Power Sector

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1. INTRODUCTION

The main aim of this report is to formulate and develop a medium term vision and propose viable strategies for the power sector, in an attempt to convert it into a financially independent sector, taking into account the existing situation, main problems, and remedial actions.

It also addresses longer term requirements and presents various approaches that need to be considered upon implementation of the necessary actions or projects, which will be required for achievement of the vision.

2. DEVELOPMENT OF MEDIUM TERM VISION

2.1 Chapter Objectives

The objective of this chapter is to present the rationale and procedure for developing the vision/objectives for the power sector, along with the development of the relevant options, for the upcoming 10-15 years, based on results obtained from the National Physical Plan Study, which had actually revealed that Lebanon's power sector has received a decent share of investment starting from the early nineties and on.

2.2 Methodology

The methodology presented here follows the steps shown in Figure 1. The core problem is first identified, and its root causes diagnosed using the problem-tree approach. Remedial measures at the technical, financial, and institutional levels, are proposed, thus forming the framework of the medium term vision. Longer term requirements are also addressed.

The existing conditions of the power sector are then described, in order to analyze the economic, institutional, and technical approaches and considerations that are required for the refinement of the future status and achievement of the objectives. A set of

performance criteria are finally developed, and they can be used later on to evaluate the options and select the preferred ones, based on location and local conditions.

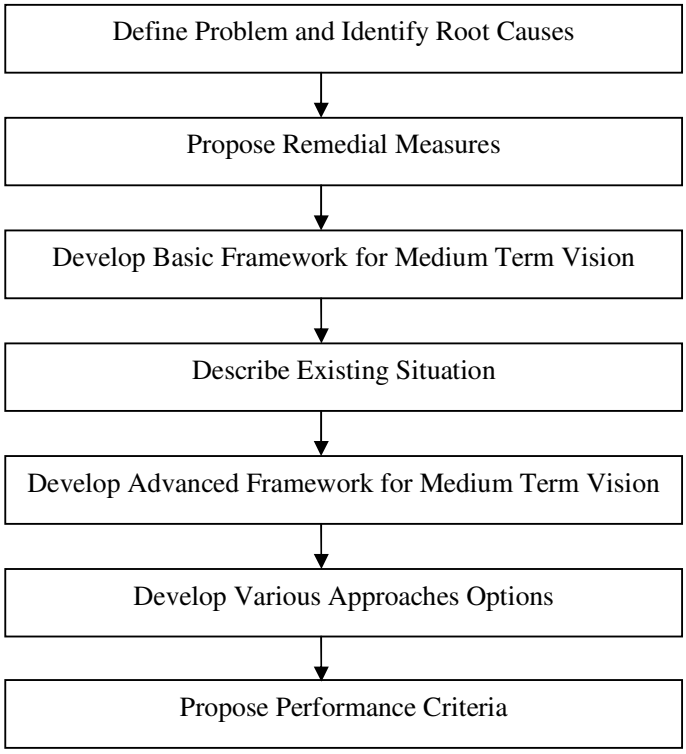

Figure 1: Schematic of the approach followed to develop the power sector Vision & Options

2.3 Problem Causes

From the citizens' perspective, it is unfortunate that electricity in Lebanon remains not only unreliable but also expensive (refer to Fig. 2, extracted from a comparison of electricity tariff in the Middle East and North Africa region - MENA).

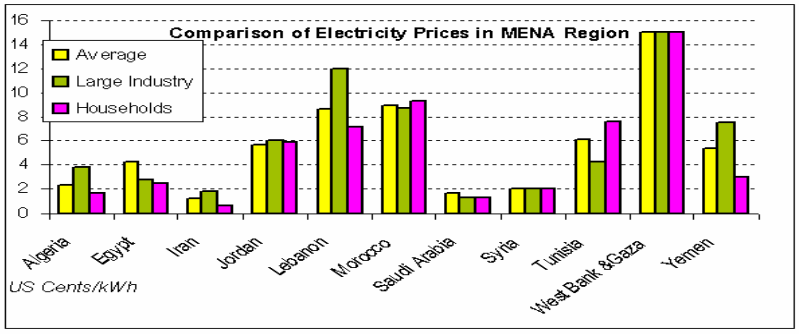

Figure 2: Comparison of Electricity Tariffs

Several areas, particularly outside Grand Beirut, still suffer from power rationing and rely heavily on private generators to overcome blackouts.

The roots for this core problem are analyzed in this part, and they include technical, financial, and institutional problems that the power sector, Electricité du Liban in particular, suffers from.

The effects of the core problem include deterioration of the quality of life, which in turn result in all possible day-to-day problems encountered due to the absence of reliable electric service, and, more broadly, decline of the economic situation and consequent hardships (reduced work opportunities, etc).

In addition, the effects include increased noise and pollution caused by local generators, which in turn lead to health problems and economic burdens, where people have to pay extra amount for privately leased generator power. The percentage of the people that rely on backup supply from private generator power is suggested to be 57%, which is considerably high.

Unreliability is mainly attributed to inadequate generation capacity, still incomplete transmission networks, inadequate equipment maintenance requirements, overload conditions, and lack of resiliency in several parts of the distribution networks. Partial or complete system shutdowns are still present and result in public panic.

High cost, on the other hand, is attributed to higher generating costs due to type of fuel, uneconomic operation of power plants, and high technical losses.

In addition, the financial revenues to EDL are low due to the international increase in fuel prices, inadequate collection, and high non-technical losses.

In regards to type of fuel, the main problem is the continued operation of the combined cycle plants Zahrani and Deir Ammar on diesel rather than natural gas. The open cycle plants Tyre and Baalbek face the same problem, where the Baalbeck plant

suffered recently major shutdown and overhauls due to the reduced quality of the used diesel.

The problem tree tool is a useful exercise in analyzing the existing situation in the sector by identifying the causes and the cause-effect relationships and their main causal relationships (refer to Fig.3).

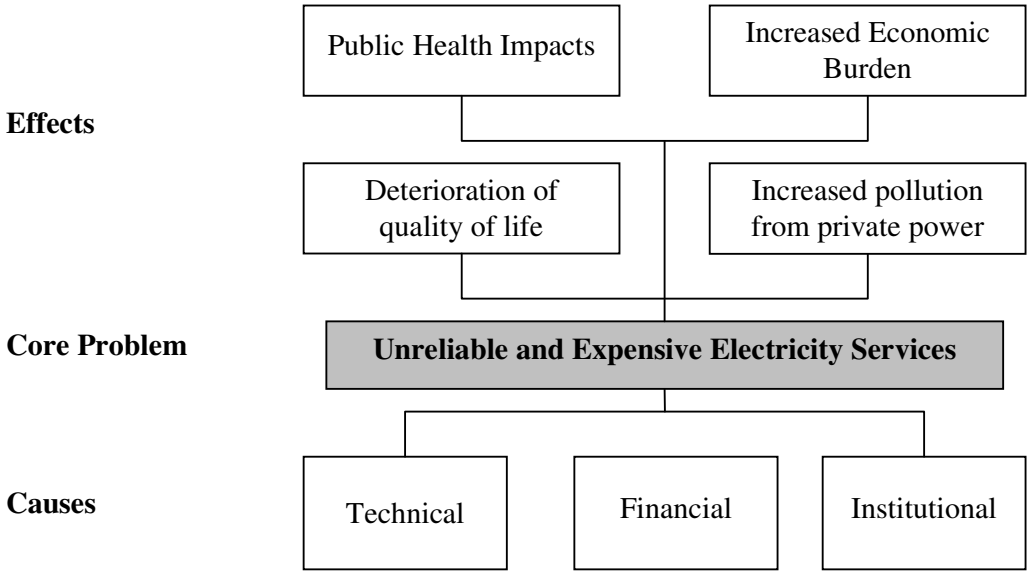

Figure 3: Problem tree for the "unreliable and expensive power services" Core Problem

The root causes of the core problem include the following:

2.3.1 Technical Problems

The power sector still suffers from certain technical problems, classified as follows:

- Generation
  - Inadequate generation capacity
  - Continued operation of the gas plants on diesel rather than natural gas,
  - Ageing and inadequate maintenance

- Transmission
  - Incomplete 220 kV network
  - Incomplete 400 kV network
  - Still Unavailable National Control Center

- Distribution

- Lack of resiliency
- Partially old and overloaded
- Subject to illegal connections

2.3.1.1 Generation

The power plants in Lebanon are summarized below in Table 1.

Currently three sources are used to generate electricity in Lebanon: heavy fuel, diesel, and hydropower (to a much smaller scale, though).

The thermal plants that run on heavy fuel include Zouk, Jieh, and Hreiche.

The combined cycle (Deir Ammar and Zahrani) and open cycle plants (Tyre and Baalbeck), still operate on diesel due to absence of natural gas infrastructure.

The remainder of the plants are smaller hydropower stations.

Plant	Number & Type of Units				Total Capacity (MW) Installed/Actual
	Thermal	Steam	Gas	Hydro	
Zouk	4				607/475
Jieh	5				346/240
Zahrani		1	2		435/410
Deir Ammar		1	2		435/410
Baalbeck			2		70/30
Tyre			2		70/30
Hreiche	1				75/50
Kadisha, Nahr Ibrahim, Nahr El Bared, Richmaya, and Litani Plants				15	221/40 (in dry seasons)
Total					**2,334/1,685**

Table 1: Lebanon's Generating Plants. Source: EDL

2.3.1.1.1 Inadequate Capacity

Lebanon's maximum demand is estimated at 1,900 megawatts in 2004. Assuming an annual increase of 3% up till 2010 and 2% up till 2020, as coordinated with EDL, the

maximum demand is estimated at 2,250 and 2,500 MW in 2010 and 2015 respectively.

As seen above, the present total actual generation output amounts to 1,685 MW. Add to that an imported energy from Syria of 140 MW, which started as of September 2005, the total actual output becomes 1,825 MW, which is short of meeting the maximum demand presently, let alone by 2015.

Furthermore, the loss of the largest turbine in the country, which is any of the Zahrani or Deir Ammar gas turbines, results in a sudden drop of 215 MW (given that the loss of the gas turbine leads also to a 50% reduction in the output of its steam counterpart).

In the absence of Syrian power and the largest turbine in the country, the total available output drops to 1,470 MW, which results in a vulnerable system. Further unscheduled turbine outages would render the situation quite unacceptable.

2.3.1.1.2 Operation on Diesel

The most recent plants are the two combined cycle plants, each of 435 MW capacity, at Deir Ammar (near Tripoli) and Zahrani (between Tyre and Saida). Each plant includes two gas turbines and a steam turbine, which uses the residual heat as thermal input. These were completed in 1999. However, both plants continue to be fuelled by diesel rather than by the more economical and environmentally friendly natural gas.

Operation on diesel results in increased costs, pollution, and turbine overhaul requirements; and, as mentioned earlier, the turbines in Baalbeck were recently decommissioned and overhauled.

Deir Ammar was expected to start receiving natural gas from Tal Kalakh in Syria, as the gas supply project is completed but not yet commissioned, and it is not anticipated that it will be in the near future, which implies that alternative gas sources have to be urgently considered.

Zahrani, on the other hand, remains unconnected to any gas infrastructure, let alone to the gas supply itself.

In addition, both open cycle plants in Tyre and Baalbek, also run on diesel. Owing to their inherently low efficiency, both operate at costs significantly greater than Zahrani and Deir Ammar.

Figure 4: Zouk Thermal Power Plant

Figure 5: Zahrani CC Power Plant

2.3.1.1.3 Ageing and Inadequate Maintenance

This problem is mainly related to the old Jieh plant, whose efficiency is seriously compromised and thus requires increased amounts of fuel.

Deir Ammar and Zahrani suffered from the same problem, although to a lesser extent, and Operation and Maintenance contracts for them were recently established.

In regards to other systems and equipment, limited maintenance is carried out by EDL personnel, but EDL confirms that there are no long term preventive maintenance contracts.

2.3.1.2 Transmission

At the transmission level, there are the following problems that contribute to compromised reliability and increased costs:

2.3.1.2.1 220 kV Network

The 220 kV overhead and underground networks as well as some power substations, are still incomplete, which in turn results in an inability to optimize the transmission of the available energy and increases the technical losses.

The following summarizes the 220 kV works that still require completion:

- Overhead Lines
  - Bsalim – Halat
  - Halat – Bahsas
  - Bsalim – Aramoun
- Underground Cables
  - Pins – Aramoun (one additional circuit to the one present)
- Substations
  - Tripoli
  - Saida
  - Baalbeck

The 220 kV loop configuration is therefore not complete, resulting in overloading and increased losses in the 150 and 66 kV systems.

Overloads are mostly experienced in the hot weather summer times, when air conditioning needs reach their utmost. What worsens this problem is that utility power lines are actually supposed to carry less rather than more current during these periods, in order to avoid increased sags and dangerous clearance violations.

Therefore meeting demands reliably during the summer is indeed a challenge, especially that the transmission network still relies heavily on the higher current

carrying 150 and 66 kV systems, which become more overloaded than their 220 kV counterpart.

The overloads contribute also to the increase in the technical losses and operating costs.

2.3.1.2.2 400 kV Network

The 400 kV overhead link between Syria and the under construction Ksara 400/220 kV Substation is still incomplete, which results in an inability at present to exchange energy with the 7-Nation EIJLLST grid and import power at emergency times, which, if made available, would reduce spare capacity and spin reserve requirements, thereby increasing the overall reliability.

2.3.1.2.3 National Control Center

This control center, which includes Supervisory Control and Data Acquisition (SCADA) facilities has not been established yet. It was called for in 1993, at the time of renovation and development of the electricity sector.

Its delayed establishment prevents centralized remote operation and control of major system components, thereby slowing down maneuvers and preventing economic load dispatch. In addition, the NCC is a pre-requisite for the interconnection with the 7-Nation grid.

The NCC was recently contracted and expected to be commissioned in the short term.

2.3.1.3 Distribution

At the distribution level, there are the following problems:

2.3.1.3.1 Lack of Resiliency

The absence of reliable loop configurations in several parts of the distribution system adds to the unreliability of the system. In many situations, maintenance problems and repair requirements dictate taking the affected portion out of service, given the absence of an alternate supply.

2.3.1.3.2 Overloading

The distribution network, particularly the 11 kV distribution network in Beirut, is overloaded, which results in increased technical losses and occasional interruptions.

2.3.1.3.3 Illegal Connections

The network is further weakened and abused by illegal connections, which results in further increased and unaccounted for loads.

2.3.2 Main Actions Required at the Technical Level

The main actions required as remedial measures to the technical problems are proposed as follows:

- Increase of power supply
  - Increase generating capacity to meet demand: Increase capacities of Deir Ammar and/or Zahrani or add a new plant, location yet to be defined
  - Enhance maintenance procedures: Establish long term maintenance contracts
- Complete the pending transmission and distribution projects
  - Complete the Transmission networks, including the connection with the 7-Nation Grid
  - Expedite the National Control Center (NCC)
- Reduce technical and non-technical losses, to reach 20% at first stage, and 12% ultimately
  - Expedite the upgrading of the distribution network to 20 kV
  - Remove illegal connections
- Update Master Plan

2.3.3 Financial Problems

Two parts constitute EDL's financial problems: high operation cost, and low return. The first part is attributed to the operation on diesel instead of natural gas, uneconomic operation of plants, and increased technical losses. On the other hand, the second part is caused by worldwide escalating price of diesel, increased non-technical losses, and inadequate collection.

2.3.3.1 Uneconomic Operation of Power Plants and unavailability of Gas

The Zahrani and Deir Ammar power plants are running on production costs at over 75% higher than on the still absent natural gas. In addition, the uneconomic operation of the power plants worsens this issue and increases the cost even further, as explained below:

- Increased amounts of diesel are required for Baalbeck and Tyre due to their inherent low efficiencies and operation as base rather than peak plants (approx LL 270/kWh)
- Increased amounts of heavy fuel are used for the Jieh steam plant, due to its low efficiency caused by ageing and reduced maintenance

Diesel increases the production cost to approximately LL 150 per kWh in the combined cycle plants. It is estimated that the use of gas in lieu of fuel will lead to a production cost of around LL 85 per kWh.

Despite their inefficiency, gas turbines are considered attractive, mainly because of their fast start ups, making them ideal for peak power plants. Combined cycle plants, where a steam turbine would use the residual heat as input thermal power from its gas counterparts, increases the overall efficiency of the plant and reduces production cost.

In the absence of easily derivable gas, which is the case in many countries, gas turbines would operate on diesel oil. The efficiency is just as good if not slightly better. The main drawbacks are increased production cost, pollution, and turbine overhaul requirements.

Unfortunately, this is the case presently in Lebanon.

2.3.3.2 High Technical and Non-Technical Losses

According to EDL, their technical and non-technical losses reached over 40% in 2004.

Expansion of the 220 kV network and aggressive removal of illegal connections have succeeded in bringing the total losses from 45% in 2002 (refer to Table 2) down to 40% presently. Undeniable political and social pressures make it slower for EDL to resolve this issue in a more efficient manner, and the total figure remains high.

Reduction of technical losses leads to a decrease in operational costs, whereas reduction of the non-technical losses, leads directly to an increase in financial returns for EDL.

Country	Losses (%)
Lebanon	45
Yemen	28-30
Morocco	18
Algeria	25
Egypt	16-18
Jordan	16
Saudi Arabia	16
Tunisia	12

Table 2: Comparison of Losses, Source: World Bank 2002

2.3.3.3 Inadequate Collection

As opposed to the Concessions, whose collection rates exceed 97%, EDL's collection rate is by far more inferior, and their total revenues are directly impacted. Collection is high in cities but insufficient in certain towns and villages, and it is often subject to political interventions. The uncollected amount is estimated at 8% of the total billed amount.

In an attempt to improve metering and collection efforts, EDL obtained in 1998 a technical proposal that outlines the main components required for high tech billing, which allows remote metering and disconnection of non-paying customers. The project did not materialize further, but the Ministry of Energy and Water confirms that it is being reactivated presently.

This problem is further worsened by inadequate police backup with EDL collectors and government assistance in collecting overdue bills from government organizations.

2.3.3.4 Major Deficit

All of the above factors contribute to decreased revenues to EDL, which leads to increased interests on the deficit, which in turn causes accelerated accumulation of the annual losses.

2.3.4 Main Actions Required at the Financial Level

The main actions required as remedial measures to the financial problems are proposed as follows:

2.3.4.1 Reduction of Fuel Cost

The options available for the reduction of fuel cost are as follows:

Option	Advantages	Disadvantages
Option A - Expedite the continuation of the Arabic gas infrastructure project into Lebanon to feed Zahrani and/or Deir Ammar	Low installation cost	leakage concerns
	Low purchase cost	Maintenance hazard
Option B - Establish a contract with a floating Liquefied Natural Gas, LNG, terminal and start importing liquid gas	Low maintenance cost	High installation cost
	Secure supply from diverse suppliers, including Algeria, Qatar, and others	Unstable transportation costs: LNG transportation cost is set through daily renting costs, and relates to transportation cost, financing cost, and operating costs.
Option C - Establish an LNG terminal and start importing liquid gas	Low maintenance cost	Unstable shipping costs
	no need for additional network infrastructure	High running cost

Option A is under implementation and expected to be commissioned by late 2007, according to the Ministry of Energy and Water, and it is the most economic solution. The line originates from Egypt and passes through Syria and Jordan, and it is actually completed up to Rihab in northern Jordan, from where it will be continued to Deir Ali in Syria, from where in turn it may be continued northward into Homs (tal Kalakh), which would secure supply to Deir Ammar through the already installed downstream infrastructure.

Also, the line may be branched westward into Lebanon to feed Zahrani. The old Tapline is already present up to Marjayoun, and so the new pipe may not have to be installed all the way up to Zahrani, depending on the status of the old pipe and whether or not it can be resued. The Ministry of Energy and Water estimates the total project cost at $120 million. Lebanon may pay for its part only or the full amount, in which case the wheeling charges would be less.

Option B, although expensive, is being considered for by the Ministry of Energy and Water for Zahrani.

Option C is under consideration, and a tentative location for an LNG terminal in Selaata is envisaged. But there are no plans to implement it in the short or medium term.

2.3.4.2 Reduction of Technical and Non-Technical Losses

At the technical level, this involves completion of the transmission and distribution projects, including upgrading of several parts of the latter to 20 kV.

At the non-technical level, this involves removal of illegal connections and enhancement of collection.

The following example illustrates the improvement of the financial situation following reduction of total losses from 40% to 20%, even with the continued use of diesel.

- Energy produced in 2004 = 10.2 TWh @ 150 LL per kWh (cost of kWh with use of diesel) = 1,530 billion LL
- Energy billed in 2004 = 10.2*0.60 TWh @ 140 LL per kWh (av.) = 848 billion LL
- This particular annual loss is around 682 billion LL, or $455 million.

Assuming that total losses are brought down to 20%, the numbers become:

Energy produced in 2004 = 10.2 TWh @ 150 LL per kWh (cost of kWh with use of diesel)= 1,530 billion LL

- Energy billed in 2004 = 10.2*0.80 TWh @ 140 LL per kWh (av.) = 1,142 billion LL
- This would reduce the losses to 388 billion LL, or approximately $258 million.

If, in addition to the above, natural gas were used, then $160 million in revenues may be expected.

2.3.5 Institutional Problems

The technical and financial problems described above are strongly compounded with institutional ones, whose immediate resolution is an urgent prerequisite to all the remedial measures mentioned above.

2.3.5.1 General Background

EDL is the public authority in charge of generating, transmitting and distributing power in Lebanon. This entity reports to the Ministry of Energy and Water. Concessions are responsible for only limited zones, as described above.

EDL's Board of Directors comprises presently five members, including the Chairman. The organization is composed of ten directorates, each headed by a director who reports directly to the General Director, who is also the Chairman. These directorates include Administrative Affairs, Financial Affairs, General Auditing, Transmission, Equipment Selection, General Affairs, Generation, Studies, Distribution for Beirut Mount Lebanon, and Distribution for Districts. Outside Beirut, there are regional offices that handle customer service and local matters.

2.3.5.2 Current Problems

The institutional problems revolve around the fact that present EDL Management, Personnel, and Structure remain a reflection of the breakdown of the decision-making process in the government, and as such they are not suitable to manage and lead this vital sector, and provide reliable electricity supply at minimum cost.

In particular, the main problems are:

- Board & Management with insufficient power of decision and influenced by politics and fear of lawsuits. There are for example delays in land expropriation necessary for erection of electric poles, and delays in finishing the projects, and which are not improved by the board of directors.
- Absence of a clear achievement criteria based on which the performance of EDL can be evaluated

- Present staff average age in the mid fifties, lack of competence and training, and inefficient procedures and adaptation to modern Management Information Systems
- Absence of high level technical coordination among various departments
- Unreliable reporting (financial, statistical, performance indicators, etc.)

2.3.5.3 Law No. 462

Law No. 462, legislated by the Parliament in September 2002, aimed at setting the framework for Regulation of the Electricity Sector.

2.3.5.3.1 Main Features

The main features of Law No. 462 are:

- Unbundling of Production, Transmission, and Distribution Activities, each of which to be financially and administratively independent
- Incorporation of "Privatized Companies" in Production and Distribution, i.e. joint-stock companies governed by provisions of the Commercial Code. These companies will be initially owned by the Lebanese Government or Public Sector
- Within a maximum period of 2 years as of the Incorporation, the Government may sell a percentage of shares of these companies not exceeding 40% to a private investor in the field (Strategic Partner), who shall manage the "Privatized Company"
- The Council of Ministers shall determine the date when the remaining shares, owned by the Lebanese Government, will be offered to private sector investors
- An autonomous National Electricity Regulatory Authority (NERA) shall be created by virtue of the present law and shall be in charge of regulating and controlling the Electricity Sector
- NERA shall issue licenses for Power Production and Distribution in Regions, effective for a period of up to 50 years.

- The transmission of electric power shall remain the responsibility of the Transmission Company, which will remain owned by the Lebanese Government
- The Law defines the Ministry's Power with regards to dealing with the Sector

Law No. 462 is a framework that, if implemented, will gradually lead to increased participation of the private sector in owning and managing the Electricity Sector in Lebanon.

2.3.5.3.2 Present Situation

Law No. 462 has not been implemented yet, and there is good reason to believe that it cannot be implemented in the near future, mainly due to the following reasons:

- Weak Management and Personnel Structure of EDL
- Gloomy Financial and Accounting Picture of the Electricity Sector (deficit, continuous losses, high fuel costs, inadequate collection, etc.)
- Government does not separate between the need for EDL to operate as a profitable commercial entity and the subsidy in the sector, resulting from the tariff, which does not cover the O&M cost, the debt service, and the depreciation of plant
- Government did not succeed so far in imposing measures to prevent theft of electricity and improve collection, thus reducing the non-technical losses, which remain high today at approximately 25%
- The above reasons makes it very difficult to find "Strategic Partners" that will be ready to bid for partial investment in this Sector (up to 40%), and take responsibility of its Operation and Management.

2.3.6 Main Actions Required at the Institutional Level

The main steps towards efficient and transparent institutional reform should aim at strengthening EDL, and they include:

- Reinstatement of EDL's privileges as an Independent Public Institution reinforcement of EDL's autonomy in regards to Employment, Classification of Employment Positions, Financial Management, Contracting with 3rd Parties, etc.
- Appointment of a qualified Board of Directors, in order to secure proper Management for this Sector. Initiation of a Plan that seeks the restructuring of the Institution, so that it remains in harmony with the current requirements for proper Management, whilst maintaining electricity service to all citizens
- Contracting with a Specialized Firm, to Manage EDL for a period of 3-5 years this Firm will support the Board of Directors in the Restructuring Process and Training of new employees
- Undertaking of various investments necessary for the 24/24 hour electricity supply to all citizens at minimum cost (new power plants, Supply of Natural Gas in lieu of Diesel, completion of the connection with the 7-Nation Grid, upgrading of the Distribution Network…)
- Establishment of a modern and transparent Billing and Accounting System
- Re-evaluation of the tariff, in order to introduce a new tariff that reflects actual costs related to Operation, Maintenance, Service Debt, in addition to catering for future investments

Should the Government intend to fix the tariff for social reasons, which would lead to a tariff under the actual cost, then she, and not the Institution, shall bear the resultant losses and subsidize the expenses. This subsidy should be part of the Government's general budget, and it should result in absolutely no losses to the Institution.

These steps are considered vital for the Restructuring of EDL, and converting this Sector into a commercially profitable one, instead of being abused, as is the case currently. Implementation of the above may allow for the implementation of Law No. 462, or amend it as necessary, in light of the prevailing conditions in due time.

2.4 Sector Vision and Objectives

The global vision of the electricity sector includes completing all technical, financial, and institutional reforms. This will enable the sector to eliminate its deficit, finance its investments autonomously, and to provide service at acceptable cost. These reforms shall address the Medium and Long Term requirements.

2.4.1 Medium Term Requirements

Implementation of all the required actions described above, starting with the institutional reforms, will allow for gradual implementation of the sector medium term vision, whose main objectives aim at resolving the core problem, i.e. providing reliable service at an affordable cost.

2.4.2 Long Term Requirements

While the medium term solutions may resolve the financial and institutional problems even at the long term, a major technical problem remains at the long term, which is inadequacy of power supply.

In order to reliably meet the ultimately anticipated demand of 3,000 MW in 2030, construction of additional power plant(s) or importing power from neighboring nations is necessary. Especially when recalling that Zouk may be decommissioned in the future.

The Master Plan, required to be updated within the medium term scope, should confirm the optimum location of the new power plant, taking into account all technical and economic parameters.

It is recommended that construction of this plant, at least its first phase, would start at during the medium term.

2.4.2.1 Addition of Power Plants

The establishment of a new combined cycle plant is under consideration by EDL. The company sees that Selaata is suitable for this purpose, since it is close to the load centers and, at the same time from gas sources in the North.

2.4.2.2 Import of Power

The other option involves purchase of external power from neighboring nations.

Under its present conditions, the 7-Nation EIJLLST grid, which includes Egypt, Iraq, Jordan, Lebanon, Syria, Libya, and Turkey, cannot serve as the main import medium of this power, as the agreement requires all nations to be self-sufficient and rely on the grid only under emergency circumstances. In turn, this implies that this option is not feasible presently.

As far as candidate sellers are concerned, it is stated that Egypt has sufficient power for export[1]. The Ministry of Energy and Water confirms that Egypt may be willing to sell Lebanon over 150 MW at approximately 5 cents per kWh. This represents good short term savings, especially when recalling that Baalbeck or Tyre's 18 cents per kWh production cost. But it cannot be considered a solid long term measure.

However on the long term, ongoing plans of a major interconnection between the EIJLLST Grid and the GCC grid, which includes Saudi Arabia, Kuwait, Bahrain, Qatar, UAE, and Oman stabilizes the combined grid further and amplifies its total capacity to 90 GW, thereby possibly paving an ultimate avenue for purchase of power on a continuous basis.

2.4.2.3 Comparison of Options

The advantages and disadvantages of either option are listed below regardless of the possibility of implementing it or not at this time.

[1] Arab Power – by Emad Ibrahim

Option	Advantages	Disadvantages
Option A - Increasing the number of power plants	Ability to meet demand autonomously, irrespective of external ties	High capital costs
	Creation of local employment opportunities	Increased pollution
		High operation and kWh production cost in absence of natural gas
	Ability to sell surplus power to external nations during low demand periods	Continuous dependence on imported fuel
Option B - Importing power	No increased pollution	Inability to meet demand autonomously, and dependence on ties with other nations for reliability
	Reduced operating cost, which may be reflected on the tariff thereby encouraging existing and future industrial plants to rely on the local power grid and to keep their generators as reserve. This will help reducing noise and pollution, as well as reducing the energy bills	Reduced local employment opportunities
		Marginal ability to sell surplus power to external nations during low demand periods

Option A is under serious consideration by EDL, mainly because it guarantees their autonomy. Nevertheless, Option B is also viable and under continuous follow up by the Ministry of Energy and Water.

3. CURRENT CONDITIONS

This Chapter dwells into technical details related to EDL's network.

3.1.1 Electrification Ratio

Lebanon has one of the highest electrification ratios in the region, where distribution almost covers the entire republic. Table 3 summarizes the electrification ratios in the region, which was even contested by EDL, who confirms that 100% of the population is served.

Electrification Ratios - % of population

Country	Total	Urban	Rural
Yemen	40	84	26
Morocco	46	68	20
Jordan	99.8	100	98.9
Egypt	98	100	96
Lebanon	98	100	96
Tunisia	98	100	93
Venezuela*	65	N/A	N/A
Bangladesh*	13	N/A	5

* For comparison only

Table 3: Electrification Ratio, Source: World Bank

3.1.2 Existing Conditions

3.1.2.1 Generation

In the generation sector, the power sector equipment include turbines, alternators, furnaces, boilers, and all further electromechanical systems. Status of these equipment and quality of their service are hard to assess, mainly because they are quite dynamic with continuously varying outputs. As coordinated with EDL, the most up-to-date data available regarding their energy outputs are as follows:

- In 2003 : 10.5 TWh (with no import from Syria)
- In 2004 : 10.4 TWh (with 216 GWh import from Syria)

This slight reduction in performance substantiates our conclusion above in that the power plants are not receiving the maintenance they deserve.

3.1.2.2 Transmission

EDL's transmission network consists of 66, 150, and 220 kV power as well as several major power substations converting power from extra high to high, extra high to medium, or high to medium voltage, for onward transmission to other substations or distribution to the end users through 11, 15, or 20 kV distribution networks (refer to Table 4 below). In addition, the network includes more than 1,615 km (1,336 km of overhead lines and 279 km of underground cables) of various voltages used for transmission and distribution. Contrary to the generation equipment, transmission systems are static and require usually less maintenance.

Table 4: Summary of substation capacities – Source: EDL

BEIRUT			
Substation name	**Capacity / M.V.A**		
	No. of Trans.	**Equipped**	**Demand at MV Level**
Unesco – 66/11	2	80	50
Basta – 150/66 and 66/11	3+3	240;60	43
Pins – 66/11	3	180	94
Pins New – 220/11	2	140	15*
Gas – 66/11	2	80	42
West – 66/11	3	60	36
Chebbak – 66/11	2	80	43
Ras Beirut – 220/20	2	140	19
Commerciale – 220/20 and 66/20	3+3	320	18
Mreisseh – 66/11	2	60	30

BEKAA			
Substation name	Capacity / M.V.A		
	No. of Trans.	Equipped	Demand at MV Level
Hermel – 66/15	1	20	10
Laboue – 66/15	1	20	9
Baalbeck – 66/15	2	50	45
Bednayel – 66/15	2	30	12
Ksara - (new) – 220/66 and 66/15	2+1	170;140	28
Ksara – 66/15	2	40	19
Anjar – 66/15	1	20	14
Jib Jinnine – 66/15	1	20	10
Abdel Al – 66/15	2	10	5
Pompage – 66/15	2	10	2

SOUTH			
Substation name	Capacity / M.V.A		
	No. of Trans.	Equipped	Demand at MV Level
Zahrani – 220/66 and 66/15	1+1	170; 40	30*
Jieh – 150/66	2	80	60*
Saida – 66/15	3	80	63
Msayleh – 66/15	2	40	28
Nabatieh – 66/15	2	60	40
Tyre – 220/66 + 66/15	2	80	52
Wadi Jilo – 66/15	1	20	11
Marjayoun – 66/15	2	40	17
Soltanieh – 66/15	2	60	38

NORTH			
Substation name	Capacity / M.V.A		
	No. of Trans.	Equipped	Demand at MV Level
Deir Ammar – 220/66 and 220/15	1+1	170; 70	60*
Orange Nassau – 66/15	2	40	30*
Tripoli -66/33	4	60	45*
Kousba 66/33	1	15	12*
Hreiche – 66/15	1	20	16*
Chekka – 66/15	2	20	16*
Selaata – 66/15	1	20	16*
Fih – 66/15	1	20	16*
Balouza – 66/15	1	10	2.5
Batroun – 66/15	1	20	9
Deir Nbouh – 220/150, 220/66, 150/66, and 66/15	2+1+1+1	120; 100; 30; 40	40
Bared 1 – 66/15	1	20	19
Halba – 66/15	2	40	29
Kobayat – 66/15	1	20	14

MOUNT LEBANON			
Substation name	Capacity / M.V.A		
	No. of Trans.	Equipped	Demand at MV Level
Jieh – 150/66	**2**	**80**	**60***
Airport – 66/11	3	60	42
Bouchrieh -66/11	3	120	69
Jdeideh – 66/11	3	60	35
Bsalim – 220/150; 150/66 and 66/15	4+2+2	100; 200; 80	42
Jamhour – 150/66 and 66/15	4+3	360; 80	32
Hazmieh-66/15	2	80	58
Zouk – 150/66 and 66/20	2+2	160;110	56
Jeita – 66/15	2	40	36
Bikfaya – 66/15	2	60	34
Aramoun – 220/150 and 150/15	2+1	100; 140	15
Mkalles – 220/15	2	140	12
Adma – 66/15	2	60	25
Batha -66/15	1	20	16
Hakel El Rayes -66/15	1	20	15
Alita -66/15	1	10	3
Amchit – 66/15	3	60	25
Naher Ibrahim3 – 66/15	3	6.3	1
Awali – 66/15	2	20	8
Choueifat – 66/15	2	80	42
Damour – 66/15	2	40	17
Sibline – 66/15	2	40	25
Aley – 66/15	1	20	11
Sofar – 66/15	2	33	10
Beiteddine – 66/20	2	30	18
Safa – 66/15	1	5	2
Halat – 220/66 and 66/15**	2+1	170;70	---

* Estimated Demand
** Not Commissioned Yet

3.1.2.3 Distribution

EDL's distribution network consists of 33, 20, 15, 11, 5, in addition to the 380 V low voltage network.

The network also contains ground and pole mounted substations. The most pre-dominant systems are the 11 and 15 kV ones, available at and outside Beirut respectively.

The 33 and 5 kV systems are old and limited to some areas in the North, where there is a 33/5 kV substation in Ouyon, out of which the 5 kV system departs to supply secondary substations. Lately, the 33 kV system was taken out of service, and its lines are presently operating at 20 kV.

Finally, the new 20 kV system is restricted to Central Beirut, Jounieh, and Beiteddine. There are plans by EDL to upgrade several parts of their system to 20 kV.

3.2 Stakeholders

3.2.1 Stakeholder Identification

As stated above, EDL remains the sole authority through which all reforms should be channeled and the vision objectives achieved. Nevertheless, there are institutions other than EDL involved in the sector, but their impact in achieving the vision is minor.

3.2.1.1 Electricité du Liban - EDL

EDL is the public authority in charge of the power sector in Lebanon, and it reports to the Ministry of Energy and Water. Founded in 1954, EDL has always been the official monopoly provider of electricity in Lebanon.

EDL's system includes steam, combined cycle and hydroelectric plants, overhead and underground transmission system including conventional and GIS primary substations, and overhead and underground distribution system including pole and ground mounted substations.

More specifically, the generation system includes (3) steam, (2) gas fired combined cycle, (2) gas fired open cycle, and (4) hydroelectric plants. The estimated current construction cost of these plants is estimated at $1.7 billion (actual would be around half of that).

The transmission system, on the other hand, includes conventional and GIS 220, 150, and 66 kV substations as well as 1,336 and 280 km of overhead lines and underground cables respectively. The estimated current construction cost of these systems is estimated at $1.3 billion.

Finally, the distribution system includes 15,000 pole and ground mounted substations as well as 11, 15, and 20 kV overhead lines and underground cables, in addition to the overhead and underground low voltage system. The estimated current construction cost of these systems is estimated at $0.7 billion.

3.2.1.2 Litani River Authority - LRA

LRA is a public establishment with administrative and financial independence constituted in 1954. LRA is involved in managing surface and underground water resources, and they own three hydroelectric plants and sell power at high voltage to EDL.

LRA's system includes (3) hydroelectric plants. The estimated current construction cost is $350 million.

3.2.1.3 Concession of Zahlé

Concession was granted for power generation and distribution in the region of Zahlé in 1910. Generation was halted in 1976. The power is currently purchased from EDL at a rate of 44.5 LL/kWh and sold to the public at EDL rates.

3.2.1.4 Concession of Jbeil

Concession was granted for power distribution in the region of Jbeil in 1950. The power is currently purchased from EDL at a rate of 63 LL/kWh and sold to the public at EDL rates.

3.2.1.5 Concession of Aley

Concession was granted for power distribution in the region in 1924. The power is currently purchased from EDL at a rate of 45 LL/kWh and sold to the public at EDL rates.

3.2.1.6 Concession of Kadisha

An old concession for generating and distributing electricity in the north (Kadisha valley) has been recently bought by EDL

4. APPROACHES TOWARDS EFFICIENT IMPLEMENTATION OF VISION OBJECTIVES

4.1 Institutional and Technical Approach

4.1.1 Redefinition of the Terms (investment, service, sector, project, contract)

For the power sector, the term "project" may be defined to mean an integrated project that assures availability of supply to the consumer, and it may therefore span the whole network starting at the turbine and going all the way down to the energy meter. Therefore, the decision makers should think in terms of integrated projects rather than distinct contracts for generation, transmission, distribution, metering, or any other stand-alone activity.

In other words, a power plant contract, as substantial or costly as it may be, cannot be labeled a project unless it is compounded with all the necessary downstream transmission and distribution systems to enable arrival of this newly furnished energy to the consumer.

4.2 Economic and Sectoral Approach

4.2.1 Impacts on Economic Demand

The effect on aggregate economic demand of the power sector presents itself in terms of the increased economic activities caused by the investment in the sector, requiring the construction of large networks.

This would correspond to increased demand in terms of expanding the workforce. Furthermore, the implementation of these projects will enhance the demand on the design firms, construction companies, and equipment suppliers.

4.2.2 Impacts on Economic Supply

Electricity is a single service that produces many applications.

These may be suited for real time and final use, such as lighting, heating, and air-conditioning. Alternatively, they can produce other fruitful downstream applications, such as water pumping, refrigeration, and endless examples of electricity dependent processes: there can be no industry without electric power.

4.2.3 Externalities

The externalities related to the power sector include:

- Socio-economic impacts resulting from land expropriation, necessary for electric sites, particularly overhead line towers
- Economic impacts resulting from the devaluation of land, due to the presence of towers or other facilities
- Environmental impacts resulting from the pollution emitted by the power plants, which include both CO_2 and SO_2 gases,
- Environmental impact caused by the noise produced by the generators and corona effect at high voltage towers

4.3 Spatial and Social Approach

Except for the locations of transmission and distribution poles, the geographic issue carries no major impact on the power sector.

Unlike facilities related to other services, e.g. sewage treatment plants, locations of the service transformers or even primary substations are flexible, particularly in the rural and open areas.

Steam or combined cycle power plants, on the other hand, cannot be placed in rural areas away from the sea, due to the unjustifiable need for cooling towers, but bringing the power lines to the required location in a small country is not problematic.

4.4 Optimization of the Supply by Sector as a Function of Adapted Performance Criteria

The performance criteria for the evaluation of the various technical, institutional, and economic options are as follows:

- Implementability and suitability for local conditions
- Requirement for trained personnel
- Requirement for land expropriation
- Requirement for imported materials or equipment
- Capital cost, Operation & Maintenance cost
- Simplicity of operation and sustainability
- Externalities, and socio-economic impacts
- Cost recovery implications

5. CONCLUSION

Although a substantial amount of power sector projects have been and continue to be executed, a lot remains to be done to improve reliability and reduce the generation, transmission and distribution costs.

The executed and in progress projects included mainly the rehabilitation of the existing power plants and transmission and distribution networks, construction of four power plants, construction of the 220 kV network, construction of the gas infrastructure for Deir Ammar plant, and all necessary installations for connection with the 7-Nation grid (although the latter two are not commissioned yet). But they excluded the additional power plants, supply of gas to the other power plants, and the automated billing systems.

As mentioned above, increase of capacity of the existing power plants and/or construction of at least one further power plant would relieve the continuously growing demands. In addition, completion and upgrading of the transmission and distribution networks is a prerequisite for the reduction of technical losses to acceptable levels. Removal of illegal connections, on the other hand, results in a reduction of the non-technical losses.

Yet none of the above is easily feasible without the immediate implementation of the institutional reforms within EDL. Only then can EDL operate efficiently and achieve the medium and longer term objectives successfully, whilst maintaining all the approaches and optimization criteria described above.