Providing electricity to Lebanese households:
A feasibility study and a sensitivity analysis

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By Invitation:

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The purpose of this note is twofold: (1) to study the feasibility of a project of providing a 24 over 24 hour electricity power to Lebanese households, and (2) to undertake a sensitivity analysis by varying the key parameters of the model. The note tackles only households because business and industry power demand is hard to ascertain. However, if such demand can be identified the model of this note can be easily expanded to incorporate the total electricity needs for Lebanon.

One point of contention is the available capacity of energy. The underlying assumption is that this actual capacity will be totally devoted to commercial usage, and hence total household energy supply starts from scratch. If this assumption is not imposed the effect on the dollar profitability of the project is to reduce it, contrary to intuition, but the effect on the pro rata profitability will remain the same. This is true because decreasing the required and purchased capacity will reduce the total dollar investment, the total revenues, the total dollar costs, and the total dollar profits in direct proportions, while keeping the average rate of return the same.

The key parameters of the model hereafter follow together with their estimated values. Total yearly demand per household is 24*365 hours of electricity. A household subscription to a private generator of 5 amperes yields on average 1.15 kW per hour. So total usage of kW per household is 1.15*24*365=10,074 kW per year or 839.5 kW per month. The number of households is taken initially to be one million. This implies an average nuclear household size between 3 to 5 members. Hence total monthly power supply must be 839.5 kW multiplied by one million. Available data on generator capacity on the internet is for a maximum of 50 MW (Mega Watts). Hence what is needed is a fleet of 839.5/50 generators or 16.8 generators. The capital cost per generator varies between US-$ 825 million and US-$ 1,368 million depending upon the supplier and the brand (https://en.tech-expo.ru/des-50MWt/). Therefore the total cost is between US-$ 13.86 and 22.98 billion. A value of US-$ 17.00 billion will be assumed, which is less than the average but includes an allowance for economies of scale in building a power plant of capacity of 839.5 MW (or more) instead of purchasing 16.8 generators of 50 MW capacity each.

Next the unit price (p) and the marginal cost (c) are to be assessed. The official price for the consumption of one kW of electricity usage is calculated as 13,556/28,621= US-$

0.474, where 13,556 is the price in Lebanese pound per kW, and 28,621 is the price of one US dollar in the parallel market (see the latest, June 30, 2022, pricing schedule of the Ministry of Energy and Water). Since private generator owners do not stick exactly to this official price, the price will be taken to be US-$ 0.52 per kW, a premium of around 10%.

Assume a constant marginal cost (c). This is not totally unrealistic because the output of one generator is a direct function of diesel oil usage. A multiplication of the diesel oil usage by two will in all likelihood increase generator output by a factor of 2. The marginal cost was estimated to be 17 cents (World Bank, May 2020, Lebanon cost-of-service and tariff design study Final report). Around that time, i.e. in May 2020 or slightly before, the price per gallon of diesel oil was US-$ 2.5. Since the current diesel price is around US-$ 5.6, then the current marginal cost is estimated to be US-$ 0.38 per kW. The model implies a total dollar yearly revenue (TR) per household to the owner of the generator, or yearly charge per household, of $TR = p * Q = 0.52 * Q$, and a total yearly cost (TC) to the generator owner of $TC = c * Q = 0.38 * Q$, where Q is the yearly energy consumption per household. Net yearly dollar profits (π) per household to generator owners are

$$\pi = TR - TC = (p - c) * Q = (0.52 - 0.38) * Q = 0.14 * Q.$$

Finally, the last parameter is the growth factor. It will be assumed that the total number of households increases by 2% yearly. This means that capacity must increase also by a compound rate of 2%. The additional capital cost for expanding the fleet of generators, to keep up with growing consumption, must also increase by a 2%, growing itself by 2%. This means that the additional cost for the first year is 2.04% of the current capital cost (which is US-$ 17 billion), for the second year is 2.081%, for the third year is 2.12%,for year 10 is 2.44%, and thereby ongoing.

Having defined the total revenues, the total costs, and the ensuing net profits, these yearly net profits are discounted to the present in order to take into consideration the time value of money. These discounted net profits will be cumulated to produce what is labelled as the NPV (i.e. the Net Present Value), also called Present Worth. The criterion is to accept the investment project if the NPV is positive. Other variables are also computed like the Internal Rate of Return (IRR) which is the discount rate that drives the sum of the present values of net cash flows to zero, and is a measure of inherent profitability and rate of return.

The discount rate has to be fixed. If it is selected to be 8.00% the NPV is around US-$ 230 million, and is equivalent to US-$ 18.4 million of yearly net cash flows. The IRR is 8.19%. At these values the electricity project is acceptable. However if the discount rate rises to 9.00% the NPV is a negative US-$ 2,030 million. Therefore the project profitability is highly sensitive to changes in the discount rate. A discount rate of 10% is sometimes advocated in the economics literature, which will dent even more the NPV. However there are two reasons for expecting a much lower rate. One, the investment is of public benefit. Public projects command usually a much lower net benefit to cost ratio of around 5% to 6%. At 5.5% the NPV is an astounding US-$ 11.961 billion, equivalent to US-$ 658 million per year ad infinitum! The second reason is that an investment in infrastructure is likely to attract funds from worldly and regional sponsoring agencies. A subsidized financing rate of 3% to 4% can be realizable and obtainable. With a discount rate of 3.5%, the NPV is simply enormous at US-$ 50.690 billion! Which shows once again that the project is highly sensitive to changes in the discount rate. This rate ought therefore to be monitored carefully, precisely and accurately. Spending money and time to improve the estimation process is recommended.

The reason for this high sensitivity is the assumption that the horizon is infinite. A US-$ 1 in perpetuity has a present value of 10 if the discount rate is 10%, which equals 1/0.1. And a US-$ 1 in perpetuity has a present value of 11.11 if the discount rate is 9%, which equals 1/0.09. Hence for a 1% decrease in the discount rate the present value rises by around 11.11%. With a similar argument, and for an increase of 1% to 11% in the discount rate, the present value of a US-$ 1 perpetuity is 9.09, a fall of 9.09%. In the literature a usual resolution of this problem is to assume a finite useful life of say 10 years. However, this necessitates the estimation of a salvage value at year 10. Assuming no loss in monetary value, if the salvage value is taken to be US-$ 17 billion, then the average internal rate of return is a rather acceptable figure of 7.8%.

There is one caveat. Investment in a diesel plant is not friendly to the environment. It has a negative externality, which must have a social cost. The adjustment to a greener economy can be incorporated in the model in two ways. One, is to increase the measured cost, and the other is to increase the discount rate. The last alternative is considered herein and consists in raising the discount rate by 2%. The adjusted discount rate would be 5.5%+2.0%=7.5%. At this rate the project is sustainable and has an NPV of US-$ 1.690 billion, which indicates failure to reject the investment proposal. The base level discount rate hereafter is taken to be 7.5%.

If the capital cost is US-$ 18 billion instead of US-$ 17 billion, i.e. an increase of approximately 6%, the NPV remains at US-$ 433 million. If the capital cost is US-$ 19 billion instead of US-$ 17 billion, i.e. an increase of approximately 12%, the NPV becomes at a negative US-$ 824 million. The capital cost needs to be raised to US-$ 18.3 billion in order to reach a zero NPV, an increase of approximately 7%. It is concluded that the feasibility of the project is rather sensitive to changes in the capital cost (not a very reassuring result).

An increase in the number of households has obviously a positive effect on the project's profitability. A 10% increase in the size of households raises the NPV to US-$ 4.0 billion, higher by 140%!

A higher household growth rate is also a favorable event. If the growth rate is 3% instead of 2%, the NPV rises by 27%. However, if the rate falls to 1% the NPV falls by almost 20%, but is still positive at US-$ 1.36 billion. Hence the project's NPV is not sensitive to a change in the growth rate, although the percent change in the NPV is high.

A higher price per unit to 54 cents from 52 cents increases the NPV by around 200% approximately. A lower price per unit to 50 cents from 52 cents decreases the NPV by 100% approximately, and the NPV is negative at US-$ 1.6 billion. The same effects are obtained if the marginal cost is reduced by 2 cents or increased by 2 cents, respectively. This is due to the fact that as long as the margin $(p - c)$ remains constant the net effect on the NPV cancels. Thus the NPV is highly sensitive to changes in the net profitability margin. This explains why electricity generator owners complain so much more about the cost of higher diesel oil market prices.

The general conclusion is that a project of providing electricity to Lebanese households is not only commendable on equity grounds but also profitable, because the merits of providing electricity for all and around the clock, exceed their monetary cost, even when the additional social cost of the damage to the environment is factored in. Changes in most of the parameters are found to affect significantly the resulting project NPV. The NPV is highly sensitive to changes in the discount rate, in the capital cost, in the growth rate, in the number of existing households, and in the net profit margin. Although the baseline scenario produces a hefty rate of return of 7.5%, this figure is highly uncertain when changes in the parameters are introduced. If total or partial financing is forthcoming the project becomes not only feasible but extremely profitable, and, moreover, the uncertainty will dissipate and become manageable.

The analysis in this note does not show abnormal profits in the generator market. An average return of 7.5% is good but not anomalous, although it is earned in a safe and hard currency. Given the ease of entry, the low fixed installation cost, and the common ignorance of the social cost in the calculus decision, the market seems to be rather saturated. The past flurry and proliferation of private generators must have ended and a more competitive equilibrium must have emerged and must have been reached.

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