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.

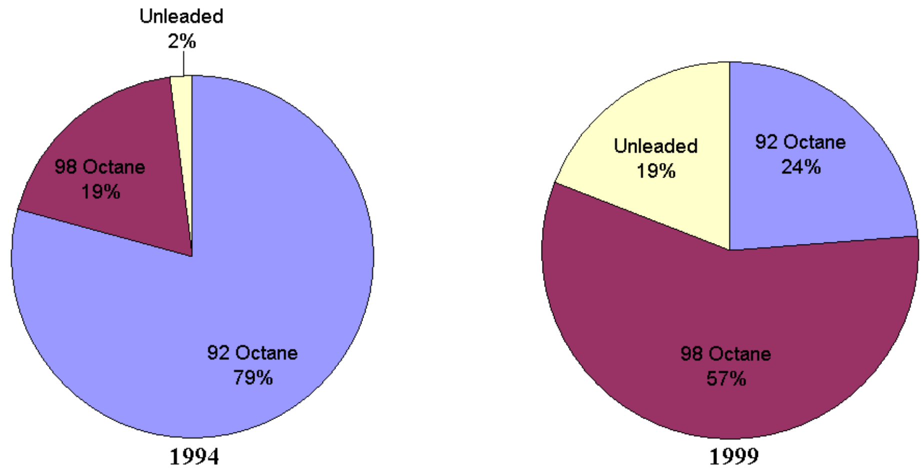

Figure 1: Breakdown of imported gasoline in 1994 and 1999.

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.

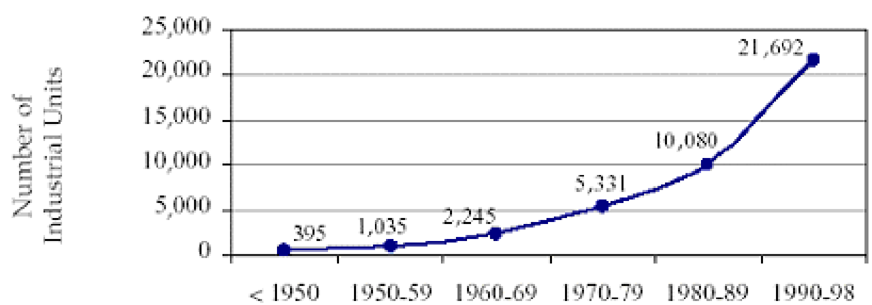

Figure 2: Evolution of industrial sector between 1950 and 1998.

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.

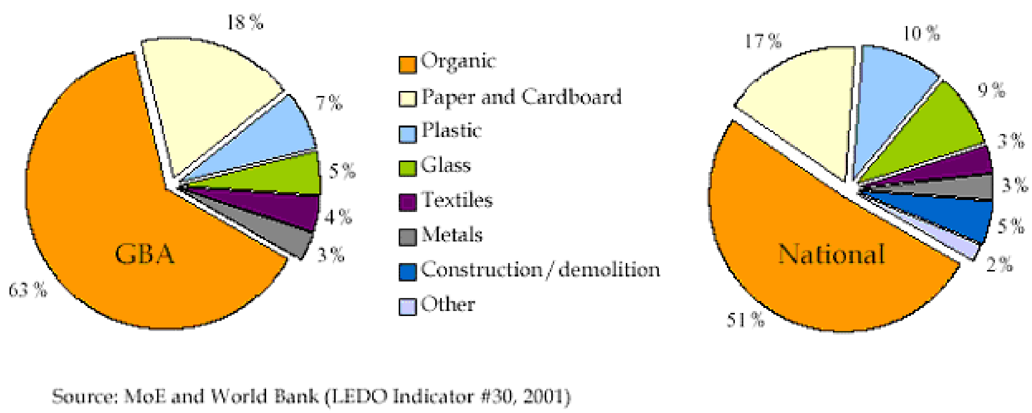

Figure 3: Composition of municipal solid waste in GBA & nationally

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], $GW\text{-}hr_{el}$	1,130
Thermal value[d], $GW\text{-}hr_{th}$	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 $kW\text{-}hr_{thermal}$ = 0.33 $kW\text{-}hr_{electrical}$
[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]

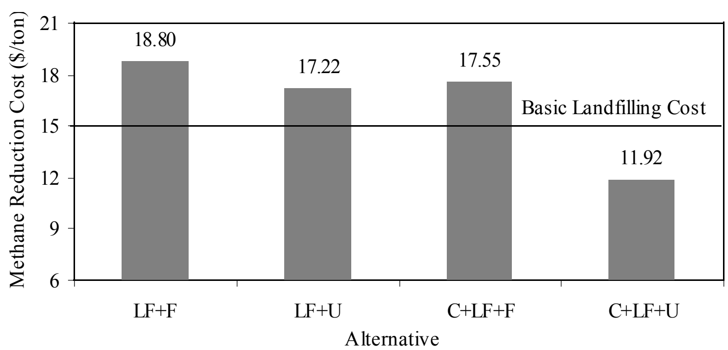

Figure 4: Comparison of selected mitigation alternatives for solid waste.

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 $1{,}383 \times 10^6$ 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”.