2.THE ELECTRICITY SUPPLY SECTOR

2.1 INTRODUCTION

The electric power supply in Lebanon is a State monopoly by law. The public agency entrusted with electricity generation, transmission and distribution is the autonomous "Electricite Du Liban" (EDL) which is responsible to the Ministry of Hydraulic and Electric Resources. Lebanon imports almost all needed resources to generate electricity (with the exception of very little contribution from the hydro power plants). These resources are fuel oil, diesel oil and natural gas in the future.

The power sector in Lebanon has been going since 1993 through a major rehabilitation program in order to cope with the consequences of 17 years of civil war. Such a program was launched by the Lebanese Council for Development and Reconstruction (CDR) in October 1993. The budget of this program is estimated at US$1.7 billion from national and foreign funding. From the preliminary assessment and forecast of future electricity supply-demand balances, made on the basis of the prevailing rehabilitation and expansion program, the following observations can be made:

- Even with the rehabilitated facilities and all expansion capacities, the total production capacity would hardly cover the peak load estimates of the years 2000 onwards. However, since the expansion of the transmission network will not be ready before 2002, it only makes sense then to install extra units starting 2002 onwards.
- A sufficient spinning reserve should be considered to provide continues electricity supply capable of responding to preventive maintenance and unit failures needs.
- A gradual withdrawal of rehabilitated facilities has to be considered from the year 2000 onwards.
- Major available and planned options depend on imported fuels.

2.2 THE BASELINE SCENARIO

The baseline scenario provides all the necessary information on activities that took place since 1994 (base line year) as well as the most likely developments that are planned for the future. Two plans have been distinguished; a short term plan extending from 1994 till 2005, and a long term plan extending from 2005 till 2040.

The supply system projections are closely linked to already announced government policy and priorities. In particular, the already announced policy of the government on the following matters:

- Commitment to full restoration of the generation, transmission and distribution networks.
- Commitment to continuously increase the capacity in the future to meet the expected increase in demand.

Lebanons demand is divided into 2 parts:

1. Industrial.
2. Residential, commercial and others including schools, hospitals, governmental buildings, electricity needs for agriculture, and concessions.

The demand growth for the years 1994-1998 has been officially recorded by EDL; however, future demand on electricity is a function of income, prices, efficiency of energy conversion and government policy. In this study, the forecast of electricity demand growth for the years 1994-2004 was made to follow the GDP trend, but for the years 2005-2040 was based on the assumptions that by that time all the necessary infrastructure projects will be over and Lebanon will become a good place to attract foreign investments. Hence, the following 3 scenarios, which are consistent with the projected economic growth of 3-6%, are proposed to accommodate possible demand growth. These are a low growth scenario: 4% annually, a medium growth scenario: 6% annually, and a high growth scenario: 8% annually. Table 1 shows the energy balance for the 4% demand growth rate. (The data provided in this Table may not tie very well with the data used by the building and industrial sectors. This is due to the energy loss, energy used in the power plants and electricity used in the agriculture which were not accounted for elsewhere.)

Table 1. Energy Balance (GWh)

	94	2000	2005	2015	2040
Total Generation	5000	7570	12400	18360	48930
Total Demand	6800	10190	12400	18360	48930
EDL shortfall	2550	2630	0	0	0

Shortages in electricity supply are to be expected at least until the year 2002 because of the unfinished works in the transmission network. Later, there is a need that every five years, necessary extra units are installed to satisfy the demand over the next five years (Table 2).

Under the assumed demand growth of 4% and technical losses of 15%, the supply of electricity with no shortages will require the yearly addition of the following capacity.

Table 2. Required yearly expansion of generation capacity

Years	2006-2010	2011-2015	2016-2020	2021-2025	2026-2030	2031-2035	2036-2040
Capacity, MW	130	154	181	222	271	332	491

The percentage contribution of various fuels to electricity generation for the years 1994-2040 under the assumption of 4% demand growth rate is shown in Fig.1.

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Fig. 1. Percentage contribution of various fuels to electricity generation

The generation of electric energy in Lebanon is done mainly through thermal units operating on fuel and diesel oils and through very little of hydro power. In 1996, two combined cycle power plants were installed but they are expected to continue operating on diesel oil until 2005. At that time natural gas is expected to become available and the combined cycle units will fully operate on natural gas. However, because the future availability of natural gas is highly uncertain, the increase in demand will be satisfied in the baseline scenario by the continuous addition of thermal units operating on fuel oil.

Using projections on future demand and generation, the total emissions for the years 1994-2040 are calculated as shown in Table 3.

Table 3. Total emissions for 2005-2040 (Gg)

	1994-2004	2005-2040		
		4%	6%	8%
Carbon Dioxide	39644	741450	1200870	1952920
Carbon Monoxide	8.76	180	275	430
Nitrogen	117	2074	3343	5421
Sulfur	557	8459	14492	24362

Transmission and distribution losses in Lebanon can be classified as technical and non-technical losses. Non-technical losses (very high in the last years reaching at some time 60%) result from theft of electricity through unauthorized connections and tempering with meter readings. Recently, these losses have been reduced significantly and will continue to reduce in the future. In this analysis, such losses were not considered. Technical losses, on the other hand, were estimated at 15% in the baseline scenario, and it is assumed that after the rehabilitation is over and normal operation goes back to the system, losses can be significantly reduce. Table 4 shows the environmental benefit that will take place if EDL succeeds in bringing its technical losses down to 10%.

Table 4. baseline scenario emissions reduction due to loss reduction

Losses (%)	Growth (%)	Discount rate (%)	Average yearly emissions reduction, Gg/year			
			CO2	CO	NOX	SOX
10	4	10	624	0.13	1.7	8
10	6	10	1028	0.21	2.8	13.5
10	8	10	1758	0.36	4.9	23

2.3 CONCLUDING REMARKS- BASELINE SCENARIO

From the baseline scenario of the electricity supply sector in Lebanon, the following conclusions can be drawn based on the results obtained:

- Shortages in electricity supply are to be expected at least until the year 2002. This is mainly due to the unfinished works in the transmission network. Between 2002-2005, the situation will depend on the availability of funds to install extra units of about 475MW. Later, there is a need that every five years, necessary extra units are installed to satisfy the demand over the next five years.
- The contribution of hydro power stations is on the decrease as there are no government plans neither to increase the capacity of the existing plants nor to build new hydro power plants. Also, the water resources in Lebanon are not expected to contribute more in the future.
- Natural gas will not be available in the market before 2005. Therefore, the new combined wer plants will continue to operate on diesel oil. A matter that defies their purpose as clean and efficient technologies. The reason for this fact is that natural gas is not available in Lebanon and the construction of pipes that will bring it from Syria has not been finished yet.
- When some thermal units are retired, the replacement will be done with units operating on fuel oil.

2.4 MITIGATION SCENARIOS

In this project, mitigation scenarios are developed under the following categories:

Category 1: Improving mix of supply through renewable energy
Category 2 : Fuel substitution through the use of natural gas.

To be consistent with the baseline scenarios, mitigation scenarios will have to ensure a 10% capacity reserve from combined cycle units operating on natural gas. This reserve will be used to facilitate scheduled maintenance, repair and to make up for unit failures.

Under category 1, scenarios will be 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 hot water systems. Since renewable energy is unlikely to significantly penetrate the market in the near future, it will be assumed that only 5% of the generated capacity can be satisfied by renewable energy until the year 2010 and that 10% penetration can be maintained between 2010 and 2040 in accordance to the following categories: 1. All solar, 2. 50% solar, 50% wind, and 3. 70% solar, 30% wind.

As natural gas will be available starting 2005, category 2 will consider it, from 2005 till 2040, as a substitution fuel to replace the fuel oil which was heavily relied on in the baseline scenario. It is worth mentioning that the move to build new lines of natural gas in the very near future in order to import from Syria 3, 6 and 10 million m^3 of gas, supports the opinion that combined cycle power plants operating on natural gas represent the technology option for the future since the current load requires only 3 millions m^3 of gas.

2.5 RESULTS AND CONCLUSIONS

The total CO_2 emissions associated with every scenario have been calculated and are summarized in Table 5.

Table 5 Total CO_2 emissions from all categories for 1994-2040

Years	1994-2004	2005-2040		
Scenario	Demand growth➔	4%	6%	8%
Baseline	39644	741450	1200870	1952920
Ren. (All Solar)	39644	711498	1150002	1865044
Ren.(50%S-50%W)	39644	719886	1164186	1889560
Ren.(70%S-30%W)	39644	716538	1158498	1879732
Natural Gas	39644	624738	949878	1476280

As can be seen, from emissions point of view, the best policy is to adopt natural gas with the corresponding combined cycle technology. The last scenario provides emission reduction of 14.95%, 20.24% and 23.92% as compared with the baseline scenario for demand growth of 4%, 6% and 8% respectively. The costs of one Ton of CO_2 reduced from various scenarios compared to the baseline one are shown in Fig. 2 below for the case of 4% growth rate and 10% discount rate.

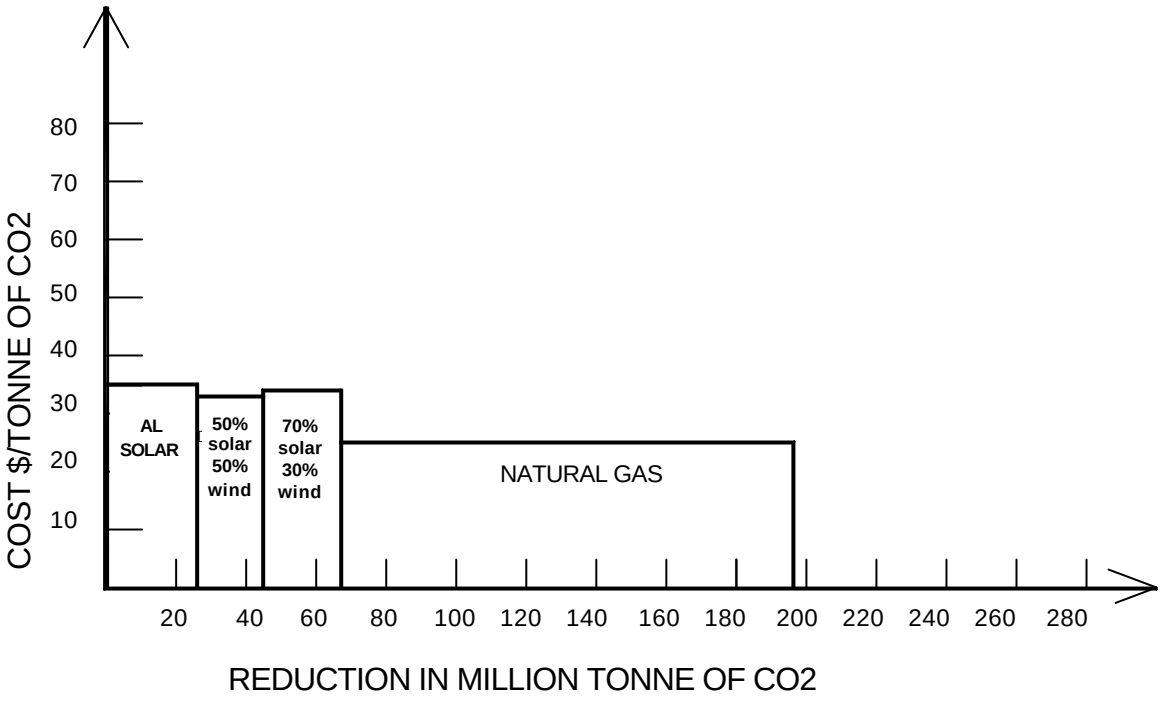

Fig. 2. The cost of one Ton CO_2 reduced: 4% growth rate

Based on the results obtained, the best strategy to be suggested for mitigating GHG in the electricity supply sector is the following:

1st. On the level of technology and fuel selection.

1. The choice of natural gas as future fuel is highly recommended
2. The choice of combined cycle power plants as the preferred technology is also highly recommended

1st. On the policy level.

1. Due to their environmental benefits, the promotion of renewable energy technologies is recommended and should be given priority when these technologies become economically competitive. However, the large penetration of renewable energy into the Lebanese system is unlikely to happen in the near future due to many institutional and technical barriers, which must be addressed carefully and overcome in future projects.

2. Mitigation options have all been evaluated without consideration of the external environmental cost associated with energy generation.The use of external cost in future economic calculations of electricity is obviously recommended as the addition of such a cost will encourage the use of environmentally friendly technologies and resources by making them economically competitive with traditional sources of energy.

2.6 PROJECT PROPOSALS AND RECOMMENDATIONS

The two options that have been identified for the electricity supply sector in Lebanon are solar and wind energy generating units, and combined cycle plants operating on natural gas. As for natural gas, the unavailability of such a resource in Lebanon is currently being addressed. The Lebanese government has already negotiated the issue of natural gas with the Syrian authorities and as a result natural gas is expected to be available around 2005. In

addition, to address the situation when Syria would not be capable of satisfying the whole Lebanese market, 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. Additional feasibility studies have to be conducted in this area.

With regard to renewable energy, a lot of work has to be done to drastically change the situation into one favoring a significant penetration of renewable on both the generation and demand sides. The following are the barriers that the project should address at present.

Information Barriers

- Lack of accurate wind and solar resource assessment. Shortage of data on patterns of end-use energy consumption in all sectors of the economy prevents practical evaluation of supply-side and demand-side management programs based on solar and wind energy.
- Lack of documentation regarding the economic, environmental and social implications of existing supply-side energy technology.

Awareness Barriers

- Decision makers are not familiar with the social, environmental and economic benefits, resulting from the introduction of renewable energy.

Economic and Financial Barriers

- There are no dedicated financing schemes or special incentives to promote renewable energy systems especially that such systems have very high capital investment costs.

Institutional Barriers

- No policy that favors renewable energy, nor there are laws that permit private electricity generation in the country.

Capacity Barriers

- There are very few people who are familiar with the installation, operation and control of solar and wind energy systems.