NATIONAL TECHNOLOGY NEEDS ASSESSMENT AND TECHNOLOGY TRANSFER

Climate Change Project

Top-up Enabling Activity- Phase II

Beirut, November 2002

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NATIONAL TECHNOLOGY NEEDS ASSESSMENT AND TECHNOLOGY TRANSFER

Introduction

The United Nations Conference on Environment and Development of Rio held in June 1992 has established a work plan for the 21st century that mainly emphasizes sustainable development of all economic sectors and set guidelines for transfer of technologies needed for GHG reduction. This work plan, known as Agenda 21, has been endorsed by all participating nations, developed and developing. Although some countries have made some progress in implementing the work plan, the majority of them are yet to successfully implement it due to difficulties arising from various social, economic, and political conditions of each country.

The developed countries have been urged to take all practicable steps to promote, facilitate and finance, as appropriate, the transfer of, or access to, environmentally sound technologies and know-how to other parties, particularly developing countries. The aim is to enable them to implement the provisions of the Convention. In this process, the developed country Parties shall support the development and enhancement of endogenous capacities and technologies of developing country Parties.

Recently, the UNFCCC has organized two workshops to aid parties in their fulfillment of these objectives. The expert meeting organized by the UNFCCC/UNDP in Seoul between the 23rd and 25th of April 2002 on technology needs assessment and technology transfer which also prepared for 16th session meeting of the Subsidiary Body for Scientific and Technological Advise (SBSTA) that took place between 2-14 June 2002 in Bonn.

The 4th Conference of the Parties (COP4) urged non-annex I parties to submit their prioritized technology needs, especially those related to key technologies to address climate change. In a step to overcome financial barriers, the COP directed Global Environment Facility (GEF) to provide funding for developing countries to assist them in the process of technology needs assessment and technology transfer.

Lebanon has ratified the United Nations Framework Convention on Climate Change (UNFCCC) in December 1994 through Law No. 359 dated 1/8/94. Under phase I of the Climate Change Project, and pursuant to Article 4.1 of the Convention, Lebanon has prepared and submitted to the secretariat of the convention its First National Communication (LFNC) report in 1999, through funding from GEF, management of the United Nations Environment Program (UNDP) and execution by the Ministry of Environment (MOE). The LFNC report established a national inventory of greenhouse gases (GHG), assessed Lebanon's vulnerability to climate change, and proposed a mitigation strategy to reduce GHG emissions in the various sectors along with some adaptation measures.

In early 2001, and through the Expedited Financing for Interim Measures for Capacity Building in Priority areas Part II, the UNDP and the MOE have mobilized a top-up funding from GEF to update the GHG inventory in limited sectors, and undertake capacity building in the area of technology needs assessment (TNA) and technology transfer (TT). The Climate Change Enabling Activity –phase II project has been launched in November 2001 with one of its objectives being to address and prepare a detailed report on TNA/TT and conduct capacity building for the different stakeholders.

This report is focused on the technology needs assessment and technology transfer for mitigation of greenhouse gas (GHG) emissions as well as adaptation to climate change impacts in Lebanon. The major tasks performed in association with the project constituted:

a. Assessment of different existing methodologies for TNA/TT and building on the methodology developed by the Climate Technology Initiative (CTI) and the experiences of other developing countries.
b. Developing and implementing a tailored country specific methodology for TNA/TT.
c. Conducting consultative process with all concerned governmental and non-governmental institutions. Individual and collective meetings with the concerned

institutions have been organized to assess the existing technology as well as the needed technology to curb GHG emissions.

d. Preparing an initial workshop involving all the concerned institutions as well as representatives of the donor community (WB,EU, USAID,AFD, CID and others represented in the country to present the developed methodology and survey results.
e. Conducting two training activities for national stakeholders-including NGOs and representatives from the private sector for capacity building to design, implement and monitor projects related to national technology needs and technology transfer.
f. Capacity building for the five focal point network through on-the-job-training and establishing a roster of experts and researchers in the fields of technology transfer for the Ministry of Environment.

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l. Capacity building for the five focal point network through on-the-job-training and establishing a roster of experts and researchers in the fields of technology transfer for the MOE.

II. Overview of Major Economic Sectors in Lebanon

The major economic sectors considered in this project are the electric power, transport, industry, solid waste and buildings. In what follows is a brief overview of these sectors.

II.1 The Power Sector

The Lebanese electric power sector is one of the main sources of GHG emissions. In 1994, this sector has contributed to around 30% of all CO_2 emissions and this figure has increased to 33% in 1999. In 1999, the primary energy consumption was 4.393 mtoe, and the electric energy consumption reached 9032 GWh with corresponding primary energy and electric energy densities of 0.32 koe/$ and 0.65 kWh/$, respectively. The per capita primary energy and electric energy consumptions are 1.18 toe/year and 2.42 MWh/year respectively. On the operational level, the cost of imported energy (fossil fuel) constituted 93%, 13% and 5.7% of the total Lebanese exports, total imports and 1999 GDP, respectively.

The yearly growth in electric energy demand in Lebanon over the next 10 years is estimated to be about 3-5%. The misuse of electricity and the inability of national power utility “EDL” to collect sufficient revenues have recently prompted government officials to call for urgent resolutions of EDL problems that include measures for changing the current culture of energy consumption in favor of energy conservation and efficient usage. Recently the Lebanese Parliament passed a law to privatize the generation and distribution sectors of the power utility. Accordingly these sectors will be sold to private companies, with the transmission sector kept under the EDL control and management.

Electric power generation and distribution exert pressures on the environment. It is associated with significant amounts of pollutants including GHG into the atmosphere. In addition, leaking underground storage tanks containing petroleum products and accidental oil spills could lead to significant pollution of soil, fresh water resources, and the sea. Major air pollutants are SO_2, NO_x, and particulate matter.

II.2 The Transport Sector

The transport sector is the major source of GHG emissions in the country. The motor vehicles fleet of Lebanon constituted by the end of 2001 over 1.3 million registered vehicles, with almost two thirds of this number being in actual use. It is also estimated that over 70% of the vehicles are more than 15 years old and 12% are older than 25 years. Passenger cars constitute up to 75% of the total number of registered vehicles.

The public transport system of Lebanon became quite sizeable since 1995 when the Government has provided 20,000 new licenses in addition to the existing 10,000. Taking other public licenses, this has brought total number of public transport vehicles up to around 38,000 including shared-taxis, taxis, buses and minivans. These vehicles, being mostly concentrated in GBA, and in other major cities, are causing increasing traffic congestion, transport delays, and air pollution. Reliance on public transport, on the other hand, is very low due to the low reliability of the sector in terms of scheduling and networking.

The aviation movement in the international airport of Beirut has been on the increase with the expansion of the airport facilities to serve six million passengers. The number of passengers as well as freight movement has been increasing steadily, at an annual rate of 10%.

The CO_2 emissions in 1999 have totaled 4585 Gg compared to around 3957 Gg in 1994, and with an increase of around 16%. Leaded gasoline fuel has been the main fuel used for land transport over the past decade. In 2001, the Government introduced, as an incentive, a cost increment of 10% followed in 3 months by another 10%. This measure has led to a wide shift to unleaded fuel, and starting July 2002, leaded fuel has been officially banned.

Emissions from motor vehicles are excessive due to the lack of inspection and maintenance program.

II.3 The Industrial Sector

The Ministry of Industry (MOI) statistics for 1998-1999 indicated a 2% growth compared to 1994 and more than a 50% increase compared to the early 1990s. In 1998, there were 22,025 industrial facilities in Lebanon, the bulk of which (88.6%) belong to 8 major industrial branches. These are food and beverages, textiles, clothing and fur, leathering and tanning, wood products (excluding furniture), non-metal & metal products, furniture and assimilated products.
In 1994, the energy consumption figures reached about 970 ktoe, releasing 1924 Gg of CO_2. The energy for heat and power, including around 149 ktoe used for local electricity generation, represents 15.9% of total fuel used in industry. In 1999, the sector released 1916 Gg of CO_2, in addition to other GHG such as CO (0.003 Gg), and SO_2 (1.12 Gg).

The most recent data on energy consumption in industry is based on the survey information, made available by the Association of Lebanese Industries, which has shown that fuel oil and LPG are used mainly in boilers and furnaces, while diesel oil is used mainly for local generation.

II.4 Solid Waste Management (SWM)

With the exception of municipal solid waste (MSW) management in the extended Greater Beirut Area, and to a lesser extent in Greater Tripoli, solid waste continues to be managed in a manner that is not protective of either human health and/or the environment. Even in the extended GBA, serious questions are raised about the financial sustainability and replicability of the Emergency Plan for SWM implemented since 1997. The Government has yet to make serious policy commitments to promoting, and eventually requiring, sustainable and environmentally-friendly SWM practices throughout the country and by all sectors (population, industry, agriculture, construction, tourism, energy).

MSW makes up about 90% of the total solid waste stream generated in Lebanon. The main sources of MSW are households, commercial establishments, street markets, street cleaning operations, and public garden pruning.

Lebanon generated about 1,44 million tons of MSW in 2001 (about 3,940 tons per day), or about 0.92 kg per person per day, and emits around 78% of all methane emitted. This estimate is higher than the 1.2 million tons of MSW (3,300 tons per day) reported by the MOE National Strategy for SWM

Organic waste is by far the single largest component of the MSW stream, representing over 63% of the total MSW quantity in GBA and slightly over 50% at the national level. Organic content at the national level may be lower than in GBA because people feed some of their organic waste (vegetable cuts, fruit remains, etc.) to their domestic animals in rural areas (the best possible form of recycling). The high organic content suggests potentially strong opportunities for recycling the organic materials present in the MSW through composting.
Major GHG emissions from the waste sector are methane (CH_4) and CO_2.

II.5 The Building Sector

The building sector is a substantial energy consumer in Lebanon, especially in the absence of effective energy conservation standards. In 1999, the building sector has consumed around 4111 GWH, constituting 38% of the total electricity consumed in the country and around 740 toe, constituting 13.8% of the total amount of fuel consumed in 1999. The sector has witnessed a growth rate of around 8.5% in electricity consumption and 5.4% in fuel consumption.

There are 1.45 million dwelling units of which 73% are residential and almost 27% are non-residential. Residential units include primary and secondary residences, and empty units. Non-residential units include establishments, public administrations, and empty/closed units.
In 1996-1997, there were 198,436 establishments in Lebanon. These include services other than shops (e.g., transport, insurance, water and electricity, hotels and restaurants, health care, and postal services), industries, educational and cultural establishments, as well as shops and other commercial outlets.

According to Lebanon's technical annex on climate change, the building sector consumed 13.77×10^6 GJ for space heating and cooling in 1994. This energy consumption that was obtained from electricity (44%), gas/diesel oil (40%) and wood (16%) resulted in the emissions of 1,016 Gg of CO_2.

The residential and commercial sectors consumed in 1994 30% of the final energy consumption. The most consuming equipment, representing 80% of the total electricity consumption, are electric heaters (31%), electric domestic hot water systems (22%), air conditioning (13%), lighting (8.5%), and refrigeration (6%).

III. Technology Needs Assessment and Technology Transfer for Lebanon

The proposed steps/ activities needed to implement TNA and TT can be initiated by forming institutional arrangements, followed by technology needs assessment, and technology transfer implementation as described below.

III.1 Forming Institutional Arrangements

The formation of institutional arrangements to facilitate technology needs assessment and technology transfer may be done according to Figure 1 shown below. Detailed discussion on each block is presented below.

Block 1: Identify Relevant Stakeholders; Consult Key Agencies
The technology transfer process must be country driven in order to identify and treat local concerns and to ensure commitment of relevant stakeholders. In this respect, and based on the findings of Lebanon's first national communication under the UNFCCC, several economic sectors have been identified as being significant in terms of GHG emissions and key elements in the national economy. These sectors are the electric power, transport, building, industry, and waste sectors. In order to get a feedback on technology needs in each sector as well as decision criteria, constraints and policy instruments needed to accelerate the transfer of technology to the country, each of the above sectors was represented by one or several experts such as government officials, directors, consultants, academics, active NGOs and relevant international agencies.

Block 2: Convene Meeting to Explore Objectives and Scope

Individual interviews/meetings have been carried out with the identified stakeholders with the purpose of exploring objectives and scope of the project as well as to get feedback on priority technology options in each sector and national policy to be adopted for the acceleration of the technology transfer process. The discussion also covered adaptation strategies.

Block 3: Establish the Core Team
After individual interviews/meetings with the various sectors representatives, a brain-storming meeting has been scheduled to expose sectors representatives to the technological options identified in all sectors and to unify the rather conflicting opinions regarding the establishment of the national policy on technology transfer. This leads to refining the opinions collected prior to starting the analysis using the Analytic Hierarchy Process (AHP) and performing technology ranking analysis (See section IV below). The meetings should also lead to establishing a core team for project follow-up.

Block 4: Define Processes for Ongoing Involvement of all Stakeholders
A framework for ensuring project sustainability should be recommended and ongoing involvement of all stakeholders is the corner stone in TNA and TT sustainability.

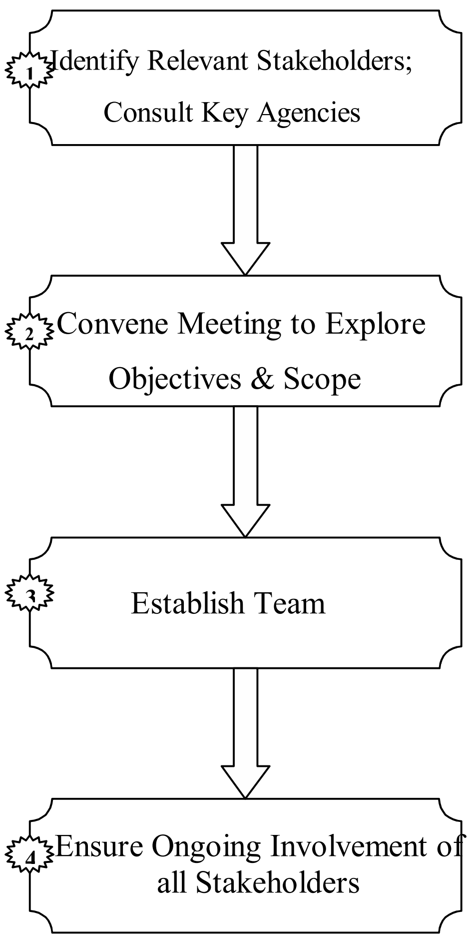


Figure 1. Formation of institutional arrangements

III. 2 The Technology Need Assessment Process

The TNA process proposed for the country meets the guidelines established by UNFCCC, as described in section I above. Figure 2 below presents a block diagram of the relevant steps needed to accomplish technology needs assessment. The process proposed for Lebanon falls into 8 levels or blocks as described below:

Block 1: Establishment of Criteria for Selecting Technology Transfer Priorities
TNA is to be done under two systematic approaches. The first approach identifies criteria for technology selection in every sector identified as a priority sector, and then establish matrix forms to evaluate and rank technology options based on the set criteria. The second approach uses a decision analysis technique in order to establish a national policy to help accelerate and smoothly achieve technology transfer in these sectors. In this work, the decision analysis tool used is the AHP.

The decision criteria selected for justifying the support for technology transfer are development benefits, market potential and contribution to climate change response goals. Concerning the development benefits, national efficiency improvement and energy savings are under the same category considering social equity and use of local resources. With respect to Implementation/Market Potential the criteria here is stimulate market growth, local and foreign investment and sustainability. While with respect to the contribution to climate change response goals, we observe the reduction potential of GHG as the main objective.

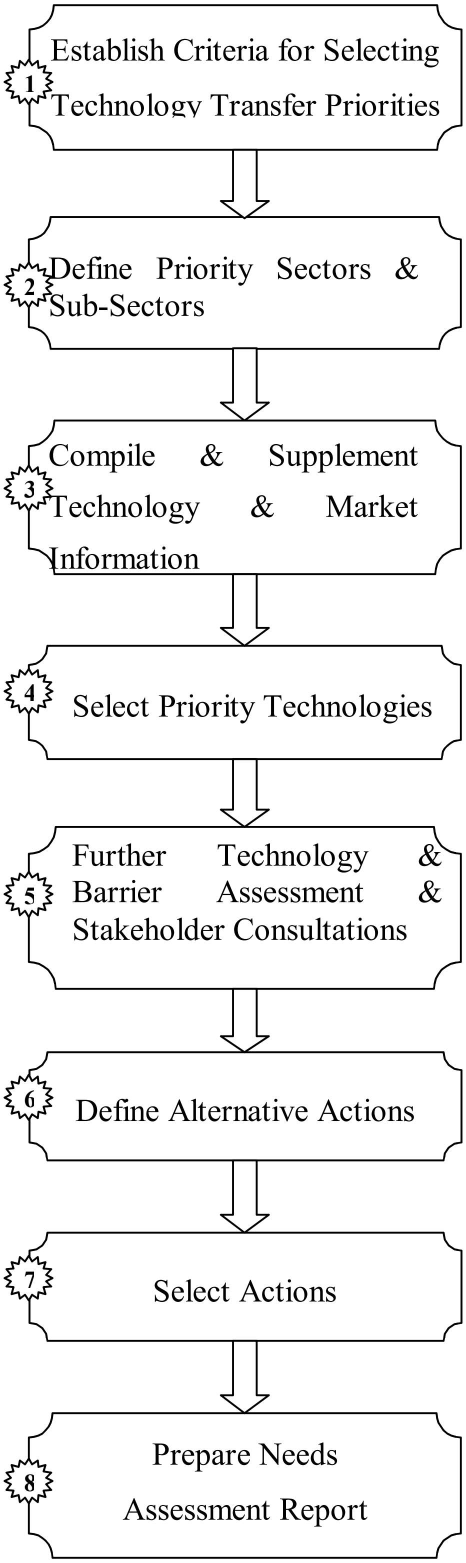


Figure 2. The Need Assessment Process

As to constraints facing the technology transfer process, six categories have been considered. These are: (1) the adequacy of local policies and legislation, and more importantly the enforcement of law, (2) the availability of funding whether from local/international investors, government money, and international donor agencies, (3) commerciality and competitiveness also is an important constraint as the inability to market and sell the proposed technology will eventually lead to its phase-out. (4) Adequacy of local resources is another critical constraint as Lebanon must have developed supportive institutions including appropriate industrial bases for provision of technical support, suitable human expertise, etc. (5) immaturity of technology as a successful technology transfer must promote proven and well established technologies. The promotion of technologies with failing characteristics and/or non attracting economic return will negatively affect the transfer of other technologies. Finally, (6) public awareness is a very important constraint and needs to be increased on the level of all stakeholders including ordinary citizens, government officials, manufacturers, etc….

The last step in the national policy for accelerating the technology transfer process is the adoption of one or more policy instruments that lead to an effective technology transfer. The policy instruments recommended are (1) setting of appropriate laws and regulations, (2) establishment of market based programs that mainly entail introduction of taxes or provision of incentives, (3) effective engagement of the private sector, and (4) effectively benefiting from the work programs of NGOs and international donor agencies.

Block 2: Definition of Priority Sectors & Sub-Sectors
Based on Lebanon's first national communications under the UNFCCC, the following sectors are identified: The transport sector, the electric power sector, the industry sector, the buildings sector and the waste sector. As for adaptation on climate change the water and forestry sectors were also considered in the priority list.

Block 3: Compile & Supplement Technology & Market Information, and
Block 4: Select Priority Technologies
The considerations that fall under these blocks include provision of summary of alternative climate change response technologies, development benefits, implementation and investment potential, contribution to climate change response goals, information on technology performance & costs, identification of implementation barriers, existing and planning programs designed, and recommendation on how to facilitate the widespread of the recommended technologies. All of this information can be found Lebanon's first national communications under the United Nations Framework Convention on Climate Change, some ESCWA and GEF studies. A brief about the status of each of the considered sectors together with the issues raised above has been compiled for the purpose of this project.

Block 5: Further Technology, Barrier Assessment & Stakeholder Consultations, and
Block 6: Define Alternative Actions

Four points are considered: (1) Identification and analysis of specific barriers to achieve the full implementation of technology transfer, (2) Evaluation of effectiveness of Lebanon's and donor programs and their anticipated impact on technology transfer, (3) identification of specific opportunities to accelerate implementation such as private and public investments, market based programs, etc. and (4) the identifications of potential actions to facilitate implementation. All of these activities have been entertained in the AHP analysis mentioned above and are in the agenda of the meetings scheduled with stakeholders.

Block 7: Select Actions
At this level, the selection of the highest priority actions is to be considered. This can now be achieved because of the good knowledge of country priorities and needs, variety of options and actions that can be used to achieve effective technology transfer and sectoral information available from existing documents and interaction with stakeholders. A good synthesis is now needed to prioritize options and actions.

Block 8: Technology Needs Assessment Report
The assessment report must include (1) an overview of TNA and TT in other countries as well as summaries of methodologies recommended by the United Nations, (2) a description of the status of the various sectors of interest, (3) Lebanon's approach to TNA and TT, (4) results and recommendations of undertaken studies for technology transfer. This should provide the priority technologies and proposed implementation actions, key implementation Barriers, integration with the existing development programs, and key recommendations for implementation on national level.

III.3 Preparing and Implementing Technology Transfer Actions and Plans

The plan proposed for preparing and implementing TT actions and plans is shown in Figure 3, and constitutes six major steps (blocks).

Block 1: Secure Resources
Securing resources requires working with donor organizations and domestic agencies, and leveraging new resources with existing country, donor and stakeholder programs. For this specific purpose, short meeting sessions have been planned with local financing agencies, mainly banks, and relevant international donor/lending agencies including the World Bank, UNDP, EU, USAID, etc. Such meeting sessions are expected in the final workshop scheduled end of October 2002.

Block 2: Develop Implementation Strategies
The implementation strategy recognizes three levels of intervention. The first level entails identification and prioritization of decision criteria that justify and support actions to facilitate technology transfer. The second level sets the constraints and barriers that must be analyzed and overcome to enable technology transfer to the various sectors. Finally, the third level recommends a set of policy options, which must be adopted individually, or collectively to ensure short and long term transfer of technologies.

The finalization of such a strategy requires interaction with stakeholders first individually in the form of interviews and second in the form of a brain storming sessions to be organized at a later stage.

Block 3: Integrate With existing Development programs and
Block 4: Prepare Technology Transfer Plans.

Effectively integrate implementation regarding technology transfer with other national, and/or international development programs. It is anticipated that integration will be mainly with UNDP, IPP projects, technology related projects controlled by the CDR and anticipated plans on privatization.

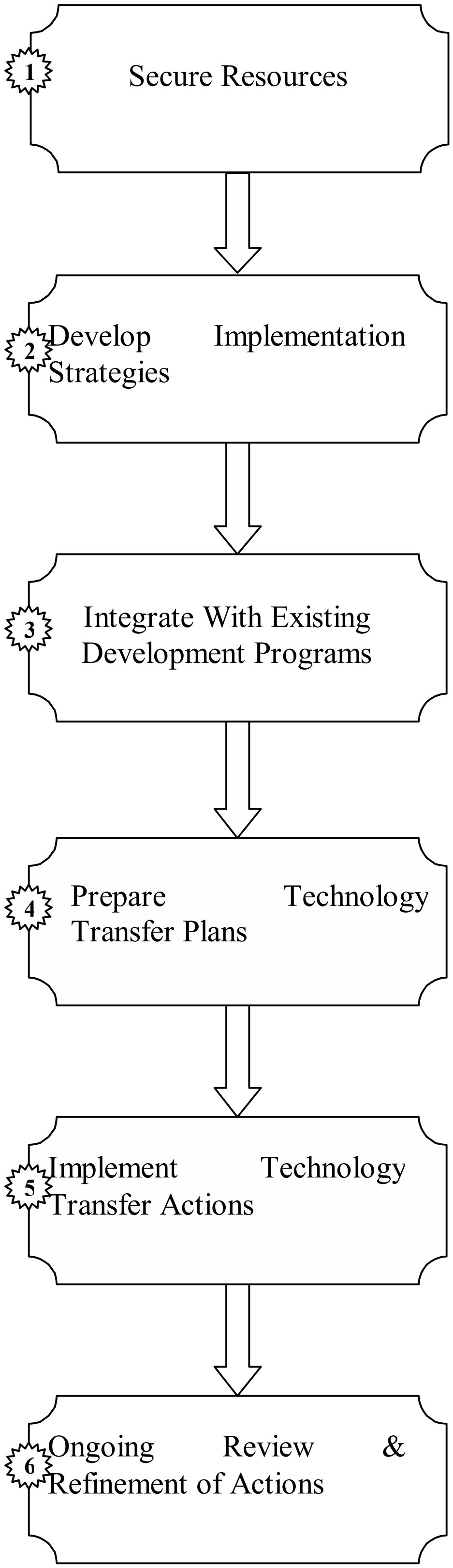


Figure 3. Preparing and Implementing Technology Transfer Actions and Plans

Block 5: Implement Technology Transfer Actions, and
Block 6: Ongoing Review and Refinement of Actions
Blocks 5 and 6 consist of implementation of the technology transfer plan, ongoing assessment and refinement of climate change technology transfer, implementing refinements, and developing new actions. A follow-up committee from all stakeholders will be formed to ensure implementation and project sustainability.

IV. The AHP Approach

The AHP was first developed by Professor Thomas L Saaty in the 1970s and since that time it has been widely applied in a variety of areas. Among these areas are the complex decisions power systems, transport systems, and conflict analysis. The AHP has been accepted by the international scientific community as a very useful tool for dealing with Complex decision problems. In addition many corporations and governments routinely use the AHP for major policy decisions.

The AHP is an intuitive and relatively easy method for formulating and analyzing decisions. The use of AHP in decision analysis requires the following steps:

- Define the problem and determine what you want to know.
- Structure the hierarchy from the top (the objectives) through the intermediate levels (criteria on which subsequent levels depend) to the lowest level (usually a list of the alternatives).
- Construct a set of pairwise comparison matrices for each of the lower levels- one matrix for each element in the level immediately above.
- Having made all the pairwise comparisons and entered the data, the consistency is determined using the eigenvalue.
- Steps 3, 4, and 5 are performed for all levels in the hierarchy.
- Hierarchical synthesis is now used to weight the eigenvectors by the weights of the criteria and the sum is taken over all weighted eigenvector entries corresponding to those in the next lower level of the hierarchy.
- The consistency of the entire hierarchy is checked before any conclusion is made.

IV.1 Building our AHP model: The Hierarchy

Having explored all the variables that affect the technology transfer process and introduced the AHP method, the problem is formulated in terms of the hierarchy shown in Figure 4, in the way explained earlier. Such a hierarchy is composed of 4 levels, each consisting of several elements. Below is a description of all elements in the hierarchy.

Level 1: Main Objective
Our main objective is to accelerate the technology transfer process on a national scale. This will be the top level of our hierarchy: “Acceleration of Technology Transfer”.

Next, the criteria that affect this main objective is addressed by trying to solve the problems rendering it poor, and to capitalize on the issues that improve it.

Level 2: Decision Criteria

Three main elements that directly affect the transfer of technology have been identified and are placed in the next level after breaking each element into its various components. These are development benefits (DB), market potential (MP) and environmental quality (EQ).

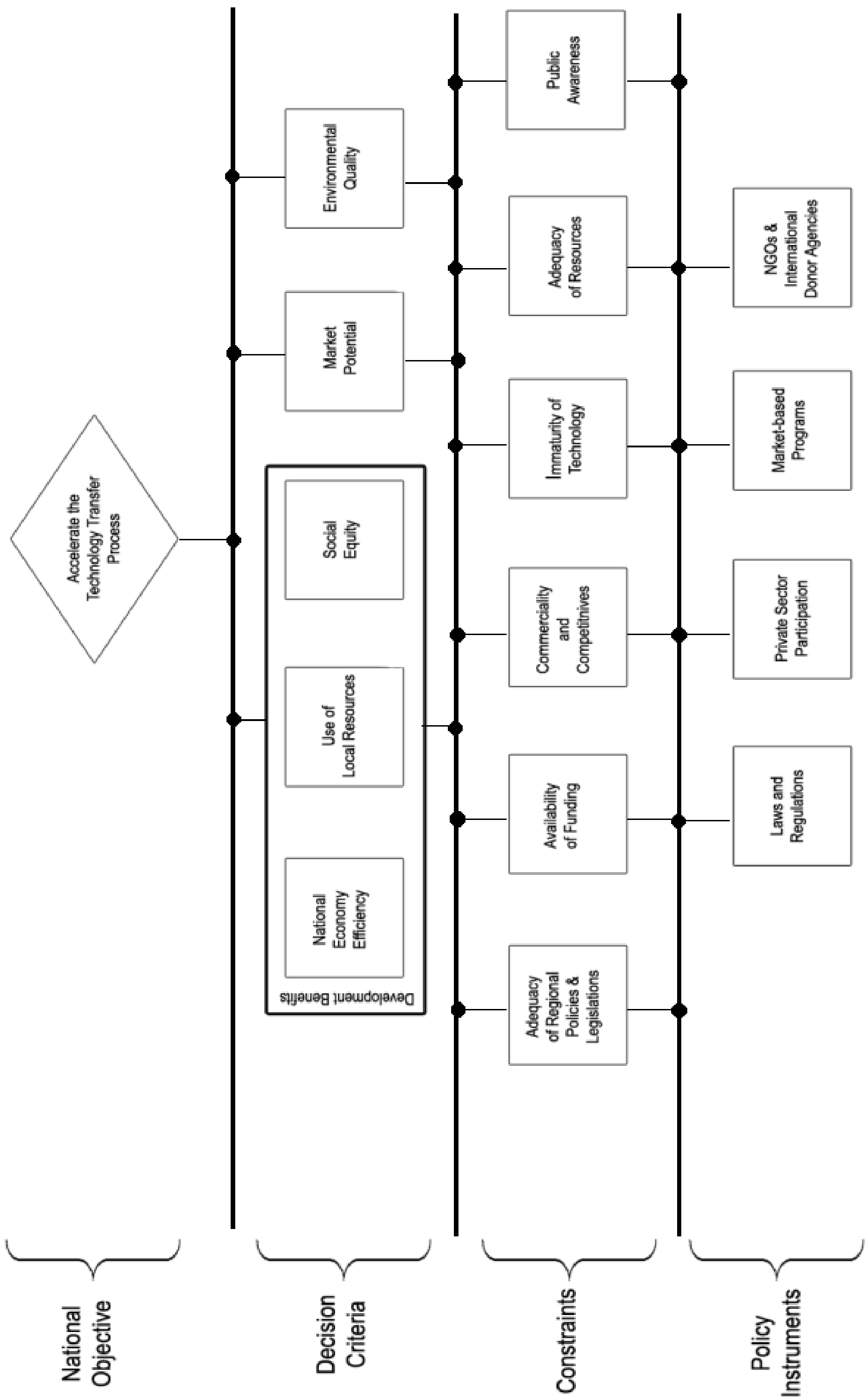


Figure 4: AHP Hierarchy

Development Benefits: As exposed earlier, the identification of priority technologies in priority sectors requires a view of the contribution that new technologies in different sectors might bring to social, environmental and development goals. It also requires that the cost effectiveness of so doing, in terms of the possible high investments on new and alternative technologies be considered.

Looking closely into this issue, we find that national development is realized through (1) national economy efficiency (NEE), (2) use of local resources (ULR) and (3) social equity (SE).

NEE are benefits that can be realized by utilizing high efficiency technologies in the various sectors of economy including residential, industrial, electricity generation and transport sectors.

ULR. An important aspect for national development is the transfer of appropriate technologies that harness local national resources such as wind and solar , and provide job opportunities for the qualified human resources as to enhance capacity buildings in technological upgrades.

SE is at the heart of government policies. Equity can be a decisive element in technology transfer such as in transport where a cheap and reliable transport should be available to all citizens even in the most remote and rural areas. Also, the provision of electricity, health services, improvement of women work conditions are all important aspects of equity that technology transfer should address.

Market potential Any new technology should offer the potential to answer several market concerns including justifications for any additional capital and operating costs relative to alternatives, commercial availability, social acceptability and sustainability for country conditions and replicability and potential scale of utilization.

Environmental quality is a major decision criterion; the following issues influence largely the decision concerning EQ:

GHG emissions reduction potential
Adaptation potential
Enhancement of CO2 sinks

Level 3: Factors/Constraints

While trying to improve the performance by acting on the various criteria, some other factors (or attributes) are to be taken into consideration, as they affect our ability to act on some or all of the problems: these are the possibilities available for us to use, or the constraints that limit our actions. They are divided into Legislative, economic, social, technological, marketing and infrastructure.

Policies and Legislatives: These are the conditions that greatly affect our actions for they can be the real barriers, some are the following: Regulations and standards that preclude new technologies, distorting market interventions such as subsidies for polluting industries, regulated markets that create disincentives for new technologies, planning system issues, etc. On the other hand, the practical application of existing laws is an important factor that must be enforced and respected.
Availability of Funding: New technologies are cost intensive, even if operating and lifetime costs are low, potential investors may lack the financial resources required to bear the upfront cost.

Commerciality and Competitiveness (CC): This constitutes one of the main barriers of accelerating the technology transfer process. CC is influenced by the monopoly powers that reduce incentives to innovate and erect barriers to new entrants and dominant interests that erect barriers to new entrants and may discourage innovation.

Immaturity of Technology also known as information barrier, this may take several forms; the simplest is where potential purchasers are ignorant of new technology possibilities. They may also be faced with multiple and conflicting information and have limited ability/time to absorb it, and choose a known option in preference to new alternative.

Adequacy of Resources The transfer of new technologies requires the existence of supporting infrastructure. For example, testing laboratories, skilled labor for regular maintenance, and availability of local manufacturing facilities to support minor modifications and spare parts are all important elements for a successful technology transfer process.

Public Awareness and appropriate educational system have made a major barrier hindering the widespread of cost-effective new technologies. Awareness about the benefits that new technologies offer as well as the provision of alternatives are very important for facilitating acceptance of new technological options. Cultural and societal barriers are also important and need to be addressed.

The above factors constitute the 3rd level of our hierarchy, while the 4th and lowest level lists the policy options or alternatives that could be adopted on a national scale to facilitate technology transfer. These options need to be studied and compared in order to set the best possible scenario for an effective transfer of technologies.

Level 4: Policy Alternatives

Laws and Regulations: The introduction of new laws and regulations might constitute a solution to technology transfer. Examples include alleviation of tax import on certain products, enforcing a ban on certain fuel (e.g. leaded fuel in 2002), restructuring of certain sectors and ministries (e.g. the merging of Ministry of hydro-electric resources and Ministry of petroleum into one ministry which is the Ministry of Energy and Water)

Private Sector Participation: The private sector in Lebanon has been the driving force in national economy. Finding ways to ensure private sector participation in technology related projects would be crucial to ensure effective technology transfer process.

Market based Programs such as incentives to acquire new technologies and taxing polluters. (e.g. the tax of about 1000 Lebanese pounds on leaded fuel has led to phasing out this product completely from the market in less than one year !)

NGOs and International Donor Agencies The work of NGOs and international donor agencies have been very useful and important to the country. Several projects were executed by UNDP, EU, USAID, local NGOs and other regional and international organizations. A systematic approach to progress achieved by these organizations is needed in order to get the utmost benefits of their work.

The hierarchy to be used for examining technology transfer for Lebanon is now complete and is shown below. Abbreviation used in this hierarchy is found in Chapter three.

V. The Decision Matrices for Technology Needs Assessment and Technology Options Ranking

To conduct an evaluation/ranking process for various mitigation options in Lebanon a number of criteria has been adopted in a manner similar to that applied by recent ESCWA studies. Based on the analysis conducted for the economic sectors, as described in Chapter 3, decision matrices have been designed based on seven selected criteria for evaluating and ranking mitigation options applicable for each of the sectors.

V.1 Criteria Elements

The selected criteria include the GHG reduction potential, impacts related to efficiency improvement and energy savings, capital and operation costs and the payback period, option sustainability, and other non- environmental impacts. In what follows is a listing of the criteria elements and the percentage weight assigned for each element with brief justification.

GHG reduction potential: Being the main objective of the TNA and TT tasks, this criterion is given the highest weight of 35%.

Efficiency improvement and energy saving. Energy saving and system efficiency improvement is also an important criterion since it leads to further benefits such as energy conservation and lower operation and maintenance costs. A weight of 25% is given for this criterion.

Capital investment. The cost of various technologies plays a significant role in its acceptance and wide spread especially in developing economies. Many of the options will require substantial investment for the purchase of equipment and equipments, establishment of infrastructure, introduction of new technologies, and training. This criterion has been assigned a weighting of 10%.

Operation and maintenance costs. These periodic costs are associated with running and sustaining emission-reduction measures after initial implementation. This criterion has been assigned a weighting of 10%.

Option sustainability. Options that can financially generate their own momentum tend to be self-sustaining. This criterion has been also assigned a 10% weighting.

Payback period. Profitable GHG mitigating options offer an attractive alternative for investments. Since it has been partially accounted for in the energy savings option, the weight assigned for this criterion is 5%.

Societal and economic benefits: Several options under consideration have the potential to deliver other non- environmental economic and social benefits in addition to reducing GHG emissions. Here also these benefits are partially accounted in the energy saving criterion, hence, a 5% weight has been assigned. Table 1 shows a sample (from transport) of the criteria elements, their weight, score, and the total score obtained with brief rational for scoring.

Table 1: A sample of the mitigation options ranking matrix.

Criteria element	Criteria weight (%)	Option score (%)	Rational for scoring	Final score
GHG reduction	35	86	Transport sector contributes to 20-25% of the CO2 emissions from burnt fossil fuels. Other transport-related GHG include N2O and CFC and HCFC from AC systems.	30
Efficiency improvement and energy saving	25	90	Improving vehicle maintenance and engine tuning greatly reduces emissions of GHGs and other pollutants by up to 30%. This leads to substantial energy and cost savings.	22.5
Capital Investment	10	65	Establish a vehicle I&M programme requires capital investment for the purchase and installation of testing units.	6.5
Operation and maintenance cost	10	50	To keep motor vehicles in proper operating conditions, and thereby maintaining returns in terms of lower GHG emissions, regular spending on labour, materials and spare parts will be required.	5
Option sustainability	10	60	Sustainability will depend on financial, technical and regulatory support. Vehicle maintenance requires annual investment by all stake holders	6
Payback period	5	50	Payback period is not easy to specify since I&M should be a continuous process	2.5
Societal and economic benefits	5	80	Proper maintenance and periodic inspection can reduce costs for items such as fuel and spare parts, and also increase the vehicle's resale value and extend its lifespan. Additionally, demand for vehicle servicing and for I&M centers will generate jobs.	4
			Total	**76.5**

V.2 Mitigation Options for Various Sectors

The evaluation process is performed by specifying a number of mitigation options for each sector such that:

In the Power sector: switching to natural gas, deployment of combined cycle, technology upgrading, electric interconnection, reduction of network losses, reducing/phasing out subsidies, demand side management, and partial switching to renewable energy.

In the Transport sector: improving the technical status of the fleet, improving traffic management, promoting mass transport, enforcing environmental standards and regulation, urban planning and land use, and switching to alternative fuels (natural gas).

In the Industry sector: switching to natural gas, energy- efficient systems, cogeneration, boiler improvement, and efficient motors.

In the Waste sector: wide- spread of composting, landfills, adopting anaerobic and aerobic digestion, and promoting the concept of reduce/reuse/recycle.

In the Building sector: building envelope, technology upgrading, solar heating water systems, and efficient lighting.

The criteria elements and the corresponding weights are unified for all sectors. Each criteria element is given a score which when multiplied by the criteria weight will give a final score for the element. A brief rationale for each score is also noted. The total score for each mitigation option is then obtained as the sum of the scores of all criteria elements.

VI. Concluding Remarks and Recommendations

In this project, an effort has been made to assess technology needs in the various sectors of economy for Lebanon. Also, a decision analysis tool has been developed to help decision makers and experts understand the influence of the various parameters that affect the technology transfer process.

The first contribution this project has made is in the development of an effective and innovative approach for technology transfer in Lebanon. This approach is based on conducting the TNA and TT as two separate activities and whose outcomes should be combined as to create a national plan on the matter. TNA is assessed through ranking matrices that examine the various technological alternatives and provide scores to facilitate ranking of the options, and the TT is accomplished through the development of a decision analysis tool that examines with the help of stakeholders the decision criteria, constraints and the appropriate policy options that facilitate the technology transfer process.

A. On the Level of Technology Needs Assessment:

Five sectors have been identified as major sectors contributing to GHG emissions in Lebanon. These are the power sector, transport, industry, buildings and waste sectors. The options for each sector were identified from the interviews that were made with a variety of stakeholders, and from the First National Communication of Lebanon, and other studies published by UN-ESCWA and MOE.

In the power sector, eight options have been found suitable to mitigate GHG emissions. The identified options are electricity interconnection, deployment of combined cycle technology, switching to natural gas, partial switching to renewable energy, phasing-out subsidies, demand side management programs, technology upgrading and technical loss reduction. Based on the comparative analysis made possible by the ranking tables designed for that purpose, it was found that electricity interconnection is the most important option, followed by combined cycle technology, switching to natural gas and then partial switching to renewable energy, see Table 2.

Table 2: Summary of technology options ranking in the power sector.

Option	**Overall Score**
Electric Interconnection	82.1
Deployment of Combined Cycles	80.3
Switching to Natural Gas	77.4
Partially Switching to Renewable Energy	77
Recycling/phasing out Subsidies	75.3
Reduction of Transmission losses	71.1
Demand-Side Management	70.95
Technology upgrading	70.55

The transport sector was analyzed under six options. These are the promotion of mass transport, improving the technical status of the fleet, switching to alternative fuels, improving traffic management, updating and enforcing environmental standards and regulations and finally improving urban planning and land use. The study concluded that the promotion of mass transport is the most significant option followed by improvement of technical status of the fleet and switch to alternative fuels, see Table 3.

Table 3: Summary of technology options ranking in the transport sector.

Option	**Overall Score**
Promoting mass transport	78.2
Improving technical status of the fleet	76.5
Switching to alternative fuels (NG)	73.75
Improving traffic management	69.3
Environmental standards and regulations	68.5
Urban planning and land use	62.5

In the industrial sector, five options were identified. These are switching to natural gas, boiler improvement, energy efficient systems, co-generation, and efficient motors. Natural gas option has occupied the first place in terms of importance, see Table 4, followed by boiler improvement, energy efficient systems, co-generation and finally efficient motors.

Table 4: Summary of technology options ranking in the industry sector.

Option	Overall Score
Switching to Natural Gas	80.75
Boiler Improvement	80.3
Energy Efficient Systems	78.8
Cogeneration	71.15
Efficient Motors	70

In the waste sector, five options were identified as the most appropriate. The ranking of these options suggests that recycling options is the most significant option, followed by anaerobic digestion, then landfill, composting and finally aerobic digestion, see Table 5.

Table 5: Summary of technology options ranking in the waste sector.

Option	Overall Score
Recycle/Reuse/Reduce	81.85
Anaerobic Digestion	79
Landfill	74.65
Composting	73.35
Aerobic Digestion	73

Finally, in the building sector, the diffusion of solar water heating systems (SHWS) turned out to be by far the most important option far exceeding, by its grade, other options, see Table 6. The next option in the order of importance is improvement of building envelops, followed by efficient lighting, technology upgrade and efficient air-conditioning.

Table 6: Summary of technology options ranking in the building sector.

Option	Overall Score
SHWS	85.58
Efficient Lighting	77.55
Building Envelop	77
Technology Upgrade	75.1
Efficient A/C	66.5

B. On the Level of Technology Transfer

Having identified technology needs and most needed technological options in each of the relevant sectors of economy, the study relied on the AHP technique to develop a decision analysis tool that helps explore all the influencing variables on technology transfer, and understand the relative importance of each with respect to each other and with respect to the overall goal. In this respect, a hierarchy describing the problem was developed and consisted of three layers describing the decision criteria, constraints and policy options. Interviews were made with 20 experts to collect their views regarding the importance of each element in the Hierarchy on technology transfer. These views were then entered into the AHP software and ranking by merit of priority was made to all decision criteria, all constraints and all policy instruments identified for the purpose of accelerating technology transfer for Lebanon.

The AHP analysis revealed that the most important policy option is the development of suitable market based programs, followed by the engagement of the private sector in projects related to climate change and involving technology transfer, followed by the need to update and enforce laws and regulations and finally benefit from the work programs of international donor agencies.
On the level of constraints, the AHP analysis revealed that laws, policies and legislation concerned must be updated and enforced. The overcoming of this constraint was ranked first, followed by availability of funding, then by public awareness. Other constraints of less importance are commerciality and competitiveness, adequacy supporting infrastructure and immaturity of technology.

On the level of decision criteria, the most important criteria were found to be in the order of importance as follows: The satisfaction of national economy efficiency was ranked first, followed by the efficient use of local human, natural and technical resources, then by insurance of environmental quality. The creation of market potential and insurance of social equity were of less concern.

In view of the above, it is recommended that the Lebanese Government does its best ensure that projects executed through its own funds or through loans or grants utilize technologies recommended by this projects. This would have the effect of not only curbing GHG emissions but certainly ensure economic return. Failure to do so, will have adverse impact on both the environment and economy and will result in acquiring technology that is either outdated, or not suitable, or

Finally, the Lebanese model for TNA and TT can be replicable in other countries of similar social and economic structure. It is very simple to use and to implement and its outcomes are based on interactions with relevant stakeholders. A matter that is consistent with the GEF recommendations that TNA and TT must be a country driven process.

Chapter One

Methods for Climate Change Technology Transfer Needs Assessments and Implementing Activities

The initiation task in the project has been the establishment of a background regarding different existing methodologies for TNA/TT assessment, and building on the methodology developed by the Climate Technology Initiative (CTI) and the UNDP/GEF report for understanding TNA, in addition to experiences of other developing countries. In what follows is a summary of the CTI and GEF guidelines on the subject.

1.1 Climate Technology Initiative (CTI)

The aim of the Climate Technology Initiative (CTI) is to provide developing and transition countries with a summary of methods for conducting climate change technology needs assessments and implementation activities. These methods are based on the experiences of countries that have conducted TNA and implemented technology transfer programs, as well as the perspectives of technical experts from governments, the private sector, international donor organizations, financiers, and research institutions working in this area [CTI, 2002].

The CTI is a report provided for the use of countries undertaking technology needs assessment activities, including countries currently undertaking such assessments sponsored by the Global Environment Facility (GEF) through the United Nations Development and Environment Programs (UNDP and UNEP, respectively). This document is designed to provide guidance to countries utilizing funds and other resources to conduct climate change technology needs assessments and implement the resulting plans for technology transfer activities. In order to provide a methodology that is more robust than a series of steps, each major implementation step is discussed in depth, including fundamental elements, recommended steps, variations that can adapt the methods to country-specific considerations, case examples of approaches in different countries, and schematic representations of various processes.

The methods presented are oriented toward a country-driven approach and allow for adjustments to fit national circumstances. Experience has shown that TNA and implementation activities are most effective when they are undertaken through a strategic approach that brings together a broad based group of stakeholders and considers multiple objectives.

Successful technology transfer programs have generally included variations of the following 5 steps:

1. Establishment of collaborative partnerships between key stakeholders with the common purpose of enhancing technology transfer.
2. Implementation of technology transfer needs assessments.
3. Design and implementation of technology transfer plans and specific actions.
4. Evaluation and refinement of the actions and plans.
5. Dissemination of technology information.

Forming an effective team with the appropriate authority at the beginning of the process is critically important to the success of the technology transfer enterprise. Teams can be formed in a number of ways. The two primary options are to have the entire group consider all technologies, or to divide the technologies among smaller, more specialized sub-groups. The formation of the team as a whole must address some considerations among which is identifying, consulting, and engaging the relevant stakeholders; Defining the objectives and desired outcomes of the technology transfer effort; Forming a team to carry out the work, typically including an overall coordinating agency, a lead technical institution, and relevant experts and/or organizations; and Defining a process that includes ongoing involvement of all relevant stakeholders.

The objective of this stage of the process is to engage all the relevant stakeholders in a collaboration that builds on their mutual interests. While each country's national circumstances will define its key stakeholders, lists of prospective stakeholders include Government agencies, Environment, Energy, Infrastructure, Transportation Agriculture, Forest, and Water; Local and International businesses, including project developers, technology suppliers, and sales and service groups; Trade organizations; Technical institutions; Technology end-users; International financial and donor institutions; Non-governmental organizations and community groups; and International technical experts.

1.1.1 The Needs Assessment Process

Technology needs assessments (TNA) allow developing and transition countries to identify their climate change technology transfer (TT) priorities and develop effective strategies to address these priorities. They can be powerful instruments for focusing the attention of government agencies, the international donor community and private sector investors on a well-defined set of priority activities.

TNA will be most successful when they focus on technologies and actions that meet national development objectives while also responding to climate change concerns, and when implementation actions complement existing development programs.

The needs assessment phase of the work constitutes a country's primary means to define its technology transfer priorities and the most effective mechanisms to address them. The TNA process should be tailored to fit each country's particular circumstances. Many countries have used three basic criteria to evaluate priority technologies and activities: (1) development benefits, (2) implementation potential and (3) contribution to climate change response goals.

The needs assessment process can be realized through the following steps:

1. Defining Priority Sectors and Sub Sectors: Once established, the selection criteria can then be applied to determine which sectors should be the primary focus of technology transfer activities.

2. Compiling and Supplementing Technology and Market Information. After identifying the sectors of interest, country teams together with international experts can then proceed to collect information on alternative climate change response technologies, their potential markets and impacts, implementation barriers, and existing and planned programs to promote their adoption and diffusion.

3. Select Priority Technologies and Sectors. Using the compiled information on alternative technologies for the priority sectors and sub-sectors, country teams can proceed with selection of priority technologies and practices.

4. Further Technology and Barrier Assessment, and Stakeholder Consultations. The purpose of the technology assessments at this stage is to support decisions on the actions that will be pursued to overcome key technology transfer and diffusion barriers.

5. Defining Alternative Actions. While the previous step usually includes identification of actions to address key barriers to technology transfer and diffusion, countries have generally found it helpful to further define the scope and impact of these actions before finalizing their selection of implementation actions.

6. Selecting High Priority Actions for Further Development and Implementation. In previous experiences, countries have generally selected 1-3 priority actions for further development and implementation for each priority technology.

7. Preparing Needs Assessment Report. A summary report may then be prepared that describes the process that countries used to select their priority actions, the results of each stage of this process, and a description of each action.

The TNA process produces an initial plan for the implementation of technology transfer. The implementation phase can usefully be thought of as an iterative process in which the plan is periodically revised in view of what has been learned along the way. The steps considered here are:

- Securing Resources for Action Design and Implementation
- Development of Implementation Strategies
- Integration with Existing Development Programs
- Preparation of Technology Transfer Plans
- Implementation of Technology Transfer Actions
- Ongoing Review and Refinement of Actions;

The availability and distribution of accurate, up-to-date technical information is a critical component of the technology transfer process. The technology transfer team must draw from multiple types and sources of information to develop its technology priorities and implementation plans. Distribution of this information will in turn help to secure domestic resources and international technical and financial assistance to implement technology transfer activities

1.2 The UNDP/GEF Handbook on Methodologies for Technology Needs Assessments.

The purpose of this handbook is to assist countries in responding to the decisions of the UNFCCC on activities to enhance technology transfer, and to help ensure that lessons are learned from the 'first mover' nations for the benefit of all involved in this process. It provides a clear description of what effective TNA is likely to entail, highlighting generic issues and drawing on case studies to provide examples [UNDP/GEF, 2002].

The handbook provides an introduction to the concept of a 'methodology' for TNA and considers the parallel processes involved in preparation of TNA; considers in detail the activities required in the assessment process, discusses the particular issues in considering adaptation options and provides a brief review of technologies and a detailed review of technology information sources.

The handbook is made for professionals working within non-annex-I countries to prepare TNAs, most commonly under the auspices of the relevant government departments. It has NGOs and relevant industries (both private and public sector) with a guide to a process with which it is likely to be fruitful for them to engage.

TNA consists of an evaluation of the opportunities available to countries to reduce GHG emissions and climate vulnerability and to contribute to other policy goals — on the basis of the technologies, practices and reforms that might be implemented in different sectors. It can inform and assist in a range of activities to improve and accelerate the uptake and development of new technologies in all countries. Thus TNA is not a stand-alone activity; rather it is a development of the work most countries have already carried out for their National Communications and through other activities to enhance technology transfer.

A survey undertaken by the UNDP of countries undertaking top ups found that countries are at different stages of implementation and that whilst some are well advanced others are experiencing difficulties. The survey found that technology transfer is an increasing priority, there is a need for a practical and integrated approach for assessing technology transfer, and objectives, approaches and activities vary widely, perhaps reflecting the limited amount of guidance available in the early stages.

The handbook provides a straightforward approach to TNA that countries can apply as part of integrated technology transfer processes, examples of 'real-world' success, in the form of case studies from countries that are well advanced with TNA, an introduction to key technology options, and to the means by which needs, technologies and resources may be evaluated, and a reference list of technology information sources.

Chapter Two

Experience of Other Countries

Technology transfer has been the focus of efforts for mitigating and adapting to global climate change. Country experiences with technology transfer activities along with a growing body of literature examining these experiences provides valuable lessons to countries and organizations intending to pursue technology transfer programs.

2.1 Opportunities for Technology Transfer Promotion

Activities that can create opportunities to promote the transfer of technology include but not restricted to: a) government policies creating favorable conditions for both public-sector and private-sector transfers; b) institutional support and training for assessing, developing, and managing new technologies; c) information networks and clearinghouses that disseminate information and provide advice and training; d) collaborative networks of technology research and demonstration centers; e) international programs for cooperation and assistance in research and development and capacity building; f) technology-assessment capabilities among international organizations; and g) long-term collaborative arrangements between private businesses for foreign direct investment and joint ventures.

Governments in many countries are undertaking such actions by developing legal instruments, tax regimes that reward technology upgrading, targeted lending programs from public and private banks, public/private partnerships to support the import/export of Environmentally sound Technologies (EST), tax refunds or subsidies for the import and implementation of ESTs, subsidized infrastructure, tariff protection, and providing clear information about government programs and actions. Some governments are also using economic instruments together with traditional command and control regulations (for example, emission standards) to achieve environmental goals and to encourage the transfer of technologies. Case studies suggest that no single policy instrument is likely to be sufficient to address environmental problems, and that therefore, a combination of instruments is likely to be needed.

2.2 Barriers Facing Technology Transfer

The barriers that generally inhabit the technology transfer process could be institutional, political, technological, economic, informational, financial, cultural, social etc. A first step in overcoming these barriers is to identify and assess them according to the technologies chosen and the targeted categories of users.

It is not possible to give a general assessment of the comparative importance of various types of barriers. However, the key barriers, in order of decreasing importance, appear to be financial, economic, technological, institutional and cultural.

Countries like Belize, Guinea, Latvia, Mali, Poland and Republic of Korea had financial barriers due to the lack of funding; moreover, Mali had the inability to obtain international finances for dissemination of indigenous technologies.

From Economic point of view, Mali, Kiribati, Poland and Zimbabwe had barriers like high investment cost, high cost of service and maintenance and affordability for technology end users in case of Zimbabwe.

From technological point of view, the key barriers are lack of access to technical information and spare parts and lack of technical capacity. The countries concerned are Albania, Panama, Mali, and Egypt.

Egypt, Guinea and Indonesia had institutional barriers of lack of local management skills and training of personnel, while Barbados and Costa Rica suffered from lack of public acceptance arising from low level of public awareness.

2.3 Case Studies

The following case studies are presented to highlight typical barriers and opportunities for TNA and TT dissemination. Full reports to these and other nations are available on the UNFCCC website [www.unfccc.int]

2.3.1 The Case of African Nations

African countries, like other developing countries, are utilizing ESTs in various economic sectors, such as energy, industry, forestry, transportation, and waste management, though climate change concerns have not been the main driving force behind this. In the energy supply area, these technologies are used mostly by the power sector, while for energy demand they are used in the household, industrial and transport sectors. Improved agricultural practices are being examined in few countries as a means of improving production and minimizing the use of organic fertilizers. Improved forestry practices are being used in several countries with the aim of increasing the forest cover.

In many countries, the various economic sectors are adopting energy efficient technologies, using both software and hardware options. The technologies used in the energy sector by respective countries can be summarized as follows:

Nigeria and Algeria have adopted improved technologies for production and waste management in the exploitation of natural gas. New gas pipelines are being constructed for supply within and outside the continent. South Africa and Zimbabwe are deploying improved methods for extracting coal together with cleaner coal processing methods. Tunisia and Ghana are among countries that use modern and efficient power production technologies, such as combined cycles, and co-generating plants are under construction; The industrial sectors of Senegal and Kenya are good examples of such practices, while Côte d’Ivoire offers its household and transport sectors as examples on energy efficient practices.

The utilization of biomass as a high-energy source in the power sector through the use of agricultural waste has widespread in countries with wood, palm crops and sugar industries such as Mauritius. Zimbabwe and Kenya use ethanol made from sugar waste to blend gasoline in the transport sector.

The use of renewable energy technologies in the form of solar electrical and thermal systems has witnessed widespread throughout several countries such as Egypt, Morocco and many others.

Despite these "success stories" there are still serious barriers that will affect the rate of technology acquisition in African countries, especially, for the least developed nations. They can be classified as technological, institutional, information, financial and market barriers. A significant number of African countries do not have an explicit national policy that supports technology development, a matter creating obstacles for all the stakeholders, including government institutions.

The inadequate enabling environment for non-government stakeholders is another barrier. Many believe that this obstacle contributes greatly to the low flow of foreign investments to the continent. Factors contributing to the lack of an enabling environment include inadequate macro-economic policies, and lack of communications, suitable small and medium scale firms for sub-contracting, appropriate financial systems and insufficient highly skilled workers.

Another general obstacle is the absence of feasible and appropriate standards based on local conditions in many countries, though most countries have institutions that are expected to perform this function. Lack of adequate support facilities and management has eroded their performance significantly, resulting in poor technology sourcing, selection and assessment. Investments by governments in this area and establishing effective linkages with the national education system could reduce this obstacle by ensuring that standards are regularly updated.

The relatively low level of technological capability in African countries compared with other developing countries is the greatest technical barrier to technology transfer and development in the continent. The major reason for the low capability is inadequate highly skilled technical manpower. A critical mass of human capital with the needed technical knowledge and skills is crucial for technology development and transfer.

Institutional inertia, or the reluctance to change, is another obstacle and is worse in a relatively uncompetitive environment as is the case in many African countries. This deters the introduction of new methods and techniques into the productive sector and generates inefficiencies.

Finally, the structure of markets, often monopolistic, is a barrier to establishing a fair pricing system. In many cases, the financial systems fail to give price signals; therefore energy efficiency measures may not be introduced. As a result, further development of the technological base of related industries becomes unnecessary.

Financial institutions should be encouraged to create an enabling environment to attract credit facilities. A national policy with built-in tax incentives has to be formulated to ensure easy transfer and widespread utilization of energy efficient technologies and products.

2.3.2 The Case of China

In China a wide variety of technology measures can be adopted for mitigating GHG emissions, e.g. technologies for improving energy efficiency, using renewable energy and alternative energy. It is shown from research on technology priorities that many barriers will hinder the development of these GHG mitigation technologies. The Technology Cooperation Framework (TCF) activities established by the Authorities may be helpful to overcome those barriers, and implement UNFCCC provisions on technology transfer.

The technologies considered in TCF are the development priorities and included in the corresponding government departments' plans. Some specific projects are already placed in national or department development plans. The next steps' work will focus on specific projects and serving donors and domestic funding. The TCF will also be integrated with China's "National Communication" and "National Action Plans," that have not been available.

Relevant departments will fund the projects involved in national or department development plans. If these projects are selected in TCF activities, then support from relevant departments will be guaranteed.

Next steps include further completion of the organization of in-country team to guarantee the fulfillment of all TCF tasks. This may include establishment of implementation teams for each priority technology. Also includes a review of existing market information for the priority technologies and conducting further market assessments to better define the specific, near-term opportunities for accelerating technology investment. An important task in this aspect is the selection of several technology priority projects for implementing the private investment programs and removing market barriers, and preparing financing proposals to international investment organizations for these actions.

Chapter Three

Situation Analysis of Major Economic Sectors in Lebanon

This chapter presents a brief description of the current situation of the major economic sectors in Lebanon. Data presented here are gathered from several resources mainly the State of the Environment Report, the First National Communication, ESCWA reports, and published technical papers on climate change.

3.1 The Power Sector

In Lebanon, the electric power sector is regarded as the main source of GHG emissions. In 1994, this sector has contributed to around 30% of all CO_2 emissions and this figure has increased to 33% in 1999 [GHG-2, 2002]. Although the consumption of electricity in Lebanon is relatively low compared with most industrialized countries, it is high compared with many developing countries of similar conditions.

3.1.1 The Sector Overview

In 1999, the primary energy consumption was 4.393 mtoe, as shown in Table 1, and the electric energy consumption reached 9032 GWh with corresponding primary energy and electric energy densities of 0.32 koe/$ and 0.65 kWh/$, respectively. As the population in Lebanon is 3.725 million, then the per capita primary energy and electric energy consumptions are 1.18 toe/year and 2.42 MWh/year respectively. On the operational level, the cost of imported energy (fossil fuel) constituted 93%, 13% and 5.7% of the total Lebanese exports, total imports and 1999 GDP, respectively [GHG, 2002].

Table 1: Fuel imports between 1995 and 1999, in ktons

Fuel Type	**1995**	**1996**	**1997**	**1998**	**1999**
Gasoline	1346.9	1420.7	1320	1411.7	1344.1
Gas Oil	1010.3	763.8	1038.1	881.3	867
Aircraft oil	109.6	115.6	108.5	106.9	126.2
Liquid gas	121.6	123.7	141.2	138.0	135.3
Fuel oil	1432.7	1623.3	1805	1588.4	1525.1
Diesel oil	-	166.5	337.4	543.3	881.1
Tar	67.7	112.5	87.6	109.5	83.3
Kerosene	103	-	-	-	-
Total	**4191.8**	**4326.1**	**4837.8**	**4779.1**	**4963.0**

The yearly growth in electric energy demand in Lebanon over the next 10 years is estimated to be about 3-5%. Such an increase in energy demand is problematic for Lebanon since its economy is almost totally dependent on imported fuel, which contributes up to 97% of the overall energy requirements. The postwar emergency "Power Sector Master Plan" , initiated in 1993, has focused on both the rehabilitation of the electric network and the expansion of the generation capacity. This plan has brought a heavy financial burden on the treasury and did not help the national power utility (EDL) to go from an indebted utility to a profitable one. In addition, the general culture of overusing electricity that prevailed during the Lebanese civil war is still intact despite the recent improvement in the collection process.

The misuse of electricity and the inability of power utility "EDL" to collect sufficient revenues have recently prompted government officials to call for urgent resolutions of EDL problems that include measures for changing the current culture of energy consumption in favor of energy conservation and efficient usage. Recently the Lebanese Parliament passed a law to privatize the generation and distribution sectors of the power utility. Accordingly these sectors will be sold to private companies, with the transmission sector being kept under the EDL control and management.

The electric utility (EDL) is a state owned entity under the jurisdiction of the Ministry of Environment (MOE). EDL operates eight thermal plants and at least five major hydroelectric plants. In addition, Lebanon imports electricity from Syria via a shared grid system. Electricity imports began in 1995 at 292 KWh and have since almost tripled to reach 846 KWh in 1999. In 1999, total electricity consumption in Lebanon (generation and imports) was 9,032 KWh, up from 5,207 KWh in 1995, see Table 2 for details.

The thermal power capacity has greatly increased over the past five years. New gas turbines were installed at Sour and Baalbeck (in service since the end of 1996). Two combined-cycle plants of 435 MW each were installed between 1998 and 2000 in Zahrani and Beddawi (Deir Amar). Thermal power plants use different fuel types including diesel, fuel oil, and natural gas. In 1999, the efficiency of thermal power plants reached only 33%.

Table 2: Power generation between 1995 and 1999 in KWh

Source	1995	1996	1997	1998	1999
Hydropower					
Kadisha	41	37.5	75.1	66.9	52.3
El Safa	12.9	22	25.6	23.8	11.2
Nahr Ibrahim	87	87.9	84.6	87.2	67
El Bared	48.2	48.2	67.9	53.4	34.6
Litani	508.1	570.4	485.6	554.8	166.2
Subtotal	697.2	765.9	735.8	786.1	331.3
Thermal					
Zouk (fuel oil)	3083.1	3485.3	3818.6	3210.2	2929.5
Zouk (gas oil)	60.6	42.9	67.5	45.1	30.2
Jiyeh (fuel oil)	1073.9	1571.6	1614.5	1834.4	1686
Hreyshe-Qadisha (steam)	-	-	378.9	398.7	333
Baalbeck (gas oil)	-	212.6	435.7	398.9	383.8
Sour (gas oil)	-	224.3	498.5	450.7	460.5
Zahrani	-	-	125.2	634.1	1003.1
Beddawi	-	-	42.4	598.2	1028.6
Subtotal	4217.6	5536.6	6981.3	7570.2	7854.7
Total	**4914.8**	**6302.6**	**7717.1**	**8356.3**	**8186**

Power generation from hydroelectric plants has fluctuated in recent years, peaking in 1998 at 786 KWh, then sharply declining to just 331 KWh in 1999. Despite significant improvements to the distribution network since 1993, power shortages and rationing are still widespread, particularly during summer and following major storms. As a result, people have reverted to alternative private power generators. Neighborhood power generators supply electricity to subscribers informally. In 1996-97, nearly 10% of all buildings were equipped with private power generators.

The oil and gas sectors are controlled by the Government. The MOEW is responsible for licensing petroleum imports and for setting the price of petroleum products. The government, several large industries (e.g., Chekka and Sibline Portland cement plants and Selaata fertilizer plant), and 22 companies import petroleum products, primarily through sea lines, and store those products at more than 30 locations along the coastline [SOE, 2002].

3.1.2 Impact on the Environment

Energy storage, production and distribution exert pressures on the environment. Petroleum products, charcoal, and other combustibles represent 97% of the primary energy available in Lebanon. The combustion of these energy sources release significant amounts of pollutants including GHG into the atmosphere. In addition, leaking underground storage tanks containing petroleum products and accidental oil spills could lead to significant pollution of soil, fresh water resources, and the sea. Major air pollutants are SO_2, NOx, and postulate matter.

3.1.3 Mitigation Options for the Power Sector

3.1.3.1 Energy Pricing

The MOEW is responsible for regulating prices of all petroleum derivatives in Lebanon. Fuels used to be subsidized these subsidies were lifted and electricity tariffs structure has been changed. Electricity tariffs were raised in October 1996 and in March 1997 but with no substantial effect on demand patterns due to incomplete bill collection, energy theft and tempering with meters.

The price of electricity supplied for domestic use ranges from 35LL to 200LL. Small industries pay a flat rate of 115LL/KWh, down from 130LL in 1995. Other industries supplied from a medium voltage grid pay 320LL/KWh during peak hour. In addition, subscribers pay a municipal surcharge plus operation and maintenance fees (about 5,000LL per month) and subscription fees (about 7,000LL per month), see Table 3.

Table 3: Price of electricity supply

End user	Monthly consumption (kWh)	Price (LL/kWh)	Price (US cents/kWh)
Residential	Up to 100	35	2.3
	100-300	55	3.6
	300-4000	80	5.3
	400-500	120	8.0
	>500	200	13.2
Small Industry	Flat	115	7.6
Agriculture	Flat	115	7.6
Public	Flat	140	9.3

The price of electricity in the high range of monthly residential consumption is about 200LL or $13.2 per KWh. It is believed that an appropriate tariff structure may influence the electricity consumption among various user classes and lead to improvement in consumption efficiency and conservation.

3.1.3.2 Technical and Non-Technical Losses

As long as technical and non-technical losses are high, local decision makers and international donors can hardly be convinced that energy efficiency measures are a priority. The total losses in the Lebanese electric power system are estimated at around 50% of generated electricity and are composed of 15% as technical losses and the remaining part as non-technical losses which are due to energy theft (illegal connections, tempering with meters, etc.). With improved management, installation of additional meters, and dedicated follow up by EDL, the improvement in bill collection is estimated to continue annually at high rates.

3.1.3.3 Technology Selection

– Natural Gas

The newly built combined cycle plants can not be put fully in use because the transmission network is not ready yet. According to EDL, the transmission network is expected to be ready during the year 2003-04 and therefore the combined cycle power plants will resume full service only at that date. Since 1998, the combined cycle power plants have been running on diesel oil, which renders their operation inefficient and does not demonstrate their environmental advantage. To address any future shortages in supply, the USTDA (United States Trade and Development Agency) has sponsored a study to check the feasibility of importing gas from Europe and doing all the necessary treatment here in Lebanon to make it satisfy the required specifications.

– Improving mix of supply through renewable energy

According to the Climate Change Technical Annex [GHG-I, 1998], scenarios were developed to account for the use of solar and wind energy in Lebanon. A justification for such scenarios arises from the fact that the current contribution of renewable energy is less than 1% and is mainly through the installation of domestic solar water heater systems. Additionally, it has been confirmed through field measurements that Lebanon has very good solar resources estimated at an average of 4.8 KWh/m^2 /day [Chedid et al, 2002]. As to wind resources, there are no real measurements to properly evaluate the wind energy potential in Lebanon, but preliminary studies as well as old field measurement suggest that wind speeds of 5-6 m/s exist in many regions for a period of time ranging from 3 to 7 months [El-Fadel et al, 2002]

Although officials at EDL have expressed their support to renewable energy (in particular for solar energy), it would be difficult to drastically change the situation into one favoring a significant penetration of renewable on both the generation and demand sides. In addition, it has been clear from recent years that the contribution of existing hydropower stations is on the decrease and that no official plans have been announced for building any new hydro power stations.

3.2 The Transport Sector

The transport sector, being an energy conversion sector, is locally and globally regarded as the major sources of air pollution and hence air quality degradation. It imposes serious pollution and health problems since it is closely associated with heavy urbanization and high population densities, and it contributes significantly to GHG emissions. The transport sector has many stakeholders, including private and commercial users, cars manufacturers and traders, fuel suppliers, road planners and builders, and other transport- related services providers. Measures to reduce GHG emissions from transport often challenge the interests of one or more stakeholders and this may increase the failure risks.

3.2.1 The Sector Overview

The motor vehicles fleet of Lebanon constitutes over 1.3 million registered vehicles, with almost two thirds of this number being in actual use. It is also estimated that over 70% of the vehicles are more than 15 years old and 12% are older than 25 years. Passenger cars constitute up to 75% of the total number of registered vehicles whereas other vehicles mainly small trucks, minivans, and buses constitute the rest. This relatively old fleet, and in the presence of effective inspection and maintenance program, may impose serious hazardous environmental problems [Chaaban et al, 2001].

According to a 1997 survey of living conditions, 62.4% of households in Lebanon have at least one car. In Mount Lebanon 28% of households own two cars, compared to 20.6% in Beirut, and 10% in each of North Lebanon, South Lebanon, Nabatiyeh, and Bekaa. The proportion of households without a car has declined from 52% to 35% between 1969 and 1997.

The public transport system of Lebanon became quite sizeable since 1995 when the Government has provided 20,000 new licenses in addition to the existing 10,000. Taking other public licenses, this has brought total number of public transport vehicles up to about 38,000 including shared-taxis, taxis, buses and minivans. These vehicles, being mostly concentrated in GBA, and in other major cities, are causing increasing traffic congestion, transport delays, and air pollution. Reliance on public transport, on the other hand, is very low due to the low reliability of the sector in terms of scheduling and networking.

During the last decade, the prices of fuel used for transport in Lebanon have been increased due to additional taxation gradually imposed by the Government. It should be noted, however, that these increases had small impact on fuel consumption due to the lack of alternative means for transport and due to the fact the fuel is still cheap compared to other countries and compared to average income.

By the end of 2001, Lebanon had about 22,000km of which 30% are classified and fall under the authority of the MoPWT, while the remaining 70% are non-classified roads governed by municipalities. International roads make up to 15% of the total network. It is expected that the full use of modern road networks, especially in GBA, will lead to demographic changes in which citizens will tend to live in the “cheaper” outskirts of Beirut thus leading to longer daily trips.

3.2.2 Air Transport

The aviation movement in the international airport of Beirut has been on the increase with the expansion of the airport facilities to serve six million passengers. The number of passengers as well as freight movement has been increasing steadily, at an annual rate of 10%. Beirut airport activities in 1999 compared to 1994 are listed in Table 4.

Table 4: Airport activities in 1994 and 1999.

Year	**1994**	**1999**
Flights in	9523	13940
Flights out	9523	13938
TOTAL	19045	27878
Passengers in	717040	1050001
Passengers out	721258	1060655
Transit	51131	111688
TOTAL	1489429	2222344
Freight (tons)	54007	52439

The railway network in Lebanon is still non- operable with most lines being out of order and even completely blocked by private constructions.

3.2.3 Impact on the Environment

Land, sea, and air transport cause significant and diverse impacts on the environment. Most transport infrastructure (in particular roads and harbors) was built without any regard for the protection of landscape, wild life, and natural resources [SOE, 2002]. GHG mitigation in the transport sector presents for many countries a particular challenge because of the unique role that travel and goods movement play in the social and economic development of these countries.

The Lebanese Government has reclaimed the exclusivity right to import fuel oil in 1996, and for diesel import in 1997. Gasoline is still being imported by the private sector. A major shift towards unleaded gasoline took place in 2001 due to the price incentive introduced by the Government. The overall import of transport- related fuels in 1999 was around 1,611,157 tons, with a 12.7% increase over the 1994 figure, see Table 5.

Table 5: Transport- related fuel imports in 1994 and 1999.

Fuel	1994 Imports (Tons)	1999 Imports (Tons)	Percentage change
92 Octane	983810	319905	-67
98 Octane	234212	764965	67
Unleaded	24781	259226	946
Jet Kerosene	145910	126166	-13
Diesel	40906	140895	244

The share of unleaded fuel has increased from 2% in 1994 to 19% in 1999, and leaded 98- octane gasoline has increased drastically from 19% in 1994 up to 57% in 1999, refer to Figure 1.

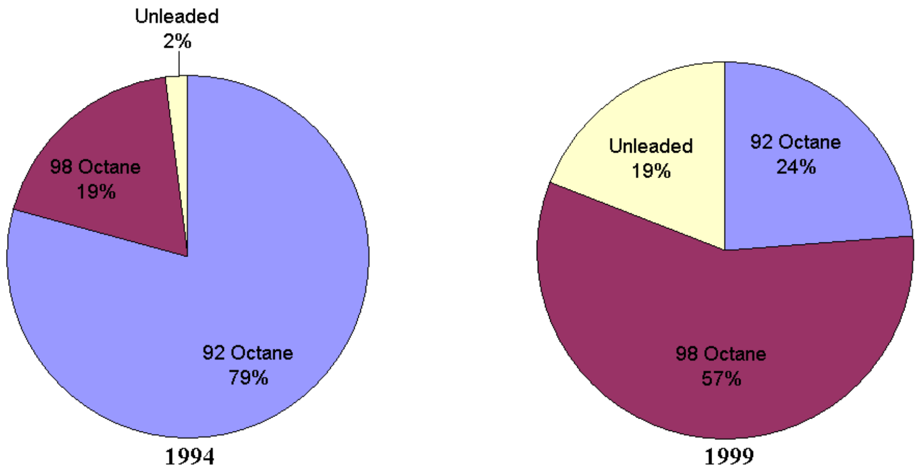


Figure 1: Breakdown of imported gasoline in 1994 and 1999.

Table 6 shows a comparison of CO_2 emissions from the transport sector in years 1994 and 1999 as reported in the recent GHG national inventory [GHG-II, 2002]. The CO_2 emissions in 1999 have totaled 4585 Gg compared to around 3957 Gg in 1994, and with an increase of around 16%. Emissions from jet kerosene have dropped while a significant increase has been recorded in emissions from diesel. This could be attributed to the new diesel power plants in Baalbeck and in Tyre, that were put into operation in 1998, and to the wide spread use of diesel for small public transport buses and taxi passenger cars.

Table 6: Carbon dioxide emissions from transport

CO_2 Emissions [Gg]	**1994**	**1999**
Gasoline	3820	4131
Diesel	130	448
Jet kerosene	6	5.2

The CO_2/capita rate has increased from 1072.7 kg in 1994 up to 1110 kg in 1999, whereas the emissions/GDP has increased from 437 to 574 g/$ of GDP, [GHG-II].

Leaded gasoline fuel has been the main fuel used for land transport over the past decade. Although unleaded fuel has been introduced to the market as early as 1992, its wide spread did not take place until the turn of the 21st century. In 2001, the Government introduced, as an incentive, a cost increment of 10% followed in 3 months by another 10%. This measure has led to a wide shift to unleaded fuel, and starting July 2002, leaded fuel has been officially banned.

Another polluting problem has risen when the Government allowed in 1995 the import of minivans and buses that use diesel to be used for public transport. As a result, the share of low- quality diesel has increased and a large number of small taxi vehicles opted illegally to shift to diesel as well due to its low price compared to gasoline. This uncontrolled wide spread use of diesel has significantly effected air quality especially in major cities and regions of heavy traffic. In June 2002, diesel fuel has been banned from use in passenger cars, followed in August 2002 by a ban on its use in minivans and busses up to 15 passengers.

Emissions from motor vehicles in the Lebanese fleet are excessive due to the lack of inspection and maintenance program that controls the technical status of motor vehicles. It is intended, however, to reintroduce the program with emphasis on exhaust emissions.

– Other Impacts

The major Lebanese cities do suffer from persistent traffic delays and high traffic-related noise levels. Delays represent 50 to 70% of the total travel time between two random points in the GBA according to recent studies [SOE, 2002]. This delay leads to excessive fuel consumption and hence excessive GHG emission rates from transport. These cities also suffer from severe shortage in parking space, primarily due to the conversion, over a period of decades, of underground parking spaces to warehouses, workshops, and stores.

Road accidents cause nearly around 350 deaths and over 3,000 injuries on average per year [soe]. Although such statistics are lower than in some other countries, they remain very high for a country like Lebanon where traveled distances are relatively short [soe].

3.2.4 Mitigation Options

There exists a wide scope of established technologies, policies, and measures aimed at reducing GHG emissions from transport. In what follows is a brief description of some measures applicable to Lebanon.

3.2.4.1 Technologies

Transport systems technologies are evolving rapidly. Although these advances have focused on enhancing performance and safety of the vehicle rather than its consumption and emission rates, a number of technological and mitigation options are proven to be cost-effective in many countries. The cost-effectiveness of these technical options may vary depending on availability of resources, institutional capacity and technology, as well as on local and regional market conditions.

– Energy-efficiency Improvements

Technical design parameters such as lighter bodies with enhanced aerodynamics, improved tiers designs, automatic transmissions, and improved engine designs have reportedly led to around 50% reduction in fuel consumption. Moreover, new legislations have been imposed in many industrial nations aimed at setting fuel economy standards. It is expected that cost-effective savings in 2020 might amount to 10-25% of projected energy use, with price increases in the range $500-1500 per vehicle. This trend, however, has been paralleled by a sharp increase in the fleet size, the lengths of distances traveled, and consequently the amount of fuel consumed.
The new law “341” is aimed at improving the energy efficiency through regular inspection and maintenance programs, improved fuel quality, and better transport management systems.

– Alternative Energy Sources

Alternative fuels and renewable energy sources, mainly natural gas and solar power, have the potential to reduce GHG emissions from vehicle by up to 80%. New technologies such as electric and hybrid electric vehicles (HEV) with high- energy efficiency offer significant drop in fuel consumption and hence in GHG emission rate.

Widespread use of alternative fuels depends on overcoming various barriers, including the costs of shifting to new vehicle types, fuel production and distribution technology, concerns about safety and toxicity, and possible performance problems in some climates. Fossil fuel alternatives to gasoline, namely natural gas can offer 10-30% emission reductions, and are already cost-effective for small urban buses and delivery vans. The widespread use of natural gas will require a sizeable infrastructure for gas import, storage, and distribution throughout the country.

– Infrastructure and System Changes

Transport systems volumes and infrastructure can affect the distance travel on daily basis. These factors are usually designed predominantly for objectives other than GHG mitigation. Traffic and fleet management systems have the potential to achieve energy savings on the order of 10% or more in urban areas. Modal shifts from road to rail may result in energy savings of up to 50%, often resulting in commensurate or greater GHG emission reductions, especially where trains are powered by electricity from non-fossil fuel sources.

3.2.4.2 Measures

Long-term management of GHG emissions from the transport sector will depend on implementing policies and strategies that include fuel economy standards, fuel taxes, incentives for alternative fuels, measures to reduce vehicle use, and investing in research and development (R&D) related to vehicle and transport system technology and planning. Many of these measures might be justified wholly or partly by objectives other than GHG mitigation.

Governments can adopt some of these measures individually or combined. For example, fuel economy standards and incentives can result in a lower driving cost, hence more traffic, unless implemented in conjunction with fuel taxes, road pricing, or other measures to discourage driving. Effective measures also include implementing computerized traffic control; parking restrictions and charges; use of tolls, road pricing and vehicle access restrictions.

3.3 The Industrial Sector

The industrial sector in Lebanon has experienced a major expansion since the end of the war (1975-1990). However, ill-defined industrial zones, inadequate reforms and future economic uncertainties have undermined the industrial sector since the mid-1990s. Industries in Lebanon are frequently blamed for many environmental problems as they generate industrial effluents, solid waste and potentially toxic air emissions.

Currently, most of the liquid, solid and gaseous emissions are discharged into the environment without any form of treatment. While recognizing the need to support the industrial sector, the Ministry of Environment is working to introduce effective and enforceable pollution control regulations.

3.3.1 The Sector Overview

The Ministry of Industry (MoI) statistics for 1998-1999 suggest a 2% growth compared to 1994 and more than a 50% increase compared to the early 1990s. Figure 2 shows the approximate evolution of the number of industrial units over the last 50 years.

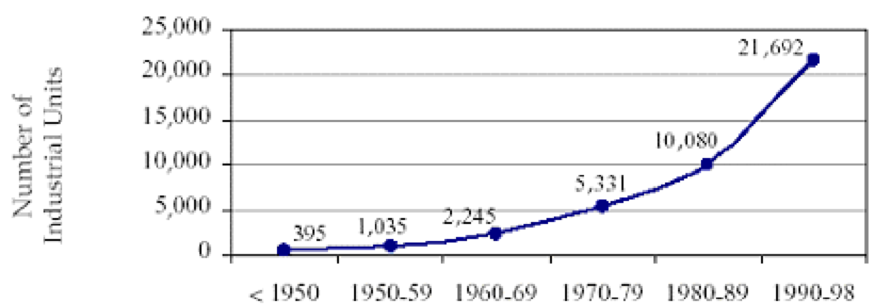


Figure 2: Evolution of industrial sector between 1950 and 1998.

In 1998, there were 22,025 industrial facilities in Lebanon, the bulk of which (88.6%) belong to 8 major industrial branches. These include food and beverages, textiles, clothing and fur, leathering and tanning ,wood products (excluding furniture), non-metal & metal products, furniture and assimilated products. The main features of these industries are summarized below: [ESCWA Industry, 2001].

(a) *The food and beverage industry* is the largest industry in the country. It represents over 20% of the industrial facilities, about 23% of the total workforce in the industry, 26% of the total industrial output and more than 25% of the industrial value added.

(b) *Building materials industries.* These include metals and non-metallic and mineral products such as cement, ceramic and wood products/building materials industries. They represent about 38% of industrial establishments and 30% of the workforce. The value-added to the output in non-metallic sector is 47.5%, which is significantly higher than the industry average of 43.2%.

(c) *The clothing and textiles industries* lost 25% of its establishments and 40% of its workers between 1994 and 1998. Output in this sector fell by 33%, whereas an average 11.5% increase was observed in the industrial sector.

(d) *Furniture and manufactures products* include two main industries: furniture manufactures and jewelry. This sector represents up to around 10.7% of all industrial establishments. It employs 11.7% of the total industrial workforce. For the furniture industries, the value-added compared to output is around 51%. In the jewelry sector, the ratio of value-added to output only reaches 36%. The jewelry sector remains a small industry mainly limited to transformation with relatively expensive raw material.

The main indicators of the industrial sector are presented in Table 7 that also shows that the total industrial value of output is \$ 3.953 billion for the year 1998 and the total value added is about \$1.707 billion.

Table 7: Main indicators of the Lebanese sub-sectors

Industrial sub-sector	No. of establishments		No. of employees		Output ('000 $)		Value-added ('000 US$)		Energy expenditure/ Total inputs
	1998	% of total	1998	% of total	1998	% of total	1998	% of total	(%)
Food and beverage	4480	20.3	18344	23.3	1011313	25.6	432796	25.4	3.5
Metal products	3553	16.1	9.342	11.9	454976	11.5	185168	10.8	5.4
Metal products	2530	11.5	10045	12.8	552374	14.0	262397	15.4	24.6
Furniture, other products	2352	10.7	7512	9.6	327890	8.3	159026	9.3	4.2
Clothing	2262	10.3	6654	8.5	212026	5.4	91497	5.4	4.4
Wood products (except furniture)	2246	10.2	3490	4.4	112926	2.9	52860	3.1	7.6
Leather and tanning	1291	5.9	4212	5.4	111012	2.8	45113	2.6	4.8
Textiles	804	3.7	2207	2.8	100874	2.6	41078	2.4	5.6
Other industries	2507	11.4	16834	21.4	1069519	27.1	436874	25.6	6.6
Total	22025	100	78640	100	3952910	100	1706809	100	7.6

3.3.2 Industrial Energy Consumption

In 1994, the industrial sector consumed around 970 ktoe. The energy for heat and power, including around 149 ktoe used for local electricity generation, represents 15.9% of total fuel used in industry. The sector emitted in 1994 a total of 1924 Gg of CO2, compared to 1916 Gg of CO2, 0.003 Gg of CO, and 1.12 Gg of SO2 in 1999. The average energy expenditures in Lebanese industry count for 7.6% of the total industrial inputs. However, it varies from 3.5 to 7.6 for different industrial sub-sectors, with the exception of the non-metallic product sub-sectors, where it reaches 24.6%.

Residual fuel oil is the largest energy source used by the industrial sector. It is followed by diesel oil and then electricity. Fuel oil is mainly used in boilers that are more than 20 years old and inefficient. A significant shift to natural gas is pending the establishment of the regional network, starting in 2005.

The most recent data on energy consumption in industry is based on the survey information, made available by the Association of Lebanese Industries, which has shown that fuel oil and LPG are used mainly in boilers and furnaces, while diesel oil is used mainly for local generation. Table 8 provides a summary of the plants data provided by major consumers in Lebanese industry for the years 1998, 1999 and 2000.

Table 5: Fuel consumption by sub-sector for the surveyed industrial plants, in tons.

Industry	**No. of plants**	**1998**			**1999**			**2000**		
		Fuel oil	**Diesel**	**LPG**	**Fuel oil**	**Diesel**	**LPG**	**Fuel oil**	**Diesel**	**LPG**
Food	37	32041.2	18035	--	40209.5	23015	2890	39575	23375	288
Textiles	12	1323.3	1378.4	--	1498.1	1346.4	--	1400	1377.2	--
Paper	18	34317.7	10087	--	34425.7	10246	--	34398	12664	--
Chemicals	26	32050	7051.6	--	32050	9209.9	9.5	32200	10819	--
Cement & non-metallic mineral	13	186348	19575	4688	169539	19506	4635	173973	20912	6050
Basic metals	5	8500	7172	1071	8500	8631.5	1048	8500	9028	1150
Fabricated metal products	22	92.3	11477	110	300	11683	130	200	10061	135
Wood & wood products	7	--	545	--	--	584.4	27	--	461.6	--
Total	**140**	**298323**	**75171**	**5869**	**286693**	**85208**	**6240**	**290246**	**88698**	**7623**

3.3.3 Impact on the Environment

The majority of the Lebanese industries lack pollution control equipments. While existing industrial zones, where only 18% of all industries are located, are poorly equipped to collect and/or treat industrial waste, such infrastructure is completely lacking outside industrial zones, where 82% of the industries are allocated. Industrial units located within residential areas pose severe risks to public comfort, health and safety. Industries generate wastes that have adverse impacts on water and soil quality and are a major source of air and noise pollution [SOE 2002].

The industrial sector emissions constitute, in addition to GHG, all major pollutants such as particulate matter, CO, SO_x, NO_x, lead, and other toxic metals. Zones close to the major industries have been suffering from air quality degradation, and severe health problems have been reported. The industrial sector emitted almost 14% of all CO_2 emissions in 1994, compared to 11% in 1999 [GHG-II, 2002]. The substantial portion of the industries also suffer drastically from indoor air pollution and excessive noise levels inside the establishments.

The most recent effort to develop a management strategy for industrial and hazardous waste related specifically to local industries had estimated that Lebanon generates about 188,850 tons of industrial solid waste annually.

3.3.4 Mitigation Options

The technological options for reducing energy demand include mainly energy efficiency measures and fuel switching on either supply or demand sides. Below is a description of GHG mitigation options in some industrial sectors as recommended by Lebanon's technical annex on climate change.

3.3.4.1 Cement industry options

About 38% of 1994-cement production comes from an old technology while 62% of the cement production is from both retrofit and new plants. The energy efficiency options for cement plants were proposed through two scenarios, which examine opportunities for increased efficiencies in the grinding processes and pyro-processes in the kiln system. One option involves replacing some of the clinker with steel wastes such as granulated blast-furnace slag. Considering the fact that reduction in both energy and process CO_2 emissions is 5-20% per year, the conservation and preheating in the pyro-processing can also save 10% in fuel energy. Implementing such an option would save at least 5% of the electric energy use.

3.3.4.2 Motor drive system improvement and replacement

Motor-driven systems account for more than 70% of all electricity used by the industrial sector in Lebanon. Improvements in the efficiency of electric motor systems can translate directly into enhanced productivity, competitiveness and environmental performance. In Lebanon, a large number of motor drive systems are relatively old, or second-hand. Replacing old motors with new ones may represent a great opportunity for improving the system efficiency. But this has to go hand in hand with motor control improvements.

3.3.4.3 Adoption of high efficiency lighting

Lighting frequently constitutes 10 to 15 % of electrical loads in industry. In addition to eliminating unneeded fixtures and lamps, more efficient lamps can replace the current ones. Industries that are most likely to benefit from investments in high efficiency lighting systems are the textile, chemical, pharmaceutical, and food industries. Electricity savings of 15 to 20 % are common and payback periods may be less than a year.

3.3.4.4. Boilers and furnaces improvements and fuel switching

Efforts to increase the efficiency of industrial processes should also focus on improving the efficiency of boilers and furnaces. Many industrial processes involve the use of direct thermal heating either from steam or using electricity directly. Conventional boilers used in industry are mostly operated using fuel oil followed by gas oil and a small percentage of LPG. Heating furnaces are also operated using fuel oil. Accurate data on age distribution and age-efficiency of boilers used in the industrial sector in Lebanon are not available. The current state of boiler equipment in industry is similar to that of electric motors, where the average age of boilers would vary between 20 to 30 years. The energy efficiency options consider either improvement in boiler efficiency where old boilers are replaced with new efficient ones operating on the same fuel type, or replacing inefficient industrial boilers with efficient ones that operate on a cleaner fuel such as LPG or natural gas.

3.3.4.5 Glass industrial sub-sector

Two energy efficiency scenarios were considered. The first assumes the use of the technology that reduces fuel use by 20% and the second assumes that the input fuel use is reduced by 40% with the state of the art oxy-fuel combustion technology. A third energy efficiency scenario was also considered assuming a glass recycle percentile of 30% of the plant glass batch input by year 2005, with a drop in energy intensity in the melting process of 7.5% of the batch. The melting furnace generally consumes 40-70% of total energy requirements for glass production.

3.3.4.6 Co-generation and heat recovery systems

A significant number of industrial enterprises in Lebanon generate their electricity through standby diesel generation units that range in capacity from 0.5 MW to 50MW or more. This makes the combined heat and power "CHP" technologies, and integrated combined cycle technologies, a significant source for saving substantial amounts of energy, carbon and money. Many new systems require little operator attention or maintenance, and provide enhanced power system efficiency. A recent study by ESCWA treated cogeneration and waste heat recovery as the most important energy efficient option for the industry in Lebanon [E/ESCWA/ENR/2001/14].

3.3.4.7 Private Diesel Electric Generators Replacement

The private diesel generators in the industrial sector operate mostly with an average age of 15 years and with a low thermal efficiency around 20%. With improved new generators and the use of co-generation, the fuel input to the supply-side can significantly be reduced.

3.4 Solid Waste Management

Varying degrees of solid waste management (SWH) is currently practiced in different parts of the country. With the exception of municipal solid waste (MSW) management in the extended Greater Beirut Area, and to a lesser extent in Greater Tripoli, solid waste continues to be managed in a manner that is not protective of either human health and/or the environment. Even in the extended GBA, serious questions are raised about the financial sustainability and replicability of the Emergency Plan for SWM implemented since 1997. The Government has yet to make serious policy commitments to promoting, and eventually requiring, sustainable and environmentally friendly SWM practices throughout the country and by all sectors (population, industry, agriculture, construction, tourism, energy) [SOE, 2002]

3.4.1. The Sector Overview

Municipal solid waste (MSW) makes up about 90% of the total solid waste stream generated in Lebanon and contributes to around 78% of all methane emitted. The main sources of MSW are households, commercial establishments, street markets, street cleaning operations, and public garden pruning.

Lebanon generated about 1,44 million tons of MSW in 2001 (about 3,940 tons per day), or about 0.92 kg per person per day. This estimate is higher than the 1.2 million tons of MSW (3,300 tons per day) reported by the MoE National Strategy for SWM

Various research and educational institutions have conducted studies on the composition of the MSW stream in Lebanon since 1995. Organic waste is by far the single largest component of the MSW stream, representing over 63% of the total MSW quantity in GBA and slightly over 50% at the national level, see Figure 3. Organic content at the national level may be lower than in GBA because people feed some of their organic waste (vegetable cuts, fruit remains, etc.) to their domestic animals in rural areas (the best possible form of recycling). The high organic content suggests potentially strong opportunities for recycling the organic materials present in the MSW through composting. Table 9 shows a comparison in GHG between 1994 and 1999 as reported in the GHG inventory update [GHG-II, 2002].

Table 9: Solid waste statistics for 1994 and 1999.

Indicator	1994	1999	% Variation
Solid waste generation rate, kg/cap/day	0.8	0.86	7.5
Annual solid waste generation, Gg/year	1087.7	1,296.4	19.2
Landfilled Waste, %	55	66.5	20.9
Landfilled Waste, Gg/year	598.2	862.1	44.1
Waste composition			
Paper/cardboard	11.3	11.3	
Food waste	62.4	62.4	
Diapers/garments	4.2	4.2	
Plastics	11.0	11.0	
Glass/Brick	5.6	5.6	
Metals	2.9	2.9	
Other (Wood)	2.6	2.6	
Methane generation per year, Gg	41.64	64.4	54.66
Methane burned per year, %	0	46	
Methane emitted per year, Gg	41.64	34.8	-16.52
Per capita methane emitted per year, $Gg*10^{-6}$	11.18	8.42	-24.69

To be effective, however, composting requires a high degree of waste separation, preferably at the source, to avoid contamination of the organic material (with broken glass, plastic shreds, and heavy metals). Such contamination would lead to a compost of poor quality that most end users would not want to apply to their lands. Source separation also would improve the marketability of certain recyclable materials, such as paper and cardboard and plastics. Apart from select small villages, however, source separation has not been implemented with any success in any urban area of Lebanon.

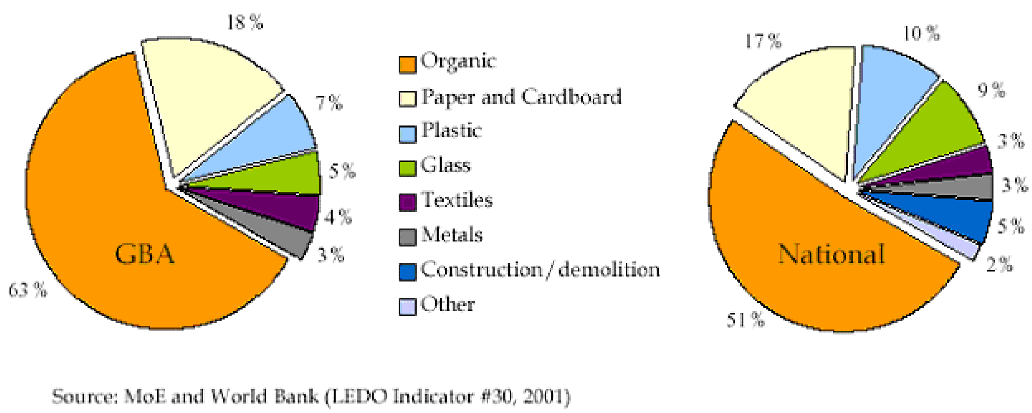


Figure 3: Composition of municipal solid waste in GBA & nationally

3.4.2. Impact on the Environment

The vast majority of the industrial waste generated in Lebanon is managed with little or no environmental controls. Industrial solid waste continues to be dumped into the environment, either directly or indirectly through sewer networks. Main air emissions from during places include methane gas and CO_2.

With grant funding from METAP/World Bank and the Italian Government, the MoE is implementing a one-year hazardous waste management project. The project is supported by an advisory board consisting of representatives from CDR, MOIM, MOPH, MOEW, ALIND, and several industrial branches [SOE, 2002]. The project will:

1. Assess the yearly quantities of hazardous waste generated in Lebanon;
2. Recommend a strategy for the sound management of hazardous waste;

3. Develop hazardous waste legislation; and
4. Train MoE staff, other stakeholders and concerned groups on the safe handling and management of hazardous waste.

MoE is also drafting pertinent legislation, including: (1) a decree to classify (according to the EWC) and manage industrial hazardous waste, (2) a decree to manage healthcare waste (also termed *medical* waste), and (3) a permitting and authorization decree for handling any kind of hazardous waste. This decree will set environmental guidelines and procedures for the safe handling of hazardous waste including its temporary storage, transport, treatment and final disposal. Medical waste management will be based on source segregation, using five health care waste categories labeled–infectious disinfection and land filling, or thermal treatment in a centralized facility.

Lebanon generates an estimated 11 tons of hospital risk waste per day, or about 4,000 tons per year and this figure is expected to reach 5,000 tons in 2010 [CDR 1999]. This estimate is based on several assumptions, including:

- 160 hospitals in 1999, totaling 13,493 beds;
- Average hospital risk waste generation of 1.5 kg of per day per occupied bed;
- Average bed occupancy of 56%.

Lebanon generates about 40,000 tons of slaughterhouse waste a year. To date there are no centralized facilities for handling slaughterhouse waste. Poultry houses also generate significant quantities of waste from dead broilers. Because of its nature, waste generated by slaughterhouses and butcheries can be a source of odor and disease propagation if not disposed properly. Currently, all such wastes are dumped into the environment.

3.4.3. Mitigation Options

The use of biomass fuel in Lebanon is minor and was confined in 1994 to the use of 100,000 tons of wood, 1,560 tons of charcoal and 180,000 tons of cooking coal [GHG_II, 2002]. Biomass energy resources from agricultural wastes could not be calculated due to insufficient data particularly about the amount and type of agricultural waste. The potential power generation could be calculated assuming that 1.5 tons of crop residue produces 1 MWh of electrical energy. Concerning biomass energy from municipal waste, Table 10 shows the energy content in landfill gas for the year 2040. However, not all gas generated at a certain landfill can be recovered for exploitation. In fact, typically 50% of theoretical methane generation is actually generated and only 25 to 45% of the theoretical gas generation potential can be recovered. Gas recovery projects for energy use require relatively large landfills that accept adequate quantities of waste with high biodegradable organic fraction. The trend in Lebanon is towards constructing such landfills. While gas flaring does not provide economic incentives for landfill operators and can only be imposed through government regulations, gas recovery may be economically beneficial irrespective of government intervention [El-Fadel et al, 2002].

Table 10: Energy content in landfill gas

Mass of CH_4 generation potential, Gg	269
Volume of CH_4 generation potential[a], 10^6 Nm^3	377
Oil value[b], 10^3 tons	313
Electric value[c], GW-hr_{el}	1,130
Thermal value[d], GW-hr_{th}	3,763
Caloric value[e], 10^{12} J	13,500
Equivalent CO_2 reduction based on GWP, Gg	5,066
Equivalent annual CO_2 reduction based on GWP, Gg[f]	127

[a] 1 Nm^3 (at STP) = 714 g of CH_4
[b] 1 J = 2.389×10^{-11} ton oil equivalent
[c] J = 2.77×10^{-7} kW-hr (thermal)
[d] 1 kW-$hr_{thermal}$ = 0.33 kW-$hr_{electrical}$
[e] Caloric value of CH_4 = 35,900 kJ/Nm^3 $\Rightarrow$ Caloric value of LFG = 17,950 kJ/Nm^3
[e] Based on a 40 year period

A potential biomass energy source in Lebanon is methane from solid waste. Depending on the adopted management alternative, methane control strategies can reduce GHG emissions from the solid waste sector by 50 to 90%. The amount of CH_4 production from municipal solid waste (MSW) disposal accounted for about 6% of the total country GWP from GHG emissions. Therefore, a maximum of 90% reduction in methane emissions from landfills is equivalent to 5.4% of the total country GWP from GHG emissions. An economic assessment was conducted to evaluate the cost of three waste management options (composting, incineration and landfilling) that are planned for several Lebanese cities. Table 11 summarizes the associated cost with the three options clearly favoring the landfilling option.

Table 11: Economy of waste management options

Waste management option	**Cost [1995 $/ton]**
Incineration	65-75
Composting	35-40
Landfilling	15-25

Source: World Bank, (1995).

Based on these costs, the current and future government policies on MSW advocate an integrated waste management system of recycling, composting and landfilling. Separation of food waste at source can be accomplished by installing kitchen grinders or by manual separation into different waste bins; but this requires significant public participation and government enforcement, and even with extensive awareness campaigns the probability of its occurrence is low in the near future. Accordingly, landfilling and composting constitute the most likely plans for the baseline years. Both plans have two options for emission reduction: a) gas recovery and flaring or b) gas recovery and utilization thus leading to a total of four alternatives as follows:

(1) Landfilling with gas recovery and flaring (LF+F);
(2) Landfilling with gas recovery and utilization (LF+U);
(3) Composting and landfilling with gas recovery and flaring (C+LF+F); and
(4) Composting and landfilling with gas recovery and utilization (C+LF+U).

A preliminary economic assessment to estimate the cost of CH_4 emission reduction and the quantity of CH_4 emissions reduced over the life-time of the facility for the four alternatives was conducted. The net present value concept was applied and comparison of alternatives was done using the following typical average values: 1) average operations and maintenance costs = 10% of gas flaring/utilization capital cost; 2) average revenues = 30% of gas utilization capital cost; and 3) average discount rate = 10%. These values were obtained from typical installations in Europe and the US. Based on these criteria, the composting and landfilling with gas recovery and utilization alternative ranked first among the selected mitigation options, see Figure 4 [El-Fadel et al, 2002]

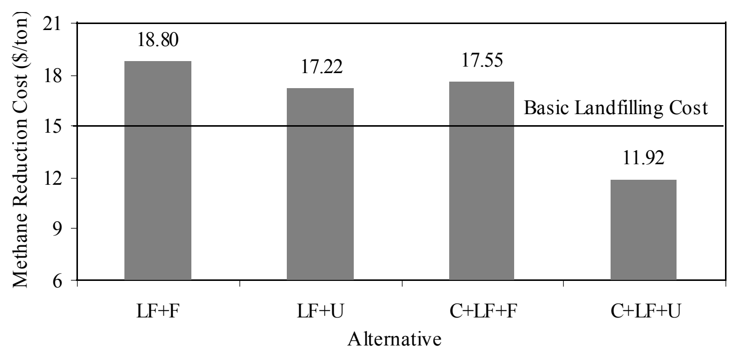


Figure 4: Comparison of selected mitigation alternatives for solid waste.

Another source of biomass is agricultural waste that can be converted into electricity through gasification, biogas digestion or combustion processes. This source of energy is not exploited in Lebanon as agricultural wastes are typically burned. Limited applications have been initiated by non-governmental organizations (NGOs) by establishing biogas digesters for rural areas within the framework of community development projects financed by USAID, and have been operating efficiently.

3.5. The Building Sector

The building sector is a substantial energy consumer in Lebanon, especially in the absence of effective energy conservation standards. In 1999, the building sector has consumed around 4111 GWH, constituting 38% of the total electricity consumed in the country and around 740 toe, constituting 13.8% of the total amount of fuel consumed in 1999. The sector has witnessed a growth rate of around 8.5% in electricity consumption and 5.4% in fuel consumption [GHG-II, 2002].

3.5.1. The Sector Overview

Between 1996 and 1998, the Central Administration of Statistics (CAS) conducted a census of all buildings and establishments throughout the country. In 1996, there were 518,858 buildings in Lebanon, see Table 12. This includes buildings under construction or restoration, buildings marked for demolition, as well as improvised buildings. Buildings can be grouped into three major categories: residential, non-residential, and mixed buildings.

Table 12: Distribution of buildings by Mohafaza and by mode of use [SOE, 2002]

Mohafaza	Total buildings	Residential	Non-Residential	Mixed	Other
Beirut	18,810	6,257	2,320	8,616	1,617
Mount Lebanon	168,475	104,963	18,813	37,873	6,826
North Lebanon	107,268	65,388	13,434	23,285	5,161
South Lebanon	69,873	48,389	7,578	10,714	3,192
Nabatiyeh	56,705	42,172	4,405	7,531	2,597
Bekaa	97,727	64,357	11,977	18,049	3,344
TOTAL	518,858	331,526	58,527	106,068	22,737

There are 1.45 million dwelling units of which 73% are residential and almost 27% are non-residential. Residential units include primary and secondary residences, and empty units. Non-residential units include establishments, public administrations, and empty/closed units.

In 1996-1997, there were 198,436 establishments in Lebanon. These include services other than shops (e.g., transport, insurance, water and electricity, hotels and restaurants, health care, and postal services), industries, educational and cultural establishments, as well as shops and other commercial outlets [GHG-I, 1998].

According to Lebanon's technical annex on climate change, the building sector consumed 13.77x10^6 GJ for space heating and cooling in 1994. This energy consumption that was obtained from electricity (44%), gas/diesel oil (40%) and wood (16%) resulted in the emissions of 1,016 Gg of CO_2 [GHG-I, 1998].

The residential and commercial sectors consumed in 1994 30% of the final energy consumption. The most consuming equipment, representing 80% of the total electricity consumption, are:

- Electric heaters (for space heating), 31%
- Electric domestic hot water systems, 22%
- Air conditioning (A/C), 13%
- Lighting, 8.5%
- Refrigeration, 6%

The energy sources used in the building sector in Lebanon are LPG for cooking and space heating, diesel oil for space heating and provision of hot water and wood for space heating and minor cooking.

3.5.2. Impact on the Environment

Being a major consumer of energy, the buildings sector emits large amounts of GHG annually. In 1994, the sector recorded around 1737 Gg of CO_2. On the other hand, buildings consume space and natural resources. They require cement and other building materials, some of which are extracted from quarries (aggregate, sand). Table 13 summarizes the key environmental impacts associated with the construction sector, as adopted from the French Institute for the Environment [State of the Environment, 2002].

Table 13: Environmental impacts of construction

Environmental Impacts	Description	Potential impacts on		
		Air	Water	Soils & land cover
Extracting raw Materials	Sand and gravel	Particulate emissions	Water courses near quarries are altered	Landscape degradation
Manufacturing Building material	Cement production	Particulate emissions, CO, SOx, NO_x	-	Disposition of dust
Constructing buildings	Transporting materials	NO_x and CO_2 emissions	-	Taking up new areas of land
	Building sites	Noise, particulate emissions	-	-
Using Buildings	Energy consumption	CO_2 Emissions	-	-
	Water consumption	-	Wastewater discharges containing detergents and organic matter	-
	Wear and tear of materials	Asbestos fibers, indoor random emissions	-	-
Demolishing Buildings		Noise, particulate emissions	-	Demolition waste to be land filled or reused for sea reclamation

3.5.3. Mitigation Options

Since there are no specific policies for the management of demand in Lebanon, energy efficiency in the residential and commercial sectors is slightly and slowly improved by the introduction of some efficient equipment, due to the market's dynamics but with different payback times, penetration rates and incremental costs. Mitigation options in the building sector are generally focused on energy conservation and on adopting energy- efficient technologies. Emphasis should also be placed on building designs with improved building envelop that minimizes leaks and lighting needs.

Applicable options may include:

1. Improved building thermal envelop. According to the Technical annex on climate change, the analysis of the business-as-usual scenario of the building sector indicated that 1,383x10^6 GJ would be needed for heating and cooling (H&C) during 1994-2040 with 761,100 TJ in the form of electric energy,

484,000 TJ from gas/diesel oil conversion and the remaining part will be from wood combustion.

2. Energy- efficient lamps, such as electronic ballasts that increases the efficiency of fluorescent lamps by up to 40%, with estimated energy savings of around 1330kWh over 10 years. Options also include compact fluorescent lamps with 4 times higher efficiency than old incandescent lamps.
3. Roof and walls insulation, with 5 cm polystyrene for example, may lead reduce the total energy consumed by 30% to 40% [Karagouli, 2001].
4. Low- emissivity, double glazed windows, to reduce thermal losses in winter, and AC leaks in summer.
5. Energy- efficient hot water and air conditioning systems. Options here include the deployment of solar energy for water heating.

The steps to be adopted for accelerating the diffusion of the options in question are:

At short and medium terms:

1. Adjustment of the electricity prices to reflect the real production cost
2. Establishment of a quality control system such as certificates and labels of quality in order to better guide the consumer
3. Training of technicians on energy saving issues and especially on the solar domestic hot water equipment
4. Development of new customs policies and laws in favor of the performing equipment instead of the consuming one.
5. Awareness campaigns

At the long term:

1. Establishment of quality norms
2. Development of local industries, especially solar domestic hot water and efficient refrigerators
3. Development of lending system for credit sales on energy performing equipments at low rates for the industries, contractors and consumers

4. Establishment of regulations in the residential and commercial sectors for installing solar domestic hot water systems
5. Integration of the energy pricing procedure of the notion of “environmental cost”.

Chapter Four

Technology Needs Assessment and Technology Transfer for Lebanon

The proposed steps/ activities needed to implement TNA and TT can be initiated by forming institutional arrangements followed by TNA and TT. Implementation is as described below.

4.1. Forming Institution Arrangements

The formation of institutional arrangements to facilitate technology needs assessment and technology transfer may be done according to Figure 5. Detailed discussion on each block is presented below.

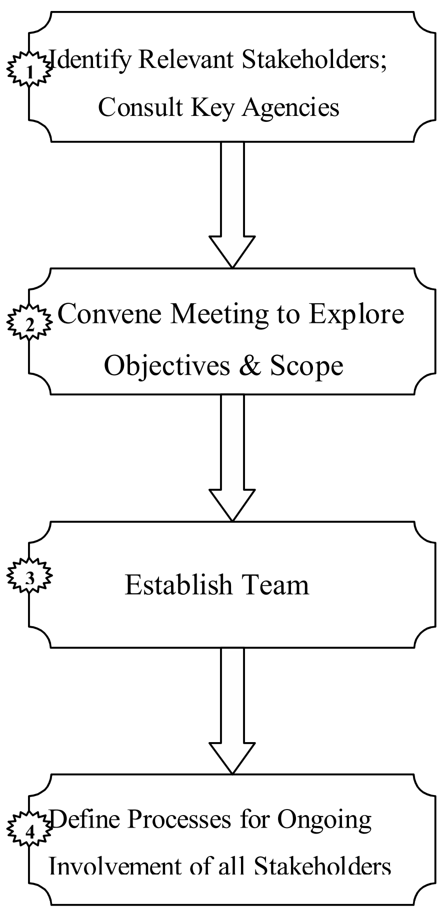


Figure 5: Forming institution arrangements

Block 1: Identify Relevant Stakeholders; Consult key Agencies

The technology transfer process must be country driven in order to identify and treat local concerns and to ensure commitment of relevant stakeholders. In this respect, and based on the findings of Lebanon's first national communication under the UNFCCC, several economic sectors have been identified as being significant in terms of GHG emissions and key elements in the national economy. These sectors are the electric power, transport, building, industry, and waste treatment sector. In order to get a feedback on technology needs in each sector as well as decision criteria, constraints and policy instruments needed to accelerate the transfer of technology to the country, each of the above sectors was represented by one or several experts such as government officials, directors, consultants, academics, active NGOs and relevant international agencies (See Appendix).

Block 2: Convene Meeting to Explore Objectives and Scope

Individual interviews/meetings have been carried out with the identified stakeholders with the purpose of exploring objectives and scope of the project as well as to get feedback on priority technology options in each sector and national policy to be adopted for the acceleration of the technology transfer process. The discussion also covered adaptation strategies.

Block 3: Establish the Core Team

After individual interviews/meetings with the various sectors representatives, a brain-storming meeting has been scheduled to expose sectors representatives to the technological options identified in all sectors and to unify the rather conflicting opinions regarding the establishment of the national policy on technology transfer. This leads to refining the opinions collected prior to starting the analysis using the Analytic Hierarchy Process (AHP) and performing technology ranking analysis (See section 4.3). The meeting should also lead to establishing a core team for project follow-up.

Block 4: Define Processes for Ongoing Involvement of all Stakeholders

During this meeting a framework for ensuring project sustainability should be recommended and ongoing involvement of all stakeholders is the corner stone in TNA and TT sustainability.

4.2. The Technology Need Assessment Process

The TNA process proposed for the country meets the guidelines established by UNFCCC, as described in chapter 1. Figure 6 presents a block diagram of the relevant steps.

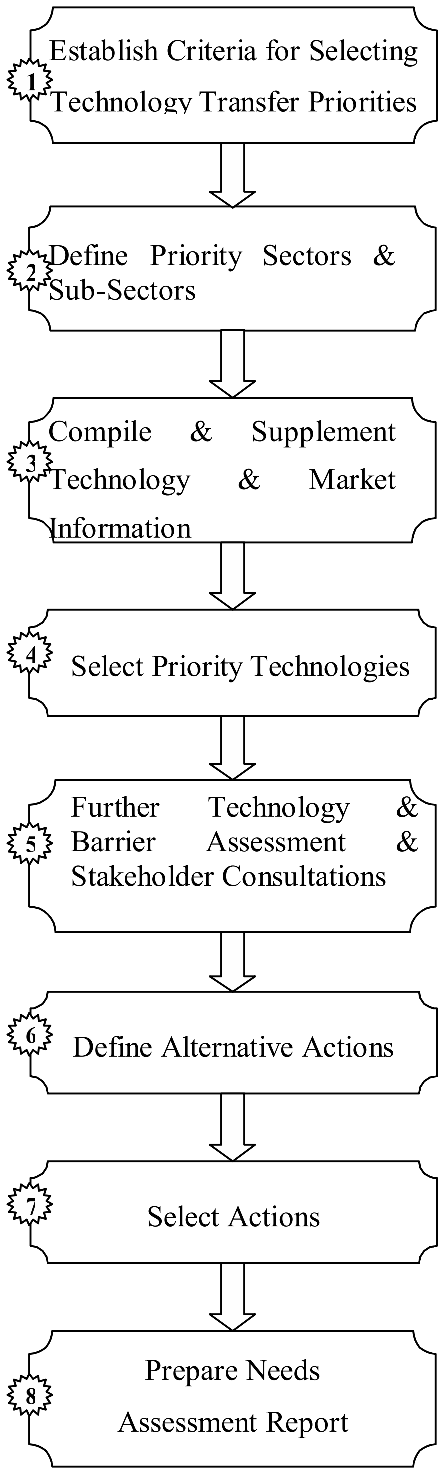


Figure 6: The need assessment process

The Need Assessment process proposed for Lebanon falls into 8 levels or blocks as described below:

Block 1: Establishment of Criteria for Selecting Technology Transfer Priorities
Technology needs assessment is to be done under two systematic approaches. The first approach identifies criteria for technology inventory in every sector identified as priority sector, and the second approach uses a decision analysis technique in order to establish a national policy to help accelerate and smoothly achieve technology transfer in these sectors. In this work, the decision analysis tool used is the Analytic Hierarchy Process (AHP).

In the AHP model, the three decision criteria selected for justifying the support for technology transfer are development benefits, market potential and contribution to climate change response goals. With respect to development benefits national efficiency improvement and energy savings under the same category considering social equity and use of local resources. With respect to Implementation/Market Potential the criteria here is stimulate market growth, local and foreign investment and sustainability. While with respect to the contribution to climate change response goals, we observe the reduction potential of GHG as the main objective.

As to constraints, six categories have been considered. These are (1) the adequacy of local policies and legislation, and more importantly the enforcement of law, (2) the availability of funding whether from local/international investors, government money, and international donor agencies, (3) commerciality and competitiveness also is an important constraint as the inability to market and sell the proposed technology will eventually lead to its phase-out. (4) adequacy of local resources is another critical constraint as Lebanon must have developed supportive institutions including appropriate industrial bases for provision of technical support, suitable human expertise, etc. (5) immaturity of technology as a successful technology transfer must promote proven and well established technologies. The promotion of technologies with failing characteristics and/or non attracting economic return will negatively affect the transfer of other technologies. Finally, (6) public awareness is a very important constraints and needs to be increased on the level of all stakeholders including ordinary citizens, government officials, manufacturers, etc….

The last step in the national policy for accelerating the technology transfer process is the adoption of one or more policy instruments that lead to an effective technology transfer. The policy instruments recommended are (1) setting of appropriate laws and regulations, (2) establishment of market based programs that mainly entail introduction of taxes or provision of incentives, (3) effective engagement of the private sector, and (4) effectively benefiting from the work programs of NGOs and international donor agencies.

Block 2: Definition of Priority Sectors & Sub-Sectors
Based on Lebanon's first national communications under the UNFCCC, the following sectors are identified: The transport sector, the electric power sector, the industry sector, the buildings sector and the waste sector. As for adaptation on climate change the water and forestry sectors were also considered in the priority list.

Block 3: Compile & Supplement Technology & Market Information, and
Block 4: Select Priority Technologies
The considerations that fall under these blocks include provision of summary of alternative climate change response technologies, development benefits, implementation and investment potential, contribution to climate change response goals, information on technology performance & costs, identification of implementation barriers, existing and planning programs designed, and recommendation on how to facilitate the widespread of the recommended technologies. All of this information can be found Lebanon's first national communications under the United Nations Framework Convention on Climate Change, some ESCWA and GEF studies. A brief about the status of each of the considered sectors together with the issues raised above has been compiled for the purpose of this project.

Block 5: Further Technology, Barrier Assessment & Stakeholder Consultations, and **Block 6:** Define Alternative Actions

Four points are considered: (1) Identification and analysis of specific barriers to achieve the full implementation of technology transfer, (2) Evaluation of effectiveness of Lebanon's and donor programs and their anticipated impact on technology transfer, (3) identification of specific opportunities to accelerate implementation such as private and public investments, market based programs, etc. and (4) the identifications of potential actions to facilitate implementation. All of these activities have been entertained in the AHP analysis mentioned above and are in the agenda of the meetings scheduled with stakeholders.

Block 7: Select Actions

At this level, the selection of the highest priority actions is to be considered. This can now be achieved because of the good knowledge of country priorities and needs, variety of options and actions that can be used to achieve effective technology transfer and sectoral information available from existing documents and interaction with stakeholders. A good synthesis is now needed to prioritize options and actions.

Block 8: Technology Needs Assessment Report

The assessment report must include (1) an overview of TNA and TT in other countries as well as summaries of methodologies recommended by the United Nations, (2) a description of the status of the various sectors of interest, (3) Lebanon's approach to TNA and TT, (4) results and recommendations of undertaken studies for technology transfer. This should provide the priority technologies and proposed implementation actions, key implementation Barriers, integration with the existing development programs, and key recommendations for implementation on national level.

4.3. Preparing and Implementing Technology Transfer Actions and Plans

The plan proposed for preparing and implementing TT actions and plans, shown in Figure 7, constitutes six major steps (blocks).

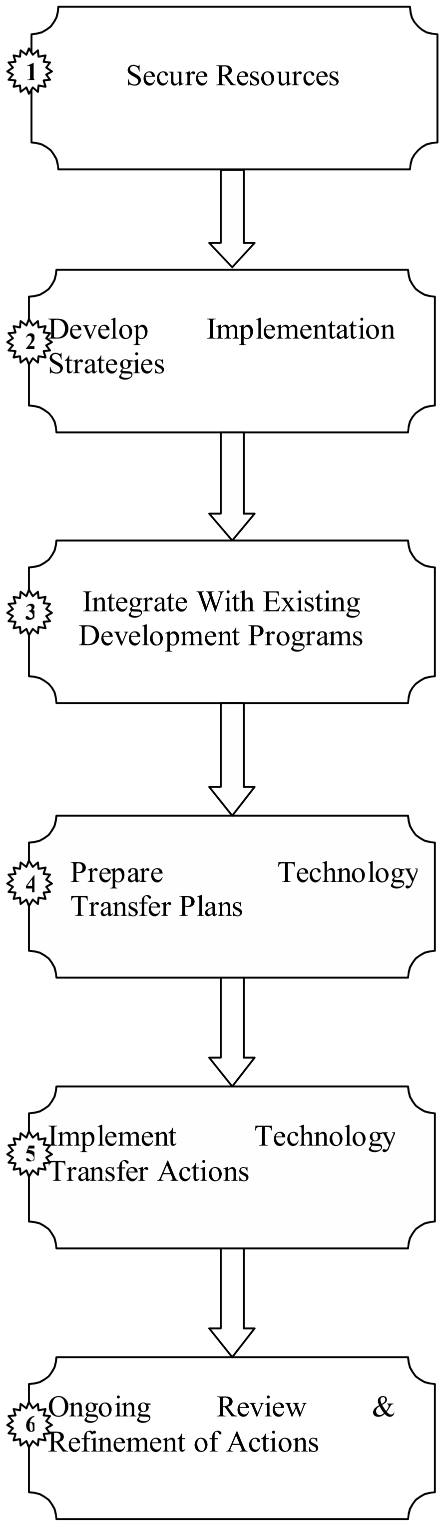


Figure 7: Preparing and implementing technology transfer actions and plans

Block 1: Secure Resources

Securing resources requires working with donor organizations and domestic agencies, and leveraging new resources with existing country, donor and stakeholder programs. For this specific purpose, short meeting sessions have been planned with local financing agencies, mainly banks, and relevant international donor/lending agencies including the World Bank, UNDP, EU, USAID, etc. Such meeting sessions are expected in the final workshop scheduled end of October 2002.

Block 2: Develop Implementation Strategies

The implementation strategy recognizes three levels of intervention. The first level entails identification and prioritization of decision criteria that justify and support actions to facilitate technology transfer. The second level sets the constraints and barriers that must be analyzed and overcome to enable technology transfer to the various sectors. Finally, the third level recommends a set of policy options which must be adopted individually or collectively to ensure short and long term transfer of technologies.

The finalization of such a strategy requires interaction with stakeholders first individually in the form of interviews and second in the form of a brain storming sessions to be organized at a later stage.

Block 3: Integrate With existing Development programs and **Block 4:** Prepare Technology Transfer plans

Effectively integrate implementation regarding technology transfer with other national, and/or international development programs. It is anticipated that integration will be mainly with UNDP, IPP projects, technology related projects controlled by the CDR and anticipated plans on privatization.

Block 5: Implement Technology Transfer Actions, and **Block 6:** Ongoing Review and Refinement of Actions

Blocks 5 and 6 consist of implementation of the technology transfer plan, ongoing assessment and refinement of climate change technology transfer, implementing refinements, and developing new actions. A follow-up committee from all stakeholders will be formed to ensure implementation and project sustainability.

4.4. The Analytic Hierarchy Process (AHP)

The AHP was first developed by Professor Thomas L Saaty in the 1970s [Saaty, 1980] and since that time it has been widely applied in a variety of areas. Among these areas are the complex decisions in arms control, transport systems, and conflict analysis. The AHP has been accepted by the international scientific community as a very useful tool for dealing with complex decision problems. In addition many corporations and governments routinely use the AHP for major policy decisions.

4.4.1. The Philosophy of AHP

The AHP is an intuitive and relatively easy method for formulating and analyzing decisions. The three major concepts behind the AHP are: analytic, hierarchy, and process.

- Analytic

The AHP uses numbers. In holistic decision making no numbers are needed in order to reach a decision; simply the alternative that is most desired is chosen. However there are good reasons for using mathematics to understand and/or describe this choice. In this sense, all methods, which seek to describe it decision, are analytic, since they must use mathematical/logical reasoning.

- Hierarchy

It is a particular type of system, which is based on the assumption that the entities, which we have identified, can be grouped into disjoint sets, with the entities of one group influencing the entities of only one other group, and being influenced by the entities of only one other group. The elements in each group (level) of the hierarchy are assumed to be independent.

Hierarchies were not invented in corporation and governments to take care of their affairs. They are basic to the human way of breaking reality into clusters and sub clusters. To illustrate this we take again the case at hand: we are trying to find “a most appropriate” solution, among many others, to the technology transfer process for

Lebanon, in order to achieve a smooth and effective transfer, taking into consideration the various factors and constraints that are encountered while implementing such task.

The problem is structured into a hierarchy by decomposing it into levels; starting from the overall objective (acceleration of technology transfer process), down to sub objectives that we call decision criteria (like enhancing the development benefits, strengthening the market potential and improving environmental quality), down to the constraints that affect these sub objectives (legislations, funding, status of technology, etc) and finally down to the strategies that could be implemented (updating laws and regulations, increasing the participation of private sector, …etc). The though hierarchy will then look as shown in Fig.3.

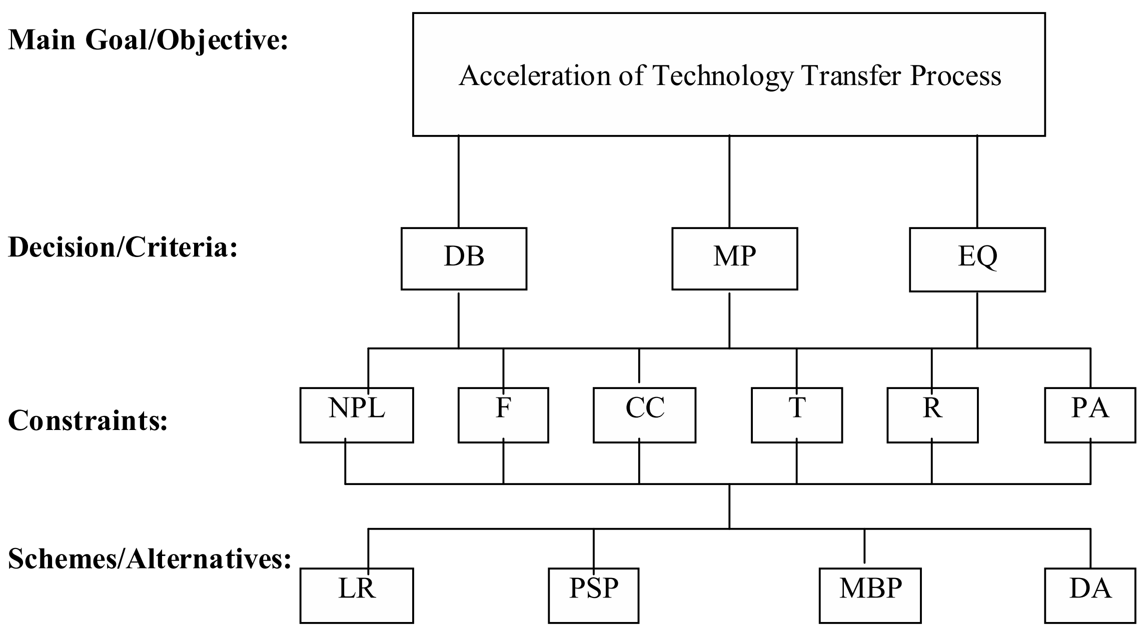


Figure 8: AHP block diagram

In the above hierarchy, in level 2: DB is Development Benefits,
MP is Market Potential, and
EQ is Environmental Quality.

In level 3, NLR is Adequacy of National Policies and Legislation,
F denotes Availability of Funding,
CC is Commerciality and Competitiveness,
T is Immaturity of Technology,
R A is adequacy of Resources and,
PA is Public Awareness.

In level 4, LR is used to denote Laws and Regulations,
PSP is Private Sector Participation,
MBP is Market Based Programs and,
DA represents NGOs and International Donor Agencies.

It is evident that components of each level interact with components of the level above and below.

The established hierarchy is not by itself sufficient for us to make a decision; there is a need to know the intensity of the influence of the elements in one level on elements in the next higher level, so that the impact of the lowest level on the highest level (Objective) can be determined. This is done through pairwise comparisons.

4.4.2. Process

Any real decision problem involves a process of learning, debating and revising priorities. The AHP is meant to be a tool to aid and shorten this decision process through the insights, which this method can generate; it has never and will never replace the overall decision process. The AHP points to where more information is needed, where major points of disagreement lie etc. If the outcome of the process appears unsatisfactory i.e. not to represent feelings accurately a decision-maker may return to the hierarchy to see if any true feelings have been misrepresented, or it may be that intuitive feelings will change after considering the problem in detail. This process is unavoidable and is in fact quite healthy; the AHP is meant to aid and not destroy this natural process of decision-making.

Pair Wise Comparison

Elements of a certain level are compared in pairs with respect to their relative impact (weight) on a property they share in common, in this case an element of the next higher level. For example, in the proposed hierarchy, criteria of level 2 can be compared with respect to their influence on accomplishing the overall objective in level 1: the question to be asked is: "For accelerating the technology transfer process, how does the Environmental element compare with the social one? With the market element? And with the developmental factors? Then, how does Market Potential compare with Environmental, and with Social Element?" and so on, until every element is compared with other elements in the same level, which influence a common element of the upper level.

These pair wise comparisons are reduced to a matrix form, which is a square array in which numbers are arranged in rows and columns as shown below:

$$
\begin{array}{c|c}
 & \begin{array}{ccccc} A_1 & A_2 & A_3 & & A_n \end{array} \\
\begin{array}{c} A_1 \\ A_2 \\ A_3 \\ \cdot \\ \cdot \\ \cdot \\ A_n \end{array} &
\begin{pmatrix}
a_{11} & a_{12} & a_{13} & \dots & a_{1n} \\
a_{21} & a_{22} & a_{23} & \dots & a_{2n} \\
a_{31} & a_{32} & a_{33} & \dots & a_{3n} \\
\cdot & \cdot & & & \\
\cdot & \cdot & & & \\
\cdot & \cdot & & & \\
a_{n1} & a_{n2} & a_{n3} & \dots & a_{nn}
\end{pmatrix}
\end{array}
$$

where

$A_1 \dots A_n$ is a set of n elements that are compared to each other, and a_{ij} is the relative importance or weight w of element i over element j with respect to the common criterion. ($a_{ij} = w_i/w_j$). It is important to note that $a_{ji} = 1/ a_{ij}$ (reciprocal).

When problems are structured hierarchically, a matrix is arranged to compare the relative importance of criteria in the second level with respect to the overall objective of the first level. Similar matrices are constructed for pair wise comparisons of factors in the third level with respect to the criteria in the second level. The matrix is set up by providing the "comparison criterion" above and listing the elements to be compared on the left and top of the matrix. For example in the hierarchy presented above, the pair wise comparison matrix for level 2 with respect to level 1 is achieved by:

	NEE	ULR	SE	MP	EQ
NEE	1				
ULR		1			
SE			1		
MP				1	
EQ					1

Similarly, comparing elements in level 3 with respect to level 2, we get pairwise comparison matrices for level 3 with respect to each element of level 2. Namely:

- Relative to development benefits:

	NPL	F	CC	T	R	PA
NPL	1					
F		1				
CC			1			
T				1		
R					1	
PA						1

- Relative to market potential:

	NPL	F	CC		R	PA
NPL	1					
F		1				
CC			1			
T				1		
R					1	
PA						1

- Relative to environmental quality:

	NPL	F	CC		R	PA
NPL	1					
F		1				
CC			1			
T				1		
R					1	
PA						1

In the same manner, matrices are constructed to compare elements of level 4 with respect to each element of level 3.

In the above matrices, we considered that every element of one level is influenced by all elements of the level below. In this case the hierarchy is called “complete”. This is not always true though. Some factors could affect one element of the level above without having any influence on another element, in which case the hierarchy is “incomplete”.

4.4.3. Need for a Scale of Comparison

Having formed these matrices, the next step is to fill them in with the appropriate weights or scales “W”. The process begins with an element “A” on the left of the matrix and ask how much more important it is than an element listed on the top of the matrix “B”. When an element is compared with itself, the ratio is obviously 1, hence the diagonal in the comparison matrix has all values as 1. As mentioned previously, the values in the lower triangle of the matrix (lower side of the diagonal) are the reciprocals (W_B/W_A) of those in the upper triangle (W_A/W_B). Hence it is enough to find the weights of the upper triangle and deduct the values in the lower triangle. Therefore the total number of comparisons needed to fill a matrix of size n is n(n-1)/2.

Now, how do we deal with non-measurable entities like social, political, emotional factors, where no units like dollars, miles or kilograms exist?

Taking again the example of A and B above, what can be done (when we do not know their weights such as in Kg) is take each one in one hand and try to “feel” their relative weights. Or we might pick them up sequentially with the same hand to avoid bias in our judgment. On such basis, we cannot state that A is so and so Kg heavier than B for example, but we would be able to say that A is “slightly heavier”, “much heavier” or “absolutely heavier” than B. Similarly, when we compare the relative importance of intangible factors, we could legitimately state that one is more important or much more important…etc depending on our preferences and feelings. [Analytical planning the organization of systems, T. Saaty and K. Kearns p. 26]

4.4.4. Recommended Scale of Relative Importance

A scale that has been validated for effectiveness in many applications through a number of people, and also through theoretical comparisons with a large number of other scales, is illustrated in Table 14.

Table 14: Scale of relative importance

Intensity of relative importance	Definition	Explanation
1	Equal importance	2 activities contribute equally to the objective
3	Moderate importance of one over another	Experience and judgment slightly favor one activity over another
5	Essential or strong importance of one over another	Experience and judgment strongly favor one activity over another.
7	Demonstrated importance of one over another	An activity is strongly favored and its dominance is demonstrated in practice
9	Extreme importance of one over another	The evidence favoring one activity over another is of the highest possible order of affirmation
2,4,6,8	Intermediate values between the 2 adjacent judgments	When compromise is needed
Reciprocals	if importance of A over B (A/B) is 3 then B/A is 1/3	

The justification of using the 1 to 9 values is outside the scope of this report but can be found in [Saaty, 1980]

The AHP method can be described as follows:

Given the elements of one level, say the 3rd, of a hierarchy, and one element "e" of the next higher level (2nd). Compare the elements of level 3 pairwise in their strength of influence on "e". Insert the agreed upon numbers, reflecting the comparison, in a matrix and find the eigenvector with the largest eigenvalue. The eigenvector provides the priority ordering, and the eigenvalue is a measure of the consistency of the judgment. The following steps illustrate the method:

1. Define the problem and determine what you want to know.
2. Structure the hierarchy from the top (the objectives) through the intermediate levels (criteria on which subsequent levels depend) to the lowest level (usually a list of the alternatives).
3. Construct a set of pairwise comparison matrices for each of the lower levels-one matrix for each element in the level immediately above. An element in the higher level is said to be a governing element for those in the lower level that contribute to it or affect it. The elements in the lower level are then compared to each other based on their effect on the governing element above. This yields a square matrix of judgments expressed as integers from 1 to 9. If element A dominates element B, then the whole number is entered in row A, column B, and the reciprocal (fraction) is entered in row B, column A. if A and B are judged to be equal, a "1" is assigned to both positions.
4. There are n(n-1)/2 judgments required to develop each matrix in step 3. (Reciprocals are automatically assigned)
5. Having made all the pairwise comparisons and entered the data, the consistency is determined using the eigenvalue. The consistency index is tested then using the departure of λ_{max} from n compared with corresponding average values for random entries yielding the consistency ratio C.R.
6. Steps 3, 4, and 5 are performed for all levels in the hierarchy.
7. Hierarchical synthesis is now used to weight the eigenvectors by the weights of the criteria and the sum is taken over all weighted eigenvector entries corresponding to those in the next lower level of the hierarchy.
8. The consistency of the entire hierarchy is found by multiplying each consistency index by the priority of the corresponding criterion and adding them together. The result is then divided by the same type of expression using the random consistency index corresponding to the dimensions of each matrix weighted by the priorities as before. The consistency ratio (C.R.) should be about 10% or less to be acceptable. If not, the quality of the judgments should be improved.

4.4.5. Building our AHP Model: The Hierarchy

Having explored all the variables that affect the technology transfer process and introduced the AHP method, we now formulate our problem through a hierarchy, in the way explained earlier.

Level 1: Main Objective

Our main objective is to accelerate the technology transfer process on a national scale. This will be the top level of our hierarchy: "Acceleration of Technology Transfer".

Next, we have to address the criteria that affect this main objective by trying to solve the problems rendering it poor, and to capitalize on the issues that improve it.

Level 2: Decision Criteria

We have identified three main elements that directly affect the transfer of technology. We put them in the next level after breaking each element into its various components. These are development benefits (DB), market potential (MP) and environmental quality (EQ).

<u>Development Benefits:</u> As exposed earlier, the identification of priority technologies requires a view of the contribution that new technologies in different sectors might bring to social, environmental and development goals. It also requires that the cost effectiveness in terms of the possible high investments on new and alternative technologies be considered.

Looking closely into this issue, we find that national development is realized through (1) national economy efficiency (NEE), (2) use of local resources (ULR) and (3) social equity (SE).

- ***NEE*** are benefits that can be realized by utilizing high efficiency technologies in the various sectors of economy including residential, industrial, electricity generation and transport sectors.

- ***ULR.*** An important aspect for national development is the transfer of appropriate technologies that harness local national resources such as wind and solar , and provide job opportunities for the qualified human resources as to enhance capacity buildings in technological upgrades.

- ***SE*** is at the heart of government policies. Equity can be a decisive element in technology transfer such as in transport where a cheap and reliable transport should be available to all citizens even in the most remote and rural areas. Also, the provision of electricity, health services, improvement of women work conditions are all important aspects of equity that technology transfer should address.

Market potential Any new technology should offer the potential to answer several market concerns including justifications for any additional capital and operating costs relative to alternatives, commercial availability, social acceptability and sustainability for country conditions and replicability and potential scale of utilization.

Environmental quality is a major decision criteria, the following issues influence largely the decision concerning EQ:

i. GHG emissions reduction potential
ii. Adaptation potential
iii. Enhancement of CO2 sinks

Level 3: Factors/Constraints

While trying to improve the performance by acting on the various criteria, some other factors (or attributes) are to be taken into consideration, as they affect our ability to act on some or all of the problems: these are the possibilities available for us to use, or the constraints that limit our actions. They are divided into Legislative, economic, social, technological, marketing and infrastructure.

Policies and Legislatives: These are the conditions that greatly affect our actions for they can be the real barriers, some are the following: Regulations and standards that preclude new technologies, distorting market interventions such as subsidies for polluting industries, regulated markets that create disincentives for new technologies, planning system issues, etc. On the other hand, the practical application of existing laws is an important factor that must be enforced and respected.

Availability of Funding. New technologies are capital intensive, even if operating and lifetime costs are low, potential investors may lack the financial resources required to bear the upfront cost.

Commerciality and Competitiveness. CC is one of the main barriers of accelerating the technology transfer process. CC is influenced by the monopoly powers that reduce incentives to innovate and erect barriers to new entrants and dominant interests that erect barriers to new entrants and may discourage innovation.

Immaturity of technology also known as information barrier, this may take several forms; the simplest is where potential purchasers are ignorant of new technology possibilities. They may also be faced with multiple and conflicting information and have limited ability/time to absorb it, and choose a known option in preference to new alternative.

Adequacy of Resources The transfer of new technologies requires the existence of supporting infrastructure. For example, testing laboratories, skilled labor for regular maintenance, and availability of local manufacturing facilities to support minor modifications and spare parts are all important elements for a successful technology transfer process.

Public Awareness and appropriate educational system have made a major barriers hindering the widespread of cost-effective new technologies. Awareness about the benefits that new technologies offer as well as the provision of alternatives are very important for facilitating acceptance of new technological options. Cultural and societal barriers are also important and need to be addressed.

The above factors constitute the 3rd level of our hierarchy, while the 4th and lowest level lists the policy options or alternatives that could be adopted on a national scale to facilitate technology transfer. These options need to be studied and compared in order to set the best possible scenario for an effective transfer of technologies.

Level 4: Policy Alternatives

Laws and Regulations. The introduction of new laws and regulations might constitute a solution to technology transfer. Examples include alleviation of tax import on certain products, enforcing a ban on certain fuel (e.g. leaded fuel in 2002), restructuring of certain sectors and ministries (e.g. the merging of Ministry of hydro-electric resources and Ministry of petroleum into one ministry which is the Ministry of energy and water)

Private Sector participation. The private sector in Lebanon has been the driving force in national economy. Finding ways to ensure private sector participation in technology related projects would be crucial to ensure effective technology transfer process.

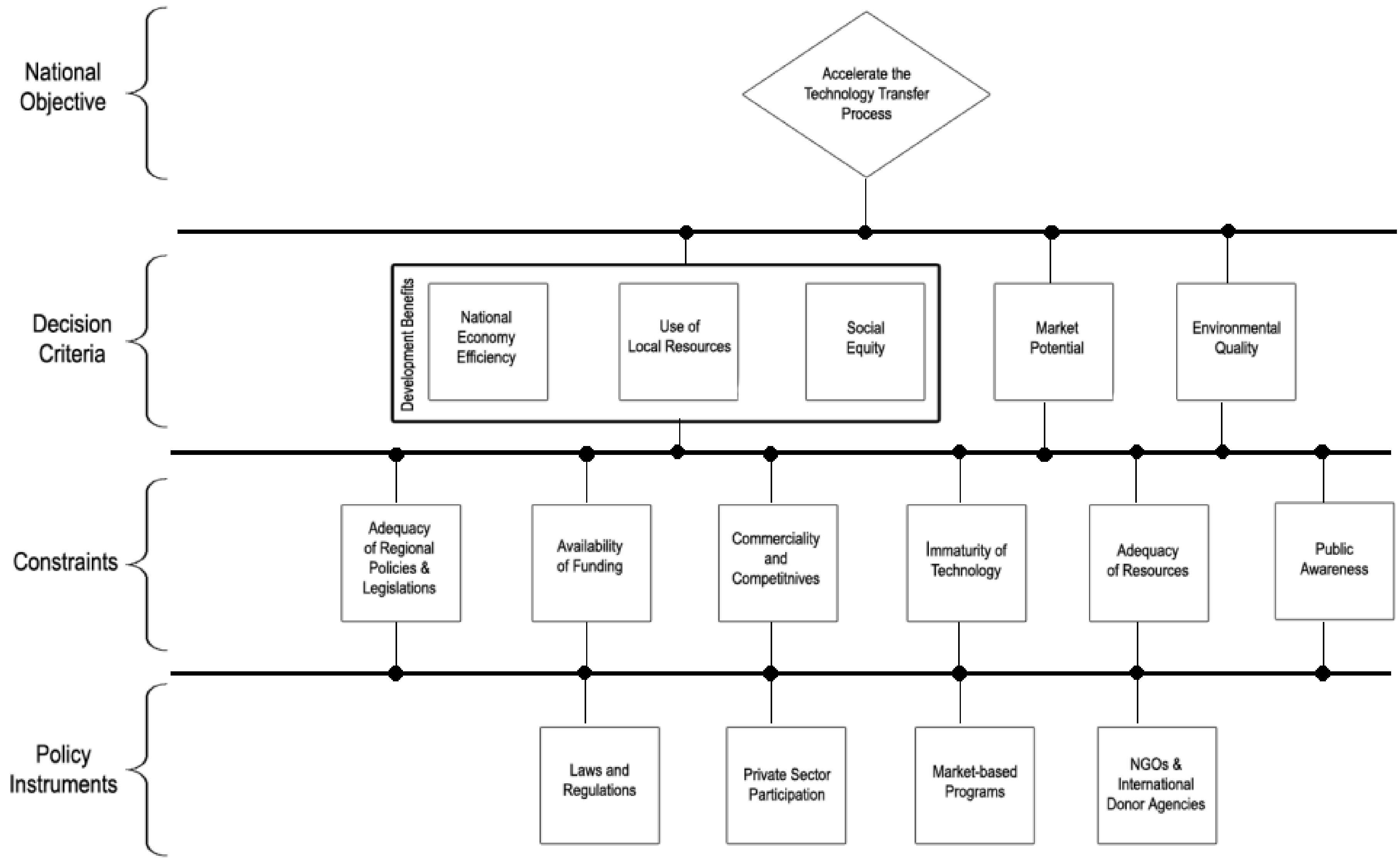
Market based Programs such as incentives to acquire new technologies and taxing polluters. (e.g. the tax of about 1000 Lebanese pounds on leaded fuel has led to phasing out this product completely from the market in less than one year !)

NGOs and International Donor Agencies The work of NGOs and international donor agencies has been very useful and important to the country. Several projects were executed by UNDP, EU, USAID, local NGOs and other regional and international organizations. A systematic approach to progress achieved by these organizations is needed in order to get the utmost benefits of their work.

The hierarchy to be used for examining technology transfer for Lebanon is now complete and is shown on the next page.

For convenience, we use some abbreviations of the various elements, as shown:

Level 1: National Objective	
1. Accelerate the technology transfer process	
Level 2: Decision Criteria	
1. Development Benefits	DB
a. National Economy Efficiency	NEE
b. Use of local Resources	ULR
c. Social Equity	SE
2. Market Potential	MP
3. Environmental Quality	EQ
Level 3: Constraints	
1. Adequacy of National Policies and Legislations	RPL
2. Availability of Funding	F
3. Commerciality and Competitiveness	CC
4. Immaturity of Technology	T
5. Adequacy of Resources	R
6. Public Awareness	PA
Level 4: Policy Instruments	
1. Laws and Regulations	LR
2. Private Sector Participation	PSP
3. Market Based Programs	MBT


National Objective
Decision Criteria
Constraints
Policy Instruments
Accelerate the Technology Transfer Process
Development Benefits
National Economy Efficiency
Use of Local Resources
Social Equity
Market Potential
Environmental Quality
Adequacy of Regional Policies & Legislations
Availability of Funding
Commerciality and Competitnives
Immaturity of Technology
Adequacy of Resources
Public Awareness
Laws and Regulations
Private Sector Participation
Market-based Programs
NGOs & International Donor Agencies

4.5. The Decision Matrices for Technology Needs Assessment and Technology Options Ranking

To conduct an evaluation/ranking process for various mitigation options in Lebanon a number of criteria has been adopted in a manner similar to that applied by recent ESCWA studies [ESCWA, 2001]. Based on the analysis conducted for the economic sectors, as described in Chapter 3, decision matrices have been designed based on seven selected criteria for evaluating and ranking mitigation options applicable for each of the sectors.

4.5.1. Criteria Elements

The selected criteria include the GHG reduction potential, impacts related to efficiency improvement and energy savings, capital and operation costs and the payback period, option sustainability, and other non- environmental impacts. In what follows is a listing of the criteria elements and the percentage weight assigned for each element with brief justification.

a) GHG reduction potential. Being the main objective of the TNA and TT tasks, this criterion is given the highest weight of 35%.

b) Efficiency improvement and energy saving. Energy saving and system efficiency improvement is also an important criterion since it leads to further benefits such as energy conservation and lower operation and maintenance costs. A weight of 25% is given for this criterion.

c) Capital investment. The cost of various technologies plays a significant role in its acceptance and wide spread especially in developing economies. Many of the options will require substantial investment for the purchase of equipment and equipments, establishment of infrastructure, introduction of new technologies, and training. This criterion has been assigned a weighting of 10%.

d) Operation and maintenance costs. These periodic costs are associated with running and sustaining emission-reduction measures after initial implementation. This criterion has been assigned a weighting of 10%.

e) Option sustainability. Options that can financially generate their own momentum tend to be self-sustaining. This criterion has been also assigned a 10% weighting.

f) Payback period. Profitable GHG mitigating options offer an attractive alternative for investments. Since it has been partially accounted for in the energy savings option, the weight assigned for this criterion is 5%.

g) Societal and economic benefits. Several options under consideration have the potential to deliver other non- environmental economic and social benefits in addition to reducing GHG emissions. Here also these benefits are partially accounted in the energy saving criterion, hence, a 5% weight has been assigned.

4.5.2. Mitigation Options

The evaluation process is performed by specifying a number of mitigation options for each sector such that:

In the Power sector: switching to natural gas, deployment of combined cycle, technology upgrading, electric interconnection, reduction of network losses, reducing/phasing out subsidies, demand side management, and partial switching to renewable energy.

In the Transport sector: improving the technical status of the fleet, improving traffic management, promoting mass transport, enforcing environmental standards and regulation, urban planning and land use, and switching to alternative fuels (natural gas).

In the Industry sector: switching to natural gas, energy- efficient systems, cogeneration, boiler improvement, and efficient motors.

In the Waste sector: wide- spread of composting, landfills, adopting anaerobic and aerobic digestion, and promoting the concept of reduce/reuse/recycle.

In the Building sector: building envelope, technology upgrading, solar heating water systems, and efficient lighting.

The criteria elements and the corresponding weights are unified for all sectors. Each criteria element is given a score which when multiplied by the criteria weight will give a final score for the element. A brief rationale for each score is also noted. The total score for each mitigation option is then obtained as the sum of the scores of all criteria elements. A sample of this evaluation process is shown in Table 15.

Table 15: A sample of the mitigation options ranking matrix.

Criteria element	Criteria weight (%)	Option score (%)	Rational for scoring	Final score
GHG reduction	35	86	Transport sector contributes to 20-25% of the CO_2 emissions from burnt fossil fuels. Other transport- related GHG include N_2O and CFC and HCFC from AC systems.	30
Efficiency improvement and energy saving	25	90	Improving vehicle maintenance and engine tuning greatly reduces emissions of GHGs and other pollutants by up to 30%. This leads to substantial energy and cost savings.	22.5
Capital Investment	10	65	Establish a vehicle I&M programme requires capital investment for the purchase and installation of testing units.	6.5
Operation and maintenance cost	10	50	To keep motor vehicles in proper operating conditions, and thereby maintaining returns in terms of lower GHG emissions, regular spending on labour, materials and spare parts will be required.	5
Option sustainability	10	60	Sustainability will depend on financial, technical and regulatory support. Vehicle maintenance requires annual investment by all stake holders	6
Payback period	5	50	Payback period is not easy to specify since I&M should be a continuous process	2.5
Societal and economic benefits	5	80	Proper maintenance and periodic inspection can reduce costs for items such as fuel and spare parts, and also increase the vehicle's resale value and extend its lifespan. Additionally, demand for vehicle servicing and for I&M centers will generate jobs.	4
			Total	**76.5**

Chapter Five

Results and Recommendations

The results obtained from the AHP and the Decision Matrices ranking process use presented in this section, which is also concluded by a set of recommendations.

5.1 AHP Implementation and Results

To populate the AHP matrices, 20 interviews were carried out with a wide scope diversity of stakeholders. These range from government officials, members of the Parliament, directors of public departments, private consultants and academics. Interviews were made both individually and collectively and the results were combined and entered into a resulting global matrix using the geometric mean of the entries in all individual matrices. Below is a description of the final matrices that were entered into the AHP software.

Level 1: National objective of the analysis weight is ‘1’

Level 2: The decision criteria in this level have impact vertically on one factor, which is the national objective. Hence, one matrix 5x5 is constructed as follows:

	NEE	ULR	SE	MP	EQ
NEE	1	1.11	2.98	1.11	1.13
ULR	0.9	1	3.26	1.02	0.87
SE	0.34	0.31	1	0.43	0.38
MP	0.9	0.98	2.31	1	1.07
EQ	0.88	1.15	2.67	0.94	1

Level 3: We have five influencing factors so a matrix of 6x6 is needed to reflect the impact on each of the factors in level 2. The relative weights with respect to the factors in the upper level are as follows:

- Relative to National Economy Efficiency (NEE):

	PL	F	CC	T	R	PA
PL	1	1.8	3.09	4.63	3.78	1.5
F	0.56	1	1.71	2.65	2.33	0.54
CC	0.32	0.59	1	1.73	1.61	0.38
T	0.22	0.38	0.58	1	0.94	0.33
R	0.26	0.43	0.62	1.06	1	0.31
PA	0.67	1.85	2.66	3.07	3.27	1

- Relative to the Use of Local Resources (ULR):

	PL	F	CC	T	R	PA
PL	1	1.60	1.87	2.39	0.88	1.26
F	0.63	1	1.42	1.72	0.75	0.83
CC	0.54	0.71	1	1.55	0.61	0.59
T	0.42	0.58	0.65	1	0.38	0.61
R	1.13	1.34	1.64	2.63	1	1.04
PA	0.79	1.21	1.70	1.64	0.96	1

- Relative to Social Equity (SE):

	PL	F	CC	T	R	PA
PL	1	2.00	2.82	3.99	2.82	1.54
F	0.5	1	1.47	2.16	1.38	0.79
CC	0.35	0.68	1	1.59	1.02	0.33
T	0.25	0.46	0.63	1	0.61	0.30
R	0.35	0.73	0.98	1.63	1	0.39
PA	0.65	1.27	3.06	3.31	2.54	1

- Relative to Market Potential (MP):

	PL	F	CC	T	R	PA
PL	1	1.03	1.01	2.74	2.05	0.93
F	0.97	1	0.91	2.28	1.71	0.85
CC	0.99	1.10	1	2.00	2.01	0.88
T	0.36	0.44	0.50	1	0.82	0.38
R	0.49	0.59	0.50	1.21	1	0.38
PA	1.08	1.18	1.14	2.66	2.65	1

- Relative to Environmental Quality (EQ):

	PL	F	CC	T	R	PA
PL	1	2.40	3.06	2.91	2.27	1.44
F	0.42	1	1.12	0.99	0.78	0.51
CC	0.33	0.89	1	0.84	0.71	0.38
T	0.34	1.01	1.19	1	0.92	0.57
R	0.44	1.28	1.41	1.09	1	0.64
PA	0.70	1.96	2.60	1.77	1.57	1

Level 4: We have here six influencing factors from level three. Six matrices each of order four were considered.

- Relative to Adequacy of Regional Policies & Legislations (RPL):

	LR	PSP	MBP	DA
LR	1	1.31	0.78	3.89
PSP	0.76	1	0.54	3.56
MBP	1.28	1.86	1	4.61
DA	0.26	0.28	0.22	1

- Relative to availability of Funding (F):

	LR	PSP	MBP	DA
LR	1	0.72	0.65	2.48
PSP	1.39	1	0.88	3.19
1MBP	1.53	1.14	1	3.06
DA	0.4	0.31	0.33	1

- Relative to Commerciality and Competitiveness (CC):

	LR	PSP	MBP	DA
LR	1	0.52	0.61	2.97
PSP	1.91	1	1.17	4.63
MBP	1.63	0.85	1	4.20
DA	0.34	0.22	0.24	1

- Relative to immaturity of Technology (T):

	LR	PSP	MBP	DA
LR	1	0.56	0.53	2.13
PSP	1.79	1	0.94	3.56
MBP	1.90	1.06	1	3.48
DA	0.47	0.28	0.29	1

- Relative to adequacy of Resources (R):

	LR	PSP	MBP	DA
LR	1	1.04	1.04	3.65
PSP	0.96	1	0.90	3.51
MBP	0.96	1.11	1	3.36
DA	0.27	0.29	0.30	1

- Relative to Public Awareness (PA):

	LR	PSP	MBP	DA
LR	1	0.63	0.54	1.04
PSP	1.58	1	0.85	1.88
MBP	1.85	1.17	1	2.11
DA	0.96	0.53	0.47	1

Figure 7 shows the policy alternatives ranking obtained from the AHP. As can be seen the design and adoption of market-based programs (MBP) is considered the best policy option for accelerating the Technology Transfer Process. The second policy option, in order of importance, is the private sector active (PSP) participation, followed by the need to modify, update and enforce the relevant laws and regulations. The last policy option in the list is to keep on supporting the- and benefiting from the programs of international donors agencies.

Figure 7 provides the Eigen vectors of the decision matrix confirming the prioritization of policy options as described above.

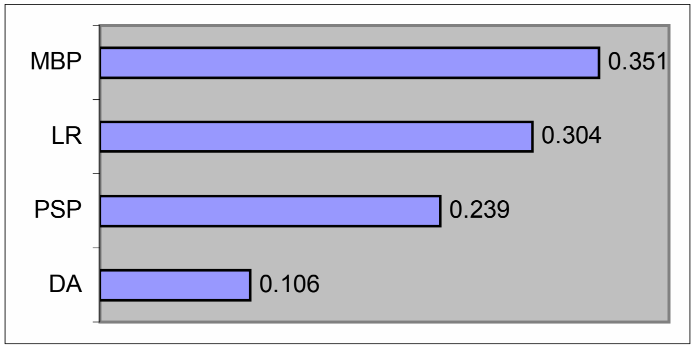


Figure 7: Policy option results/ranking

As to constraints/ factors facing technology transfer, the AHP analysis suggests that the application of existing laws and regulations as well as updating them when relevant, constitute the most important constraint. The second constraint in order of importance is the availability of financing, followed by public awareness. Whereas the Eigenvector of (PL) is 0.317, the Eigenvectors for (F) and (PA) are 0.194 and 0.185 respectively meaning that they are almost of equal importance. The other constraints in order of importance are the commercializing and competitiveness of proposed new technologies, the adequacy of supporting infrastructure and finally the immaturity of technology. Figure 8 provides the Eigenvectors of the decision matrix confirming the prioritization of constraints/factors as described above.

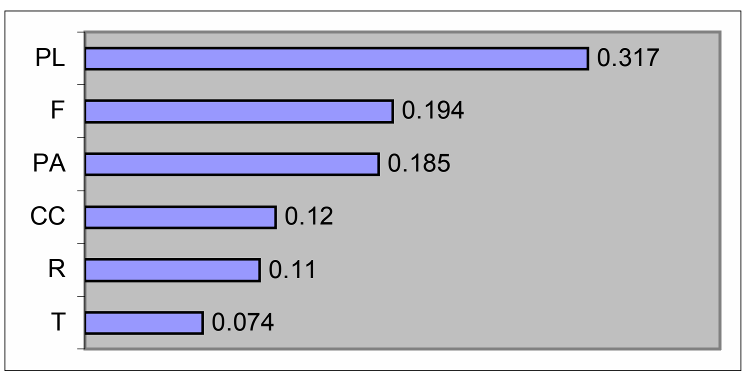


Figure 8: Ranking of constraints/factors

Finally, in terms of criteria selection for Technology Transfer, the AHP results indicate that caring for improvement of national economy efficiency is of highest priority (0.310) followed by the adequate use of available local resources followed by environmental quality (less pollution and less GHG emissions). Of less importance came the criteria of markets development and social equity.

Figure 9 provides information on eigenvector calculations for level 2 that supports the priority ranking of decision criteria mentioned above.

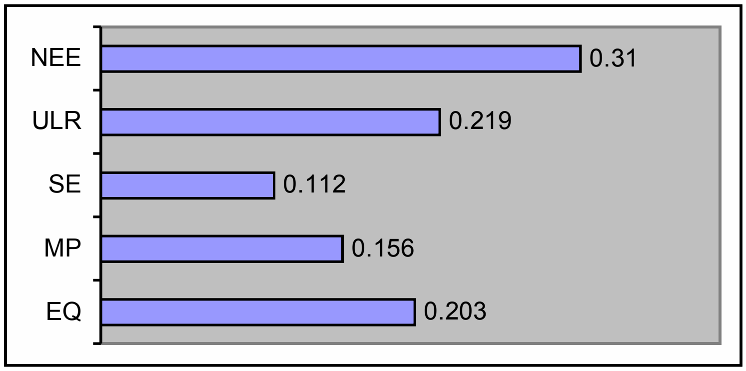


Figure 9: Ranking of decision criteria

The AHP analysis allows a kind of sensitivity analysis through which one can compare the relative importance of each element in, say, level 3 with each element of level 2. This would help better understand the logic behind the ranking of each element in each level according to their relative importance with respect to the national goal which was set as "Acceleration of Technology Transfer 'Process". For example, Figures ….. to…. show the relative importance of each element in level 3-constraints with respect to each element of level 2-decision criteria.

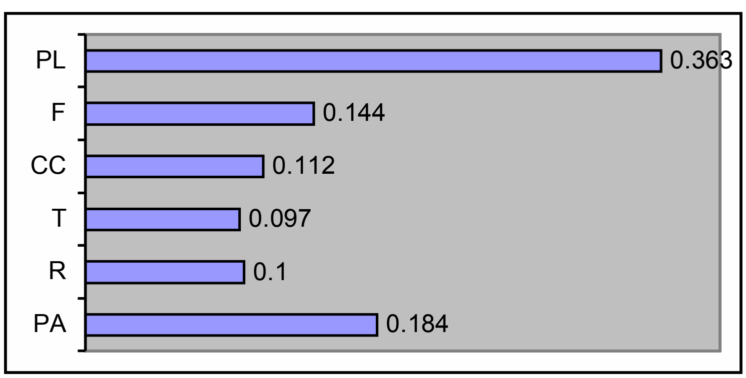


Figure 10: The relative importance of elements of level 3 with respect to EQ

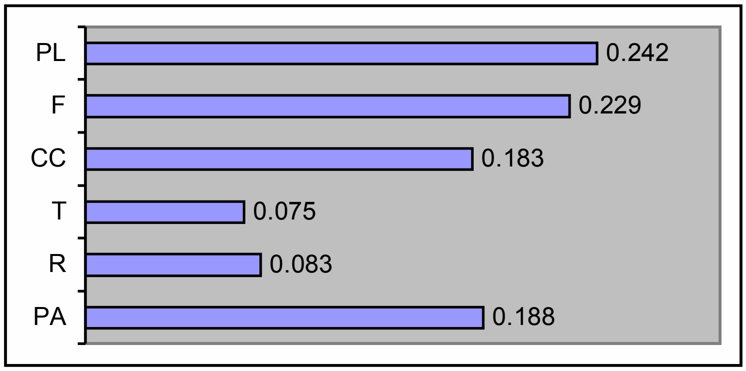


Figure 11: The relative importance of elements of level 3 with respect to MP

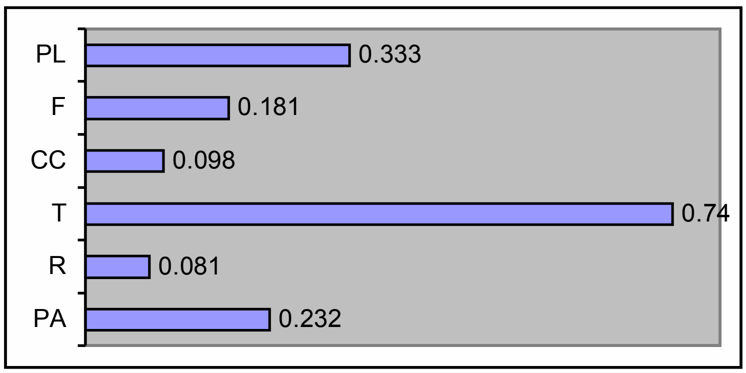


Figure 12: The relative importance of elements of level 3 with respect to SE

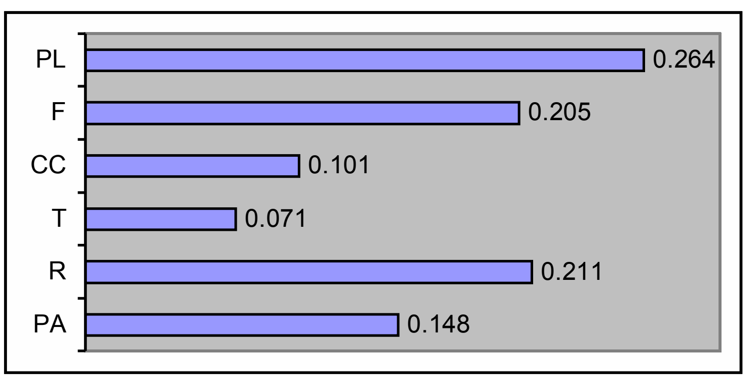


Figure13: The relative importance of elements of level 3 with respect to ULR

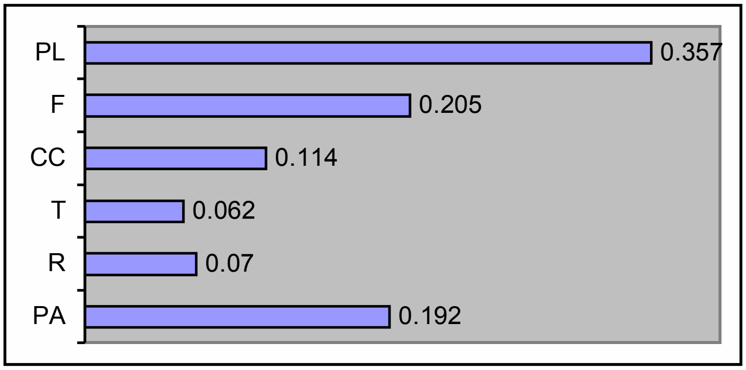


Figure 14: The relative importance of elements of level 3 with respect to NEE

5.2 Ranking of Technology Options

The ranking and evaluation of applicable technology options for each sector have been conducted by stakeholders through interviews and during the round-table meeting held during September 2002. The tables below provide the combined results of each technology option for all major economic sectors.

A. The Power Sector

Option 1: Switching to Natural Gas

No	Criteria element	Criteria weight (%)	Option score (%)	Rational for scoring	Final score
1	GHG reduction	35	90	Natural gas is very abundant and has low carbon content compared to fuel oil. Switching to NG in thermal power plants reduces CO_2 by about 30%.	31.5
2	Efficiency improvement and energy saving	25	82	Natural gas has combustion efficiency higher than that of equivalent oil by around 10% and resultant energy savings.	20.5
3	Investment Level	10	47	High capital investment is required initially for NG infrastructure including the construction of regional NG network.	4.7
4	Operation and maintenance cost	10	72	Operation and maintenance cost are comparable to those of liquid fuels	7.2
5	Option sustainability	10	71	Sustainability is secured by the availability of NG locally or through networking projects being constructed in the region.	7.1
6	Payback period	5	47	Average payback period could be relatively long due to the high capital investment. It also depends on the fuel availability and the cost of its transport/ storage infrastructure.	2.4
7	Societal and economic benefits	5	80	Establishment of infrastructure will create jobs and enhance NG penetration into other industries. It will also reduce imports of other fuels.	4
				Total	**77.4**

Option 2: Deployment of Combined Cycles

No	Criteria element	Criteria weight (%)	Option score (%)	Rational for scoring	Final score
1	GHG reduction	35	94	Combined cycles, conversion efficiencies almost double the conventional units (up to 70%), would therefore emit half the GHG	33
2	Efficiency improvement and energy saving	25	90	Combined cycles provide opportunities for energy and cost savings per kWh of generated electricity	22.5
3	Investment Level	10	51	High capital is required to deploy this option in refurbishing existing power plants.	5.1
4	Operation and maintenance cost	10	75	No substantial incremental cost will be required.	7.5
5	Option sustainability	10	72	This option is sustainable along the life span of the plant.	7.2
6	Payback period	5	55	Average payback period is between 4-5 years which is high compared to other technologies	2.75
7	Societal and economic benefits	5	45	Further increase in cooperation between neighboring countries in the field of natural gas.	2.25
				Total	**80.3**

Option 3: Technology Upgrading

No	Criteria element	Criteria weight (%)	Option score (%)	Rational for scoring	Final score
1	GHG reduction	35	60	Emissions reduction as a result of system upgrading could be up to 20%.	21
2	Efficiency improvement and energy saving	25	80	Modern technologies are associated with improved efficiencies and energy savings up to 35%.	20
3	Investment Level	10	68	Costs of purchasing and installing modern technologies will be relatively high.	6.8
4	Operation and maintenance cost	10	78	Operation and maintenance cost would drop with modern technologies.	7.8
5	Option sustainability	10	81	Option can be sustained throughout the plant lifetime.	8.1
6	Payback period	5	75	Payback period could be up to few of years.	3.75
7	Societal and economic benefits	5	62	Allows improving management commitment to energy saving and safety conditions in the plant.	3.1
				Total	**70.55**

Option 4: Electric Interconnection

No	Criteria element	Criteria weight (%)	Option Score (%)	Rational for scoring	Final score
1	GHG reduction	35	81	Potential GHG reduction in the range of 20-40% as a result of increased efficiencies, and the decrease of the reserve margin for individual systems without affecting system reliability.	28.35
2	Efficiency improvement and energy saving	25	87	Direct savings are expected from postponing the construction of new plants. Allows for units to operate at maximum- efficiency loads for most of the time.	21.75
3	Investment Level	10	69	Low to medium capital required for interconnection. This cost, however, will be shared by connected countries.	6.9
4	Operation and maintenance cost	10	81	O&M costs are in line with national grid requirements	8.1
5	Option sustainability	10	75	Technically, highly sustainable over the life span of over 25 years. Politically, it is prone to bilateral relations between nations.	7.5
6	Payback period	5	55	Estimated payback period of investment is relatively long.	5.5
7	Societal and economic benefits	5	80	Enhances the technical and economic cooperation between neighboring states. System reliability improves significantly. Economic benefits also result from the drop in fuel transport cost.	4
				Total	**82.1**

Option 5: Reduction of Network Losses

No	Criteria element	Criteria weight (%)	Option score (%)	Rational for scoring	Final score
1	GHG reduction	35	75	Reduces GHG emissions due to anticipated efficiency improvement.	26.25
2	Efficiency improvement and energy saving	25	69	Reducing the high transmission losses down to world average of around 7% will result in energy saving of the same level.	17.25
3	Investment Level	10	50	Medium–to-high capital cost investment may be required depending on the length of the line.	5
4	Operation and maintenance cost	10	85	No additional O&M costs are generally required.	8.5
5	Option sustainability	10	80	The long life span makes this option quite sustainable.	8
6	Payback period	5	70	Payback period, estimated at around 4-7 years, is short compared to the regular life span of 25 years	3.5
7	Societal and economic benefits	5	52	Improves utilities management commitment to energy savings and reduce electricity prices. It also increases the network reliability.	2.6
				Total	**71.1**

Option 6: Reducing/Phasing out Subsidies

No	Criteria element	Criteria weight (%)	Option score (%)	Rational for scoring	Final score
1	GHG reduction	35	77.5	Induces consumers to decrease consumption. Any reduction in fossil fuel generated electricity would result in reduced GHG emissions. Could result in a reduction of 7% of global GHG.	27.1
2	Efficiency improvement and energy saving	25	85	Consumers will tend to use electricity efficiently and modify their consumption patterns so as to make use of off-peak periods. This option also increases the competitiveness of renewable resources.	21.25
3	Investment Level	10	65	Financial burdens may affect large portion of the community. Investment in energy- efficient devices is expected on the demand side.	6.5
4	Operation and maintenance cost	10	90	No cost are associated with O&M.	9
5	Option sustainability	10	67.5	If enforced with appropriate legislation and in accordance with other reforms, the option sustainability can be maintained.	6.75
6	Payback period	5	64	Governments relieved of the financial burden of subsidies. On the demand side, payback period of energy- efficient appliances is short (up to 2 years).	3.2
7	Societal and economic benefits	5	30	Bearing the full cost of electricity may become a burden on consumers and this option may be faced with social resistance.	1.5
				Total	**75.3**

Option 7: Demand-Side Management

No	Criteria element	Criteria weight (%)	Option score (%)	Rational for scoring	Final score
1	GHG reduction	35	71	GHG reduction is dependent on the decrease in electricity demanded The saving achieved is however case specific.	24.85
2	Efficiency improvement and energy saving	25	75	DSM can have significant impact on reducing electricity consumption, which may avoid or delay the need to construct additional capacity with potential GHG reduction.	18.75
3	Investment Level	10	79	Many DSM programmes involve a combination of energy efficiency and conservation measures that result in low- and no cost mitigate options.	7.9
4	Operation and maintenance cost	10	77.5	Low costs will be needed for maintaining the DSM tools.	7.75
5	Option sustainability	10	56	Option sustainability requires long-term planning.	5.6
6	Payback period	5	52.5	Varies according to the specific DSM programme to be implemented and the targeted sector. Average period may vary between 1 to 3 years.	2.6
7	Societal and economic benefits	5	70	DSM programs have been consistent with the national developments in many countries. New job opportunities are created.	3.5
				Total	**70.95**

Option 8: Partially Switching to Renewable Energy (SRE)

No	Criteria element	Criteria weight (%)	Option score (%)	Rational for scoring	Final score
1	GHG reduction	35	95	GHG saving will vary according to the decrease in electricity demanded The saving achieved is however case specific.	33.25
2	Efficiency improvement and energy saving	25	75	SRE can have significant impact on reducing electricity consumption, which may avoid or delay the need to construct additional capacity with potential GHG reduction.	18.75
3	Investment Level	10	50	Many SRE programmes involve a combination of energy efficiency and conservation measures that result in low- and no cost mitigate options.	5
4	Operation and maintenance cost	10	70	Costs are equivalent to other conventional technologies.	7
5	Option sustainability	10	75	Option sustainability can be maintained throughout the technology life time.	7.5
6	Payback period	5	50	Varies according to the specific SRE programme to be implemented and the targeted sector (industrial, residential, commercial). Average period may vary between 2 to 5 years.	2.5
7	Societal and economic benefits	5	60	SRE programs have been consistent with the national developments in many countries. New job opportunities are created.	3
				Total	**77**

A.1 Summary of technology options ranking in the power sector.

Option	Overall Score
Electric Interconnection	**82.1**
Deployment of Combined Cycles	**80.3**
Switching to Natural Gas	**77.4**
Partially Switching to Renewable Energy	**77**
Recycling/phasing out Subsidies	**75.3**
Reduction of Transmission losses	**71.1**
Demand-Side Management	**70.95**
Technology Upgrading	**70.55**

B. The Transport Sector

Option 1: Improving Technical Status of the Fleet

Criteria element	Criteria weight (%)	Option score (%)	Rational for scoring	Final score
GHG reduction	35	86	Transport sector contributes to 20-25% of the CO_2 emissions from burnt fossil fuels. Other transport-related GHG include N_2O and CFC and HCFC from AC systems.	30
Efficiency improvement and energy saving	25	90	Improving vehicle maintenance and engine tuning greatly reduces emissions of GHGs and other pollutants by up to 30%. This leads to substantial energy and cost savings.	22.5
Capital Investment	10	65	Establish a vehicle I&M programme requires capital investment for the purchase and installation of testing units.	6.5
Operation and maintenance cost	10	50	To keep motor vehicles in proper operating conditions, and thereby maintaining returns in terms of lower GHG emissions, regular spending on labour, materials and spare parts will be required.	5
Option sustainability	10	60	Sustainability will depend on financial, technical and regulatory support. Vehicle maintenance requires annual investment by all stake holders	6
Payback period	5	50	Payback period is not easy to specify since I&M should be a continuous process	2.5
Societal and economic benefits	5	80	Proper maintenance and periodic inspection can reduce costs for items such as fuel and spare parts, and also increase the vehicle's resale value and extend its lifespan. Additionally, demand for vehicle servicing and for I&M centers will generate jobs.	4
			Total	**76.5**

Option 2: Improving Traffic Management

Criteria element	Criteria weight (%)	Option score (%)	Rational for scoring	Final score
GHG reduction	35	77	Improving traffic management reduces fuel consumption by reducing the journey delay time. Creating conditions for smoother traffic also reduces emissions of other pollutants such as CO, HC and NOx.	27
Efficiency improvement and energy saving	25	80	Modern traffic systems lead to vehicles being driven at optimum speeds in terms of energy consumption, and to having shorter trips duration.	20
Capital Investment	10	75	In order to improve traffic management, street networks have to be upgraded and properly managed. Such measures require moderate capital expenditure.	7.5
Operation and maintenance cost	10	70	Costs for maintenance of road networks could be rated as medium,	3.5
Option sustainability	10	60	The sustainability of this option is associated with national planning and expenditure, and therefore can be rated as medium.	6
Payback period	5	37	Payback period in this case is not easy to specify. In general, payback is a long- term parameter.	1.8
Societal and economic benefits	5	70	Improving traffic management will reduce vehicle maintenance and expenditure for spare parts. It will also reduce human stress and saves time by reducing trips duration.	3.5
			Total	**69.3**

Option 3: Promoting Mass Transport

Criteria element	Criteria weight (%)	Option score (%)	Rational for scoring	Final score
GHG reduction	35	90	Reliance on mass transport leads to substantial traffic congestion reduction and hence GHG emission reduction. Mass transport emits less per passenger/km than private vehicles and occupies less road space per passenger than cars.	31.5
Efficiency improvement and energy saving	25	80	Mass transport utilization leads to significant energy savings in terms of fuel and resources, and if well organized can improve the overall system efficiency.	20
Capital Investment	10	63	This option may require high capital investment for buses, garages, workshops, personnel, and stations.	6.3
Operation and maintenance cost	10	65	Maintenance will be required for vehicles, garages and property, at levels of annual expenditure that are rated as medium.	6.5
Option sustainability	10	80	Sustainability of this option is relatively high. After the initial effort to develop the required infrastructure, routine maintenance is generally all that is needed to achieve long-term sustainability.	8
Payback period	5	50	Payback period can span between 6 and 10 years depending on public acceptance.	2.5
Societal and economic benefits	5	68	Mass transport will improve the overall traffic system and could generate new jobs. The expansion of public transport will, however, dampen demand for taxis and minibuses.	3.4
			Total	**78.2**

Option 4: Environmental Standards and Regulations

Criteria element	Criteria weight (%)	Option score (%)	Rational for scoring	Final score
GHG reduction	35	70	The enactment and enforcement of environmental standards and regulations for the transport sector will improve the fleet status. This leads to efficiency improvement and GHG reduction.	24.5
Efficiency improvement and energy saving	25	60	Limits on exhaust emissions could only be met by optimizing the engine operating conditions (fine tuning). This also leads to efficiency improvement and GHG reduction.	15
Capital Investment	10	90	The costs associated with this option are relatively low.	9
Operation and maintenance cost	10	90	Operation and maintenance costs for this option are not relevant.	9
Option sustainability	10	55	This option's sustainability is considered weak because regulations must be updated periodically and their enforcement should be always maintained.	5.5
Payback period	5	50	Since to substantial capital investment is needed, the payback period is not relevant.	2.5
Societal and economic benefits	5	60	Increase in public awareness is a main benefit. Also complying with emission standards would inevitably lead to other health/economic benefits. However, the cost on public may be prohibitive.	3
			Total	**68.5**

Option 5: Urban Planning and Land Use

Criteria element	Criteria weight (%)	Option score (%)	Rational for scoring	Final score
GHG reduction	35	55	Enhanced urban planning leads to minimizing traffic congestion. In the long run, however, it may increase the use of private vehicles.	19.25
Efficiency improvement and energy saving	25	57	Decentralization of businesses and job centers would reduce traffic congestions, and hence GHG emissions.	14.25
Capital Investment	10	55	Urban planning requires large-scale capital investment. Benefits may be gained indirectly, however, from projects with goals other than the reduction of GHG emissions.	5.5
Operation and maintenance cost	10	90	Modifications achieved through urban planning tend to be long lasting and may require low maintenance.	9
Option sustainability	10	90	Urban planning is an ongoing project, and by its nature tends to be sustainable.	9
Payback period	5	30	This option has a long payback period.	1.5
Societal and economic benefits	5	80	Urban planning projects create employment and help to remedy housing problems. Generally it improves the living standards of citizens.	4
			Total	**62.5**

Option 6: Switching to Alternative Fuels (Natural Gas)

Criteria element	Criteria weight (%)	Option score (%)	Rational for scoring	Final score
GHG reduction	35	95	Natural gas has lower carbon content than liquid fuels, and hence it releases less GHG. NG Vehicles also emit lower levels of CO, VOC and HC and lead.	33.25
Efficiency improvement and energy saving	25	50	The energy content of NG is slightly higher than that of gasoline. NG Engines have longer life span than others.	12.5
Capital Investment	10	50	Considerable capital investment is required to establish infrastructure for import, storage and distribution of NG and for the vehicles conversion.	5
Operation and maintenance cost	10	80	Operation and maintenance costs will be comparable to those of gazoline. Incremental cost will be associated with tighter safety measures.	8
Option sustainability	10	95	This option is easy to sustain once the NG and its associated infrastructure are secured and established.	9.5
Payback period	5	50	Payback period for projects with such large infrastructure may span up to 15-20 years.	2.5
Societal and economic benefits	5	60	Introducing NG technology will create limited job opportunities to meet the anticipated demand for fuel storage and distribution	3
			Total	**73.75**

B.1 Summary of technology options ranking in the transport sector.

Option	Overall Score
Promoting mass transport	**78.2**
Improving technical status of the fleet	**76.5**
Switching to alternative fuels (NG)	**73.75**
Improving traffic management	**69.3**
Environmental standards and regulations	**68.5**

Urban planning and land use	62.5

C. The Industry Sector

Option 1: Switching to Natural Gas

No	Criteria element	Criteria weight (%)	Option Score (%)	Rational for scoring	Final Score
1	GHG reduction	35	90	Natural gas will be abundant and has low carbon content compared to fuel oil. Switching to NG in thermal power plants reduces CO_2 by about 30%.	31.5
2	Efficiency improvement and energy saving	25	85	Natural gas has combustion efficiency higher than that of equivalent oil by around 10% and resultant energy savings.	21.25
3	Investment Level	10	57	High capital investment is required initially for NG infrastructure including the construction of regional NG network.	5.7
4	Operation and maintenance cost	10	57		5.7
5	Option sustainability	10	90	Sustainability is secured by the availability of NG locally or through networking projects being constructed in the region.	9
6	Payback period	5	77	Average payback period could be from 3 to 5 years depending on the fuel availability and the cost of its transport/ storage infrastructure.	3.85
7	Societal and economic benefits	5	70	Establishment of infrastructure will create jobs and enhance NG penetration into other industries. It will also reduce imports of other fuels.	3.75
				Total	**80.75**

Option 2: Energy Efficient Systems

No	Criteria element	Criteria weight (%)	Option Score (%)	Rational for scoring	Final Score
1	GHG reduction	35	90	Reduces GHG emissions due to anticipated efficiency improvement. It has a very high impact on GHG reduction.	31.5
2	Efficiency improvement and energy saving	25	90	Very high level of expected energy savings, and efficiency improvement	22.5
3	Investment Level	10	60	High capital cost	6
4	Operation and maintenance cost	10	60	Almost Unchanged	6
5	Option sustainability	10	73	Sustainability is secured by the availability of energy efficient systems through projects being executed in the country & via official support from concerned ministries.	7.3
6	Payback period	5	60	Has a payback period of around 2-4 years	3
7	Societal and economic benefits	5	50	Create jobs & provide comfort. Reduces air pollution.	2.5
				Total	**78.8**

Option 3: Cogeneration

No	Criteria element	Criteria weight (%)	Option Score (%)	Rational for scoring	Final Score
1	GHG reduction	35	80	Cogeneration is a significant source for saving substantial amounts of energy, carbon, and money. It has a very high impact on GHG reduction.	28
2	Efficiency improvement and energy saving	25	80	Conventional electricity generation is inherently inefficient, converting only about a third of the fuels consumption of energy into usable energy. CHP systems can deliver energy with efficiencies exceeding 80%.	20
3	Investment Level	10	50	It is an attractive, rational and cost efficient energy efficient option, but has a high capital investment level.	5
4	Operation and maintenance cost	10	50		5
5	Option sustainability	10	60	Sustainability depends on the amount of power needed, thermal needs, duty cycle, space constraints, fuel availability, utility prices, interconnection issues, and emission regulations.	6
6	Payback period	5	63	The payback period is bet6ween 1-5 years.	3.15
7	Societal and economic benefits	5	80	Generating electricity on or near the point of using CHP systems avoids transmission and distribution losses and defers expansion of the electricity transmission grid.	4
				Total	**71.15**

Option 4: Boiler Improvement

No	Criteria element	Criteria weight (%)	Option score (%)	Rational for scoring	Final score
1	GHG reduction	35	90	Improvements of efficiency can be directly translated into enhanced productivity and environmental performance. The impact on GHG reduction is substantial.	31.5
2	Efficiency improvement and energy saving	25	90	The average efficiency of motors in the Lebanese industry is assumed to be 65%. Has a medium level of expected energy savings.	22.5
3	Investment Level	10	60	The current average implementation cost of the new energy efficient motor is estimated as $66/HP for the 25-50 HP range & $61/HP for the 50-100 HP range	6
4	Operation and maintenance cost	10	73	Modern systems are cheaper to maintain	7.3
5	Option sustainability	10	70	Sustainability is guaranteed due to the sustainability of the textile and food industries in the country.	7
6	Payback period	5	80	Short	4
7	Societal and economic benefits	5	40	Better environment, more reliable production	2
				Total	**80.3**

Option 5: Efficient Motors

No	Criteria element	Criteria weight (%)	Option Score (%)	Rational for scoring	Final score
1	GHG reduction	35	70	Improved efficiency leads to less fuels being burnt to supply the needed power (by up to 15%)	24.5
2	Efficiency improvement and energy saving	25	60	Energy Saving by up to 15%	15
3	Investment Level	10	70	Incremental cost is low to medium	7
4	Operation and maintenance cost	10	90	Cheaper to maintain	9
5	Option sustainability	10	80	Option highly sustainable due to long life span of new devices.	8
6	Payback period	5	70	Relatively short	3.5
7	Societal and economic benefits	5	60	Cheaper production cost.	3
				Total	**70**

C. 1 Summary of technology options ranking in the industry sector.

Option	**Overall Score**
Switching to Natural Gas	**80.75**
Boiler Improvement	**80.3**
Energy Efficient Systems	**78.8**
Cogeneration	**71.15**
Efficient Motors	**70**

D. The Waste Sector

Option 1: Composting

Criteria element	Criteria weight (%)	Option score (%)	Rational for scoring	Final score
GHG reduction	35	90	Aerobic composting leads to almost total reduction of CH4 emissions	31.5
Efficiency improvement and energy saving	25	70	The process may require some power for the air injection. Recovered gases may be used as energy resource.	17.5
Capital Investment	10	50	Substantial capital may be needed for the units purchase and, installation.	5
Operation and maintenance cost	10	50	Composting may require continuous maintenance.	5
Option sustainability	10	80	Option could be quite sustainable.	8
Payback period	5	50	Payback period is relatively long and hard to specify.	2.5
Societal and economic benefits	5	77	Increases environmental awareness and mitigates some social problems.	3.85
			Total	**73.35**

Option 2: Landfill

Criteria element	Criteria weight (%)	Option score (%)	Rational for scoring	Final score
GHG reduction	35	37	Landfills are not an effective GHG mitigation measure since effluents are not controlled.	13
Efficiency improvement and energy saving	25	80	Energy savings could be significant if recycling activities are carried out at the landfill.	20
Capital Investment	10	43	Capital will be needed for the purchase and preparation of the site for the landfill.	4.3
Operation and maintenance cost	10	47	Proper run and maintenance of a landfill could be costly.	4.7
Option sustainability	10	80	Options sustainability depends on sites availability.	8
Payback period	5	43	Payback period in the commercial sense is almost non-existing	21.5
Societal and economic benefits	5	63	Landfills may solve the garbage problem and may generate new jobs.	3.15
			Total	**74.65**

Option 3: Anaerobic Digestion

Criteria element	Criteria weight (%)	Option score (%)	Rational for scoring	Final score
GHG reduction	35	90	CH4 emissions are totally eliminated	31.5
Efficiency improvement and energy saving	25	90	Recovered CH4 could be use as an energy resources for various domestic and industrial applications	22.5
Capital Investment	10	50	Unit establishment will require a certain capital cost	5
Operation and maintenance cost	10	50	Proper run and maintenance of a landfill could be costly.	5
Option sustainability	10	80	Once established, it could be quite sustainable.	8
Payback period	5	70	Gas recovery in large amounts could lead to relatively short payback period.	3.5
Societal and economic benefits	5	70	High gas odor from the site could make it a non-attractive initiative for many regions.	3.5
			Total	**79**

Option 4: Reduce/Reuse/Recycling

Criteria element	Criteria weight (%)	Option score (%)	Rational for scoring	Final score
GHG reduction	35	80	Avoiding fuel burning leads to significant GHG emissions reduction	28
Efficiency improvement and energy saving	25	90	Large amount of energy and raw materials could be saved through recycling.	22.5
Capital Investment	10	80	No substantial capital cost is required to establish such programs	8
Operation and maintenance cost	10	80	Low maintenance cost is required	8
Option sustainability	10	80	Option is quite sustainable.	8
Payback period	5	80	Payback period is short	4
Societal and economic benefits	5	67	Leads to increased environmental awareness throughout the community	3.35
			Total	**81.85**

Option 5: Aerobic Digestion

Criteria element	Criteria weight (%)	Option score (%)	Rational for scoring	Final score
GHG reduction	35	90	CH4 recovery is very significant	31.5
Efficiency improvement and energy saving	25	70	Using recovered CH4 saves another energy resources	17.5
Capital Investment	10	50	Option requires a substantial capital cost	5
Operation and maintenance cost	10	50	Option requires a substantial operation and maintenance cost	5
Option sustainability	10	80	Option could be quite sustainable	8
Payback period	5	50	Payback period is relatively long	2.5
Societal and economic benefits	5	70	High gas odor from the site could make it a non-attractive initiative for many regions.	3.5
			Total	**73**

D.1 Summary of technology options ranking in the waste sector.

Option	Overall Score
Reduce/Reuse/Recycle	**81.85**
Anaerobic Digestion	**79**
Landfill	**74.65**
Composting	**73.35**
Aerobic Digestion	**73**

E. The Building Sector

Option 1: Building Envelop

No	Criteria element	Criteria weight (%)	Option Score (%)	Rational for scoring	Final Score
1	GHG reduction	35	75	Improving the thermal performance of building envelopes is a long-term strategy. But given the long lifespan of buildings, it is an effective strategy	26.25
2	Efficiency improvement and energy saving	25	85	There is an added benefit of improving human comfort in addition to saving space heating and cooling energy	21.25
3	Investment Level	10	50	Does increase the construction cost of building type, climatic zone, and energy reduction target. (25%, 40%, 60%, …etc. energy reduction target). Construction requires skilled labor, but no operation and maintenance if properly installed.	5
4	Operation and maintenance cost	10	90	No incremental cost is generally associated with well- designed envelop.	9
5	Option sustainability	10	90	Average lifespan of building is 75 years. This allows the efficiency strategy to be in place. Upgrade in performance is dependent on adopted codes and policies.	9
6	Payback period	5	60	The payback period is medium range, but acceptable in the context of the building lifespan.	3
7	Societal and economic benefits	5	70	Improved occupant comfort. Reduced bills for space heating and cooling, but initial investment cost.	3.5
				Total	**77**

Option 2: Technology Upgrade

No	Criteria element	Criteria weight (%)	Option Score (%)	Rational for scoring	Final Score
1	GHG reduction	35	70	Substantial reduction in GHG needed due to the drop in amounts of energy	24.5
2	Efficiency improvement and energy saving	25	75	Energy savings are in the range of 25-30%	18.75
3	Investment Level	10	60	Incremental costs are associated with improved building envelopes	6
4	Operation and maintenance cost	10	72	Moderate O&M cost are required.	7.2
5	Option sustainability	10	75	Option is quite sustainable	7.5
6	Payback period	5	65	Relatively long period	6.5
7	Societal and economic benefits	5	75	More efficient buildings lead to more comfort, and less levels.	3.75
				Total	**75.1**

Option 3: SHWS

No	Criteria element	Criteria weight (%)	Option Score (%)	Rational for scoring	Final Score
1	GHG reduction	35	95	SHWS consumes major portion of buildings energy, hence GHG & energy savings are very significant.	33.25
2	Efficiency improvement and energy saving	25	90	The clean combustion- free renewable solar energy offers attractive savings in terms of fuel combustion.	22.5
3	Investment Level	10	60	Moderate investments are needed	6
4	Operation and maintenance cost	10	70	Systems will require moderate O&M levels.	7
5	Option sustainability	10	90	Sustainable almost for the life span of the system (10-15 years)	9
6	Payback period	5	75	Relatively short (3-4 years)	3.75
7	Societal and economic benefits	5	80	Provides diversity in energy supply	4
				Total	**85.5**

Option 4: Efficient Lighting

No	Criteria element	Criteria weight (%)	Option Score (%)	Rational for scoring	Final Score
1	GHG reduction	35	80	Reduction by up to 30% are expected	28
2	Efficiency improvement and energy saving	25	80	Energy savings are by almost the same percentage	20
3	Investment Level	10	63	Efficient lamps are more expensive, and hence substantial capital investment will be needed for large scale applications	6.3
4	Operation and maintenance cost	10	70	No incremental cost is associated with efficient bulbs.	7
5	Option sustainability	10	80	Sustainable since efficient lighting is an evolving technology with further developments being anticipated.	8
6	Payback period	5	70	Relatively short due to the significant energy savings and longer lifetime.	3.5
7	Societal and economic benefits	5	75	Increased awareness and reduced bills.	3.75
				Total	**76.55**

Option 5: Efficient A/C

No	Criteria element	Criteria weight (%)	Option Score (%)	Rational for scoring	Final Score
1	GHG reduction	35	75	A/C constitute significant portion of the consumption	26.25
2	Efficiency improvement and energy saving	25	75	GHG and energy savings are quite significant	18.75
3	Investment Level	10	65	Moderate- to high	6.5
4	Operation and maintenance cost	10	70	No incremental cost in comparison to conventional units	7
5	Option sustainability	10	80	Highly sustainable	8
6	Payback period	5	65	Up to few years	3.25
7	Societal and economic benefits	5	70	Not remarkable except for quieter neighborhoods.	3.75
				Total	**66.5**

E.1 Summary of technology options ranking in the building sector.

Option	Overall Score
SHWS	**85.58**
Efficient Lighting	**77.55**
Building Envelop	**77**
Technology Upgrade	**75.1**
Efficient A/C	**66.5**

5.1 Conclusions and Recommendations

In this project, an effort has been made to assess technology needs for GHG mitigation in the major economic sectors of Lebanon. Also, a decision analysis tool has been developed to assist decision makers and experts understand the influence of various parameters that affect the technology transfer process.

The first contribution this project has made is in the development of an effective and innovative approach for technology transfer in Lebanon. This approach is based on conducting the TNA and TT as two separate activities and whose outcomes should be combined as to create a national plan on the matter. TNA is assessed through ranking matrices that examine the various technological alternatives for each sector and provide scores to facilitate ranking of the options. TT is accomplished through the development of a decision analysis tool that examines with the help of stakeholders the decision criteria, constraints and the appropriate policy options that facilitate the technology transfer process.

5.1.1 On the Level of Technology Needs Assessment:

Five sectors have been identified as major sectors contributing to GHG emissions in Lebanon. These are the power, transport, industry, solid waste, and building sectors. The evaluation was performed by experts and stakeholders individually through interviews and also collectively through a specially organized round-table meeting. Eight options have been found suitable in the power sector to mitigate GHG emissions. These options were identified from the interviews conducted with a variety of stakeholders, and from the Technical Annex of GHG inventory of Lebanon, and other studies published by UN-ESCWA and MOE. The options identified are: electricity interconnection, deployment of combined cycle technology, switching to natural gas, partial switching to renewable energy, phasing-out subsidies, demand side management programs, technology upgrading and technical loss reduction. Based on the comparative analysis made possible by the ranking tables designed for that purpose, it was found that electricity interconnection is the most feasible option, followed by combined cycle technology, switching to natural gas and then partial switching to renewable energy.

The Transport sector was analyzed taking into account under six options. These are the promotion of mass transport, improving the technical status of the fleet mainly through the re-introduction of effective inspection and maintenance program, switching to alternative fuels, improving traffic management, updating and enforcing environmental standards and regulations and, finally, improving urban planning and land use. The analysis outcome showed that the promotion of mass transport, private or public, is the most significant option followed by improvement of technical status of the fleet and switch to alternative fuels, followed by the remaining options.

In the industrial sector, five options were identified. These are switching to natural gas, boiler improvement, energy efficient systems, co-generation, and efficient motors. It was found that natural gas option gained the first place in terms of importance followed by boiler improvement, energy efficient systems, co-generation and finally efficient motors.

In the waste sector, five options were identified as the most appropriate. The ranking of these options suggests that introducing integrated reduce/reuse/recycle projects are the most significant option for the country, followed by anaerobic digestion, then landfill (the currently- applied option), composting and finally aerobic digestion.

Finally, in the building sector, the diffusion of solar water heating systems (SHWS) turned out to be the most important option far exceeding, by its grade, other options. The next option in the order of importance is improvement of efficient lighting, followed by building envelops technology upgrade and efficient air-conditioning.

5.1.2 On the Level of Technology Transfer

Having identified technology needs and most needed technological options in each of the relevant sectors of economy, the study relied on the Analytic Hierarchy Process (AHP) technique to develop a decision analysis tool that helps explore all the influencing variables on technology transfer, and understand the relative importance of each with respect to each other and with respect to the overall goal. In this respect, a hierarchy describing the problem was developed and consisted of three layers describing the decision criteria, constraints and policy options. Interviews were made with 20 experts and stakeholders to consider their views regarding the importance of each element in the hierarchy on technology transfer. These views were then entered into the AHP software and ranking by merit of priority was performed to all decision criteria, all constraints and all policy instruments identified for the purpose of accelerating technology transfer for Lebanon.

The AHP analysis revealed that the most important policy option is the development of suitable market based programs through incentives/ taxing process, followed by the engagement of the private sector in projects related to climate change and involving technology transfer, followed by the need to update and enforce laws and regulations and finally benefit from the programs of international donor agencies.

On the level of constraints, the AHP analysis revealed that laws, policies and legislation concerned must be updated and enforced. This constraint was ranked first, followed by availability of funding, then by public awareness. Other constraints of less importance are commerciality and competitiveness, adequacy supporting infrastructure and immaturity of technology.

On the level of decision criteria, the most important criteria were found to be in the order of importance as follows: The satisfaction of national economy efficiency was ranked first, followed by the efficient use of local human, natural and technical resources, then by insurance of environmental quality. The creation of market potential and social equity element was of less concern.

In the final Workshop organized, in the presence of perspective national and international donors, for information dissemination, a number of concept proposals covering all major economic sectors has been presented and discussed. A brief of these proposals is listed in

Appendix B. It is recommended that the Lebanese Government does its best to ensure that projects executed through its own funds or through loans or grants utilize technologies recommended by this project. This would have the effect of not only curbing GHG emissions but certainly ensure economic return. Failure to do so, will have adverse impact on both the environment and economy and will result in acquiring technology that is either outdated, or not suitable.

Finally, the Lebanese model for TNA and TT can be a replicable model for other countries to follow. It is very simple to use and to implement and its outcomes are based on interactions with relevant stakeholders. A matter that is consistent with the GEF recommendations that TNA and TT must be a country driven process.

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Appendix A

Institutions and their Representatives in the TNA /TT Project in Lebanon

+	Name	Position/Sector
1	Ms. Matilda Khoury/Office of Urban Planning	Project Manager/ Capacity Building for the Adoption and Application of Energy Standards in Buildings
2	H.E. Mr. Mohamad Kabbani	Chairman, Parliamentary Committee on Energy &Water and Transport
3	Mr. Saeed Hamadeh	Chairman of R&D Committee. Association of Lebanese Industrialists
4	Mr. A. H. Kaissi	Director General, Ministry of Transport
5	Dr. Walid Dghaili	Director of Studies, EDL
6	Dr. Motasem El-Fadel	Dept. of Civil and Environmental Engineering, AUB
7	Mr. Bassam Jaber	Water expert, Consultant to the World Bank
8	Dr. Nesreen Ghaddar	Chairperson, Dept. of Mechanical Engineering, AUB
9	Dr. Berj Hatjian	Director General, MOE
10	Dr. Saeed Chehab	Director, ALMEE
11	Dr. Hassan Cherif	Chief, Sustainable Development and Productivity Division, ESCWA
12	Dr. Lulwa Ali	ENRED, ESCWA/Transport
13	Dr. Mohamad Kordab	ENRED, ESCWA/Buildings
14	Mr. Ghattas Akl	Director of Forestry Division, MO Agriculture
15	Dr. Wafa Charafeddine	CDR
16	Mr. Najib Saab	Director General, MECTAT
17	Dr. Raymond Ghajjar	Dept. of Electrical Engineering, LAU
18	Dr. Adnan Jouni	Project Manager, Energy Efficiency Project
19	Mr. Lutfallah Hajj	Coordinator, Environment Committee, Order of Engineers, Beirut
20	Dr. Bassam Frenn	Director General, National Institute of Industrial Research

Appendix B

Concept Proposals

The following concept proposals have been prepared by the consultants and were discussed during the Workshop held on October 29, 2002, in the presence of perspective donating bodies. These proposals, that cover all five major economic sectors, will be further discussed with national and international donors for securing sufficient funding.

Concept Proposal Number 1

Project Title: A Network for National Air Quality Monitoring

Objectives: To monitor emission levels, and assess the actual impact of mitigation impacts on air quality

Baseline: Beirut Urban Transport Project

Project description: To establish an air monitoring network throughout the country, especially in regions of substantial emissions

Project main stakeholders: Ministry of Environment, private sector, academic institutions,…

Project outcome:
1. Data base on air quality and emissions rate in the country.
2. Assess impacts of mitigation options.
3. Establish partnership between stakeholders.
4. Promote public awareness on GHG emissions

Beneficiaries: MOE, academic institutions, public, NGOs

Duration: 3 years

Estimated budget: \$400,000 – \$500,000

Financing: International donors, private sector, academic institutions

Concept Proposal Number 2

Project Title: Centers for Inspection and Maintenance of Motor Vehicles

Objectives: To re-instate inspection and maintenance units for motor vehicles.

Baseline: Beirut Urban Transport Project

Project description: To re-establish centers for inspection and maintenance (I&M) of motor vehicles in all five districts of Lebanon, equipped with state- of- the- art technologies for tailpipe emissions measurement.

Project main stakeholders: Ministry of Interior (MoI), Ministry of Transport (MoT), Ministry of Environment (MoE), relevant governmental bodies, and private sector.

Project outcome:
1. Data base on Lebanese fleet.
2. Improved technical status of the fleet.
3. Transport fuel consumption reduction.
4. GHG emissions reduction.
5. Partnership between stakeholders.
6. Job opportunities.

Beneficiaries: MoI, MoT, MoE, relevant private and public sub-sectors.

Duration: BOT, (5 years)

Estimated budget: $800,000 – $1,000,000

Financing: International donors, relevant governmental bodies, private sector

Concept Proposal Number 3

Project Title: National Awareness Campaign on Recycling

Objectives: To promote recycling nationwide

Baseline: Recycling Project at the American University of Beirut

Project description: To promote the concept of recycling throughout the country through awareness campaign to be focused on all Lebanese schools.

Project main stakeholders: Ministry of Environment, private sector, academic institutions,…

Project outcome:
1. Reduce solid waste stream.
2. Energy conservation and GHG reduction.
3. Establish partnership between stakeholders.
4. Promote public awareness on recycling.

Beneficiaries: MOE, academic institutions, public, NGOs

Duration: 1 year

Estimated budget: \$60,000 – \$80,000

Financing: International donors, private sector, academic institutions

Concept Proposal Number 4

Project Title: Pilot Project on Deployment of Energy- efficient Lighting

Objectives: Energy conservation and electricity consumption reduction

Baseline: Project on Capacity Building for the Adoption and Application of Energy Standards in Buildings

Project description: To conduct a pilot project for promoting the widespread use of energy efficient lamps in houses and municipal establishments.

Project main stakeholders: Ministry of Environment, Ministry of Interior, private sector.

Project outcome:
1. Energy conservation and GHG reduction.
2. Establish partnership between stakeholders.
3. Increase public awareness.
4. Reduce expenditure of Municipalities.

Beneficiaries: MoE, MoI, public

Duration: 1 year

Estimated budget: \$80,000 – \$100,000

Financing: International donors, MoI, private sector.

Concept Proposal Number 5

Project Title: Electric Power Plant Energy Efficiency Improvement

Objectives:
- **To improve the efficiency of electricity generation at the power plants.**
- **To reduce fuel import**
- **To reduce environmental emissions and GHGs.**

Baseline: IPP-energy-EU, Energy Efficiency Project-UNDP.

Project description: To introduce necessary technological innovations to increase the efficiency of electricity generation. Examples include, condition monitoring equipment, boiler improvement, etc.

Project main stakeholders: EDL, Ministry of Energy and Water, CDR, MOE

Project outcome: less fuel consumption and less GHG and pollution emissions per unit of electric energy generated

Beneficiaries: EDL, the society as a whole

Duration: one year

Estimated budget: $400, 000 – $600,000

Financing: EDL in kind, International donor agencies.

Concept Proposal Number 6

Project Title: Wind Energy Atlas

Objectives:
- **To collect data about wind resources in Lebanon**
- **To establish wind atlas**

Baseline: IPP-energy-EU, Energy Efficiency Project-UNDP.

Project description: To establish wind monitoring stations in selected location in Locations in Lebanon in order to develop wind atlas in Lebanon useful for estimating the contribution of wind energy to total energy needs.

Project main stakeholders: EDL, Ministry of Energy and Water, CDR, MOE

Project outcome: Potential of wind energy resources

Beneficiaries: EDL, private sector

Duration: *one year*

Estimated budget: $200, 000

Financing: International donor agencies, private sector

<u>Concept Proposal Number 7</u>

Project Title: Assessment of Fuel Switching to Natural Gas

Objectives:

- **To improve the efficiency of electricity generation in the industrial power plants.**
- **To reduce fuel cost**
- **To reduce environmental emissions and GHGs.**

Baseline: *IPP-energy-EU, Energy Efficiency Project-UNDP.*

Project description: To undertake a feasibility study to examine the effects of switching to natural gas in the Lebanese industry when this gas becomes available.

Project main stakeholders: Ministry of Industry, ALIND, Ministry of Energy and Water, CDR, MOE.

Project outcome: Quantitative assessment of natural gas needs, identification of beneficiary industries, technology upgrade needs for retrofitting purposes, financial benefit assessment.

Beneficiaries: Ministry of Industry, ALIND, private industries.

Duration: *one year*

Estimated budget: $150, 000

Financing: International donor agencies, private sector

Concept Proposal Number 8

Project Title: Dissemination of Solar Water Heaters (SWH)

Objectives:
- **To promote clean technologies.**
- **To reduce electricity consumption and fuel import.**
- **To reduce consumer's electric energy bill and enhance purchasing power**
- **To reduce environmental emissions and GHGs.**

Baseline: *IPP-energy-EU, Energy Efficiency Project-UNDP.*

Project description: To select a model village and replace all electric water heaters by solar ones. Ensure capacity building in system installation, operation and manufacturing. Develop a system for long term data collection and analysis.

Project main stakeholders: Ministry of Industry, ALIND, Ministry of Energy and Water, CDR, MOE, Private sector.

Project outcome:
- **Demonstration of solar water heaters economic and environmental benefits**
- **Database for data collection and analysis**
- **Capacity building through training**

Beneficiaries: Ministry of Industry, ALIND, private industries, EDL and society at large.

Duration: *one year*

Estimated budget: $100,000- $150,000

Financing: International donor agencies, private sector