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Electricity of Lebanon: Problems and Recommendations

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Abstract

This paper presents a detailed review of EDL (Electricité du Liban). It displays the institution's technical problems at the level of electricity generation, transmission and distribution as well as the administrative and financial states and suggests several recommendations. It is obvious that EDL suffers a great shortage in its generating capacity and human resources and would not be effective without conducting a national strategy that includes radical solutions.

Keyword: EDL, electricity, generation, transmission, distribution

List of Terms

CAS	Central Administration for Statistics
CCGT/CC	Combined Cycle Gas Turbine
EDL	Electricity of Lebanon
GO	Gas oil
GT	Gas Turbine
HFO	Heavy Fuel Oil
HV	High Voltage
LL	Lebanese Lira
LV	Low Voltage

MEW	Ministry of Energy and Water
MV	Medium Voltage
NG	Natural Gas
OCGT	Open cycle gas turbine
ST	Steam Turbine
SWHS	Solar Water Heating System
toe	tons of oil equivalent
UNDP	United Nations Development Program
US$	United States dollar

1 Introduction

Electricity of Lebanon (EDL-Electricité du Liban) is a public institution with an industrial and commercial vocation under the control of the Ministry of Energy and Water (MEW). It was founded by Decree No. 16878 dated July 10, 1964, and mandated the responsibility of the generation, transmission, and distribution of electrical energy in Lebanon. Thus, the electricity sector is monopolized by EDL Company that, currently, controls over 90% of the Lebanese electricity sector (including the Kadisha concession in North Lebanon). Other participants in the sector include hydroelectric power plants owned by the Litani River Authority (public company), concessions for hydroelectric power plants owned by Ibrahim and Al Bared (private companies) that sell their electrical production to EDL, and distribution

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concessions in Zahle, Jbeil, Aley, and Bhamdoun [EDL website], where EDL provides them with energy at reduced prices (50 to 75 LL/kWh as compared to the real cost of 255 LL/kWh [MEW 2010]).

Before 1975, eleven major power stations, linked in a common distribution network, supplied most of the country's electricity. In 1974, EDL produced 1700 GWh of electricity, while smaller power companies produced about 0.296 GWh. In that year, 41.5% of the produced power was hydroelectric [www.photius.com]. However, during the civil war (1975-1990), the electricity sector infrastructure was subjected to a great damage and disregard. After that, a major rehabilitation plan (Power Sector Master Plan) was launched between 1992 and 2002. It involved the rehabilitation of the transmission and distribution networks as well as the expansion of generating capacity. However, this plan proved to be insufficient and deficient as the demand still exceeds the supply, where blackouts are common all around the year and in some cities reaching 13 hours per day [World Bank 2009a]. Self generation is estimated to represent up to 30% of all electricity generated [World Bank 2009b] and plays a very important role for many Lebanese to assure their need for electricity. Thus, the Lebanese are paying a double electrical bill, one for the EDL and the other for the back-up self generation that is almost twice the EDL bill [World Bank 2009a]. Moreover, considering this fact and given the low prices of electricity in the region, the Lebanese consumer currently pays the highest electricity bills, while unfortunately, experiencing the most unreliable and lowest quality service in the region.

Losses on the grid are reported amounting to 40%, 15% corresponds to technical losses while the remaining are non-technical losses [MEW 2010]. Although non-technical losses are high, they have been substantially reduced during the last decade when they were estimated to be approximately 48% [Badelt and Yehia 2000]. Non technical losses are attributed to either electricity consumed through illegal connections, meter manipulations, or are consumed without being billed due to the shortcomings in the billing system.

As stated before, the generation of electricity in Lebanon started to grow with a high rate since 1990, achieving a production of 10,5TWh in 2003 [ALMEE 2006]. In that year, 87% of the electricity was produced with oil products, mainly gas, diesel and fuel oil and the remaining 13% was produced with hydropower plants. The share of hydro power to overall electricity generation fell down to about 4.5% in 2009 [MEW 2010]. A research conducted by CAS (Central Administration for Statistics) stated that 5-12% of electricity production comes from hydropower energy depending on rainfall and thermal plants productivity.

The distribution of electricity among different sectors is: 45% for residential and business sectors (i.e. low-voltage demand), 23% for industry, 12% for administrative buildings, 5% for concessions, and 15% for technical losses [Abi Said 2005]. A document of the World Bank stated that at least 50% of the electricity went to residential and business customers, while the rest was divided (from higher demand to lower) between industrial, administrative buildings, and concessions, respectively [World Bank, 2008]. Other sources place residential demand higher at 65–73% of total electricity consumed [Houri and Korfali 2005], or 80% if combined with the commercial sector [Houri 2006].

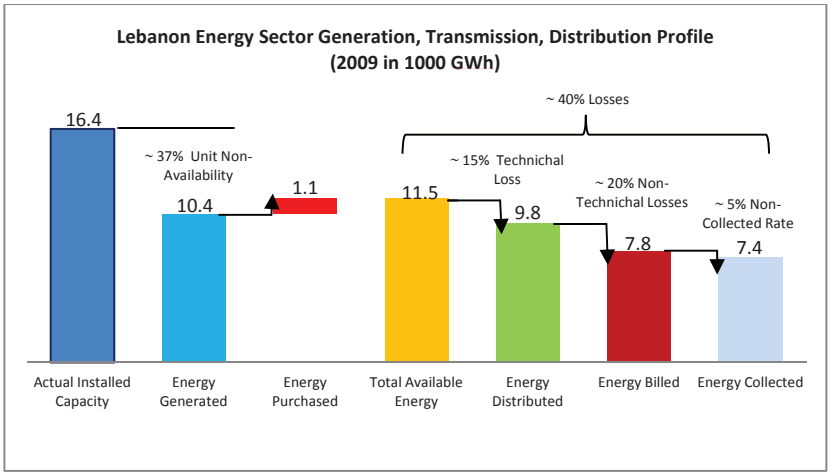

Figure 1 Lebanon electricity sector: generation, transmission, distribution [Data source: MEW 2010]

Administratively, the current number of employees at EDL is around 1700 [EDL 2011], where it should normally be 5020 employees according to EDL that is serving, more than 1,100,000 subscribers of low, medium, and high voltage. [EDL website]

With a tariff covering an oil price of only 25 US$/barrel [World Bank 2008], and a significant portion of generated electricity remaining unbilled (either due to technical losses or illegal consumption), as well as an overall inefficient management of the sector, substantial annual subsidy transfers are required from the Government to EDL. The figure below shows the subsidies that have been transferred to EDL since 1982. Tariff adjustments to compensate the cost augmentation have become commercially and politically challenging as the electricity service reliability remain a key issue, with outages occurring throughout the whole country daily.

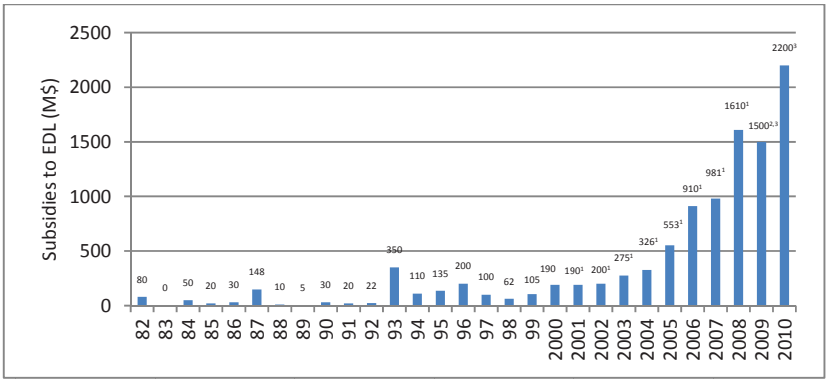

Figure 2 Subsidies to EDL between 1982 & 2010 [Data source: World Bank 2008, [1]MF 2010a, [2]MEW 2010 and [3]ALMEE 2010]

2 Generation

Currently, power generation plants in Lebanon are divided into two categories: thermal and hydraulic. EDL operates 6 thermal power plants:

- Two combined cycle gas turbine plants (CCGT), Deir-Ammar and Zahrani. Designed to operate using natural gas, these two plants are using gas oil/diesel instead [AZOROM 2007]
- Two steam turbine plants, Zouk and Jieh, which operate using heavy fuel oil (HFO) [AZOROM 2007]
- Two open cycle gas turbine plants, Baalbek and Tyre, which designed to operate using natural gas, they are using gas oil/diesel instead [AZOROM 2007]

In addition, there is a steam turbine power plant, Alhreesha, which is owned by Kadisha (Property Company of EDL) and uses HFO.

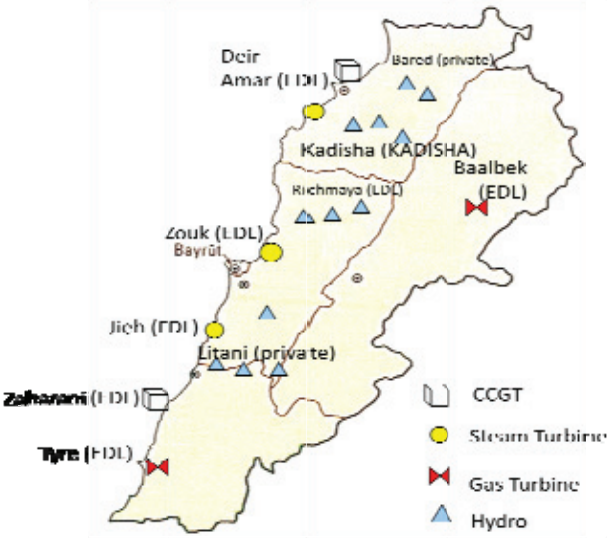

Figure 3 Power plants in Lebanon [Data source: EDL Website and AZOROM 2007]

The total installed capacity of these thermal power plants is 2038MW distributed among the as shown in table 1.

The hydraulic power plants are divided into Litani (public company), Al-Bared and Ibrahim (private companies), and Kadisha (property company of EDL) power plants. These hydro-power plants have a total installed capacity of 273.6 MW distributed as shown in table 2.

Figure 4 shows the evolution of electricity production according to the energy source between 1974 and 2010. It is noticed that hydraulic power plants have a small contribution to the total electrical production. Moreover, it could be noticed that both thermal and hydraulic power plants do not have fixed electrical production and change from one year to another.

Table 1 Installed capacity of thermal power plants (data source: 1.EDL website, 2.Abi Said 2005, 3.World Bank 2008)

Thermal Plant Name	Installed Capacity (MW)	Available Capacity in 2008 (MW)	Commissioning Date	Date of Retirement	Type of fuel
Zouk (ST)	607[1]	365[3]	1984-1987[2]	2015[2]	HFO
Jieh (ST)	346[1]	187[3]	1971-1981[2]	2010[2]	HFO
Alhreesha (ST)	75	60[2*]	1983[2]	2010[2]	HFO
Tyre (GT)	70[1]	70[3]	1996[2]	2021[2]	DO or NG
Baalbek (GT)	70[1]	70[3]	1996[2]	2021[2]	DO or NG
Zahrani (CC)	435[1]	435[3]	1997-1999[2]	2025-2030[2]	DO or NG
Deir-Ammar (CC)	435[1]	435[3]	1997-1999[2]	2025-2030[2]	DO or NG
Total	2038				

*available capacity in 2003

Table 2 Installed hydropower plants [Data source: EDL website &Green Line Association 2007]

River	Hydropower Plant Name	Installed Capacity (MW)	Installation date	Owner
Litani	Awali	108	1965	Litani Office (Public Company)
	Joun	48	1968	
	Abed Al	34	1961	
Al-Bared	Al-Bared1	13.5	1954	Private
	Al-Bared2	3.7	1962	
Safa	Safa/Richmaya	13.4	1932	Litani Office (Public Company)
Kadisha	Balouza	8.4	1961	Kadisha (Property company of the EDL)
	Abu Ali	7.4	1933	
	Mar Lichaa	3.1	1952	
	Bacharre	1.6	1929	
Ibrahim	Ibrahim 1	15	1962	Private
	Ibrahim 2	12.5	1956	
	Ibrahim 3	5	1950	
Total		273.6		

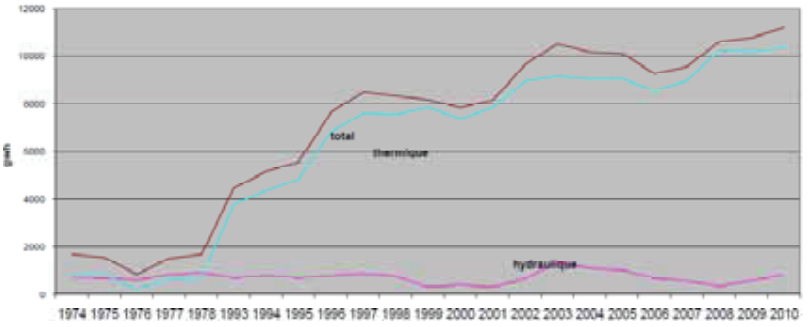

Figure 4 Evolution of electricity production by source [ALMEE 2010]

1.1 Problems

- There is a serious deficit in the generation capacity to meet demand. Figure 5 reveals the current and forecasting shortage of the power production. It is noticed that the demand increases versus a decreasing rate of supply and this fact increases the shortage gap and exerts large pressures on the government and society

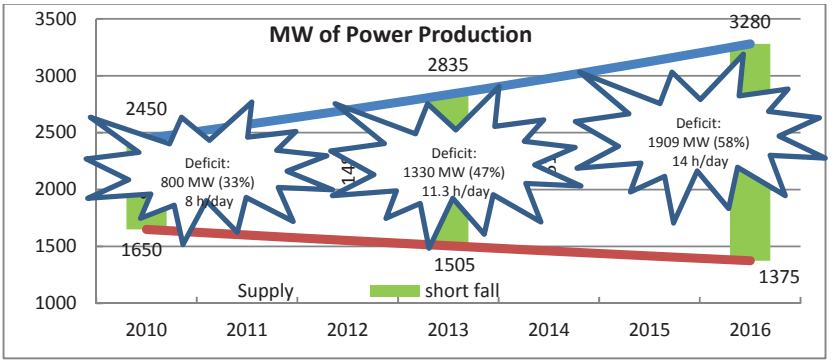

Figure 5 Forecasting of the power shortage [Data source: EDL 2011]

- There is a limitation and clear aging of two out of four major thermal groups that existed before the civil war (Zouk and Jieh). This limitation has led to an increase in the daily cost of maintenance and to a dramatic increase in technical problems and severe decrease in plant efficiencies
- Despite the fact that four of the generation plants were designed to use natural gas, they are being fuelled by expensive gas oil (diesel) which causes high generation costs. This is because natural gas is not yet effectively available
- Absence of periodic preventive maintenance
- In most cases, low quality fuel is used
- Plant availability factors are far below normal international acceptable values
- Load factors (i.e. ratio of actual output to potential output) are low, thus leading to a shortfall in the overall generation capacity
- There are significant shortfalls in thermal efficiency which raise the production cost
- The lack of proper and clear administrative orders to request fuel shipment on time. Moreover, oil installations (Zahrani and Tripoli) were forced to provide EDL with the stock market prices and the transfer of fuel in tanks, leading to additional losses

1.2 Recommendations

- The immediate substitution of diesel oil by Natural Gas for operating Deir-Ammar and Zahrani thermal power plants
- Rehabilitation of the existing power plants in Jieh and Zouk
- Develop new hydro and thermal power plants
- Establish regional electricity interconnections with the neighboring countries (Syria, Jordan, Egypt, Turkey)

- Increase of flexibility and diversify of the power supply system in order to cope with insecurities in power supply (by sources of energy, sizes, plant types, operators, etc.)
- Adopt a decentralized policy for energy production that allows commercial renewable energy investment in power generation and collection of fees [Green Line Association 2007]
- Establish operating guidelines for the informal electricity sector (private generators) that will protect and benefit consumers while ensuring continued availability of this alternative source [World Bank 2009b]

2 Transmission

EDL transmission network consists of three types of high voltage power lines: 66, 150, and 220 kV as well as 58 major power substations converting power from high voltage to medium voltage. In addition, the network, currently, includes more than 1615 km lines (1336 km of overhead lines and 279 km of underground cables) of various voltages used for transmission and distribution [EDL website].

Problems	Recommendations
• High technical losses (~15%) • There is a significant number of transformers (~11%) that are approaching the end of their average life [AZOROM 2007] • No computerized companywide management information systems exist to assist staff in the control of costs, inventory database, fault analysis, outage management, maintenance programs or work issue and reporting • Implementation of the 220 kV tension line network has not completed yet • HV porcelain lines and glass HV insulators have negative environmental effects • Many of the HV transformers are operating at high load factors which result in a lack of standby capacity • Load shedding occurs throughout the year, mainly during the day, and much less during the night • No financial independency within the Directorate to ensure good functionality • Frequent delays to work programs are caused by materials procurement difficulties	• Development of transmission network disturbance/fault analysis is urgently required to provide a benchmark for prioritizing network improvement and assessing current and future network performance • Establish management control and information systems to help the transmission staff in their work • Complete the 220 kV line which, if completed would increase stability, reduce the technical losses by more than 1% and increase the transmission capability of the system [MEW 2010] • Many HV lines require replacement [AZOROM 2007] • Atmospheric pollutions motivate the replacement of HV porcelain lines and glass HV insulators with composite types across the networks • Allocation of a sufficient budget for the Transmission Directorate in order to enhance its financial independency, at least for the procurement of low cost materials

3 Distribution

The distribution network consists of substations converting power from medium to low voltage using more than 18,000 transformers [MEW 2010] with their accessories and appurtenances in order to deliver electrical power to every subscriber.

The physical interface between EDL transmission and distribution networks is at the cable end box of the outgoing medium voltage (MV) cubicles from the main transmission stations. The distribution networks are supplied primarily at 11 kV, 15 kV and 20 kV, with some additional networks at 5.5 kV and 33 kV. The nominal low voltage (LV) is 380/220 volts [AZOROM 2007].

Problems	Recommendations
• Existence of uncollected electrical consumption bills (~5% in 2009 [MEW 2010]) • High non-technical losses (~ 20%) • There is no planned maintenance of the MV/LV substation assets and problems arising are dealt with on a "action-reaction" basis • The age profile of MV/LV transformers indicates that 37% of the transformer assets are over the average life expectancy (20 years) • There are severe overloading problems on the Beirut area MV networks • No financial independency within the Directorate to ensure good functionality • Lack of good contractor workmanship • There is a kind of staff reluctance to use the correct approved tools (e.g. earthing sets) and to wear protective clothing (e.g. Safety Helmets). • The distribution transport fleet is old and poorly maintained, resulting in a high level of vehicle breakdown. In some cases the available vehicles were inappropriate for the involved work • Tools and equipment are regarded as very poor and inadequate • Staff shortage is being a critical problem • No computerized companywide management information systems exist to assist staff in the control of costs, inventory databases, fault analysis, outage management, maintenance programs or work issue and reporting • Frequent delays to work programs are caused by materials procurement difficulties • Unacceptably low cost approval levels within the Directorate result in delays in progressing work • Substations could be classified as obsolete and resources for replacement are a major constraint	• Reduce the unpaid consumption of electricity • Install a modern and efficient billing and metering system • Reduce the electricity theft and illegal connections by application of the penal law No. 632 • Quantification, patroling and inspection of the entire network in order to assess the network extent and condition and facilitate the placement of a systematic planned maintenance programs • Introduction of distribution network continuity analysis is urgently required to provide a benchmark for prioritizing network improvement and assessing future network performance • Installation of data gathering systems for the operations and maintenance areas • Carrying out planning studies • Initiation of remedial actions such as inspecting and recording defects, fault monitoring, etc… • Implementing Geographic Information Systems for Electricity of Lebanon (GISEL) [Assi 2007] that would provide EDL with the tools for collection, monitoring, and management and consequently reduce the non-technical losses and aid the Distribution staff in their work • Maintaining and increasing the capacities of the distribution network

4 Administrative status

- The average age of the employees in EDL is about 52 years [MEW 2010] with a huge shortage that reaches more than 60% of the supposed existing staff as a result of non-employment governmental policy
- The adopted recurrent administrative configurations is assigning non qualified people and transferring skilled engineers to small departments. This fact negatively affects the system work efficiency

- Loss of the institution's independence due to the ongoing political interference in the work of administration, administrative appointments, and employments
- Absence of computerization and need for information technology (IT) equipment
- Lack of operational studies and absence of clear operational planning
- Lack of knowledge in the field of financial and technical administrative oversight of the authorities concerned
- Absence of transparent financial and non-financial reports represented in non-auditing of the accounts since 2001 [MEW 2006]

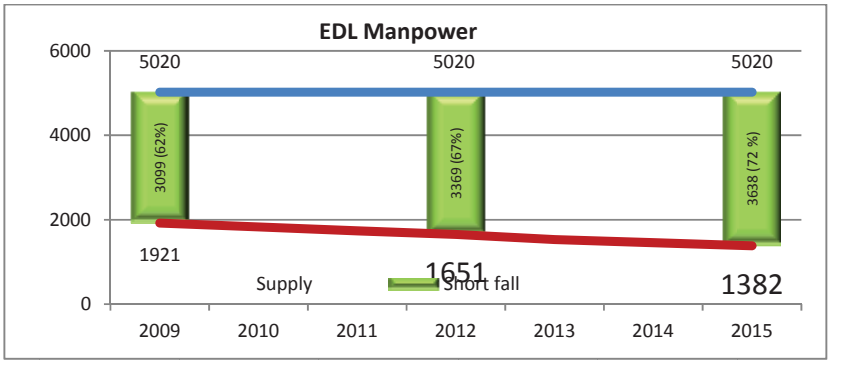

Figure 6 EDL Man Power Forecasting [Data source: EDL 2011]

Figure 6 illustrates a forecasting of the EDL staff shortage between 2009 and 2015. It reveals a current huge staff shortage, which is expected to reach more than 72% in 2015

4.1. Recommendations

- Appointment of well-qualified young employees having high technical and managerial skills to improve EDL tasks and support the introduction of renewable energy sources
- An overhang of the currently retired staff for more few years could be beneficial in order to pass their expertise to the new generation and help in the restructuring of EDL
- Encourage collectors to be more productive in work by providing them financial incentives [Halawi 2009]
- Adoption of a document backup software to save files and improve the existing archive system
- Activate the administrative links between the General Directorate and other Directorates

5 Financial status

- Tariffs are much lower than the actual cost of the produced electricity. The average cost of electrical production in 2009 was 255 LL/kWh (0.17 US$/kWh) [MEW 2010] compared to an average bill of 127 LL/kWh (0.085 US$/kWh). Thus, EDL is losing with each kWh sold and the losses will increase as it sells more

- The electricity tariff has not changed since 1996 when the oil price averaged 21 US$/barrel and has been reported by EDL to cover up to 25 US$/barrel only [World Bank 2008]
- Bad investment in new plants and assets added additional losses instead of increasing the revenues (OCGT instead of CCGT in Tyre and Baalbek power plants)
- EDL is falling deeply into dept and depending more and more on the governmental subsidies (~2200 M$ in 2010) which keeps it under the mercy and the will of the politicians to provide more credits
- The contribution of the fuel bill to EDL total budget was around 1450 M$ (75%) and 1165 M$ (62%) in 2008 and 2009 respectively. This reveals the high price of fuel that is negatively affecting the financial status of EDL
- Inability of the company to prosecute the aggressors to the network. Note that most of electrical thefts are covered by the political leaders
- Lack of seriousness in bill collections and the weakness of follow-up mechanisms that resulted in an increase of arrears, which amounted to hundreds of billions LL
- Lack of an internal auditing system which negatively affects the accuracy of institution's financial accounts [EDL 2010]
- Absence of a computerized accounting system that links all the institution accounts

5.1. Recommendations

- Adjust the tariff to better reflect the cost of electricity production, transmission and distribution
- Reduce the production cost by changing the preparation of fuel tenders in order to make them more transparent and fit the international standards [Halawi 2009]

6. Conclusion

There is no doubt that electric energy, at present time, has no longer been a luxury product but it has become one of the social security needs and living priorities for all citizens and thus meeting the electricity demand must be a priority for the government. In this study, a detailed review of the unique electricity provider in Lebanon, EDL, is displayed revealing a great shortage in the generating capacity and human resources as well as a great deficit in the administrative and financial operations. However, away from the various technical and administrative problems, EDL would not be effective without finding a serious compatible political will that aims at rehabilitating and developing the electricity sector.

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