. Low-quality by-products reduce the quantity of exported crude oil, hamper oil revenues, wear down the refining equipment prematurely including refining catalysts and pollute the environment. Thus, alteration of refining patterns is a top priority for the country's oil industries, especially in face of the current shortage of domestically refined gasoline and the ever-increasing share of imported gasoline in annual national imports.

1.2 Gas Refineries

The daily natural gas refining capacity of the country increased in by 139.6 million cubic meters during 1997-2002. During the same interval, 6,070 kilometers of natural gas pipeline was constructed and in 2002, the total natural gas pipeline network in the country was about 79,000 kilometers. During 1997-2002, the natural gas pipeline network increased by 37,534 kilometers. Meanwhile in 2002, 37.1 million people in the country had access to natural gas pipeline network (approximately 85% of the urban population in the country). The total number of industrial units consuming natural gas was raised to 4,617 by the end of 2002.

There are two types of well gases namely, sweet and sour. The sweet gas does not contain any significant amount of acidic components and therefore it can be injected into the pipeline after dehydration process. On the other hand, sour gas contains impurities like Mercaptane, H2S and CO2. The main impurity in natural gas which has to be separated is hydrogen sulfide.

A gas refinery has three major components:

- Equipments outside the refinery such as well head facilities, collection pipelines, separation centers and transfer pipelines.
- Processing equipment inside the refinery including: initial separation unit, gas sweetening unit, dew point stabilization and condensation unit, outgoing gas compressors, glycol recovery and regeneration unit, Merox unit, and gaseous liquid stabilization unit.
- Secondary equipment including: electricity generation unit, steam production unit, water treatment plant, caustic tower, caustic pit unit, industrial wastewater treatment plant and nitrogen production unit.

Major natural gas refineries in the country are as follows:

- Fajr (Kangan) Refinery with production of 110 million cubic meters per day
- Khangeyran (Hashemi nejad) Refinery with production of 44.5 million cubic meters per day
- Beed Boland Refinery with production of 22.5 million cubic meters per day
- Sarkhoon Refinery with production of 14.1 million cubic meters per day
- Daalan Refinery with production of 20 million cubic meters per day
- Govarzin Refinery with production of 1.7 million cubic meters per day
- South Pars(phase 1-5) Refinery with the production of 140 million cubic meters per day
- Others with total production of 5.2million cubic meters per day.

1.3 Petrochemical Industry

In 2002, the total production of the National Petrochemical Company (NPC) reached 13.1 million tons. In the same year, the production share of NPC from the global and the Middle East production capacity was 0.71% and 13% respectively. The feed of petrochemical industries in Iran consist of sweet gas, sour gas, heavy and light naphtha, LNG, LPG and phosphate ore. One of the advantages of petrochemical industry in Iran is the abundance of hydrocarbon resources and availability of natural gas as an economically feasible substitute feed instead of naphtha for the petrochemical projects. Thus the prevalent policy is to utilize the maximum amount of ethane present in natural gas through the national gas pipelines as well as the condensates of South Pars for the Petrochemical Special Zone and Assalouyeh Port.
The product of the petrochemical complexes could be divided into 5 main categories namely, basic chemical products, polymers, aromatics, fertilizers, pesticides. There are also by-products such as fuel and hydrocarbons. The export of petrochemical products in 1996 was 2,655 thousand tons with the value of 507 million Dollars. This increased in 2002 to 3,917 thousand tons with the value of 942 million Dollars.
The main units in petrochemical industry are: upstream units, basic/core units, intermediate units, end units and downstream units.

The future outlook of the petrochemical industry in Iran is:

- The production capacity of NPC was 15.1 million tons in 2004.
- The production capacity of methanol will reach 3.4 million tons in 2005.
- The production capacity of urea Fertilizer will reach 3.5 million tons.
- The production capacity of ethylene will increase to 4.7 million tons by 2006.
- The production capacity of aromatic products will reach 2.5 million tons by 2004.
- The production of polyesters will reach 800 thousand tons in 2005

The main petrochemical complexes in the country include Bandar-e-Imam, Razi, Shiraz, Arak, Khorasan, Tabriz, Khark, Esfahan and Orumeyeh Petrochemical Complexes.

1.4 Upstream Sector

1.4.1 Drilling Towers and Offshore Platforms

Advancement of technology has altered these systems from simple mechanical devices to intricate electrical apparatus. Thus, there are two types of drilling equipment in Iran. The mechanical drilling utilizes an electrical generator running on diesel fuel, while the main electrical generators of the drilling towers supply the drilling equipment with the required electricity.

1.4.2 Oil & Gas Transfer Facilities

These facilities must transfer oil and gas through tens of thousands of kilometers and require equipment to increase the line- pressure. The types of engines used for this purpose are either run on electricity or gas turbines. A large share of energy consumed in oil and gas industry is to boost the pressure and transfer of oil and gas from the wellhead to various locations including the refineries, petrochemical complexes, power plants and other consumers through a network of pipelines.
In the bulk of oil and gas installations like processing units, gas injection stations, pressure boosters, gas and liquid gas plants, oil platforms and electricity generation units where the energy costs are quite high, the only economically feasible and technically appropriate alternative is the utilization of gas turbines. Their primary fuels are natural gas, kerosene, diesel and liquid gas. Natural gas is the main fuel consumed in pressure boosters and gas injection

units. However, kerosene and diesel fuels are predominantly used in power plants and engine rooms that are not connected to the natural gas distribution network.

1.4.3 Natural Gas Liquid (NGL) Plants

In the late 1960's, the NGL plants were established in oil-rich regions in order to consume gases from oil wells for domestic consumption and export of natural gas liquids as well as production of LPG. Currently, there are 12 NGL plants in the country. Their main feeds are gases from oil wells and Pazanan field Gas Cap (high pressure). For the recovery of liquid gas and control of the dew point, propane refrigeration cycle or condensation turbines are used.

1.4.4 Crude Oil Desalting Units

The salt water accompanying crude oil could create numerous problems including corrosion of sour gas pipelines, puncture in storage tanks, salt sedimentation in thermal converters, and formation of hydrochloric acid in distillation process in oil refineries. Therefore, desalting process for crude oil is essential. There are 19 desalting units in oil fields of Ahwaz, Maroun, Pazanan, Aghajari, Rag Sefid and Bibi Hakimeh. The average capacity of these units is 55 thousand barrels per day.

1.4.5 Crude Oil Pumping Units

The pumping units in the terrestrial regions could be divided into two categories namely, pumps in oil processing units and in pressure boosting stations. The pumps in the first group are designed proportional with the capacity of the processing units. In the second group, the pumps are selected based on the designed capacity for transfer of oil to the export terminals and domestic refineries.

The pumps used for transfer of oil are generally of centrifuge type with the efficiency of 65% to 75%. Their driving force is either gas turbines or electrical motors. Currently, there are 50 processing units throughout the country; the majority of them are equipped with gas turbines or electrically driven pumps.

1.4.6 Storage and Loading Tanks

The Iranian crude oil is being exported from the terminals in Khark, Lavan and Salman Islands. There are 18 storage tanks in Khark Island with the capacities ranging from 272 thousand to one million barrels.

The main components in an oil terminal are:

- Storage tanks for crude oil and petroleum by-products;
- Precision instruments installed on the tanks including surface level gages, temperature gages, entrance and exit pipes;
- Pumps for transfer of crude oil and by-products from the tanks to the oil tankers;
- Laboratory for measurement and quality control of crude oil and its by-products before delivery to the oil tankers;
- Crude oil recycling and recovery system and loading piers.

1.4.7 The Crude Oil Processing Units in Terrestrial Regions

The processing units separate the crude oil from the oil well gases and subsequently stabilize the crude oil for export or delivery to the domestic refineries. There are 46 operational units in the terrestrial regions of the country with the nominal capacity of 8,440 thousand barrels per day. These units consume approximately 46.5 million cubic feet of natural gas and 25,900 kW of electricity every day. Their calculated overall energy consumption is equivalent to 131,000 kW, which 17% are in form of electrical energy and the rest is gas energy.

1.4.8 Oil Wells

The annual losses due to the burning of crude oil in the pits at the terrestrial regions are 876 thousand barrels (equivalent to 25% of daily production in the terrestrial regions). The annual losses in the offshore wells are approximately 4,800 barrels. The annual economic values of oil and gas losses (calculated based on 20 Dollars per barrel of oil and 2 Dollars per thousand cubic feet of gas) are 17.5 and 1.2 million Dollars, respectively.

1.5 GHG Emission Model

A new comprehensive model called MGEC [Please define the abbreviation] has been developed with collaboration of the Center for Environment and Energy Research & Studies (CEERS). The new GHG Emission model allows users to calculate the estimated GHG emissions avoided for the proposed advanced technology. This value can then be used to calculate the corresponding financial impact for Clean Development Mechanism (CDM). The use of this model simplifies the calculation of GHG emissions and results in substantial cost savings for users as an increased opportunity for CDM project for government and industry. The structure of the model MGEC has been prepared for calculation of GHGs emissions in oil industry based on the data on fuel consumption. The structure of this model is shown in Figure 1.1. The GHGs emission factors used in MGEC model for oil and gas sectors are shown in Table 1.1.

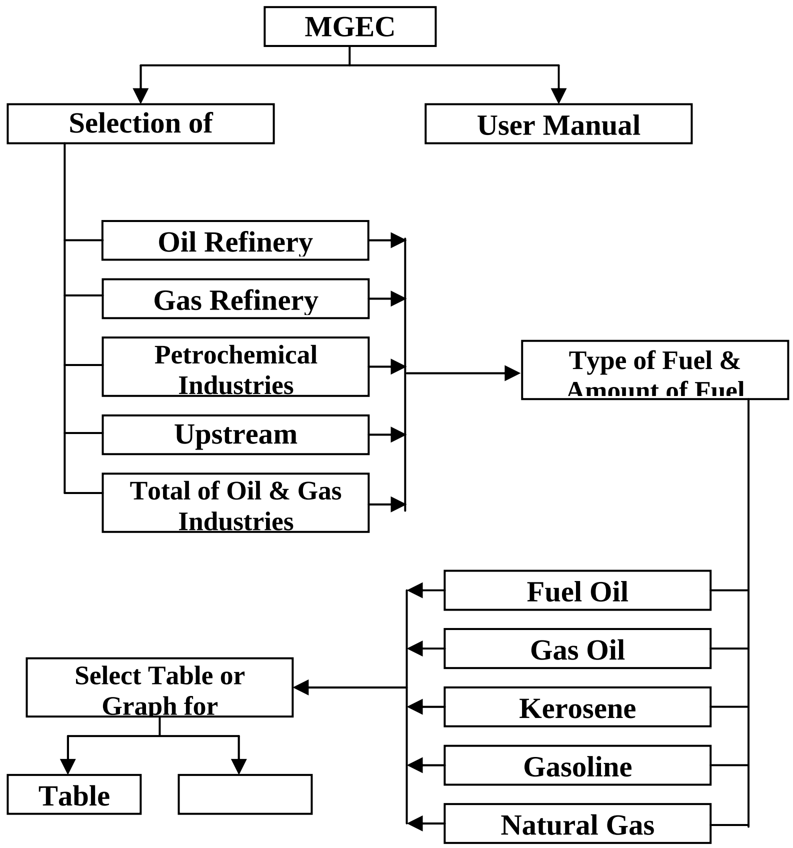

Figure 1.1 Model for GHGs emission computation

Table 1.1. Emission Factors used for calculation of GHGs in Oil & Gas Industries (gr/lit) [JICA 1997]

Pollution / Fuel	NO_X	CO2	CH	SO_2	SO_3	CO	SPM
Fuel Oil	10	2978	0.4	46.9	0.7	0.0	1
Gas Oil	5	2648	0.2	15.7	0.2	0.2	1.5
Kerosene	0.5	2415	-	2.4	-	0.8	-
Gasoline	13.5	2323	63	1.5	-	350	1.3

The GHGs emissions for oil and gas refineries as well as pressure booster stations during 1993 to 2002 based on their consumption of natural gas are provided in Table 1.2.

Table 1.2. Emission of GHGs due to the consumption of natural gas in oil and gas refineries and Compression stations.

Pollution Year	Fuel Con. (mm3)	NOX	SO2	CO2	SO3	CO	CH	SPM
1993	2,873.5	9,838.9	20.1	6,129,176	0.0	390.8	169.5	827.6
1994	2,430.16	8,320.9	17	5,183,531	0.0	330.5	143.4	699.5
1995	2,479.42	8,489.5	17.4	5,288,603	0.0	337.0	146.3	714.1
1996	2,643.62	8,435.4	17.2	5,254,901	0.0	335.1	145.4	709.5
1997	2,791.4	9,557.8	19.5	5,654,056	0.0	379.6	146.7	803.9
1998	3,760.18	12,874.9	26.3	8,020,464	0.0	511.4	221.9	1,082.9
1999	4,400.56	15,067.5	30.8	9,386,394	0.0	598.5	259.6	1,267.4
2000	4,072.16	13,943.1	28.5	5,685,917	0.0	553.8	240.3	1,172.8
2001	4,843.9	16,585.8	33.9	10,332,039	0.0	658.8	285.8	1,395
2002	6,108.24	20,914.6	42.8	13,028,876	0.0	830.7	360.4	1, 759.2

Ttables (1.3), (1.4), (1.5), (1.6) and (1.7) show the GHGs emission of Iranian oil refineries, gas industry, petrochemical industries, upstream oil industry as well as oil and gas industries, respectively. Moreover, figure (1.2) shows the GHGs Emission of Oil & Gas Industries in Iran in a pie chart.

Table 1.3. GHGs emission of oil refineries in Iran

Oil Refinery	Fuel Consumption (m^3/year)	GHGs Emission (Ton/year)
Total of Oil Refineries	91413624 (Crude Oil) 820310 (Condensate) 4011(Gas)	12,964,690

(After gas consumption by some eqipment in oil refineries)

Table 1.4. GHGs emission of gas industry in Iran

Industry	Fuel Consumption (Million m^3/year)	GHGs Emission (Ton/year)
Gas Compression Stations	630.136(Gas)	1,344,080
Khangiran Gas Refinery	1,521(Gas)	3,244,293
Bidboland Gas Refinery	954.54(Gas)	2,036,034
Qeshm Gas Refinery	5.4166(Gas)	11,554
Valieasr Gas Refinery	0.6083(Gas)	1,298
Total Gas Industries	**3,111.7009**	**6,637,259**

Table 1.5. GHGs emission of petrochemical industry in Iran

Petrochemical Industry	Fuel Consumption (Million m^3/year)	GHGs Emission (Ton/year)
Khark	11	2,335,479
Shiraz	566	1,147,105
Razi	59	417,202
Arak	196	229,164
Farabi	1	9,061
Tabriz	119	224,818
Bandar-e-Emam	850.6	2,320,276
Esfahan	61	135,495
Khorasan	230	355,105
Fanavaran	4	
Total	**2097.6**	**7,173,708**

Table 1.6. GHGs emission of upstream oil industry in Iran

Industry	Fuel Consumption (Million m³/year)	GHGs Emission (Ton/year)
Filler Gas in upstream Industries	10,585(Gas)	22,577,805
Condensates & Gas Production	6,935(Gas)	14,792,355
Desalting Units	292(Gas)	622,836
Oil Wells	39.637(Gas)	84,546
Oil Pumping Stations	5.422(Gas)	11,565
Operating Units	480.61(Gas)	1,025,141
Turbines & Diesel Generators for Oil Transportation lines	0.1818 (Kerosene) 365(Gas)	1,217,592
Total of Upstream Industries	18,702.672 (Gas) 0.1818(Kerosene)	40,331,840

Table 1.7. GHGs emission of oil & gas industries in Iran

Industry	Fuel Consumption (Million m³/year)	GHGs Emission (Ton/year)
Oil & Gas Upstream Industries	18,702.672 (Gas) 0.1818(Kerosene)	40,331,846
Gas Refineries	3,111.7009 (Gas)	6,637,259
Oil Refineries	1.480600 (Heavy Oil) 4,011 (Gas)	12,964,690
Petrochemical Industries	3,363.427428 (Gas) 107×10^{-6} (Heavy oil)	7,173,708
Total of Oil & Gas Industries	**29188.800328 (Gas)** **0.1818 (Kerosene)** **1.4806107 (Heavy oil)**	**67,707,497**

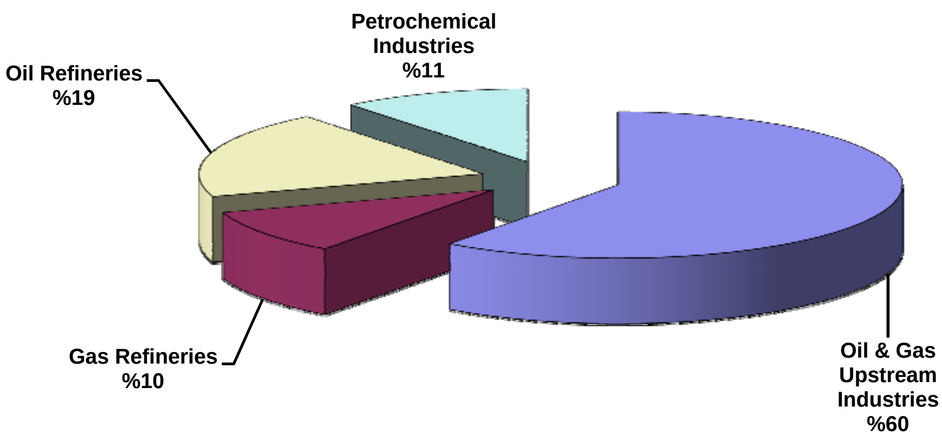

Figure (1.2) GHGs Emission of oil and gas industries in Iran

1.6 Alternatives for Energy Efficiency and GHGs Mitigation in Oil, Gas and Petrochemical Industries

Exchange of information about best practices among companies and can speed the identification and implementation of GHGs emissions reduction approaches. This section outlines the recommendations made for enhancement of efficiency and GHGs mitigation in oil, gas and petrochemical industries at nation level as well as to present newest innovations for the aforementioned objectives at international level.

1.7 The Main Sources of Energy Loss in Iranian Oil, Gas & Petrochemical Industries

Unfortunately, Iranian oil, gas and petrochemical industries are equipped with out-dated equipment and technology, inadequate investment for renovation of old parts and insufficient trained man power. The main sources of energy loss in these industries are listed below:

- Old machinery and equipment
- Outdated technology
- Low efficiency of the equipment
- Lack of an organized and proper maintenance and repair system
- Scarcity of spare parts
- Insufficient and inappropriate insulation
- Corrosion of pipelines, connections and valves
- Lack of a suitable quality control system

- Burning of excess light gases
- Loss of energy (heat) in steam production units
- Loss of energy (heat) in flare burners
- Loss of energy due to leakage of steam pipelines
- Low efficiency of steam traps
- Lack of precision instruments to measure the consumption of energy carriers accurately
- Lack of heat recycling system
- Excessive use of steam
- Discharge of condensation water without proper reuse
- Lack of recycling combustion gases in gas turbines
- Lack of thermal recycling boilers
- Higher actual consumption rate of energy carriers than the designed levels
- Inefficiency of inlet gas filters
- Loss of gases in glycol recovery & regeneration unit
- Loss of gases from the wellhead to the refinery

2 Transfer of Technology in Oil and Gas Sector

2.1 A Review of Plans and Policies for Transfer of Technology in Iranian Oil Industry

In order to attract foreign entrepreneurs to invest in the country and also facilitate transfer of technology in any industrial branches, we need to revise import/export and taxing regulations. Effective political and economic measures for absorbing foreign investments in the field of technology transfer include:

- Development of comprehensive and lenient trade policies
- Ratification of transparent laws
- Acceptance and ratification of international treaties
- Promotion of trade activities
- Deliverance of service facilities
- Reduction of bureaucratic formalities

Essential measures for successful transfer of technology are:

- Organizational harmony and cooperation within and between sectors
- Identifying the levels of technology transfer
- Establishment of Technology & Information Bank (TIB)
- Establishment of a multifaceted research centers
- Economic stability
- Development of regional and international cooperation
- Development of a technology-friendly attitude in the country
- Capital and financial credits
- Development of engineering services and design companies
- Development of promotional policies for successful transfer of technologies

Criteria for selection of technology are: capabilities and advantages of the technology; accessibility of technology; effectiveness of the technology to enhance competitive abilities; competitiveness in science, technology and global economy; utilization of appropriate technologies to reduce technological gap between the developing countries and developed countries; economic, social and cultural development of the country; increase in gross national product (GNP); new job opportunities; higher exports; waste reduction and conservation in consumption of material and energy; cultural up-grade; better hygiene; enhancement of social welfare; protection and preservation of the environment; higher national security; improvement of defensive capabilities of the country; increase of national security; food security; and effective use of rare resources.

2.2 Government Activities for Transfer of Technology in Oil, Gas and Petrochemical Industries

In oil, gas and petrochemical industries it is essential to identify the potential for improving energy performance in energy-critical equipment like furnaces, turbines and distillation columns. Moreover, improvement in heat recovery in the processes, optimization of fuel fired and operation of the steam and power systems are highly important.
Gap analysis should focus on four major areas, namely:

- Effectiveness of process heat generation
- Efficiency of power generation
- Efficiency of fired heaters
- Current Steam consumption versus Best Practice (described below)

"Best Technology Standards" should be developed by National Iranian Oil Company (NIOC), National Iranian Gas Company (NIGC), National Petrochemical Company (NPC), National Iranian Oil Refining & Distribution Company (NIORDC) and other pertinent companies through fundamental analysis and design studies on individual process units. They should take into consideration the key process parameters affecting energy consumption, such as the actual feed quality, conversion, and fractionation of performance. High energy performance could be achieved in a unit, which has an economically justifiable level of energy efficiency, and it is supported by a highly efficient steam and power system.

The plant's actual energy consumption is compared with the Best Technology (BT) allowance, which is calculated for the same configuration, same yields and processing the same feed stocks. The BT approach is effective in immediately identifying the scope for improving the energy performance. It takes into account the site's energy pricing structure and limitations.
The future product specifications depend on the changes in crude oil supply in the future (API Sp. Gr., sulphur content, metal and salts content), new environmental standards and specific regional conditions (ground, climate and restrictions). Moreover, the suggested objectives for restructuring of refineries are:

- Light ends upgrading
- Heavy products upgrading
- Incorporation of FCC unit in refineries
- Utility and hydrogen development

The current process for production of olefin and aromatic products is known as steam cracking. It is used to manufacture by-products like propylene, ethylene, methanol, benzene, toluene, butadiene and others. Since, the demand for propylene is higher than ethylene, three new technologies namely, Deep Catalytic Cracking (DCC), Catalytic Pyrolysis Process (CPP) and Fluid Catalytic Cracking (FCC) are being pursued in the petrochemical industry.

Other new technologies being pursued by the Iranian Oil, Gas and Petrochemical industries include:

- Installing measuring devices on the main gas current to the burner
- Utilization of molecular sieves
- Purchasing required equipment like compressors, thermal converters and storage tanks for recycling and re-injection of gases to the refinery fuel
- Employing molecular sieves for separation of emitting CO_2
- Establishment of a sludge removing system in the refinery
- Installation of a hydrogen recycling unit and injecting the retrieved hydrogen to the furnace for energy conservation
- Insulation of high temperature flanges
- Conducting steam tracing operation in units using fuel gas
- Applying heat integration in LPG Unit
- Using DCS (Distributed Control System) for adjustment of crude oil flow in atmospheric and vacuum distillation furnaces
- Installing soot blower for removal of sediments from convection pipes of distillation furnace
- Injection of paraffin to fuel oil
- Installing desalting apparatus for reduction of sediments in distillation furnaces
- Utilizing economizer systems in steam boilers
- Installation of cooling system for incoming gases to the sweetening towers
- Installation of data logger device to register the data for subsequent analysis
- Installation of draft gauge and oxygen analyzer on the furnaces
- Utilization of Pressure Swing Absorber (PSA) process in hydrogen unit
- Usage of low excess air and low NO_x burners
- Utilization of Forced Draft (FD) and Induced Draft (ID) fans in furnaces
- Production of electricity with Variable Voltage Variable Frequency (V.V.V.F.)
- Utilization of variable speed for fin fans
- Usage of demineralization devices for industrial waters
- Optimization of computerized blending for prevention of unwanted give away
- Installation of Kero unifier and Diesel unifier for treatment of kerosene and diesel fuels
- Horizontal drilling
- 3-D Seismic
- Remote sensing
- Measurement while drilling
- Modern drilling bits
- Pneumatic drilling

2.3 Technology Needs Assessment (TNA) for Mitigation of Greenhouse Gases in Oil, Gas and Petrochemical Industries

The following sections provide a glimpse of the most advanced and up to date technologies in the developed countries to mitigate greenhouse gases in oil, gas and petrochemical industries. Although, the cost-benefit and feasibility analysis of these techniques in Iran is yet to be conducted, they provide a comprehensive view of new endeavors at international scale and the economic as well as environmental benefits of these new technologies.

2.3.1 CO2 - Sand Fracturing

In widespread use in Canada, a stimulation technique now successfully demonstrated that has outstanding results without formation damage.

- ***Using CO2 to Fracture Oil and Gas Reservoirs***

Recompleting and fracturing an existing oil or gas well to stimulate production that has declined over time is significantly less costly than drilling a new well. First used in the mid-1930S, fracturing treatments inject fluids under high pressure into the formation, creating new fractures and enlarging existing ones. "Proppants" (commercial name; usually consists of large grained sand or glass pellets) are added to the fluid to support the open fractures, enabling hydrocarbons to flow more freely to the well bore. Fracturing is widely used to stimulate production in declining wells and to initiate production in certain unconventional settings. More than one million fracturing treatments were performed by 1988, and about 35 to 40 percent of existing wells are hydraulically fractured at least once in their lifetime. More than eight billion barrels of additional oil reserves have been recovered through this process in North America alone. Yet conventional fracturing technology has drawbacks. The water- or oil-based fluids, foams, and acids used in traditional fracturing approaches can damage the formation—for instance, by causing clay in the shale to swell—eventually plugging the formation and restricting the flow of hydrocarbons. Conventional fracturing also produces wastes requiring disposal. An advanced CO2-sand fracturing technology overcomes these problems, and is proving a cost-effective process for stimulating oil and gas production. First used in 1981 by a Canadian firm, the process blends Proppants with 100 percent liquid CO2 in a closed-system-pressurized vessel at a temperature of 0°F and a pressure of 300 psi. Nitrogen gas is used to force the resulting mixture through the blender to the suction area of the hydraulic fracture pumping units and then down hole, where it creates and enlarges fractures. The CO2 used in the process vaporizes, leaving behind a dry, damage-free Proppant pack. The technology has gained widespread commercial acceptance in Canada, where it has been used some 1,200 times. In the United States, use has been limited to demonstrations—many sponsored and co-funded by the Department of Energy (DOE)—taking place lasting recent years in about 50 wells in Kentucky, Ohio, Pennsylvania, Tennessee, Texas, New York, Colorado, and New Mexico. CO2-sand fracturing treatments average from $30,000 to $50,000, depending on well depth and rock stresses. While often higher-cost than conventional methods, these costs are offset by savings realized through eliminating both swab rigs and the hauling, disposal, and maintenance costs associated with water-based systems. As in conventional fracturing, CO2-sand treatments can significantly increase a formation's production and profitability. The economic benefits of this approach are listed in Table 2.1 and the environmental benefits are listed in Table 2.2.

Table 2.1 Economic benefits of well treatment by CO_2

ECONOMIC BENEFITS
Elimination hauling, disposal and maintenance costs of water-based systems
Can significantly increase well productivity and ultimate recovery
CO_2 vaporization leads to fast cleanup, whereas water-based fluids sometimes clear up slowly, reducing cash flow
Recovery of valuable oil and gas is optimized

Table 2.2 Environmental benefits of well treatment by CO_2.

ENVIRONMENTAL BENEFITS
Using liquid CO_2 creates long, propped fractures without formation damage
No wastes requiring disposal are created
Conventional fracturing gels and chemicals, which may damage the flow path between wellbore and formation, are not used
Groundwater resources are protected

2.3.2 Artificial Lift Optimization

Reduced emissions during production and increased productivity result from increasing the efficiency of the systems that raise oil to the surface

- ***Practical Measures with Attractive Environmental and Productivity Paybacks***

Sucker-rod pumps, the most prevalent form of artificial lift, use arm-like devices to provide up-and down motion to a downhole pump. Such rod pumping, most effective in relatively shallow and low-volume wells, can be optimized to increase lifting efficiency and minimize energy consumption. Surface and downhole energy losses can be reduced by adjusting key design parameters like pumping mode selection, counterbalancing (to balance loads on the gear box during the pumping cycle) and rod string design. A number of other advanced artificial lift technologies and practices have improved efficiency in recent years. Real-time data collection, automation, and control techniques now allow operators to monitor pumping performance and downhole conditions continuously, and to control operations accordingly. Variable-speed motors tailor pumping operations to changing conditions. New low-profile rod pumps are attractive options in sensitive urban, residential, and agricultural areas, as well as on crowded offshore platforms. Gas lift, another common form of artificial lift, pumps natural gas down the well’s annulus and injects the gas into the production tubing near the bottom of the well. The gas expands within the production tubing stream, allowing liquid hydrocarbons to be carried to the surface. Gas lift is commonly used when natural gas is readily available, and is especially prevalent offshore. Each gas lift well has an optimum injection rate and pressure. Since the injected gas raises the back pressure in the flow line leading to the field's separation and processing facilities, back pressure in one well affects all wells sharing common flow lines. Using advanced modeling techniques to develop models of multi-flow characteristics and to optimize parameters, operators today can design complex gas lift systems that maximize production from all wells in a network, given the system's constraints. Table 2.3 shows the economic benefits and Table 2.4 show the environmental benefits of gas lifting.

Table 2.3 Economic benefits of gas lifting.

ECONOMIC BENEFITS
Enhanced efficient production from existing wells
Lower equipment maintenance costs
Lower on-site power consumption and costs

Table 2.4 Environmental benefits of gas lifting.

ENVIRONMENTAL BENEFITS
Increased equipment life and fewer failures result in less work over and recompletion operations, reducing the volume of work over fluids and other wastes
Reduced air emissions due to lower power consumption

2.3.3 Gas-to-Liquids Conversion

Gas-to-liquids (GTL) conversion taps remote sources of gas to produce cleaner transportation fuels and promote energy security.

- ***Developing and Transporting Remote Gas Resources***

Roughly half the world's natural gas is unused because remote locations make it too expensive to transport to market via conventional gas pipelines or as cryogenically generated liquefied natural gas (LNG), due to distance, climate, environmental concerns, political uncertainty and the large capital investments required. On Alaska's North Slope alone, for example, approximately 25 trillion cubic feet of producible gas-in-place could be accessed with a cost effective approach such as GTL technology, with the converted liquid transported through existing pipelines and tankers.

- ***The Prospects of Gas-to-Liquids***

In 1923, German scientists Franz Fischer and Hans Tropsch introduced the first GTL conversion process. The technology can produce a variety of chemicals and fuels—of particular interest is its ability to yield large volumes of sulfur-free diesel fuel. The process involves reforming natural gas into synthesis gas ("syngas") by combining the gas with steam, air, or oxygen, then converting the synthesis gas to liquid hydrocarbons through catalytic reaction, typically with an iron- or cobalt-based catalyst. The liquid products are hydro-cracked and stabilized to create transportation fuels and chemicals. Until recently, this process has not been competitive in the petroleum marketplace, although it had been used for political reasons in noncompetitive economies such as Nazi-era Germany and apartheid-era South Africa. Dramatic recent advances in GTL technology focus on improved processes and catalysts, which are reducing costs enough to be more competitive with petroleum based fuels, depending on gas costs and oil prices.

GTL's potential to fundamentally alter oil and gas markets worldwide has generated significant private sector research and development efforts, and sparked numerous small-scale and pilot studies. The Department of Energy is committed to a goal of 200,000 barrels per day of GTL production by 2010 (assuming Alaskan North Slope gas is no longer required for reservoir re-pressurization), and it plays an active role in technology advances through support of a variety of research and assessment projects. It recently concluded an eight-year, $86 million cost-sharing agreement with a consortium of research and private sector parties. The consortium, led by Air Products and Chemicals, Inc., is working on a revolutionary ceramic membrane technology that promises to cut GTL production costs substantially.

- ***Far-Reaching Impacts of Commercial GTL Application***

GTL technology mounted on barges or offshore platforms could bring to market liquid transportation fuels from deepwater Gulf of Mexico sites without gas pipeline access. In Alaska, converted gas from the North Slope could be transported through the existing Trans-Alaska Pipeline System (TAPS), from Prudhoe Bay to Valdez, where tankers would deliver these liquids to market. This would have major ramifications for Alaska's oil and gas industry and the state's overall economy. Due to the approximate annual 10 percent decline in Prudhoe Bay oil production rates, pipeline flow may fall below the minimum volume required for cost-effective operations within the next two decades, eventually requiring that the pipeline be shut down. GTL technology could extend TAPS' life by more than 25 years and prevent shutdown of as many as 200,000 barrels per day of the last remaining North Slope crude, protecting valuable jobs and revenue. Table 2.5 shows the economic benefits and Table 2.6 shows the environmental benefits of GTL technology.

Table 2.5 Economic benefits of GTL technologies

ECONOMIC BENEFITS
Access to remote uneconomic natural gas resources
Creation of a gas-to-liquids industry resulting in thousands of new domestic jobs and potentially billions of dollars in new investments

Table 2.6 Environmental advantages of GTL technologies.

ENVIRONMENTAL BENEFITS
Reduced emissions of greenhouse gases and other air pollutants compared with conventional petroleum-based fuels
Optimized recovery of valuable gas resources
Reduced flaring of associated gas in remote fields

2.3.4 Glycol Dehydration

Effective management of dehydration systems reduces greenhouse gas emissions, improves air quality, and recovers substantial saleable natural gas.

Improved Practices and Technologies

After removing water from a stream of wet natural gas, a typical dehydration system circulates triethylene glycol (TEG) through a reboiler unit to boil off the water and gaseous compounds so that the "wet" TEG can be recycled. At the reboiler, however, methane, and in some cases other VOCs, and HAPs such as benzene, toluene, ethyl benzene, and xylene (BTEX), are vented to the atmosphere. The amount of methane and other compounds vented is directly proportional to the rate at which the glycol circulates through the dehydration system. If the circulation rate is higher than needed to achieve pipeline quality gas, more methane and other compounds are emitted, with no real improvement in the quality of the gas stream. Consequently, producers are reducing air emissions and recovering valuable methane by combining two advanced practices: first, by installing flash tank separators and condenser units at the reboiler to capture methane, VOCs, and HAPs before they are vented to the atmosphere; and second, by adjusting glycol circulation rates to optimal levels. Using a simple mathematical model, engineers can determine an optimal circulation rate, based on the characteristics of the particular gas stream, the pipeline's water content requirements, and the operator's production needs. These two processes, used in combination, yield significant environmental benefits for the producer in addition to attractive economic benefits, since the recovered methane can be used as on-site fuel or compressed and reinjected into the sales pipeline.

In a dehydration process with a flash tank separator, "lean" TEG is sent to the contactor, where it strips water, methane, BTEX, and other compounds from the gas stream before entering the separator. Here pressure is stepped down to fuel gas system or compressor suction levels, allowing most of the methane and lighter VOCs to vaporize (flash). The flashed methane can be captured and used as fuel gas or compressed and re-injected into the sales line. The TEG flows to the reboiler, where water and remaining gases are boiled off, and it is recycled back to the contactor. To prevent discharge of HAPs and VOCs not recovered through the flash process, dehydration systems can also be fitted with air- or water-cooled condensers, which capture additional compounds as they move through the reboiler stack. The economic and environmental benefits of glycol dehydration are shown in Tables 2.7 and 2.8.

Table 2.7 Economic benefits of glycol dehydration process.

ECONOMIC BENEFITS
Reduced energy consumption for circulation pumps and reboiler
Lower operating costs if captured methane is used to fuel on site equipment
Increased saleable gas
Potential for increased recovery of natural gas liquids

Table 2.8 Environmental benefits of glycol dehydration process.

ENVIRONMENTAL BENEFITS
Reduced greenhouse gas emissions
Improved local air quality due to reduction in BTEX and VOC emissions
Enhanced regulatory compliance for upcoming Federal E^P Maximum Achievable Control Technology (MACT) requirements

2.3.5 Leak Detection and Measurement Systems

New devices to detect and measure gas leaks aim to eliminate greenhouse gas emissions.

- ***High-Flow Samplers***

Advanced technologies equip the industry to detect leaks with better accuracy and efficiency. The High-Flow Sampler, samples the air surrounding leaking components using a pneumatic air mover, thus eliminating the need for bagging. Although more expensive than conventional tools, this technology offers the accuracy of bagging and the ease and speed of leak concentration measurements. It can also measure much larger leaks than standard instruments, which typically malfunction above leak detection ranges of 10,000 parts per million.

- ***Backscatter Absorption Gas Imaging***

Another new technology, Backscatter Absorption Gas Imaging (BAGI), is a state-of-the- art, remote video-imaging tool Whereas other surveys are performed with manually scanned point sensors, BAGI technology uses infrared laser-illuminating imaging. If a gas plume is present and resonating within the illumination wavelength, the plume attenuates a portion of the laser backscatter and appears as a dark cloud in the real-time video picture. The equipment can be tuned to the absorption resonances of a wide variety of gases. Remote video imaging, with the superior efficiency of covering an entire area at one time, could greatly simplify leak detection. The latest field trials indicate an impressive detection range, with flow rates as low as 0.1 standard cubic feet per hour at distances from up to 100 meters, and leaks as low as 0.02 standard cubic feet per hour at closer distances. Estimates are that BAGI will increase area leak search rates by a factor of 100 versus existing technologies. Economic and environmental benefits of advanced gas leak detection devices are shown in Tables 2.9 and 2.10.

Table 2.9 Economic benefits of advanced gas leak devices

ECONOMIC BENEFITS
More accurate information on leak characteristics and emissions, leading to successful and cost-effective leak reduction strategies
Increased recovery and usage of valuable natural gas

Table 2.10 Environmental benefits of advanced gas leak devices

ENVIRONMENTAL BENEFITS
Reduced emissions of methane, a potent greenhouse gas
Enhanced worker safety due to more effective and efficient leak detection

2.3.6 Low-Bleed Pneumatic Devices

Energy-efficient "low-bleed" pneumatic devices can dramatically reduce methane emissions and recover lost gas resources.

- ***Protecting the Ozone Layer and Saving Valuable Gas***

The natural gas production sector uses pneumatic devices to control and monitor gas and liquid flows and levels in dehydrators and separators, temperature in dehydrator regenerators and pressure in flash tanks. Approximately 250,000 pneumatic devices are used in the production sector alone, venting an estimated 35 billion cubic feet of methane annually, 70 percent of total methane emissions. Specific bleed rates are a function of the design, condition, and specific operating conditions of the device. By definition, a high-bleed device leaks more than six standard cubic feet per hour, although industry operators estimate that most devices typically bleed about three times that rate.

- ***Aggressive Replacement, Retrofitting, Inspection, and Maintenance***

New, technically advanced low-bleed devices and retrofit kits offer comparable performance characteristics to high bleed models, yet reduce methane emissions considerably, on average, they vent 90 percent less methane. Although low-bleed devices typically cost more than their high-bleed equivalents, cost-benefit analyses show that replacement or retrofit project costs are typically recouped within months. While it may be impractical to replace all an operation's high-bleed devices at once, operators are finding successful alternatives, such as combining replacements and retrofits, or installing a low-bleed device when an existing device fails or is no longer efficient. Others have implemented aggressive inspection and maintenance programs. By cleaning and repairing leaking gaskets, fittings, and seals, operators are able to reduce methane emissions substantially. Other effective practices include tuning the device to operate in the low or high end of its proportional band, minimizing regulated gas supply, and eliminating unnecessary valve position indicators. Tables 2.11 and 2.12 show the economic and environmental benefits of low-bleed pneumatic devices.

Table 2.11 Economic benefits of low-bleed pneumatic devices

ECONOMIC BENEFITS
Increased operational efficiency, as retrofit or replacement can provide better system wide performance, reliability, and monitoring of key parameters
Increased saleable product volume, as leaks are minimized

Table 2.12 Environmental benefits of low-bleed pneumatic devices

ENVIRONMENTAL BENEFITS
Reduced greenhouse gas emissions
Conservation for valuable gas resources

2.3.7 Vapor Recovery Units

Vapor recovery units cut up to 95 percent of light hydrocarbon vapors vented from crude oil storage tanks, while recovering valuable gas resources that vanish into thin air.

Crude oil storage tanks hold oil for brief periods of time to stabilize flow between production wells and pipeline or truck transport. During storage, light hydrocarbons dissolved in the oil vaporize and collect below the tank roof. The chief component of this gas is typically methane, although other gases such as propane, butane, ethane, nitrogen, and carbon dioxide may be present. These vapors also contain HAPs such as the BTEX compounds (benzene, toluene, ethyl benzene, and xylem). As the oil level in the tank fluctuates, these vapors often escape into the air, either through *flash losses* (due to pressure changes during transfer of crude oil), w*orking losses* (due to the changing fluid levels and agitation of tank contents associated with the circulation of new crude through the tank), or *breathing losses* (due to daily and seasonal temperature and pressure variations). The amount of gas lost depends on the stored oil's gravity, the tank's throughput rate, and the operating temperature and pressure of the oil being added.

- ***The Advantages of Vapor Recovery***

Vapor recovery systems can capture more than 95 percent of these fugitive emissions and recover substantial amounts of gas for use or sale. In addition to onshore use, they are also employed in offshore settings such as marine crude oil loading terminals. Producers may opt to pipe the recovered vapors to natural gas gathering pipelines for sale as a high Btu-content natural gas, or to use the gas to fuel on-site operations. Alternatively, they may strip the vapors to separate natural gas liquids (NGLs) and methane. By installing vapor recovery systems, producers may be able to avoid permitting charges, emissions fees, and other regulatory costs.

In a typical recovery system, hydrocarbon vapors are drawn from the storage tank under low pressure, usually between 0.25 and 2 psi, and then piped to a separator "suction scrubber," which collects any condensed liquids. Any recovered liquids are usually recycled back to the storage tank. The vapors then are compressed, metered, reused, or resold. To prevent the creation of a vacuum in the top of the storage tank as vapors are removed, the unit is equipped with controls that shut down the compressor, permitting reflow of vapors into the tank as necessary. These systems can recover practically all the hydrocarbon vapors that would otherwise be lost to the atmosphere with negative environmental impacts. Tables 2.13 and 2.14 show the economic and environmental benefits of vapor recovery systems.

Table 2.13 Economic benefits of vapor recovery systems

ECONOMIC BENEFITS
Lower operating costs if captured gas is used to fuel on-site equipment
Gas recovered for sale as a high-Btu natural gas
Gas recovered and stripped to separate NGLs and methane, if volume and NGL prices are sufficient
Potential avoidance of regulatory permitting and compliance costs

Table 2.14 Environmental benefits of vapor recovery systems

ENVIRONMENTAL BENEFITS
Significantly reduced greenhouse gas emissions
Improved local air quality, due to reduced emissions of VOCs and HAPs
Optimized recovery of a valuable natural resource

Chapter III:

Water Sector

Table of Contents

1. Introduction 1
2. Hydro power plants 1
   2.1. The Technology 1
   2.2. Hydropower Program in Iran 2
   2.3Future status of hydro projects.. 4
3. Underground dam type hydroelectric power plant 7
4. Desalination of brackish water 7
5. Wastewater Treatment.. 7
6 .Weather and Climate Modification 8
7. Major constraints and challenges.. 9

List of Tables:

Table 1.1.: Hydropower potential of Iran's reservoir dam……………………………………….... 2
Table 1.2.: Dropped plants, and power generation potential in Iran……………………………..... 3
Table 1.3.: Potential of the country for implementation of meandrous water plants…………………. 3
Table 1.4.: The number of minor runoff river plants……………………………………………….. 3
Table 1.5.: The structure of electricity generation in Iran…………………………………………… 3
Table1.6: Hydro plants under construction…………………………………………………………… 4
Table1.7.: Hydropower plants under study…………………………………………………………… 5
Table1.8.: Hydroelectric plants under construction…………………………………………………… 5
Table1.9: Future combination of electrical potential in Iran………………………………………… 6
Table1.10.: Volume of wastewater in Iran…………………………………………………………… 7
Table1.11: Summary of some key technologies required catalogued by objective………………… 9
Table1.12.: Technology & the Action Required……………………………………………………. 10

1. Introduction

While water sector is one of the least emitting sector emitting atmospheric pollutions, the impacts of climate change on water sector of Iran is probably one of the most severe cases, Even determining this impact on water resources of the country is the most delicate and enduring task as there are numerous variables due to the different microclimates, soils, temperature & precipitations and agricultural practices. Some of these variables have not even been clearly defined because of deficiencies in base data and lack of enough integration in the data collection interception and inter-related collaborating agencies.

Anyhow as “water” has been the most restraining factor in the civilization of this country from remote era’s even a slight and minor effect would have drastic effects in terms of devastating flood and droughts which would result in more deterioration of the economy encountering population growth and

Therefore, the exact pointing out of problems and presenting “only and one” solutions would not be a sound and logical process. Having this in mind the following guidelines are introduced based on expert judgment that should serve as main routes for more comprehensive studies for the possible mitigation of the adverse effects of climate change on the country’s dwindling water resources.

2. Hydro power plants

Electric power generation is one of the biggest single sectors emitting CO2. Considering the existing capability in the country for construction of dams, replacement of fossil fueled plants by hydropower plants can be the most efficient action which can be taken.

In the past, hydropower stations were often built as a part of large dam projects. Due to the size, cost, and environmental impacts of these dams and the reservoirs they create, new development of hydro technology mainly focuses on small scale projects in recent years. Despite various definitions for small scale, only projects that have less than 10 megawatts (MW) of generation capacity are considered here. This definition also includes mini-hydro (<1 MW), micro –hydro (<100 Kilowatts, or kW), and pico-hydro (<1 kW).

2.1. The Technology

The main components of a small-scale hydro (SSH) system are turbine and generator. Other components include the physical structures to direct and control the flow of water, mechanical and/or electronic controllers, and structures to house the associated equipment.

Different types of turbines are available and the optimum choice depends strongly on the head and the water flow rate. Generally, a high head site will require smaller and less expensive turbines and equipment.

For most hydro projects, water is supplied to the turbine from various storage reservoirs, usually created by a dam or weir. The reservoir allows water to be stored and electricity to be generated at more economically desirable times-during periods of peak electrical demand, for example when the electricity can be sold for a higher price. In these systems the amount of electrical power that can be generated is determined by the amount of water that is stored in the reservoir and the rate at which it is released

The most environmentally-sound hydro system does not have any impact on the amount or pattern of water flow that normally exists in the river stream. Such “run-of-river” systems may use a special turbine placed directly in the river to capture the energy that exist in the water flow.

A conventional small scale hydro (SSH) plant may also operate as a run-of-river system if the natural variability of the river flow is maintained. However, this type of system may generate less power during times of low water flow.

Small-scale hydro systems are modular and can generally be sized to meet individual or community needs. However, the financial viability of a project is subject to the available water resources and the distance through which the generated electricity must be transmitted.
Hydro systems do not create any pollution during operation and generally offer highly reliable power. They also have very low operating and maintenance costs, and can be operated and maintained under the supervision trained local staff.
In comparison with conventional power plants, hydro systems generally have longer lifetime. Equipment such as turbines can last 20-30 years, while concrete civil works can last 100 years. This is often not reflected in the economic analysis of small hydro power projects, where costs are usually calculated over a shorter period of time. This is important for hydro projects, as their initial capital costs tend to be comparatively high because of the need for civil works.
Although significant potential exists for further SSH development, the availability of suitable new sites is limited; particularly if dams or other structures are to be built and where local land use and planning laws may limit such a development.
A substantial number of weirs and other in-stream structures are already in place and can be fitted with hydro equipment. About 3,000 MW of these low-cost applications are estimated to exist worldwide. The environmental and land use impacts of these projects are often very low.
Detail cost analysis is the initial step in developing a hydro project. Regulatory authorities may require system structures that prevent adverse effects on flora and fauna, particularly fish. On the other hand , some hydro systems may enhance local environments through, for example, the creation of wetlands.
Although SSH is a mature technology, there is considerable scope for improvement. Electronic controls, telemetry-based remote monitoring, new plastic and anti-corrosive materials, new variable speed turbines for use in low-head applications, and new ways to minimize impacts on fauna, particularly fish, are helping to make systems more cost-effective and extend the range of potential sites.

The preliminary studies indicate that, more than 3000 regions in Iran are suitable for small hydro power plants. Since most of these regions are located in rural areas which do not have any access to general power network,, so from economic point of view we can claim that they are suitable options to be implemented. Some other advantages of small hydro are simplicity which enable local experts to establish and control the operation of these plants.

2.2. Hydropower Program in Iran

2.2.1 Hydropower generation through reservoir dams

The hydropower potentials of the country's reservoir dam are shown in Table 1.1. Totally, with 39,506 MW power, 16,917 giga Watt-Hour energy will be produced.

Table 1.1. Hydropower potential of Iran's reservoir dam [MOE 2004]

	Hydropower plants	Energy (Gig Watt -hour)	Power (MW)
Total	315	16,914.92	39,506.05

2.2.2 Hydropower generation by dropped plants

It is possible to install dropped –off bed plants, in some watershed basins of the country, most important of which is on Caspian sea coastal regions, Totally by 31 dropped –off bed plants, with 220 MW power may be generated 41 giga watt-hour energy annually.

Table 1.2.: Dropped plants, and power generation potential in Iran [MOE 2004]

Total	Plant	Energy ($\frac{gigawatt}{hour}$)	Power (MW)	Cost per KW ($)
	31	40.72	219.81	4500

- Hydro power generation by meandrous water plants.

Among the country watershed basins, 93 regions are identified to be suitable for establishment of meandrous water plants with potential of power generation of 2,212 MW equivalent to 441 giga Watt-hours of energy.

Table 1.3.: Potential of the country for implementation of meandrous water plants [MOE 2004]

Total	Plant	Energy ($\frac{gigawatt}{hour}$)	Power (MW)	Cost per KW ($)
	93	441.14	2212.68	3800

-The number of minor runoff-river plants and the possible power and energy generation are shown in Table 1.4.

Table 1.4.: The number of minor runoff river plants [MOE 2004]

Total	Plant	Energy ($\frac{gigawatt}{hour}$)	Power (MW)	Cost per KW ($)
	3000	150	250	2500

In 2001 the total generated energy in the country was about 121,337,000 MW from which 11,508 MW is generated by the Ministry of Energy.
The structure of electricity generation in Iran is shown in Table 1.5.

Table 1.5.:The structure of electricity generation in Iran [MOE 2004]

	100 MWh	Total Energy (percentage)%
Hydro power	3,650	3.3
Steam	78,332	66.5
Combined cycle	25,115	22.5
Gas turbines	8,250	7.4
Diesel	361	0.3

2.3 Future status of hydro projects

Power plants under construction are given in Table 1.6:

Table1.6: Hydro plants under construction [MOE 2004]

Catchment	Potential		In operation		Under const.		Under study	
	Cap'y (MW)	Energy (TWH/year)	Cap'y (MW)	Energy (TWH/year)	Cap'y (MW)	Energy (TWH/year)	Cap'y (MW)	Energy (TWH/year)
Karun	15.000	30	1.000	4	7.000	14.2	6.000	8
Dez	5,250	9	520	1.7	0	0	4.000	5.2
Karkheh	3.165	6	0	0	879	1.8	2.280	3.3
Other	1.036	5	480	1.1	201	0.4	358	0.7
Total	24.451	50	2000	6.8	8.080	16.4	12.644	17.2

2.3.1 Demand prediction

The annual growth in electric power consumption is predicted to be around 1,200 to 1,500 MW. The mean annual consumption growth for short- and medium- term plans is predicted to be 6% and 5%, respectively. Demand was 24,000 MW in 2002, and is expected to increase to 28,000 MW by 2005, to 34,000 MW by 2010 and to 49,000 MW by 2020.

2.3.2 Potential in demand management

The power consumption management activities are divided into two main groups:

- Measures which mainly cause a reduction in power consumption; and,
- Measures which mainly cause a reduction in consumption peaks.

As a result, coordination with industries for load shifting and regulating the working hours of other businesses have been prioritized in connection with demand management.

2.3.3 Productivity development

Among the most important government policies to increase productivity and reduce the construction costs of hydro electric generation following achievements can be mentioned:

- Enhancing the country’s engineering capabilities for the construction of Hydro-power plants;
- Benefiting from past experience in the erection of erecting new plants;
- Reducing the implementation time of project;
- Purchasing advanced equipment;
- Selecting construction sites which cause lower construction costs; and,
- Paying attention to co-benefits of these kinds of projects (flood control, irrigation and potable water supply, construction of recreational areas, development of the tourism industry, breeding of fish and other aquatic animal, etc.).

2.3.4 Potential for new Projects

In mid-1990s, the development of the country’s hydroelectric potential was given top priority which resulted in construction of a number of new power plants. To this end, based on the plans made, implementation of new hydro plants with a total capacity of 8,000 MW of power was launched. Studies are also to be carried out to construct additional 13,000 MW (Tables 1.7. and 1.8.).

Table1.7. Hydropower plants under study [MOE 2004]

No.	Project (dam and plant)	Province	River	Type of dam	Height of dam (m)	Reservoir capacity (million m^3)	Installed capacity (MW)	Mean annual energy (GWh)
1	Karun п	Khuzestan	Karun	CG	125	206	600	1950
2	Khersan I	Chahar mahal	Khersan	TGA	170	263	391	1218
3	Khersan п		Khersan	RD	120	2304	580	1689
4	Khersanш		Khersan	TCA	175	778	300	968
5	Bazoft		Bazoft	CA	160	262	163	487
6	Karun		Karun	RD	173	1176	452	826
7	Sazbon		Seymareh	CGA	152	1609	500	797
8	Paalam	Ilam	Karkheh	CGA	156	3596	800	1278
9	Kuran Buzan	Lorestan	Seymareh	CFRD	134	2338	201	550
10	Tang-e-Mashure	Chahar mahal	Kashkan	RCC	128	1019	166	500
11	Roudbar Lorestan	Lorestan Lorestan	Roudbar	RCC OR	169	285	400	1050
12	Bakhtiari	Lorestan	Bakhtiiari	CA	260	4845	1220	2957
13	Lyro	Lorestan	Zalaki	CA	210	520	470	1045
14	Zalaki	Lorestan	Zalaki	CA	210	2517	466	1333
15	Sadasht	West Azarbaijan	Glass	CRD	126	1050	418	734
16	Shivashan	West Azarbaijan	Glass	RD	121	588	155	273
17	Siah Bisheh	Mazandaran	Chalus	RD	106		1000	1250

Table1.8.: Hydroelectric plants under construction [MOE 2004]

No.	Project (dam and plant)	Province	River	Type of dam	Height of dam (m)	Reservoir capacity (million m^3)	Installed capacity (MW)	Project (dam and plant)	Date of commercial operation
1	Masjed-e-Soleiman	Khuzestan	Karun	CRD	177	230	2000	3700	2002-2005
2	Khersanш	Khuzestan	Karun	TCA	205	2750	2000	4137	2005
3	Karun I (Development)	Khuzestan	Karun	TCA	200	3139	1000	4000	2003
4	Karun Chahar mahal	Chahar	Karun	TCA	230	2190	1000	2107	2006
5	Gotvand	Khuzestan	Karun	CRD	180	4500	1000	4500	2009
6	Karkheh	Khuzestan	Karkheh	CED	127	7300	400	934	2002-2003
7	Seymareh	Ilam	Seymareh	TCA	180	3200	400	850	2007

2.3.5 General direction of development

At present, the contribution of hydroelectric power to national electricity production is about 6%. The Ministry of Energy is trying to increase this share to 19% within the term of the Third and Fourth Economic Development Plans (up to 2005 and 2010, respectively). Therefore, the Ministry of Energy is seeking to increase the capacity of the power plants in the next decade from 20,000 MW to 53,000 MW (see Table 1.9.). The increase in the share of hydroelectric power plants has especial importance in terms of reducing environmental damage (by avoided fossil- fuel based electricity generation), lower operational costs, and longer life of the facilities. For an arid and semi-arid country like Iran, the construction of hydro plants can lead to a number of secondary benefits such as sustainable water supply and flood control in addition to the primary goal of energy production.

Table1.9: Future combination of electrical potential in Iran [MOE 2004]

Item	Type of Plant	2005				2010				2020			
		Installed capacity		Energy production (GWh)		Installed capacity		Energy production (GWh)		Installed capacity		Energy production (GWh)	
		MW	%	MW	%	MW	%	MW	%	MW	%	MW	%
1	Steam	12.500	40.0	143.000	86.3	18.800	35.5	190.0000	86	19.000	22.1	324.000	90
2	Combined cycle	5.700	15.0			13.800	26			35.000	40.7		
3	Gas turbine	8.500	22.4			9.000	17			15.000	18.0		
4	Diesel generator	400	1.1			400	1			400	0.5		
5	Nuclear	1.000	2.6	6.200	3.7	1.000	2	6.300	3	1.000	1.2	6.300	2
6	Hydropower	7.200	18.9	16.500	10	10.000	19	24.500	11	15.000	17.5	29.000	8
	Total	33.000	100	165.700	180	53.000	100	220.800	100	85.900	226	359.300	100

2.3.6 Incentives for investment

Persuading the private sector to invest and also attracting foreign investment are also among the main objectives of Ministry of Energy. The high amount of investment required for development of the electrical industry, makes the dependence on foreign inevitable

Following Cabinet's approval of the administrative regulation of the Investment Encouragement and Support Low, and constraint removal through foreign investment in the country, use of this investment for development of production facilities will be possible. Ministry of Energy will also issues licenses to the private sector for construction of power plants and will guarantee to purchase the power. Pursuant to the third plan low, the surplus electricity generated by units, which produce electricity for their own requirements, will be purchased at prices at which they are generated. The Ministry of Energy can offer its power plant, up to 10 % of the national power generation capacity, for sale to the non- public sector at spot prices, demanding 40% of the price in cash and the rest in 5-year installments.

3. Underground dam type hydroelectric power plant

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As a result of invisibility it is difficult to estimate the potential and availability of ground water resources.. In constructing underground dams it is important to consider technical issues such as climate instability which may result in irregular rainfall and drought in most part of Iran.

Lack of a reliable water supply to meet even basic needs is a serious hindrance to human settlement in rural areas. Like other semi-arid regions of the world, Iran has shallow, rocky soils with low water retention capacity, a low organic material content and a high susceptibility to erosion. There are various options for creating and tapping water reservoirs in this region. Surface reservoirs are the most commonly used, since geological conditions are conducive to a high degree of surface drainage. However, the evaporative losses are high. Another option is to make use of groundwater. However, the underlying crystalline bedrock lacks the porous structure necessary to store a large volume of water and maintain a high rate of extraction.

To overcome these shortcomings a further option of creating artificial aquifers using underground dams as a means of storing large quantities of good quality water for domestic use by animals, or even for small-scale irrigation has been devised. Under semi-arid conditions alluvial pools are used as a widespread phenomenon. This natural pooling of water, a common process in watersheds with crystalline bedrock, lends itself to construction of underground dams in the surface alluvium. Such dams have the advantages of being able to store large volume of water in comparison with natural aquifers in this area, and of being less susceptible to evaporative losses as the water is stored underground.

4 .Desalination of brackish water

Scarcity of fresh water in the today's world makes desalination of brackish water an inevitable task in the future. Desalination is a costly process and the water obtained by desalination proves much costlier than naturally available-treated water. By using modern equipments for water desalination, the cost of producing fresh water from sea water has been reduced by about seven times, but it is still about three to ten times costlier than the cost of natural water treatment.

Technology transfer in the field of new technology such as nanotechnology for desalinating of brackish water is indispensable.

5. Wastewater Treatment

Considering wastewater treatment, the technology transfer activities should focus on development of basic urban infrastructure and wastewater treatment services. The purpose of municipal wastewater treatment is to prevent pollution from entering watercourse. Depending on the type of sewer collection system and industrial wastes entering the sewers, characteristics of municipal wastewaters vary from place to place. Factors such as the application of streams and lakes' water into which waste is entered determine the degree into which waste treatment is required.

The wastewater volume of the country is presented in Table 1.10.

Table 1.10: Volume of wastewater in Iran

Wastewater	year 2000 (MCM)	year 2020 (MCM)
Agricultural wastewater	26	32
Civil wastewater	1.8	5
Industrial wastewater	1.2	3
Total	26	32

6 .Weather and Climate Modification

6.1 Cloud seeding

Adequate availability of water through rainfall has always been the major worry of mankind, making him amenable to any activity that could bring him rain.

Defining the present state of knowledge in the field of precipitation enhancement, it was stated that: cloud seeding technology should be developed to provide the ways and means to achieve this kind of intervention in cloud processes. Scientific considerations should provide the necessary equipments and guidance for application of this technology.

Considering issues related to climate modification, technology transfer activities must address the following issues:

- Implementation of cloud seeding projects throughout the country in cooperation with countries which are pioneer in cloud seeding, for gradual transfer of this technology aiming at attaining the technical independence.
- Explore new water resources, Climate modification
- Spatial conditioning and timely transfer of rainfall.
- Flood control
- To transform hail to rain.
- To postpone thunder and lightning
- To increase the hydropower plant capacity.

6.2 Protection of soil moisture

Certain amount of water is required for crop production below which it seems to be an impossible task. Relatively small increases in moisture supply may result in a marked increase in crop yield. Such improved moisture regions in the soil can be achieved in two ways:

a) Increase the amounts of water stored in the root zone.
b) Reduction of evaporative loss.

Water storage in crop root zone

The amount of precipitation taken in by soil depends on runoff and infiltration. By reduction of runoff and increasing infiltration, the amount of water stored in the soil can be increased.

Reducing evaporation from soil can be minimized in a number of ways:

1) Decreasing turbulent transfer of water vapour to the atmosphere, by windbreaks mulches, etc.

2) Decreasing capillary continuity of surface layer.

3) Decreasing capillary flow and the moisture-holding capacity of the surface soil layer.

4) Chemical treatments to control evaporation from soil and water bodies. It has been found that hexadecanol, a long chain alcohol, mixed with one-quarter inch of the soil reduced evaporation by 40 percent. This material which is resistant to microbial activity remains effective for more than a year.

6.3 Water Harvesting

Several methods are used for water harvesting. Soil surface can be treated with chemicals to prevent the water from soaking into the soil. An increased runoff can then be utilized by crop fields situated at lower levels.

It has been demonstrated that runoff can be increased to a great extent if smooth sandy loam and clay soil are treated with 400 pounds of sodium carbonate per acre. Similar results have been obtained using sodium chloride.

6.4 Wells electrify

Electrifying pumps of operational wells instead of using fossil fuels diesel generators is another ways for decreasing the emission of green house gases.
There are about 444,142 deep and semi- deep wells in Iran, of which about 102,911 wells been equipped by electrical pump so far. Wide application of electrical pumps is predicted in 4th national development plan of the country.

7. Major constraints and challenges

The major challenges encountered in relation to the development and operation of hydro power-plants in Iran are:

- Restricted financial resources for investment in new plants;
- Relatively long construction phases, which discourage foreign investors from investing in hydro projects on a BOT basis;
- Necessity for watershed management, to reduce sedimentation in reservoirs and increase their useful life;
- Necessity to maximize the use of domestic potential in design and construction of projects, to stimulate job creation;
- Large subsidies allocated to energy sector, particularly in the oil and gas sector, which in certain cases justifies the use of alternative power plants, especially gas plants, instead of hydropower; and,
- Necessity of environmental consideration in assessment of power plants from economical point of view.

Table No 1.11. and 1.12 show some key technology and action required.

Table 1.11.: Summary of some key technologies required catalogued by objective

NO	Option	Constraints
1	Hydropower	Insufficient investment, technology, experience and equipment
2	Underground Dam	Insufficient investment, technology, experience and equipment
3	Desalination of Brackish Water	Insufficient investment, technology, experience and equipment
4	Waste Water treatment	Insufficient investment, technology and equipment
5	Weather and Climate modification	Insufficient investment, technology, experience and equipment
6	Protection of Soil Moisture	Insufficient investment
7	Water Harvesting	Investment

Table1.12.: Technology & the Action Required

NO	Technology	Mitigation	Adaptation	Potential Impact	Relative Cost	Time Path
1	Hydropower	Yes	Yes	*H	**M	Years
2	Underground Dam	No	Yes	H	H	Decades
3	Desalination of Brackish Water	No	Yes	H	M	Years
4	Waste Water treatment	No	Yes	H	M	Years
5	Weather and Climate modification	No	Yes	H	M	Years
6	Protection of Soil Moisture	No	Yes	H	M	Year
7	Water Harvesting	No	Yes	M	M	Year

* H=High
** M=Medium

Chapter IV:

Agricultural Sector

Table of Contents

1. Introduction 1
1.1.Status of agriculture in Iran..3
1.2. Vulnerability of Iranian agriculture...4
1.3. Vulnerability of farming system 2
2.Adaptation Technology……………………………………………………………………4
2.1.Development of crop varieties or species. 2
2.2.Agricultural water resource adaptation 3
3.Mitigation Technology………………..6
4. Technology teransfer in agricultural sector. 6
4.1. Barriers to adaptation and mitigation technology transfer. 7
4.2. Institutes responsible for agricultural technology transfer 8
4.2.1. Soil and Water Research Institute 8
4.2.2 Rice Research Institute. 8
4.2.3. Palm Dates and Tropical Fruits Research Institute 8
4.2.4. Dry Farming Research Institute 8
4.2.5. Cotton Research Institute 9
4.2.6. Pistachio Research Institute 9
4.2.7. Sugar Beet Seed Improvement Institute 9
4.2.8. Agricultural Biotechnology Research Institute 10
4.2.9. National Salinity Research Center 10
4.2.10. Soil Conservation and Watershed Management Research Center 10
4.2.11. Rural Research Center 10
4.2.12. Forest and Range Research Institute 10
4.2.13 Animal Science Research Institute 11
4.2.14. Fishery Research Institute... 11
4.2.15. International cooperation for technology transfer 11
5. Programmes and Policies to Encourage Technology Transfer 12

List of Tables

Table 1.1..: Examples of new varieties developed by the agricultural research and education institute 3
Table 1.2.: Examples of water resource adaptation measures [BAR 2003]... 3
Table 1.3.: Total GHGs emissions for agricultural sector 4
Table 1.4.: Some of the emission sources and mitigation practices in agriculture 4
Table 1.5.: Estimates of methane emissions from paddy fields.. 5
Table 1.6.: Examples of technologies that can be transferred in agricultural sector of…………8
Table 1.7: Examples of barriers to adaptation and mitigation technologies……………………..9

1. Introduction

Agriculture in Islamic Republic of Iran is a strategic sector as compared to other sectors of economy, expected to rapidly expand its production in the next 20 years in order to feed its growing population. Yet as it is situated in an arid and semi arid region, is effected by climate change through increased variability as well as temperature and moisture changes. In spite of its considerable potential, agricultural adaptation to climate variability and changes will require new technology, genetic stock, improved irrigation efficiency, and more storage of runoff, moisture conservation, improved nutrient efficiency, production management techniques and better risk management.
Contribution of agriculture to mitigation of GHGs is through a number of activities, inter alia; carbon sequestration in soil, appropriate land use practices, reducing methane from ruminants through straw ammoniation and better feed efficiency, reducing methane from paddy fields through water management practices.
In addition, nitrous oxide (N_2O) can be reduced through better nutrient management. To address climate change consequences a diverse portfolio of techniques is required to be adopted and transferred. However, lack of technical knowhow, infrastructures, financial resources, small farm holding, fragmented lands discourage transfer of technology to risk adverse farmers. These constraints and hindrances can hardly be tackled, unless the transferred technology profitability has higher chance of quickly solving the immediate problem encountered in the farming system.

The role of government in technology transfer is crucial and can facilitate it through providing incentives by regulations and better constitution arrangement. Farmers in the country, for centuries adopted themselves to variability and adverse effect of climate; however, distorted markets prevailing in the country make farmers less susceptible to changes in yield and prices.
There are evidences in the country that the success of a response to an actual climate change shows that the required technology can be transferred and adopted. Recent prolonged droughts in the country (1991-2001) has obliged farmers to switch to new water saving and increased irrigation efficiency by adopting pressurized irrigation systems such as dripped and sprinkler. Though the growth rate of adaptation may not be rapid due to technological and financial barriers, it demonstrates success of the government policy that response to the needs.

1.1. Status of the Agriculture in Iran

Based on the soil resource studies carried out by the Soil and Water Research Institute of the Ministry of Agriculture, the agricultural sector in Iran is endowed with over 37 million hectares of arable lands. Annually about 87 billion cubic meters of water is allocated for agriculture. It has 112 million hectares of rangeland and forests, considerable aquatic resources, highly diverse climate, skilled manpower and relatively access to technologies.
At the present, agricultural sector provides over 82 percent of food requirement of the population, 90 percent of the raw material for processing industries, contributing 14% to the GDP and 25 % in non- oil export value and 23% of the total employment

1.2. Vulnerability of Iranian Agriculture

Much of the agricultural production depends on endowment of surface water and ground water resources. Any considerable change in availability of water resources in the arid and semi arid regions of the country would impact agriculture. During the recent years, in addition to the frequent droughts and chronic water shortage causing serious damages to food production, flooding has become a serious problem requiring adaptation. Possible changes in water resources demand would require management of adaptation measures and new investment for capacity expansion, operation of existing systems for optimum and sustainable use, including water resource management and irrigation management. As a consequence any adaptation measure may come at the expense of economic and environmental costs. Decrease in total annual precipitation and high evaporation as the result of global warming and climate change may strongly affect total production of both annual and perennial crops. Production of wheat crop, which is the main staple food in the country, may undergo considerable reduction.

1.3. Vulnerability of farming system

A large number of small size farm holding is the main characteristic of agriculture in Iran. The average size of holding is about 6.95 hectares of both marginal rainfed and irrigated lands. The total number of holdings possessing less than 10 hectares of land is estimated to be 77% of the total holdings. Land fragmentation is a critical issue in Iranian agriculture. About tow third of farm households possess less than 5 hectares, which may be 15 scattered plots. Large portion of holdings is under marginal lands. Climate changes would certainly affect small farmers, especially those operating in the marginal lands.

2. Adaptation technology

Historically Iranian agriculture has proven to be adaptive to changing climate conditions. In the central region of the country with arid condition, the type of farming practices and high efficient use of water resources and especially use of Qanats (manmade underground galleries) for irrigating crops are indications of adaptation, but there is uncertainty with regards to adaptation to potential climate change. Some losses due to climate change can be tolerated but some of the effects can be modified through technological adaptations. New advances like application of water saving techniques, rain water harvesting, introduction of salt tolerant crop varieties in the country during past decades, has adopted measures to combat adverse effect of climate change

2.1. Development of crop varieties or species.

For most crops especially wheat, barley, sunflower, rice, sugar cane, cotton and sugar beet new tolerant and resistive varieties are developed. Table 1.1. provides a list of available adaptation opportunities that can be applied at the farm or farmer’s community level. It is likely that in the light of research findings in the country, autonomous adjustment of the farmers will continue to be important as the climate changes, provided that farmers potentially have access to these research findings, information and tools.

Table 1.1..: Examples of new varieties developed by the agricultural research and education institute [BAR 2003]

Crop	Name of improved variety	Characteristics
Irrigated wheat	Alamoot	Grown in winter season, frost tolerance, tolerant to lodging, tolerant to yellow and brown rust
Irrigated wheat	Atrack	Very tolerant to lodging, early maturing, tolerant to yellow and brown rust, relatively tolerant to fuzarium disease
Irrigated wheat	Alvand	Tolerant to lodging and grain loss, tolerant to salinity and water deficiency, frost tolerant and resistive to yellow rust
Irrigated wheat (durum wheat)	Stork	Grown in spring time, tolerant to lodging and disease and grain loss

2.2. Agricultural water resource adaptation

Adaptation measures to be taken depend totally on the extent of climate change impacts and the capacity to adapt. Water resource adaptation may be quite costly and needs huge investment. The following adaptations may be taken to mitigate the impact of climate change

Table 1.2.: Examples of water resource adaptation measures [BAR 2003]

Response strategy	Adaptation options
Supply management	Construction of small dams
	Rehabilitation of Qanats
	Rehabilitation of springs
Demand management	Lining canals (specially tertiary and quaternary canals
	Maintenance of irrigation canals
	Using closed conduits (pipes) for water conveyance
	Re use of drainage waters
	Conjunctive use of surface and ground water resources
	Development of complementary irrigation for rainfed agriculture
	On farm land improvement
Technological adaptation	Use of pressurized irrigation systems (both sprinkler and drip)
	Cultivation of tolerant and less water consuming crops
	Development of salt tolerant crops

3. Mitigation technology

Based on 1994 figures the CH_4 emission from rice cultivation, enteric fermentation of domestic livestock, manure management and burning of agricultural residues is estimated at 643.1 Gg] (Iran's Initial National Communication to UNFCCC, 2003]. The total amount of CO2 equivalent is about 30,313.3 G(Table 1.3).

Table 1.3.: Total GHGs emissions for agricultural sector [INC]

Source	CH_4	N_2O	NO_x	CO
Entric fermentation	496.78	NE	NE	NA
Animal wastes	19.51	21.33	NE	NA
Rice cultivation	114.495	NE	NE	NA
Agricultural soils	NA	32.61	NE	NA
Agricultural crop residue burning	12.32	0.28	10.02	258.98
Total	643.105	54.22	10.02	258.98
GWPs	21	310	NE	NA
Total CO2 equivalent	13505.2	16808.2	NA	NA

NE: Not estimated, NV: Not available

A significant amount of the GHGs emission from agriculture can be avoided if some combination of the agricultural management practices is adopted in the country (Table 1.4).

Table 1.4.: Some of the emission sources and mitigation practices in agriculture

Emission source	Mitigation practice
A: Ruminant livestock	
Increased feed digestibility	Enrichment of forage by adding nitrogen
Manure management	Manure spreading
	Use of manure in bio gas plants
	Drying of manure in poultry farms
B: Crop residue burning	Preventing crop residue burning
	Incorporating crop residue into soil
C: Flooded rice fields	Mid term drainage of flooded lands
	Better agricultural practices
	Direct deeding of rice
	Nutrient management
Agricultural soils	Carbon sequestration practices such as conservation tillage (minimum and no tillage)

To compare the conventional methods and technologies used and the proposed new technologies, no research is available in the country and though some of the available adopted technologies can be used to mitigate GHGs, they have not been considered for this purpose. But the effect of these technologies in mitigating GHGs is being measured through different researches in few countries, some of which are briefly pointed out below.

3.1 Rice cultivation

The conventional method of rice cultivation in the country is flooding system, in which intermittent or mid season drainage is not possible and practical. But recently, through "on farm land improvement" carried out in limited areas in the Northern provinces, the land is provided for adopting the technique of incorporating midterm drainage.
As methane production occurs only under reduced conditions, midterm drainage decreases CH_4 emissions. There are three processes in which CH_4 is released into the atmosphere from rice paddy. During the early stages of plant growth and to some extent at the weeding time, methane is lost as bubbles. In the second process, which is basically a slow process, CH_4 is lost through diffusion across the water surface. The third process, transport through rice plant aerenchyma and release to atmosphere through the shoot nodes, which are not subject to stomatal control. The last one is the most important emission mechanism. No attempt so far is made to measure methane emission from rice fields in the country, but a research was conducted in the country to assess the effect of midterm drainage on yield increase of paddy (Effect of Midterm Drainage on Rice production, Mazandaran Rice Research Center, Mazandaran Agricultural Organization, 1994). Some studies have been carried out in few countries in the world as reported by IPCC second assessment report (1995)

Table 1.5.: Estimates of methane emissions from paddy fields

Country	Total area of rice paddy (Mha)	Total rice grain yield Mt/yr)	CH4 emission (Mt/yr)
China	32.2	174.7	13-17
India	42.2	92.4	2.4-6
Japan	2.3	13.4	0.02-1.04
Thailand	9.6	19.2	0.5- 8.8
Philippines	3.5	8.9	0.3-0.7
USA	1.0	6.4	0.04-0.5
Other	54.6	158.5	9.2-20
World total	147.5	473.5	25.4-54

*As shown by Sass et al. (1992), draining the field at specific times decreases CH_4 production by 88% without decreasing rice yield. But in practice the effect will not be more than 50% in the field. Therefore, considering the above estimates, the total CH_4 emission in the country, released from paddy field can be reduced by half.

3.2 Plant residue or biomass burning

Burning of crop biomass results in emission of carbon dioxide and methane, the latter is mainly due to incomplete combustion. As it was pointed out in the Table 6.3 parts of the CH_4 and CO2 emissions in the country are attributed to burning of crop residue. Due to the lack of reliable data the figure reported in Table 4.3 seems to be under estimated and needs to be more investigated. The burning of crop residues in the country is mainly adopted by the farmers to combat outbreak of pests and diseases and to get rid of plant residues for the next cultivation. Technologies like integrated pest management and biological pest controls are already in place and adopted in some parts of the country. In addition, use of green manure has been recognized as an agricultural practice. It consists of incorporating non decomposed vegetative matter into the soil, with the objective of conserving or restoring the productivity of agricultural lands. Today it is considered as a crop in rotation, followed or associated with commercial crops, and incorporated into soil or left on the surface as mulch to offer protection.
The object is to improve or restore the physical, chemical and biological properties of the soil.

As the technology is being applied to a very limited area of the country, this part of emission can be eliminated through replication of the technologies to other areas.

3.3 Carbon sequestration

Land use, land management and change in the area under cultivation can bring about changes in the biomass stocks and organic matter. Soil degradation process such as erosion, degradation of soil structure, mineralization or oxidation of humid substances can lead to decline of soil organic matter and the soil organic carbon. Studies carried out in the world indicate that agricultural practices such as restoration of degraded lands, adoption of conservation tillage and combination of various land management and cropping pattern enhance carbon sequestration in agricultural lands .

Technologies such as conservation tillage, which is a tillage system, defined as covering soil with crop residue, can protect soil organic matter from decomposition by minimizing the chance of soil erosion.

4. Transfer of technology in agriculture

As it was stated earlier, the mitigation options such as irrigation management, carbon sequestration, and yield increase of crops, genetic improvement of livestock and improvement of diet quality can result in a considerable decrease in GHGs emission. These options are likely to increase crop and livestock productivity.

A wide range of adaptation and mitigation technology options related to agriculture can be suggested and some of them are already in place in the country. Most of these technologies to abate climate change will be of immediate benefit and can be considered "no-regret technologies". Table1.6 summarizes some of the major technologies that are in place in Iran or can be easily adopted.

Table 1.6.: Examples of technologies that can be transferred in agricultural sector of Iran [Ref: Research findings of Agricultural Research, Training and Extension Organization,2004]

Objectives	Technology	Mitigation	Adaptation	Impact	Relative cost
Higher yield and productivity	Improved cultivars		+	Medium	Medium
	Timeliness of sowing		+	Medium	Low
	Livestock genetic improvement	+	+	Medium	High
	Biological control of pests	+	+	Medium	Medium
	Nitrogen fixing in soil (Legume cropping)	+		Medium	Medium
Reduced emission	Mid season drainage of paddy fields (intermittent flooding)	+	+	Low	Low
	Improved feed efficiency	+	+	Medium	Medium
	Bio gas use from manure	+	+	High	Medium
	Improve nitrogen efficiency	+	+	Medium	Medium

	Manure management	+	+	Medium	Low
CO_2 sequestration in soil	Reduced bare fallow	+	+	Medium	Low
	Conservation tillage (reduced tillage)	+	+	Medium	High
	Protection of marginal lands	+	+	Medium	Low
	Straw ammoniation	+	+	Low	Low
	Crop residue composting	+	+	Low	Low
	Preventing crop residue (biomass)burning	+	+	Low	Low

In transferring technology links should be established between technology adoption and diffusion and enhancing income of farmers for using technology services. Lack of financial resources and incentives is and will be the major constraints to adopt new technology. For instance, the current endeavor in the country to combat water shortage through adoption of high efficient pressurized irrigation system could not fully meet the objectives envisaged in the development plans. The main constraints in accelerating adoption of pressurized irrigation systems are financial limitations and lack of farmers' awareness.

4.1. Barriers to adaptation and mitigation technology transfer

Some of the adaptation and mitigation technologies could not be easily implemented due to the many barriers that may be encountered in technology transfer as shown in Table 1.7.

Table 1.7.: Examples of barriers to adaptation and mitigation technologies

Adaptation options	Barriers
Development of irrigation water supply	High cost of new source water development
Irrigation efficiency improvement	Requires large investment in implementing pressurized irrigation
	Requires high investment in farm land improvement
	Requires large investment in canal lining and conveying water through pipes
Development and introduction of new cultivars	High investment in research works
Conservation tillage	Increased pest outbreak
	Risk of yield reduction
	New machinery needed
Higher livestock productivity	
- Genetic improvement	Requires high investment
- Ammoniation of straw for animal feed	Ammonium sulphate is more expensive than urea

4.2. Institutes responsible for agricultural technology transfer

The agriculture sector in Iran has a network of research and training programs to develop and introduce and transfer the technologies to farmers throughout the country. The network includes 21 national research institutes, 6 provincial research centers and 64 training centers at the national and provincial levels and 350 research stations. The following are the research agencies already in place in the country:

4.2.1. Soil and Water Research Institute

The Soil and Water Research Institute has 9 research departments as follows:

- Soil formation, classification and identification
- Land evaluation
- GIS and RS
- Soil chemistry, soil fertility and plant nutrition
- Soil biology
- Irrigation and soil physics
- Land reclamation and sustainable land management
- Laboratories

In addition, there is a research station for technical and research services.

4.2.2. Rice Research Institute

The Rice Research Institute has five research departments:

- Seed improvement
- Pest and disease
- Technical and engineering
- Soil and water
- Technical and research services

The main responsibility of this institute is to conduct research on seed improvement, development and introduction of tolerant varieties to water deficiency, introducing bio technology and rice mechanization.

4.2.3. Palm Dates and Tropical Fruits Research Institute

This institute is comprised of six departments as follows:

- Plant breading
- Plant pathology
- Irrigation and plant nutrition
- Crop production, processing and storage
- Technical and research services

4.2.4. Dry Farming Research Institute

The main responsibility of this institute is to conduct research on rainfed crops including cereals (wheat and barley), pulses (chick pea and lentil), oil seeds and forage crops. It has seven research departments as follows:

- Cereal
- Pulses
- Forage crops
- Oil seeds
- Resource management
- Technical services
- Seed improvement and certification

4.2.5. Cotton Research Institute

As cotton plays vital role in development of oil extracting and textile industries in the country, Cotton Research Institute was established to support these industries through development and introduction of high yielding and disease tolerant cultivars, suitable for different climates of Iran. This institute has 5 research departments as follows:

- Plant breeding
- Technical and engineering
- Technical and research services
- Plant pathology
- Improvement of farming practices

4.2.6 Pistachio Research Institute

As the pistachio is a high value crop in the country, the Pistachio Research Institute was established to undertake research activities for improving the quality of pistachio through introduction of tolerant species and improving cultural practices. It has six departments as follows:

- Plant pathology
- Improving cultural practices
- Plant breeding
- Irrigation and plant nutrition
- Production, processing and storage engineering
- Technical and research services

4.2.7. Sugar Beet Seed Improvement Institute

This institute is comprised of six departments:

- Plant breeding
- Improving cultural practices
- Sugar beet technology
- Biotechnology
- Plant pathology
- Technical and research services.

4.2.8. Agricultural Biotechnology Research Institute

This institute is one of the key institutes affiliated to the Agricultural Research and Educational Organization, which was established in 1999 and has the following departments:

- Physiology
- Genetic
- Tissue culture and transgenic
- Genomix
- Technical services and research support

4.2.9 National Salinity Research Center

This center was established in the year 2000, with objective to conduct researches on soil and water salinity and recommend solution for improving agricultural production in salt effected soils. It has the following five departments:

- Irrigation and drainage
- Soil nutrition and soil chemistry
- Farming and horticulture
- Technical and research services
- Dissemination of research findings

4.2.10 Soil Conservation and Watershed Management Research Center

This research center has 6 departments:

- Watershed management
- Soil conservation
- Water resource development
- Flood management and utilization
- River engineering
- Coastal conservation

4.2.11 Rural Research Center

This center has 3 following sections:

- Social studies
- Economic studies
- Information and scientific support

4.2.12. Forest and Range Research Institute

This institute has 10 departments as follows:

- Forest
- Range
- Agronomy
- Desert
- Medicinal plants

- Mechanization of natural resources
- Wood and paper science
- Plant pests and diseases
- Genetic and physiology

4.2.13 Animal Science Research Institute

This institute has 6 departments as follows:

- Live stock and poultry management
- Animal products processing
- livestock and poultry genetic and breeding
- Livestock and poultry physiology and nutrition
- Biotechnology
- Sericulture

4.2.14. Fishery Research Institute

This institute is comprised of 5 departments:

- Fish rearing
- Water resource ecology
- Biotechnology
- Fish resource management and utilization
- Fish health and diseases

4.2.15. International cooperation for technology transfer

The international network of research, development and technology transfer is already in place for many decades. The global system of research is constituted of three main players: national Agriculture Research System (NARS), International Agricultural Research Centers (IARCs) and advanced laboratories and institutes in developing countries. The National Research Institutes was briefly introduced above. It is the main player in the country responsible for research activities and transfer of technology to farmers and producers within the country. This player interacts with other international centers in a number of ways, including bilateral agreements, multi lateral agreements and research networks. The Islamic Republic of Iran like other countries is involved in this research network in many ways and has already invested considerable financial resources to participate in the global research network.
The Consultative Group on International Agricultural Research (CGAR) since 1960s has established 16 IARCs.

- **International Center for Agricultural in Dry Areas (ICARDA) and Iran Collaboration**

The collaborative research between ICARDA and Iran has begun since establishment of this center. Some of the collaborative research conducting jointly with ICARDA by Iran is summarized as follows:

- Farm survey and investigations. It has contributed to identify production obstacles, development research plans and activities

- Crop varieties. One of the main objectives of ICARDA/Iran collaborative research was to improve the productivity of major food crops, including wheat, barley, chick pea and lentil. Wheat as the main staple food grain in the country has been at risk due to a host of biotic and obiotic factors. Collaborative research works were developed to identify and release of genetically diverse varieties to create a genetic mosaic pattern in major wheat growing areas.

As the result of this collaboration different varieties for bread wheat, both for irrigated (eight varieties) and rain fed (three varieties) and for durum wheat (one variety), were developed. These varieties are tolerant to diseases like yellow rust and karnal Burnt. and possess other improved characteristics.
Under the expanded collaboration, a number of improved lines in many other crops such as oil seeds and forage crops have been identified and the technologies are being tested and action is being taken to transfer them to the farmers.
Similar collaborative research is being implemented, in which few examples can be listed as follows:

- Research on agronomic control of dwarf bunt
- Chemical control of dwarf bunt
- Virulence and race study of common bunt
- Growth habit and ecological adaptation for wheat varieties
- Effect of subzero temperature on performance of cereal
- Promotion of partnership and capacity building

5. Programmes and Policies to Encourage Technology Transfer

5.1 Adaptation technology

Historically Iranian agriculture has shown a considerable ability to adapt to changing conditions. If the climate change is slow and gradual, it is possible that adjustment goes largely unnoticed as part of response to more profound changes due to technology and policy and that the process is one largely of autonomous adjustment. Therefore, many adaptations will happen autonomously and without the need for conscious response by farmers and planners and decision makers. If the rate and magnitude of climate change exceed that of normal change in agriculture, specific technologies and management will need to be adopted to avoid adverse effect of climate change.
In spite of uncertainty, a wide range of adaptation technologies such as those mentioned below, can be employed in agriculture sector at the farm, national and regional levels to increase the flexibility of the adaptation systems and at least slow down or reverse the trend that can increase vulnerability.
Many technologies that can be used to adapt to climate change are already in place in many parts of the country. During the First, Second and Third Five-Year National Plans a wide range of strategies, programmes and policies were adopted to enhance and improve agricultural production and adopt technologies and management systems to combat resource limitations, such as water deficiency and food insecurity in the country, some of which are briefly described below:

5.2. Water use efficiency

As it is projected, during the next 20 years the water resources in the country will become a serious problem for agricultural production as irrigation is considered to be the main source of agricultural production, accounting for about 90% of the crop production. Development, introduction and adaptation of irrigation and water saving technologies and management systems that can improve water use efficiency will have high priority during the above said period as has been a key and important issue in the Third Five Year Development Plan.

It is envisaged that within a period of 10 years about 1.8 million hectares of irrigated agricultural lands will be covered by pressurized irrigation system. The diffusion of high efficient irrigation technology in Iran, which is encountered with water shortage problem, can increase the ability to adapt climate change. The adaptation of new technologies such as pressurized irrigation system imposes additional costs especially to the low income farmers who can not afford this additional cost. Although at present application of pressurized irrigation system is a planned adaptation policy and encouraged by the government, limitation of financial resources is the obstacle encountered in the development and adaptation of this technology. Though the government provides subsidies, the rate of technology adaptation is not in pace with the projected objectives and targets.

The other barrier to irrigation technology transfer to the farmers is lack of recipients awareness and technological knowhow for selecting appropriate and effective irrigation technology.

In order to overcome this difficulty, technical assistance such as training and extension programmes is envisaged to be provided by the relevant government agencies.

5.3. On farm land improvement

The transfer of adaptation technology at the farm level has been the major strategies of the Iranian government to enhance the productivity of land and water resources. There is a wide scope for enhancing irrigation efficiency at farm level, through water conserving technologies, but successful adaptation will require substantial changes in how irrigation systems are managed and how water resources are priced. Because inadequate and inappropriate water systems are responsible for low efficiency of water usage, land degradation and low water productivity, there is a need for change in management and improvement of land and water resources especially at farm level and transferring the transferable technology to farmers. Land leveling, lining of traditional canals, using closed conduits instead of open canals, reuse of drainage water and land consolidation are the measures already taken to improve water use efficiency at the farm level. This adaptation requires additional costs, which cannot be afforded by poor farmers and there is a wide range of government programmes and policies to encourage on farm land improvement throughout the country, including land leveling, land consolidation, canal lining and provision of irrigation and drainage systems. These activities are being considered during the short term development plans.

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Abbreviations

CIE: Compression Ignition Engine

CMC: Car Manufacturing Companies

CNG: Compressed Natural Gas

CNGFV: CNG – fueled vehicles

EER Energy and Environment Review (the report prepared by World Bank and Department of Environment)

EPA: Environmental Protection Agency

FFVs: Flexible Fueled Vehicles

FWD: Four Wheel Drive

HEV: Hybrid Electric Vehicles

ICM: Internal Combustion Motors

ICMC: Iranian Car Manufacturing Companies

ICSID: International Council of Societies of Industrial Design

IEEO: Iran Energy Efficiency Organization (SABA in Farsi)

IFCO: Iran Fuel Conservation Organization

ISC: Iran Statistical Centre

ISIC: International Standard Industrial Classification

JICA: Japan International Cooperation Agency

MFHV: Methanol Fueled Heavy-duty Vehicles

MGCP: Model on Global Warming Combat Policies in Energy Sector of Iran

MIM: Ministry of Industry & Mines

MOE: Ministry of Energy

NMVOCs: Non-methane Volatile Organic Compounds

SANA: Stands for Iran Organization Renewable Energy

TIB: Technology Information Bank

UNFCCC: United Nations Framework Convention on Climate Change