GREENPEACE
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NO MORE EXCUSES:

TIME TO GO RENEWABLE

Assessment of Lebanon's Updated Electricity Policy Paper

GREENPEACE MENA

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I. EXECUTIVE SUMMARY

In April 2019, the Lebanese ministry of energy and water announced a plan for the electricity sector with the objective to supply round the clock power by 2020 with the least impact on the economy and the environment. This study from GP MENA focuses on analyzing the plans of the ministry looking at its commitment to develop and roll out renewables in the country and provides an alternative plan that favors renewables.

The first observation in the analysis shows that the ministry plan, predominantly focuses on thermal power plants (natural gas), which is not in line with the country's 30% renewable energy commitment by 2030 goal although it acknowledges it. Indeed, implementing the plan as is would make it very challenging to reach the renewable energy goal as it locks in an excess of thermal capacity and leaves little room and time for enough renewable energy deployment. Considering the Lebanese context, planning a mass deployment of renewable energy after the implementation of the policy plan (after 2026) to reach the 30% objective is a risky approach. Once 24h electricity has been secured through a massive investment on natural gas thermal power plants, incentives to significantly invest in renewable energy will be lower since energy security would no longer be an issue. Furthermore, current deployment of centralized renewable energy plants has been progressing at a very slow pace, due to various reasons, raising doubts about the feasibility of mass renewable energy deployment in just 5 years (2026-2030) to reach the 30% objective.

On the economic side, GP MENA made a comparative analysis between the ministry plan and a proposed optimal scenario that favors a significant deployment of renewable energy coupled with energy efficiency. The analysis demonstrates that the state will profit more by the latter. Reaching a 31.2% share of renewable energy in electricity consumption by 2026 will lead to a 14% increase in profit for the public utility, 'Electricité du Liban', compared to the ministry plan. Although the report focuses solely on technical and economical perspectives, the environmental and public health benefits of switching to renewables are undeniable and will also lead to indirect economic benefits that were not quantified. This is even more critical considering the country's rampant air pollution problems that are well documented, including in a global analysis done by Greenpeace for the period of June to September 2018. In that analysis, Lebanon has been identified as a pollution hotspot with the city of Jounieh ranking 23rd worldwide in NOx pollution, a dangerous pollutant produced by the combustion of fossil fuels such as oil and natural gas. The optimal scenario will lead to the cancellation of 740 MW of thermal capacity that would be equivalent to scrapping plans for a new Zouk power plant and downsizing the Jieh plant by 190 MW.

Therefore, it is our recommendation that the plan should be revisited to reflect the mass deployment of renewable energy in parallel to any plan in the pursuit of securing 24h electricity. In brief, more renewable energy means more economic, environmental and health benefits. There are no more excuses: It is time for Lebanon to (seriously) go renewable!

II. BACKGROUND

In 2010, the ministry of energy and water published the first policy paper for the electricity sector, aiming at achieving 24/24 electricity supply by 2015.

The policy paper was built on three major pillars, including infrastructure, legal framework, and supply and demand. Despite efforts to implement the policy paper and massive investments through electricity power barges, the 24/24 target was not achieved.

In 2019, the ministry of energy and water updated the electricity policy paper, with more focus on reduction of technical and non-technical losses, and the objective to achieve 24/24 electricity supply by 2020.

The updated policy paper continues in the same guidelines of the 2010 policy paper with a bigger focus on construction and rehabilitation of thermal power plants and little attention given to energy efficiency and renewable energy even though the 30% renewable energy objective by 2030 is mentioned.

A major milestone in the updated policy paper to achieve 24/24 electricity supply is through the support of 1,450 MW interim power plants, without a clear indication of whether they are to be in the form of barges, distributed generators, or temporary central plants.

1. Assumptions

In order to complete the assessment, certain assumptions are made based on local context, market growth, and published reports. These assumptions are presented in the following table:

	Factor	Assumption	Rationale
[a]	Private generators capacity	750 MW	Published in different papers to be 25 to 35%
[b]	Private generators electricity	6,000 GWh/yr	Published in different papers to be 25 to 35%
[c]	Additional Hydro capacity	100 MW by 2023	Mentioned in annex to be 50 to 100 MW new capacity
[d]	Additional distributed PV	10 MW per year	Following the pattern of the last 2 years in DREG
[e]	Natural gas energy yield	6,000 MWh/MW	Based on international market average by EIA
[f]	Solar PV energy yield	1,500 MWh/MW	Based on DREG report
[g]	Wind energy yield	3,500 MWh/MW	Based on UNDP-Climate Change report
[h]	New fuel for power plants	Natural Gas	Based on the intention to switch to Natural Gas
[i]	Import from Syria end	2020	With added capacity, there will be no need for imports
[j]	Hydro energy yield	4,000 MWh/MW	Based on average yield for hydro plants in Lebanon
[k]	Power plants O&M Cost	15%	Based on international benchmarks
[l]	Wind LCOE 2020	¢10 /kWh	Based on current wind farms PPA negotiation price
[m]	Wind LCOE forecast	5% drop/year	Based on IRENA's Power to Change 2016 report
[n]	Solar PV LCOE 2020	¢7 /kWh	Based on current PV farms PPA negotiation price
[o]	Solar PV LCOE forecast	7.6% drop/year	Based on IRENA's Power to Change 2016 report
[p]	PV Storage LCOE 2020	¢12 /kWh	Based on current PV farms PPA negotiation price
[q]	PV Storage LCOE forecast	7.6% drop/year	Based on IRENA's Power to Change 2016 report
[r]	EDL increased tariff	¢14.47/kW	Based on initial version of updated policy plan. Tariff

2. Legends

Throughout the report and the analysis tables, the following highlights and indicators are used:

Ownership	EDL	Interim	IPPs	Imports	RE	
Fuel	HFO	NG	NG OCGT	Diesel	RE	Other

III. EXPANSION PLAN OVERVIEW

The expansion plan presented in the policy paper extends from 2019 to 2026, with no clear prospects beyond this time. But according to the numbers that will be presented, the capacity expected to be in operation by the end of 2026 would be sufficient to cover 2026 demand. If no more capacity is added, and following the same demand growth rate of 3%, as mentioned in the policy paper, by 2030, there will be an expected deficit of 9%.

The expansion plan as per the paper is presented in the following sections:

A. Thermal Power Plants

Currently, thermal power plants use diesel oil or heavy fuel oil, with a total of 9 power plants in Zouk, Zahrani, Jiyeh, Deir Amar, Baalbeck, Tyr, and Hrayche. Hrayche is owned by a third party with an independent power producer (IPP) signed with EDL.

Over the years, 1 power plant is proposed to be built in Selaata, in addition to the addition of thermal units in Zahrani and Deir Amar with an additional capacity of 910 MW each, and expansion of other existing plants.

The new installations in MW over the years 2019 to 2026 are presented in the following table:

	Current	2020	2021	2022	2023	2024	2025	2026
Zouk 1	440			-440		360	190	
Zouk 2	157			-157				
Jieh 1	180			-180		360		190
Jieh 2	63			-63				
Zahrani 1	420							
Zahrani 2				360	190			
Deir Amar 1	430							
Deir Amar 2			360	190				
Baalbeck	57							
Tyr	56				100			
Hrayche	46	-46				300		
Selaata 1				360	190			
TOTAL	**1,849**	**-46**	**360**	**70**	**480**	**1,020**	**190**	**190**

Accordingly, the cumulative installed capacity over the years is as follows:

	2019	2020	2021	2022	2023	2024	2025	2026
Zouk 1	440	440	440	0	0	360	550	550
Zouk 2	157	157	157	0	0	0	0	0
Jieh 1	180	180	180	0	0	360	360	550
Jieh 2	63	63	63	0	0	0	0	0
Zahrani 1	420	420	420	420	420	420	420	420
Zahrani 2	0	0	0	360	550	550	550	550
Deir Amar 1	430	430	430	430	430	430	430	430
Deir Amar 2	0	0	360	550	550	550	550	550
Baalbeck	57	57	57	57	57	57	57	57
Tyr	56	56	56	56	156	156	156	156
Hrche	46	0	0	0	0	300	300	300
Selaata 1	0	0	0	360	550	550	550	550
TOTAL	**1,849**	**1,803**	**2,163**	**2,233**	**2,713**	**3,733**	**3,923**	**4,113**

B. Interim Power

With a current deficit of around 30%, there are currently two major sources of power to provide back up electricity. The first is through two power ships (barges) in Zouk and Jiyeh, while the second is through distributed private diesel generators, where end-users deal directly with the operator. The current barges have a total capacity of 374 MW (with an effective capacity of 390 MW in 2018), while private generators are estimated to have a total capacity of 750 MW.

The policy paper aims at eliminating the need for distributed private generators through adding an interim power capacity of 1,450 MW, without specifying the technology and fuels to be utilized.

The newly installations in MW over the years 2019 to 2026 are presented in the following table:

	Current	2020	2021	2022	2023	2024	2025	2026
Zouk Barge	195			-195				
Jiyeh Barge	195			-195				
Zouk Interim		100				-100		
Jieh Interim		200				-200		
Zahrani Interim		700				-700		
Deir Amar Interim		450				-450		
Private Generators	*750*	-750						
TOTAL	**1,140**	**700**	**0**	**-390**	**0**	**-1,450**	**0**	**0**

Accordingly, the cumulative installed capacity over the years is as follows:

	2019	2020	2021	2022	2023	2024	2025	2026
Zouk Barge	195	195	195	0	0	0	0	0
Jiyeh Barge	195	195	195	0	0	0	0	0
Zouk Interim	0	100	100	100	100	0	0	0
Jieh Interim	0	200	200	200	200	0	0	0
Zahrani Interim	0	700	700	700	700	0	0	0
Deir Amar Interim	0	450	450	450	450	0	0	0
Private Generators	750	0	0	0	0	0	0	0
TOTAL	**1,140**	**1,840**	**1,840**	**1,840**	**1,450**	**0**	**0**	**0**

C. Electricity Import

For the past decade, Lebanon has been importing electricity from Syria to supply areas adjacent to the border, especially with the deficit in electricity supply through EDL. In 2017, the overall import was 533,803 MWh per year. The installations in MW over the years 2019 to 2026 are presented in the following table:

	Current	2020	2021	2022	2023	2024	2025	2026
Import from Syria	69	*-69*						
TOTAL	**69**	**-69**	**0**	**0**	**0**	**0**	**0**	**0**

Accordingly, the cumulative installed capacity over the years is as follows:

	2019	2019	2020	2021	2022	2023	2024	2025	2026
Import from Syria	69	69	0	0	0	0	0	0	0
TOTAL	**69**	**0**	**-69**	**0**	**0**	**0**	**0**	**0**	**0**

D. Landfill Power

In December 2016, seven electricity generating sets were installed on Naameh landfill, each with a capacity of 1 MW. The 7-MW power plant is made up of two parts, one is the treatment system of the landfill gas through carbon filters, and the second part is the generation plant itself. The power plant is connected to the Damour substation via 12km 20kV underground cables to feed the local network.

The capacity installation in MW over the years 2019 to 2026 are presented in the following table:

	Current	2020	2021	2022	2023	2024	2025	2026
Naameh Landfill	7							
TOTAL	**7**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

Accordingly, the cumulative installed capacity over the years is as follows:

	2019	2020	2021	2022	2023	2024	2025	2026
Naameh Landfill	7	7	7	7	7	7	7	7
TOTAL	**7**	**7**	**7**	**7**	**7**	**7**	**7**	**7**

E. Hydroelectric Power

Lebanon has been using hydroelectric power for decades, with a share sometimes reaching more than 70% of the national electricity demand. This share varies by water availability, but most importantly drops by the increase in demand and drop in additional installations of hydropower plants.

The highest share of hydropower of the overall supplied electricity by EDL (excluding private generators) in the past decade was in 2012, when it reached 11.8%. Which then dropped annually to reach 2.76% in 2017.

The plan doesn't focus on hydropower as a major component, only mentioning that there will be new installations without mentioning the locations, capacities, and availability. Going through the annex, there is an intention to achieve 50 to 100 MW of new hydropower plants by 2023. Considering the best-case scenario, we are assuming an installation of 100 MW of Hydropower in 2023.

Note: In general, Greenpeace supports the trend to focus on small and 'smart' hydro projects that do not involve the construction of dams, but the issues that arise are complex and often very ecosystem specific. Not all 'large' hydro projects are bad, and some 'small' hydro projects can be very destructive. However, hydro power can and must play a significant role in a sustainable energy future.

The capacity installation in MW over the years 2019 to 2026 are presented in the following table:

	Current	2020	2021	2022	2023	2024	2025	2026
Richmaya	3							
Litani	47							
Nahr Irahim	17							
Bared	6							
Kadisha	15							
Other					*100*			
TOTAL	**88**	**0**	**0**	**0**	**100**	**0**	**0**	**0**

Accordingly, the cumulative installed capacity over the years is as follows:

	2019	2020	2021	2022	2023	2024	2025	2026
Richmaya	3	3	3	3	3	3	3	3
Litani	47	47	47	47	47	47	47	47
Nahr Ibrahim	17	17	17	17	17	17	17	17
Bared	6	6	6	6	6	6	6	6
Kadisha	15	15	15	15	15	15	15	15
Other	0	0	0	0	100	100	100	100
TOTAL	**88**	**88**	**88**	**88**	**188**	**188**	**188**	**188**

F. Renewable Energy

According to the policy paper, a total of 45 MW renewable energy capacity are currently installed (mainly solar PV), with an intention to add a total of 480 MW of solar energy by 2022, and 620 MW of wind energy by 2023.

Although not mentioned in the policy itself, the annex mentions the intention to add 7 MW to the existing Beirut River Solar Snake (BRSS) PV plant. Also not mentioned in the policy paper is the annual installation of decentralized PV systems estimated at an annual average of 10 MW (see assumption table).

The capacity installation in MW over the years 2019 to 2026 are presented in the following table:

	Current	2019	2020	2021	2022	2023	2024	2025	2026
Distributed PV	44	*10*	*10*	*10*	*10*	*10*	*10*	*10*	*10*
Wind			220			400			
Solar PV	1		187						
Solar + Storage					300				
TOTAL	**45**	**10**	**417**	**10**	**310**	**410**	**10**	**10**	**10**

Accordingly, the cumulative installed capacity over the years is as follows:

	Curren	2019	2020	2021	2022	2023	2024	2025	2026
Distributed PV	44	54	64	74	84	94	104	114	124
Wind	0	0	220	220	220	620	620	620	620
Solar PV	1	1	188	188	188	188	188	188	188
Solar + Storage	0	0	0	0	300	300	300	300	300
TOTAL	**45**	**55**	**472**	**482**	**792**	**1,202**	**1,212**	**1,222**	**1,232**

IV. ENERGY MIX ANALYSIS

This section provides an in depth analysis of the:

1. Energy mix presented in the policy paper and its annexes
2. 30x30 scenario that builds upon the policy paper and extend to 2030 to reach the 30% renewable energy objective
3. Optimal scenario developed by GP MENA to reach an optimum energy mix in 2030 from an environmental and economic perspective

1. Policy Paper Analysis

A- ENERGY ANALYSIS

The results show sufficient supply starting 2020 all through the decade until 2026. But with the shy utilization of renewable energy, its share by 2026 would not exceed 13.5% of electricity consumption making the 30% by 2030 target very difficult to attain.

As for the 2020 target of 12%, with only 6.3% achievable renewable energy share, it is clearly missed even when adding the solar water heating installed capacity.

POLICY PAPER SCENARIO ENERGY MIX INDICATORS					
	**Deficit by 2020**	**0%**		**2020 RE Share**	**6.30%**
	**Deficit by 2026**	**0%**		**2026 RE Share (Demand)**	**13.5%**

It is worth noting that the energy demand projections are based on the demand growth rate of 3% per year, but do not take into consideration the possible drop in demand upon the end of war in Syria, which is expected to reach at least 500 MW.

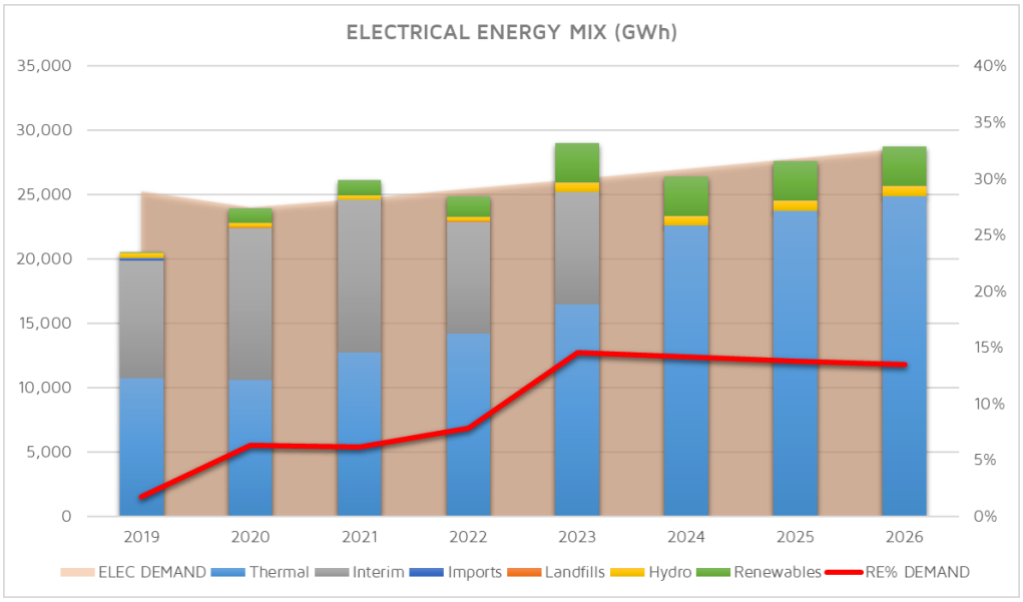

Figure 1: Policy Paper scenario electrical energy mix 2019-2026

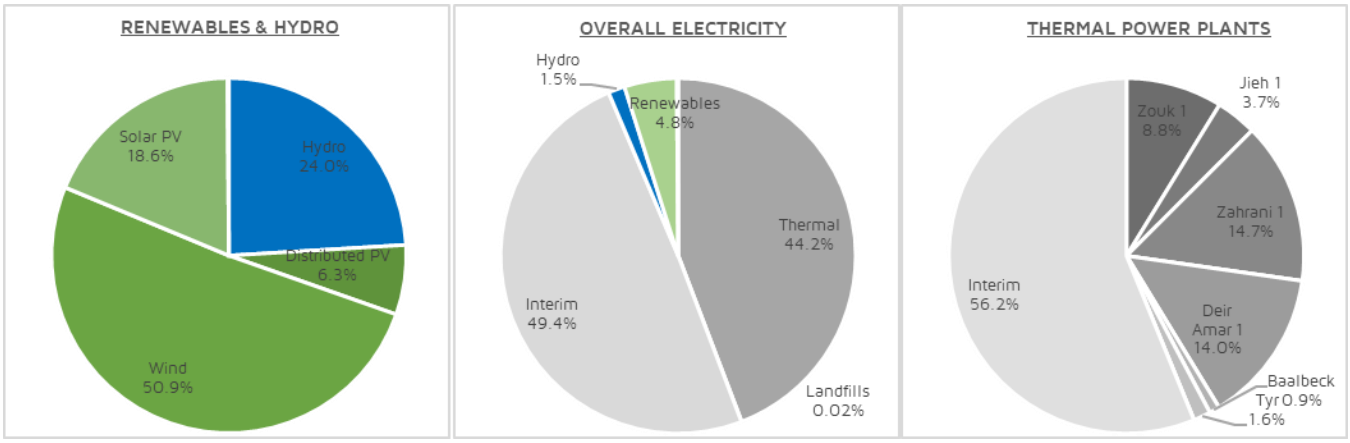

Figure 2: Policy Paper electrical energy consumption breakdown in 2020

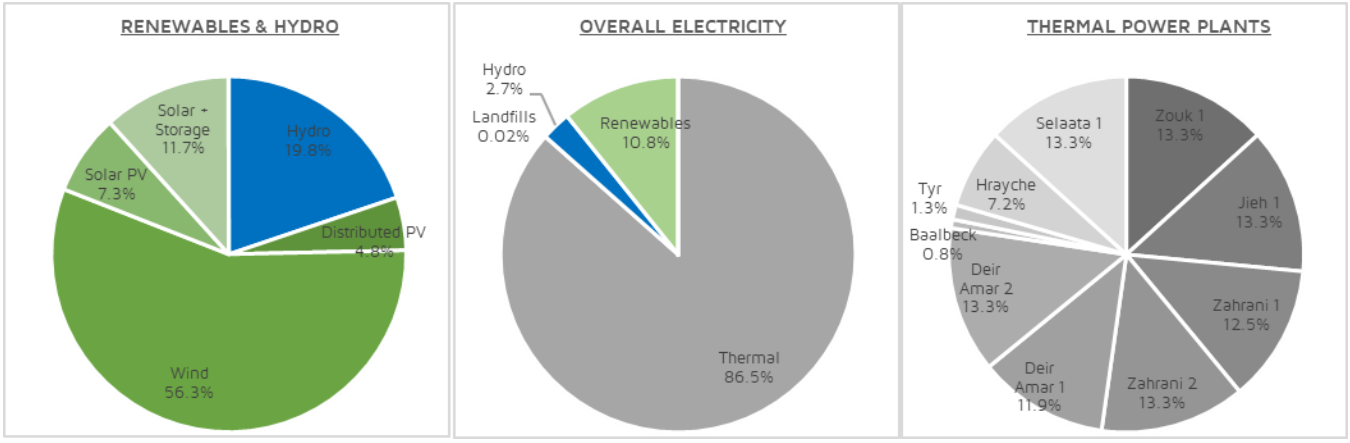

Figure 3: Policy Paper scenario electrical energy consumption breakdown in 2026

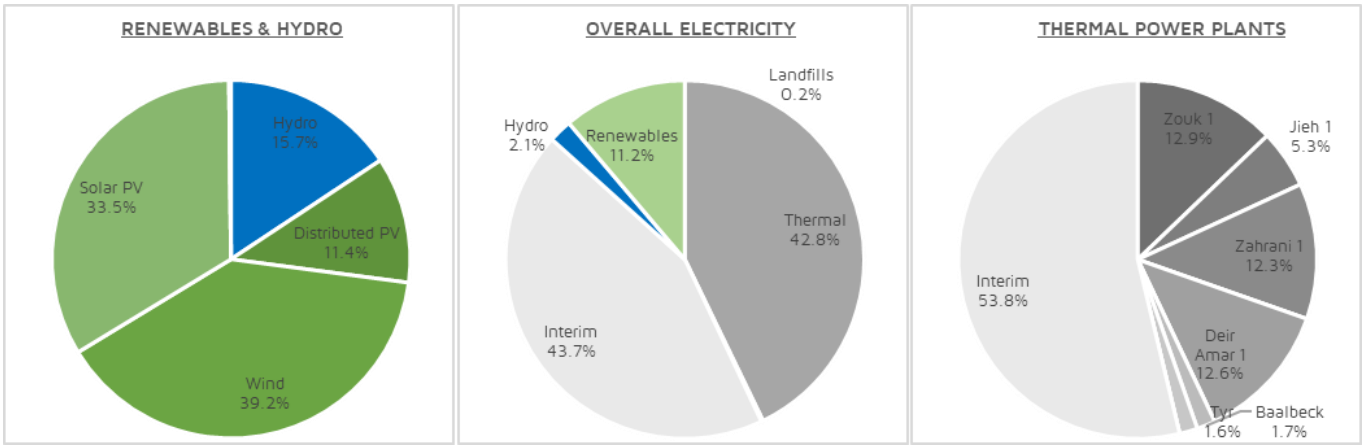

Figure 4: Policy Paper scenario installed capacity breakdown in 2020

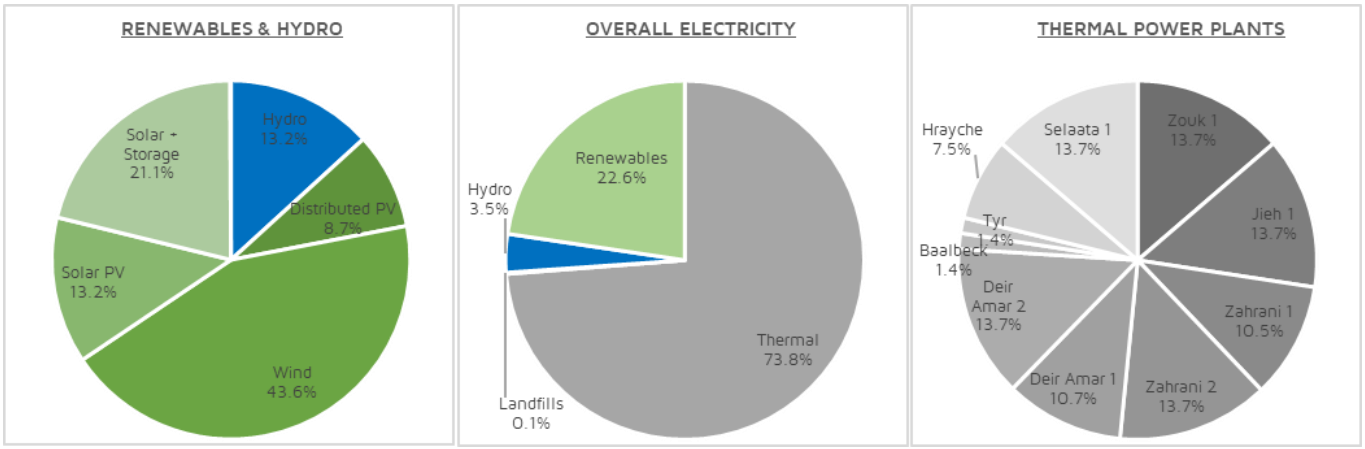

Figure 5: Policy Paper scenario installed capacity breakdown in 2026

POLICY PAPER SCENARIO ENERGY CAPACITY/SUPPLY INDICATORS							
Installed Capacity MW (Surplus/Deficit)				Energy Supply GWh (Surplus/Deficit)			
👎	2019	-1,280	-35%	👎	2019	-10,763	-43%
👍	2020	733	21%	👎	2020	-28	-0.1%
👍	2026	1,289	31%	👍	2026	105	0.4%

B- COST ANALYSIS

This energy mix contributes to a reduction in the electricity production cost rates, with a drop from 14.48 US Cents per kWh in 2019 to 10.41 US Cents 2026.

The analysis is performed using production prices as reported by EDL for the year 2017, using the oil prices for that specific year as an indicative value.

For renewable energy generation, distributed generation is not accounted for in the cost since these do not require any operational expenses from EDL. On the other hand for renewable energy applications through PPA, including BRSS phase 2, the average market prices are used based on latest PPA agreements in Lebanon and the pricing trends according to IRENA, with detailed prices in the assumptions section.

If we consider an increase in tariffs to reach ¢14.47 starting 2020, the kWh cost to price difference would drop from ¢5.28 loss in 2019 to ¢4.06 gain in 2026. *Note: Final tariff will be determined based on an ongoing World Bank study. For the sake of comparison, a tariff of ¢14.47 has been adopted in this analysis.*

POLICY PAPER SCENARIO PRICING INDICATORS								
kWh Cost			kWh Price			Annual Balance		
2019	¢14.48		2019	¢9.20		2019	-$956,195,424	-45%
2020	¢14.94		2020	¢14.47		2020	-$357,073,981	-10%
2026	¢10.41		2026	¢14.47		2026	$1,037,865,978	35%

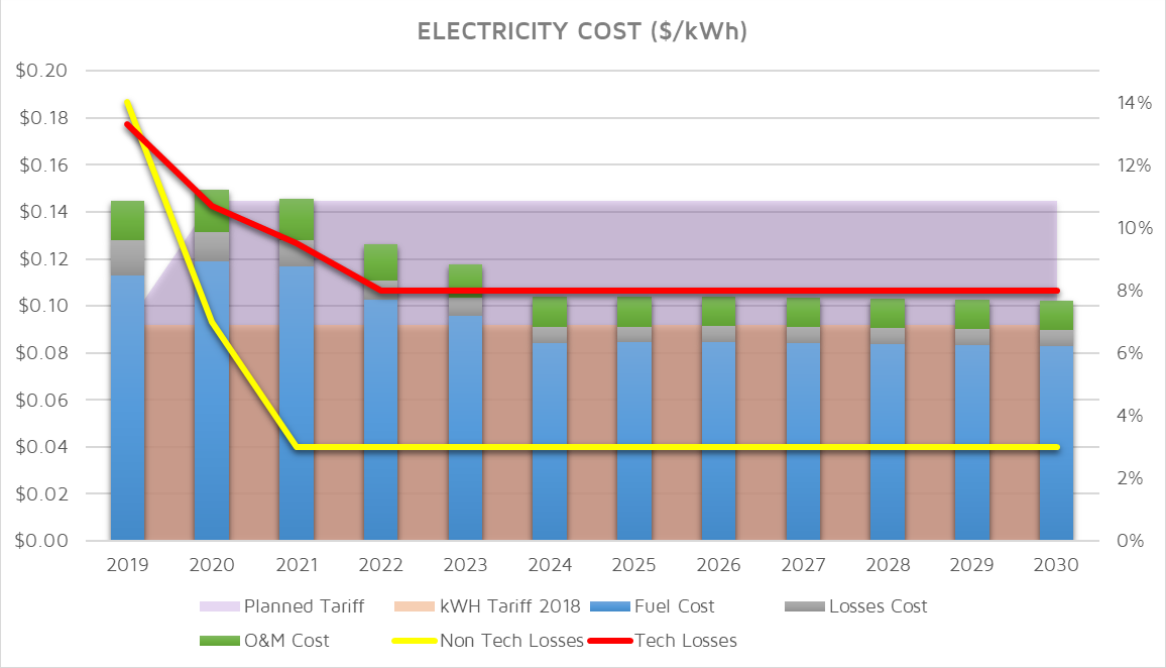

Figure 6: Policy Paper scenario electricity cost analysis 2019-2030

Considering the planned tariff change and reduction in technical and non-technical losses, combined with the energy mix as presented in the policy paper scenario, EDL is expected to breakeven starting 2020, to reach an overall profit of $1,037,865,978 estimated to offer a 35% surplus as compared to electricity operational expenses, excluding construction expenses by 2026.

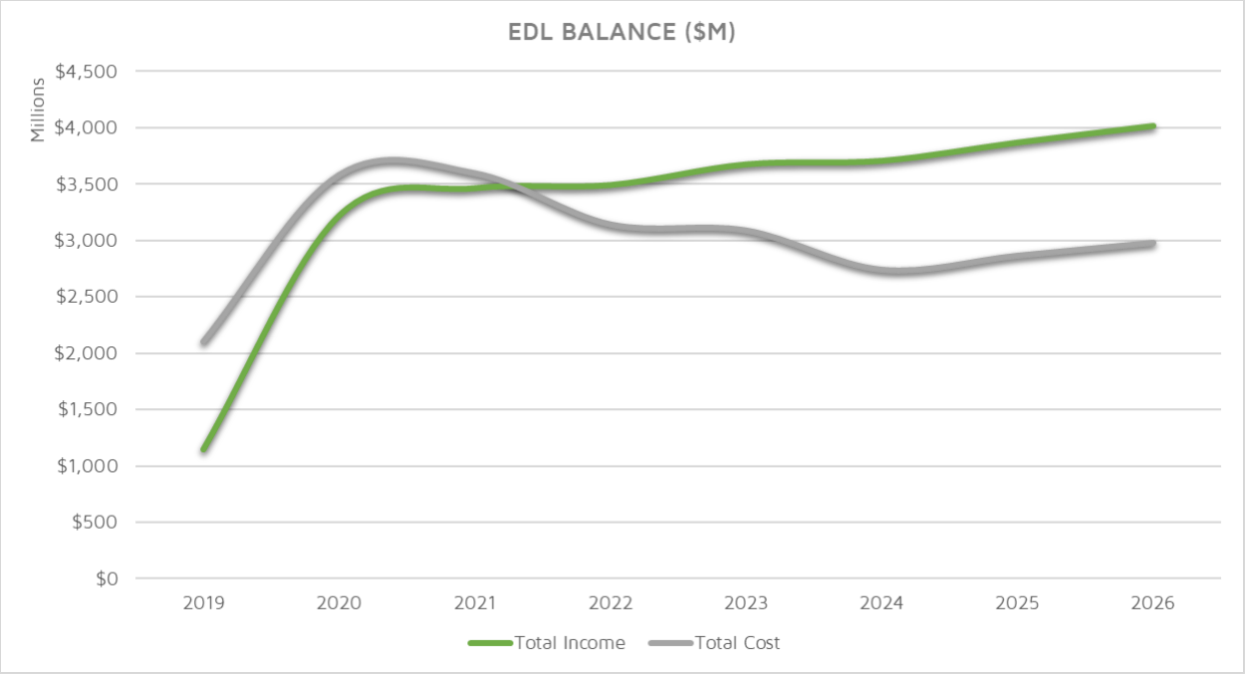

Figure 7: Policy Paper scenario EDL financial standing and annual balance

Note: In principle, the increase in tariff leads to an overall reduction in energy consumption. This reduction is not considered in the modeling approach.

2. 30x30 Scenario

This scenario builds on the policy paper data, its annexes, then focuses only on renewable energy over the years 2026 to 2030 to achieve the 30% electricity consumption by 2030 renewable energy target. It adds the following to the policy paper scenario:

- The projection to achieve an overall installed distributed PV capacity of 100 MW by 2020, with an annual installation rate of 24 MW per year is used for the years 2019 and 2020, then a 20 MW per year rate for the years after.
- Additional installed capacity of 1,200 MW of wind farms over a five year period (2026-2030)
- Additional installed capacity of 1,000 MW of solar PV farms over five year period (2026-2030)

30x30 scenario details are presented in Annex 1.

A- ENERGY ANALYSIS

The results show sufficient supply starting 2020 all through the decade until 2030. With the very aggressive utilization of renewable energy starting 2026, the renewables share would reach 30% of the electricity consumption by 2030, but this requires very significant investment in renewable energy without the addition of any other thermal plants in a relatively short period of time (2026 - 2030).

Although this is achievable in theory, it clearly indicates that the 2019 policy paper did not properly factor in the achievement of the 2030 target. Indeed the plan mostly focuses on conventional energy up till 2026 leaving little time and incentive to allow renewable energy to contribute to 30% of electricity consumption by 2030.

Even with a 100MW distributed PV capacity assumption, the 2020 target of 12% is far from being achieved with a RE share of only 6.48% (excluding solar water heaters).

30-30 SCENARIO ENERGY MIX INDICATORS					
	Deficit by 2020	0%		2020 RE Share	6.48%
	Deficit by 2026	0%		2026 RE Share (Demand)	18.8%
	Deficit by 2030	0%		2030 RE Share (Demand)	30.42%

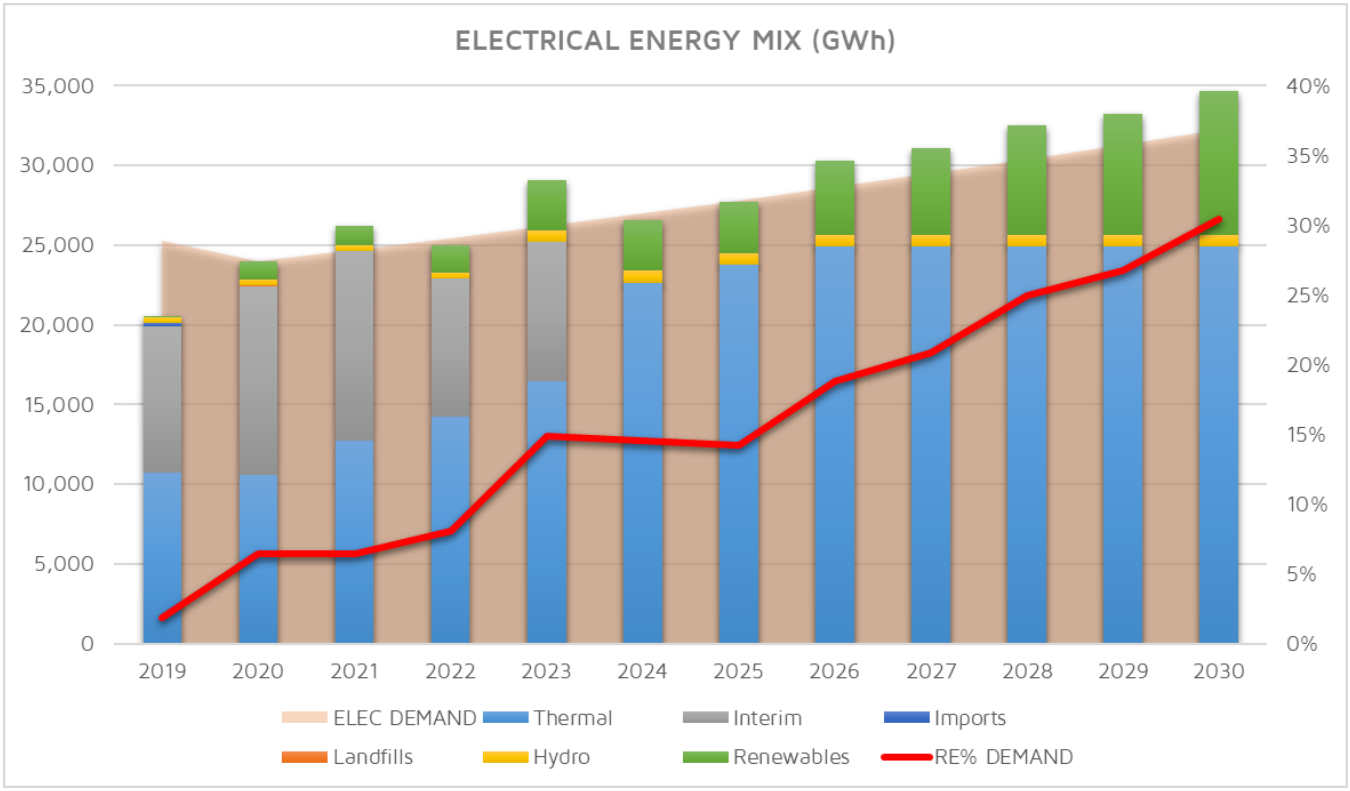

Figure 8: 30-30 scenario electrical energy mix 2019-2030

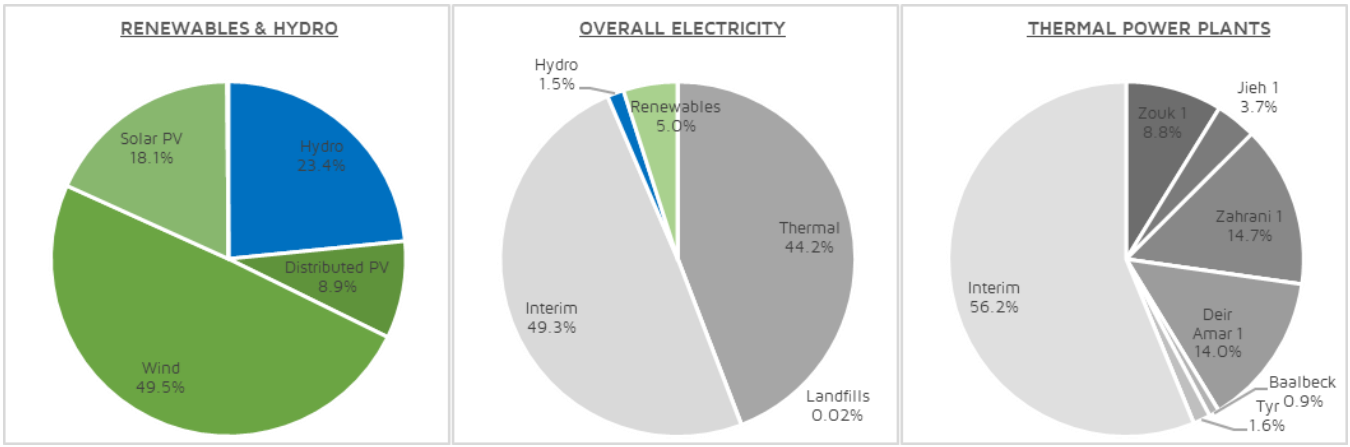

Figure 9: 30-30 scenario electrical energy consumption breakdown in 2020

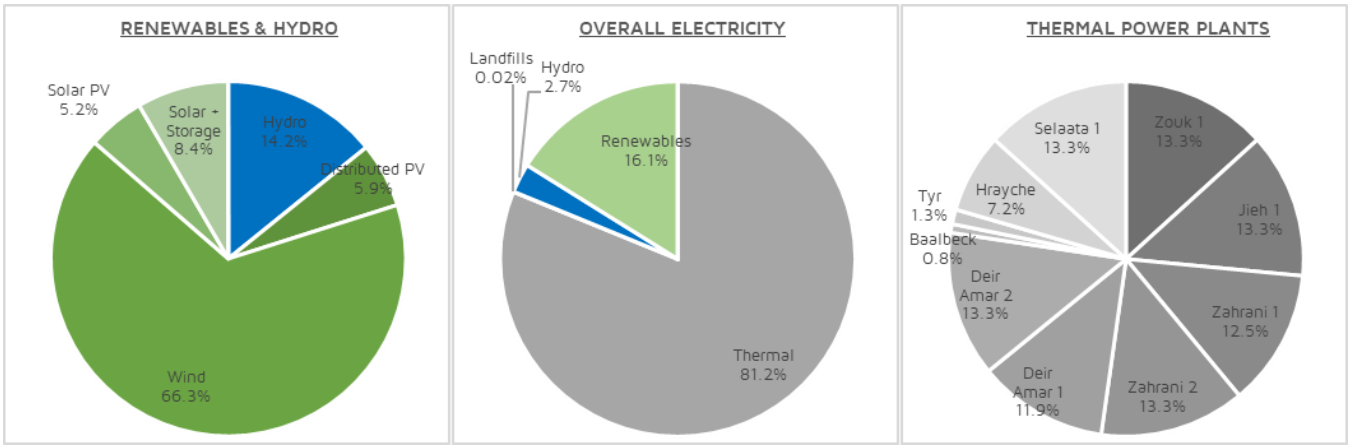

Figure 10: 30-30 scenario electrical energy consumption breakdown in 2026

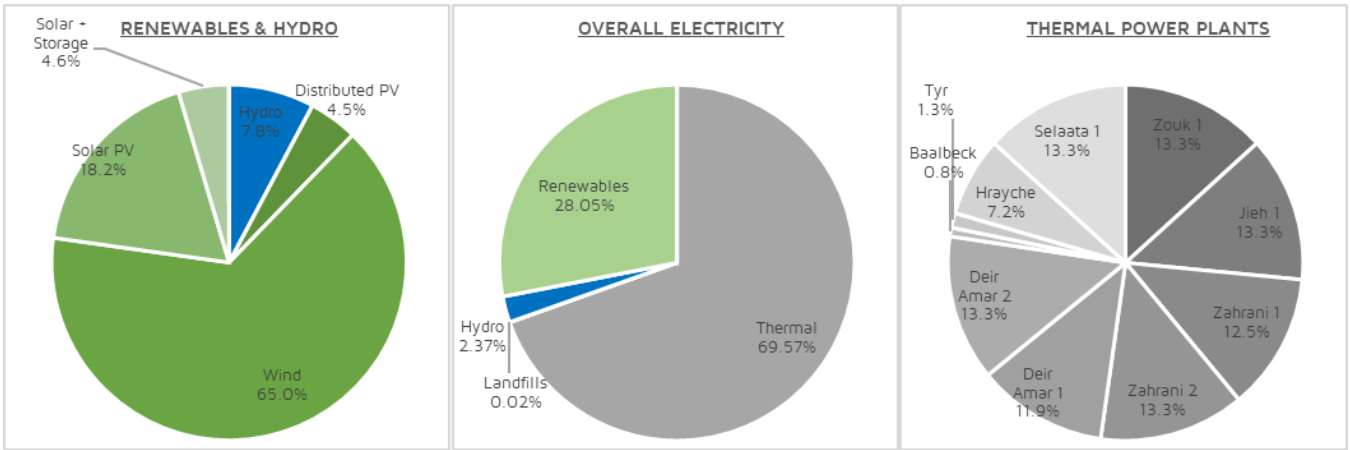

Figure 11: 30-30 scenario electrical energy consumption breakdown in 2030

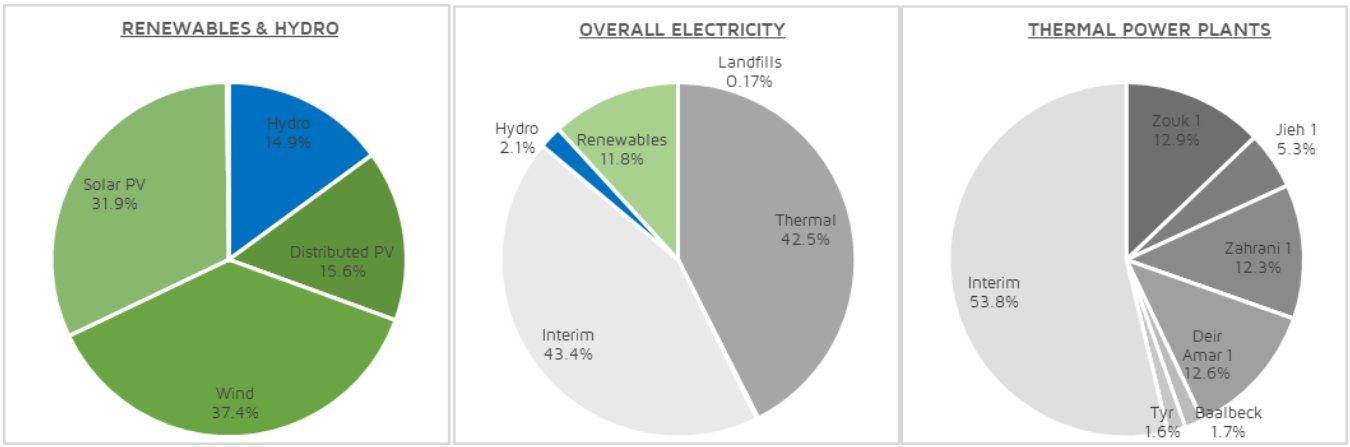

Figure 12: 30-30 scenario installed capacity breakdown in 2020

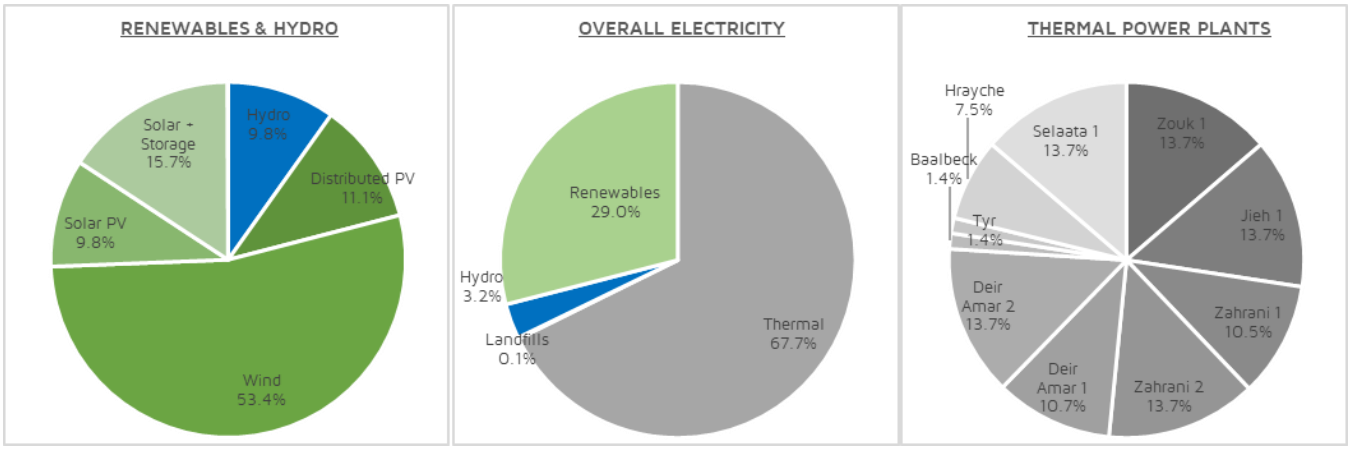

Figure 13: 30-30 scenario installed capacity breakdown in 2026

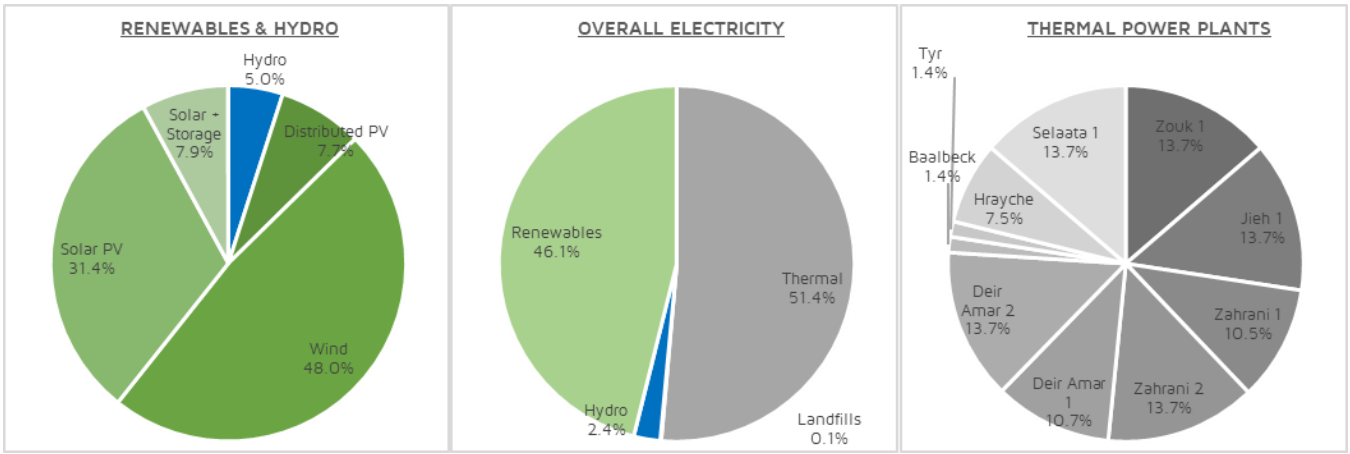

Figure 14: 30-30 scenario installed capacity breakdown in 2030

30-30 SCENARIO ENERGY CAPACITY INDICATORS							
Installed Capacity MW (Surplus/Deficit)				Energy Supply GWh (Surplus/Deficit)			
	2019	-1,266	-35%		2019	-10,742	-42%
	2020	761	22%		2020	14	0.1%
	2026	1,777	43%		2026	1,637	5.7%
	2030	3,136	67%		2030	2,463	8%

B- COST ANALYSIS

This energy mix contributes to a reduction in the electricity production cost rates, with a drop from 14.46 US Cents in 2019 to almost 66% of that in 2030 at 9.43 US Cents.

The analysis is performed using production prices as reported by EDL for the year 2017, using the oil prices for that specific year as an indicative value.

For renewable energy generation, distributed generation is not accounted for in the cost since these do not inquire any operational expenses from EDL. On the other hand renewable energy applications through PPA, including BRSS phase 2, the average market prices are used based on latest PPA agreements in Lebanon and the pricing trends according to IRENA, with detailed prices in the assumptions section.

If we consider an increase in tariffs to reach ¢14.47 starting 2020, the kWh cost to price difference would drop from ¢5.26 loss in 2018 to ¢4.12 gain in 2025, and ¢5.04 gain in 2030. Note: Final tariff will be determined based on an ongoing World Bank study. For the sake of comparison, a tariff of ¢14.47 has been adopted in this analysis.

30-30 SCENARIO PRICING INDICATORS								
kWh Cost			kWh Price			Annual Balance		
2019	¢14.46		2019	¢9.20		2019	-$954,533,904	-45%
2020	¢14.92		2020	¢14.47		2020	-$351,157,700	-10%
2026	¢10.27		2026	¢14.47		2026	$1,078,331,075	37%
2030	¢9.43		2030	¢14.47		2030	$1,483,105,993	49%

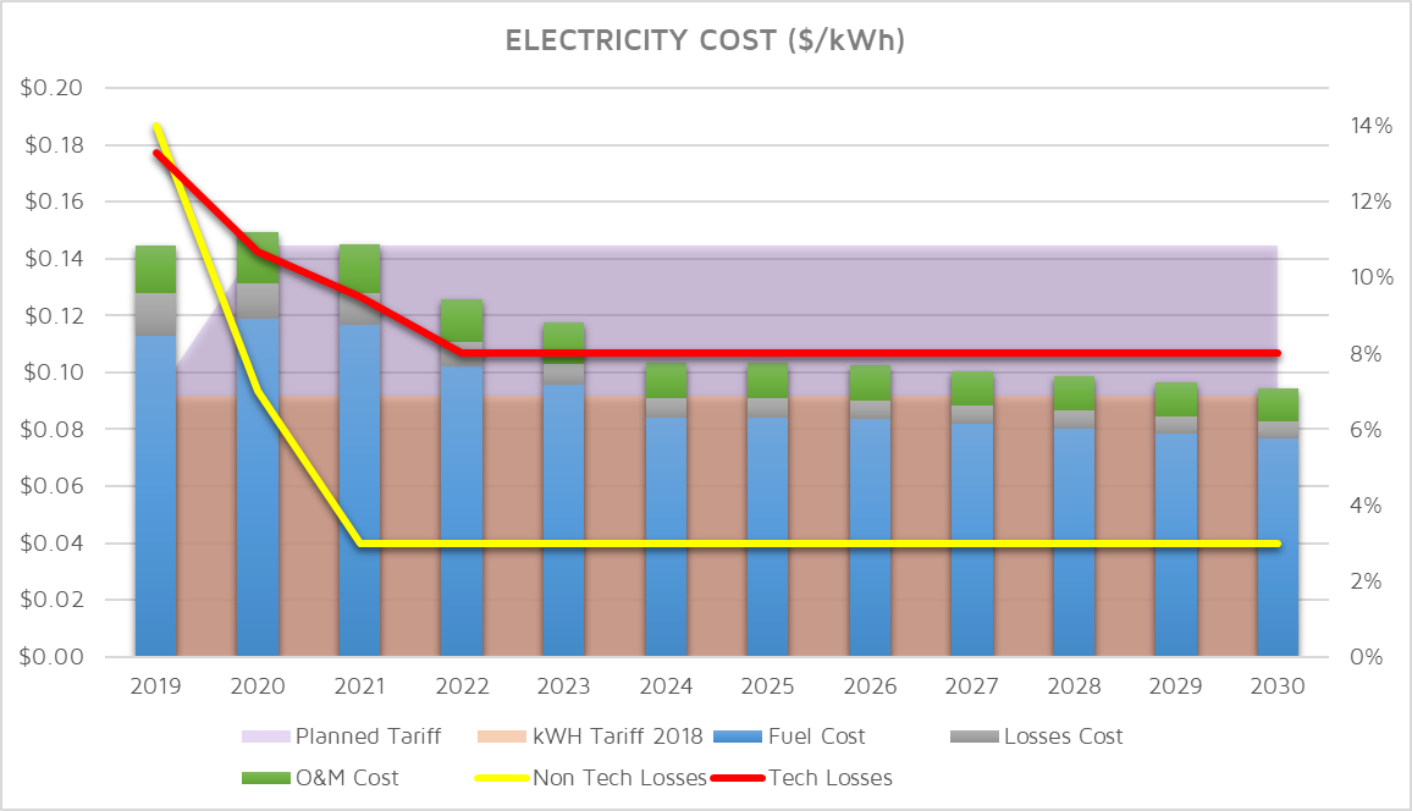

Figure 15: 30-30 scenario electricity cost analysis 2019-2030

Considering the planned tariff change and reduction in technical and non-technical losses, combined with the energy mix as presented in the policy paper scenario, EDL is expected to breakeven starting 2020, to reach an overall profit of $1,483,105,993 by 2030, estimated to offer a 49% surplus as compared to electricity operational expenses, excluding construction expenses.

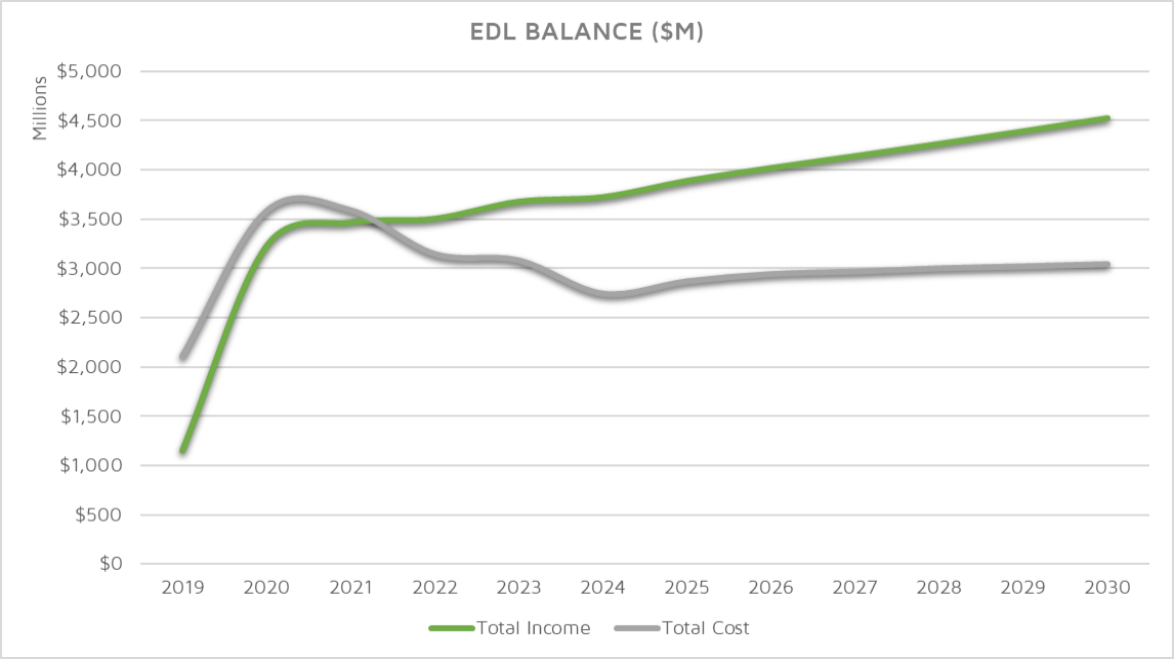

Figure 16: 30-30 scenario EDL financial standing and annual balance

3. Optimal Scenario

This scenario has been developed by GP MENA as the optimal energy mix to keep up with the growing demand, avoiding unnecessary construction of additional thermal power plant and with a lower impact on our environment and economy compared to previous scenario.

This scenario proposes an alternative scenario on the policy paper data. It focuses on renewable energy and relies on it as a major source for growth. It eliminates some actions and adds others to the policy paper scenario with the following major modifications:

- The projection to achieve an overall installed distributed PV capacity of 100 MW by 2020, with an installation rate of 24 MW per year used for the years 2019 and 2020, then a 20 MW per year until 2022.
- Bigger focus on energy efficiency to reduce annual energy demand growth rate from 3% to 1.5%
- Increasing the annual installation rate for decentralized PV to 50 MW per year from 2022 and on
- Installation of an additional capacity of 1,200 MW of wind and 2,000 MW of solar PV by 2030
- Reduction of thermal power plants installed capacity by 740 MW (could lead to shutting down the Zouk power plant, and limiting Jiyeh power plant to 360 MW instead of 550 MW for instance)

Optimal scenario details are presented in Annex 2

A- ENERGY ANALYSIS

The results show sufficient supply starting 2020 until 2030. With this integrated plan with a spread and gradual deployment of renewable energy throughout, its share reaches 42.85% of electricity consumption in 2030.

Even with a 100MW distributed PV capacity assumption, the 2020 target of 12% is far from being achieved with a RE share of only 6.5% (excluding solar water heaters).

OPTIMAL SCENARIO ENERGY MIX INDICATORS					
	Deficit by 2020	0%		2020 RE Share	6.5%
	Deficit by 2026	0%		2026 RE Share (Demand)	31.2%
	Deficit by 2030	0%		2030 RE Share (Demand)	42.85%

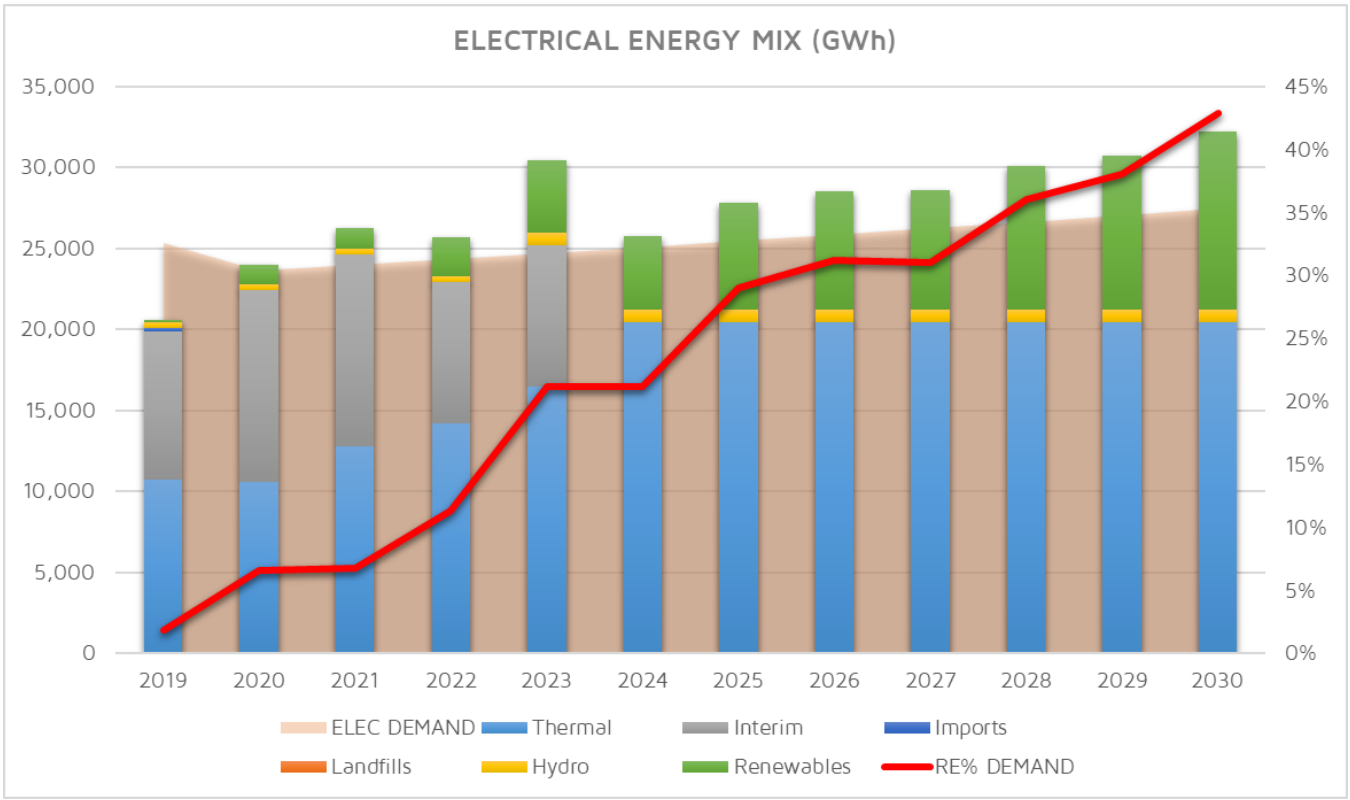

Figure 17: Ideal scenario electrical energy mix 2019-2030

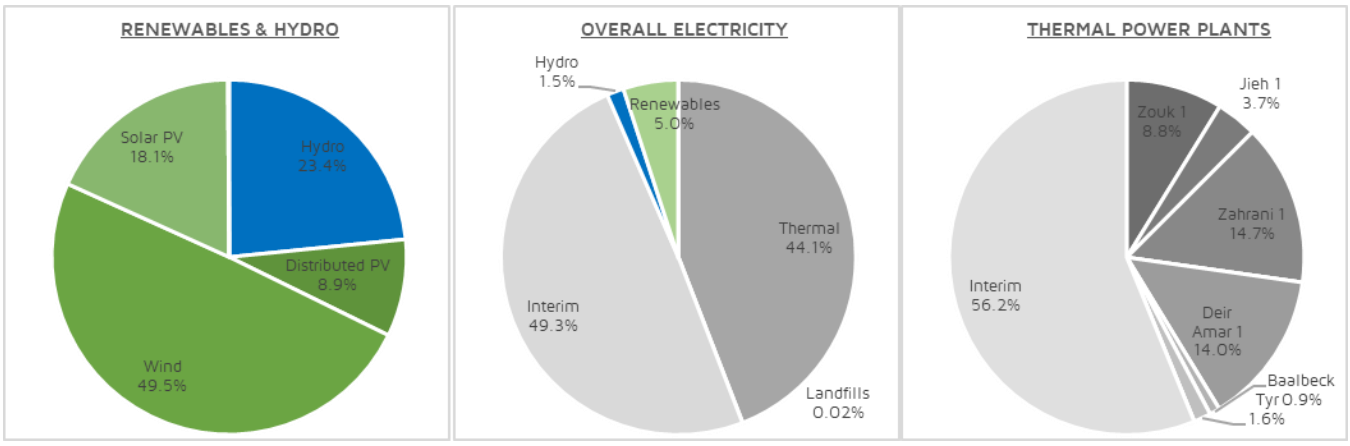

Figure 18: Optimal scenario electrical energy consumption breakdown in 2020

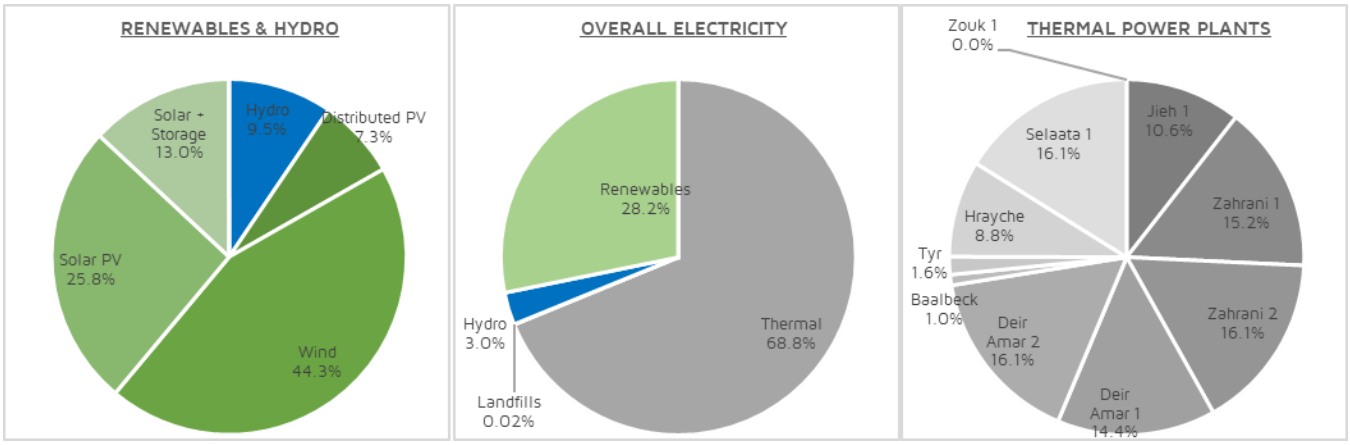

Figure 19: Optimal scenario electrical energy consumption breakdown in 2026

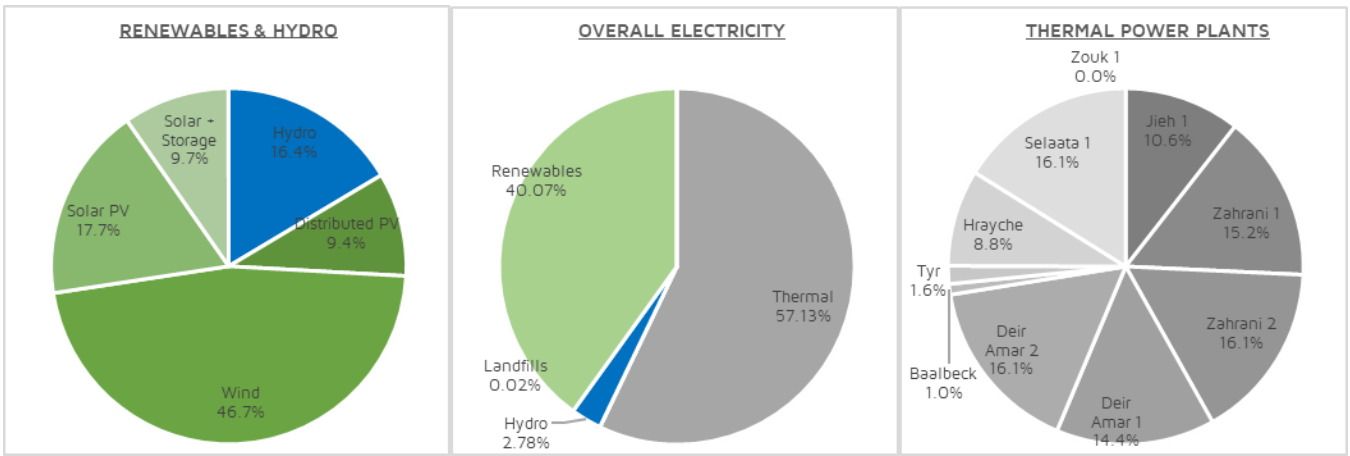

Figure 20: Optimal scenario electrical energy consumption breakdown in 2030

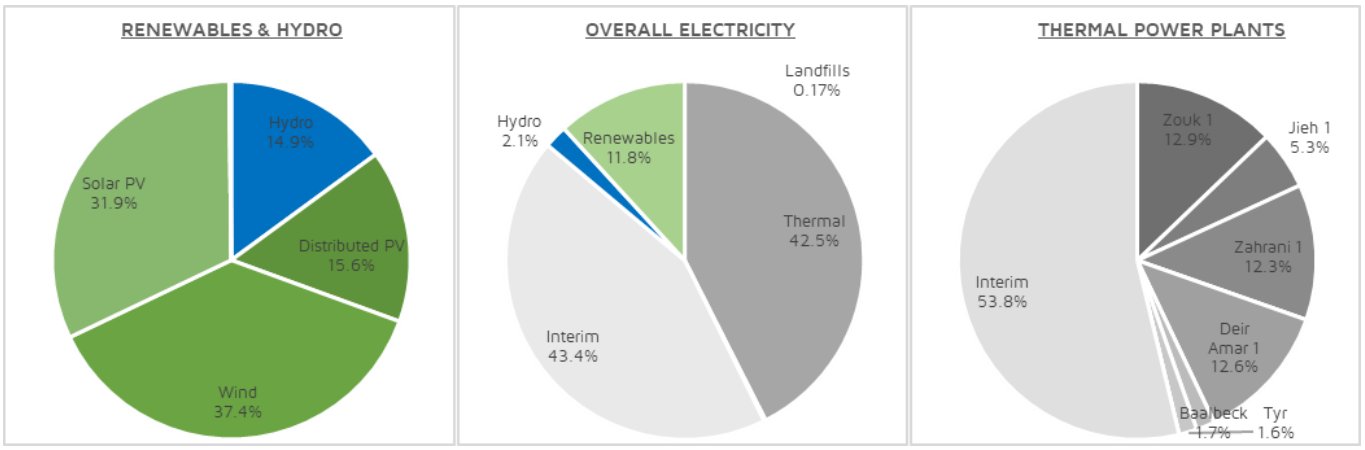

Figure 21: Optimal scenario installed capacity breakdown in 2020

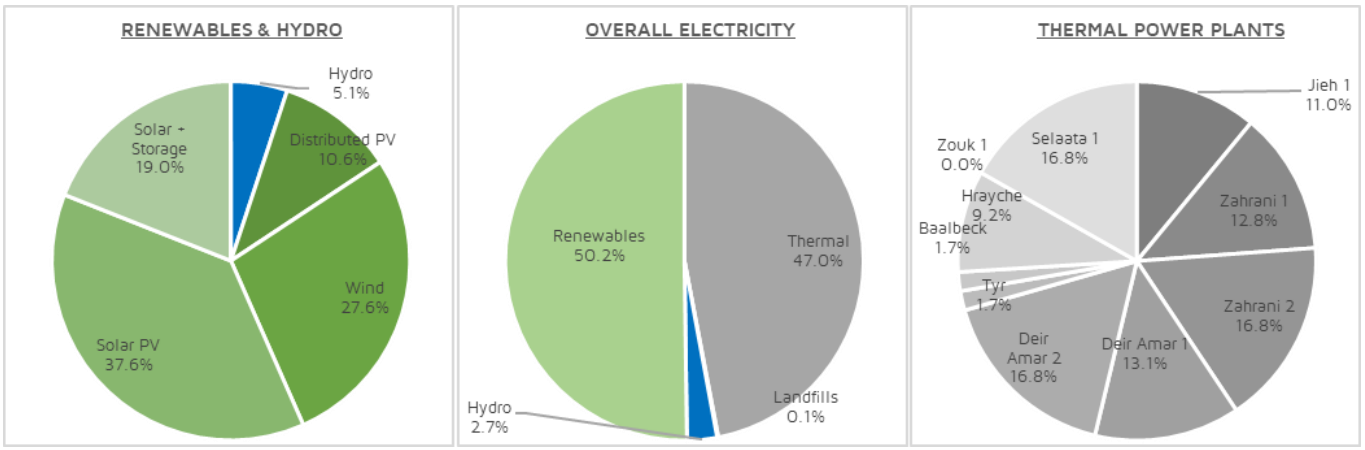

Figure 22: Optimal scenario installed capacity breakdown in 2026

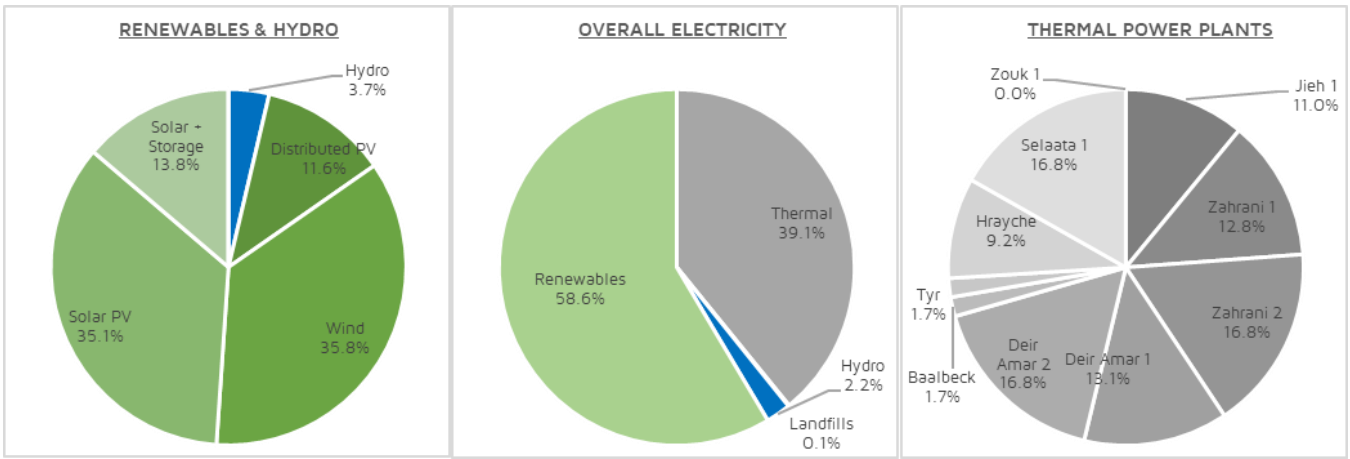

Figure 23: Optimal scenario installed capacity breakdown in 2030

OPTIMAL SCENARIO ENERGY CAPACITY INDICATORS							
Installed Capacity MW (Surplus/Deficit)				Energy Supply GWh (Surplus/Deficit)			
	2019	-1,266	-35%		2019	-10,742	-42%
	2020	812	24%		2020	363	1.5%
	2026	3,222	86%		2026	2,662	10.3%
	2030	4,392	110%		2030	4,776	17%

B- COST ANALYSIS

This energy mix contributes to a reduction in the electricity production cost rates, with a drop from 14.46 US Cents per kWh in 2018 to almost half that in 2030 at 8.50 US Cents.

The analysis is performed using production prices as reported by EDL for the year 2017, using the oil prices for that specific year as an indicative value.

For renewable energy generation through solar PV and wind, distributed generation is not accounted for in the cost since these do not inquire any operational expenses from EDL. For renewable energy applications through PPA, including BRSS phase 2, average market prices are used based on latest PPA agreements in Lebanon and the pricing trends according to IRENA, with detailed prices in the assumptions section.

If we consider an increase in tariffs to reach ¢14.47 starting 2020, the kWh cost to price difference would drop from ¢5.26 loss in 2018 to ¢4.76 gain in 2025 and ¢5.897 gain in 2030. Note: Final tariff will be determined based on an ongoing World Bank study. For the sake of comparison, a tariff of ¢14.47 has been adopted in this analysis.

OPTIMAL SCENARIO PRICING INDICATORS									
kWh Cost				kWh Price				Annual Balance			
	2019	¢14.46			2019	¢9.20			2019	-$954,533,904	-45%
	2020	¢14.91			2020	¢14.47			2020	-$344,520,595	-10%
	2026	¢9.45			2026	¢14.47			2026	$1,184,365,514	48%
	2030	¢8.5			2030	¢14.47			2030	$1,517,617,399	65%

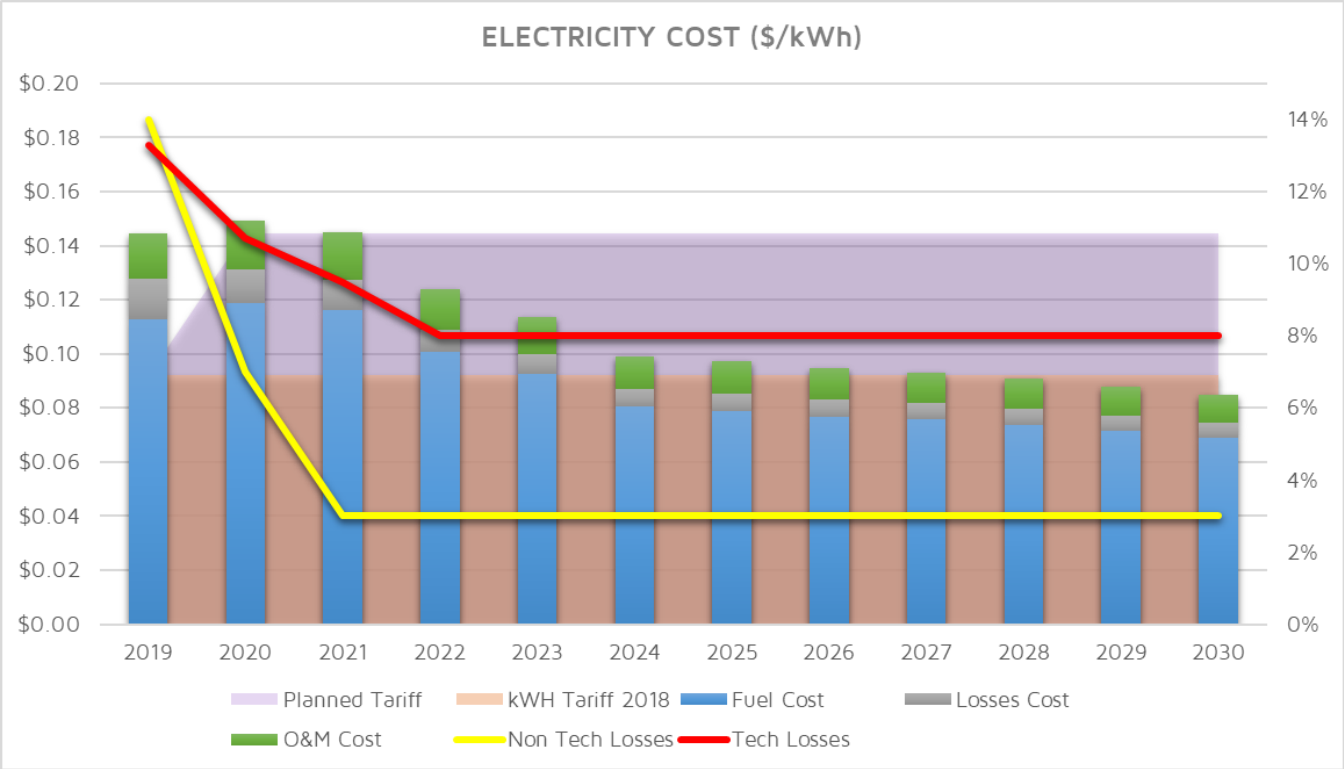

Figure 24: Optimal scenario electricity cost analysis 2019-2030

Considering the planned tariff change and reduction in technical and non-technical losses, combined with the energy mix as presented in the policy paper scenario, EDL is expected to breakeven starting 2020, to reach an overall profit of $1,517,617,399 by 2030, estimated to offer a 65% surplus as compared to electricity operational expenses, excluding construction expenses.

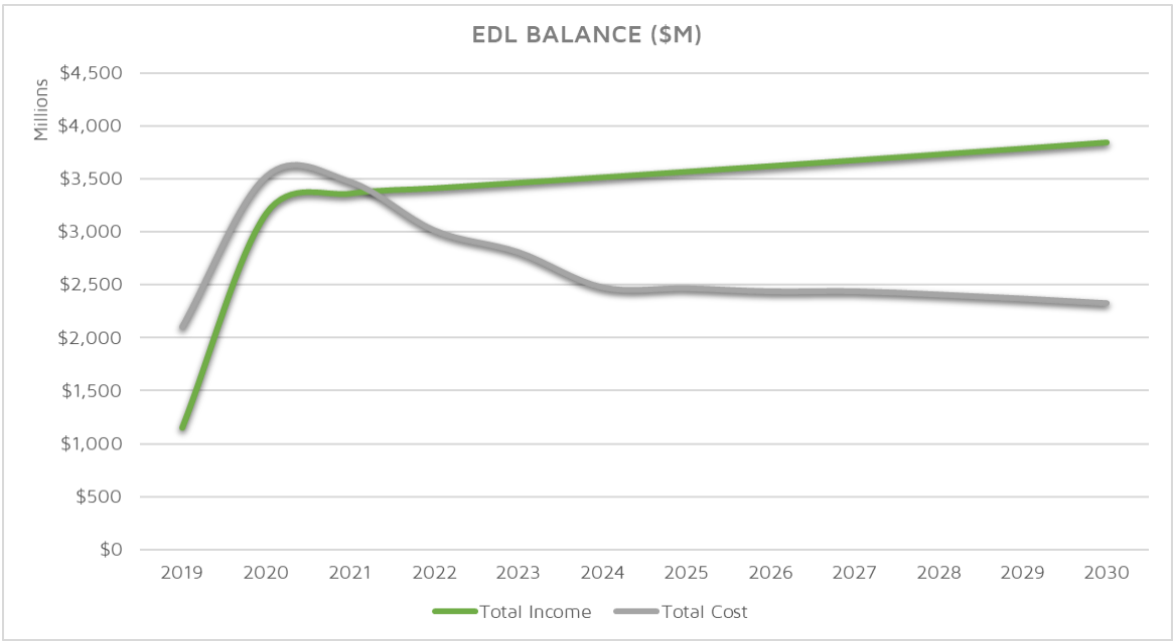

Figure 25: Optimal scenario EDL financial standing and annual balance

V. SUMMARY OF THE SCENARIOS

		Policy Paper	30x30 Scenario	Optimal Scenario
RE Demand Share	2020	6.30%	6.48%	6.57%
	2026	13.45%	18.80%	31.16%
	2030		30.42%	42.85%
Annual EDL Profit/Loss	2020	-$357,073,981	-$351,157,700	-$344,520,595
	2026	$1,037,865,978	$1,078,331,075	$1,184,365,514
	2030		$1,483,105,993	$1,517,617,399
Energy Surplus/Deficit	2020	-0.1%	0.1%	1.5%
	2026	0.4%	5.7%	10.3%
	2030		8%	17%

The optimal scenario leads to a 14% increase in profits and 9.9% increase in electricity surplus by 2026 compared to the policy paper.

The 30-30 scenario costs EDL $3,040M to save $1,483M, while the optimal scenario costs $2,331M to save $1,517M. This is due to the reduced energy demand as annual growth drops from 3% in 30-30 to 1.5% in the optimal scenario.

VI. REMARKS & RECOMMENDATIONS

We have summarized a number of observations (remarks), recommendations and requirements that should be taken forward in the revision of the ministry plan:

- REMARK: While the policy paper mentions the 30% renewable energy by 2030 goal, it seems to have been developed in disconnection with this objective. As demonstrated in the analysis, if the planned thermal power plants are implemented it would render very challenging to achieve the “renewable” objective by 2030.

- REMARK: Renewable energy (centralized and decentralized) is underrated in the policy paper while it should be a major pillar in the sustainable development of the electricity sector. It enhances the environmental impact of the electricity sector, improves the national energy security, promotes energy justice especially rural areas, and definitely provides a cheaper option with renewable energy prices on the drop (as estimated to drop by more than 60% by 2030 as per IRENA renewable energy cost report).
-
- RECOMMENDATION: The policy paper should be revisited in order to consider and properly reflect an earlier, faster and more significant deployment of renewable energy and to revise downwards the targeted thermal plant overall capacity. As demonstrated by this analysis, more renewable energy and less thermal energy will lead to a lower cost, higher profit, with the obvious positive impact on air quality and therefore public health. The ministry should at least revisit the plan to incorporate the roadmap it is currently developing with IRENA to achieve the 30% renewable energy goal by 2030, even if this would require to scrap off some thermal plant capacity.

- REMARK: By 2020, when the three wind farms enter the grid as planned, they would be celebrating 10 year of planning, negotiations and implementation. The 180 MW solar farms are expected to exceed three years before being implemented. The current pace of renewable energy deployment is very slow and needs to be improved in case we want to promote clean energy and create an enabling environment. Better planning is required: by removing barriers and learning from previous experiences to avoid similar delays in upcoming activities. This reinforces the perspective of not achieving the 30% renewable energy goal by 2030 if this plan is implemented as is, since it leaves very little time and lower incentive to deploy massively renewable energy.

- RECOMMENDATION: The policy paper should be revised to properly consider energy efficiency. The ministry of energy and water should make the adoption of an energy

conservation law a priority. Measures like mandatory energy audits for large consumers, enforcing standards and labels to promote energy-efficient appliances, and creating an enabling environment to energy conservation and energy efficient processes in commercial, industrial, and residential sectors should be implemented as soon as possible.

- REQUIREMENT: The ministry of energy and water should ensure that strict environmental conditions would be applied for both interim and permanent power plants through the development and implementation of Environmental Impact Assessments (EIA). The development of an EIA should be a pre-requirement in any tender.

- REQUIREMENT: Interim production of 1,450 MW is proposed by 2020, without any clear presentation of the technologies, the methods, or the fuel to be used. It is essential to set strong criteria to eliminate the dirtiest options and fuels as soon as possible by providing clear guidelines.

LONG TERM RECOMMENDATIONS BEYOND THE PLAN THAT WILL BE ESSENTIAL TO DEVELOP RENEWABLES IN LEBANON:

- RECOMMENDATION 1: Hydro power plants suffer from a very low effective-to-installed capacity ratio due to lack of maintenance and the need of rehabilitation. The policy paper of 2010 planned performing maintenance works on these power plants, while the 2019 paper did not focus on this aspect. It would be worthy to consider improving the performance of existing hydroelectric power plants and increase their productivity.

- RECOMMENDATION 2: Decentralization installations of solar PV systems have shown to come with a positive impact on the grid and the national electricity consumption. It would be only wise to further support such initiatives and remove the barriers hindering the growth of this subsector. Working with municipalities would be a sustainable way of doing this, through offering subsidies or long-term soft loans. The ministry of energy and water should support local communities and municipalities and pursue the promotion of decentralized renewable energy systems.

- RECOMMENDATION 3: Net-metering had a major impact on the growth of decentralized renewable energy systems, especially solar PV. This impact should continue with a consideration to improve it through introducing Feed-in tariff, allowing consumers with grid-connected renewable energy systems to get paid for their energy feed-in. Therefore, a committee should be established to study the feasibility and applicability of feed-in tariff in Lebanon, analyzing the barriers and setting up an achievable action plan.

- RECOMMENDATION 4: The Electricity Regulatory Authority should be established as soon as possible to ensure proper sector regulation.

- RECOMMENDATION 5: Lebanon suffers from an extremely high electricity demand during summer season, which is requiring additional capacity to be installed to meet this demand. This additional capacity would not be needed in winter, spring, and fall seasons. Managing to shave the summer peak would require less installed capacity and thus require less capital investment. We recommend considering a seasonal tariff whereby it increases during summer and then decreases in other seasons. This alone could lead to a reduction in electricity consumption during summer season and thus eliminate the need for additional capacity.

- RECOMMENDATION 6: To ensure a fair and community focused tariff we recommend considering a tariff tailored for each consumption tranche where the highest tranche would bear the biggest increase. This would also contribute to a drop in the demand.

ANNEXES

1. Annex 1: 30-30 Scenario Details
2. Annex 2: Optimal Scenario Details
3. Annex 3: Reference Material

Annex 1: 30-30 Scenario Details

THERMAL POWER PLANT

	Current	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Added Capacity (MW)													
Zouk 1	440				-440		360	190					
Zouk 2	157				-157								
Jieh 1	180				-180		360		190				
Jieh 2	63				-63								
Zahrani 1	420												
Zahrani 2					360	190							
Deir Amar 1	430												
Deir Amar 2				360	190								
Baalbeck	57												
Tyr	56					*100*							
Hrayche	46		-46				300						
Selaata 1					360	190							
TOTAL	**1,849**	**0**	**-46**	**360**	**70**	**480**	**1,02**	**190**	**190**	**0**	**0**	**0**	**0**

Cumulative Installed Capacity (MW)													
Zouk 1	440	440	440	440	0	0	360	550	550	550	550	550	550
Zouk 2	157	157	157	157	0	0	0	0	0	0	0	0	0
Jieh 1	180	180	180	180	0	0	360	360	550	550	550	550	550
Jieh 2	63	63	63	63	0	0	0	0	0	0	0	0	0
Zahrani 1	420	420	420	420	420	420	420	420	420	420	420	420	420
Zahrani 2	0	0	0	0	360	550	550	550	550	550	550	550	550
Deir Amar 1	430	430	430	430	430	430	430	430	430	430	430	430	430
Deir Amar 2	0	0	0	360	550	550	550	550	550	550	550	550	550
Baalbeck	57	57	57	57	57	57	57	57	57	57	57	57	57
Tyr	56	56	56	56	56	156	156	156	156	156	156	156	156
Hrayche	46	46	0	0	0	0	300	300	300	300	300	300	300
Selaata 1	0	0	0	0	360	550	550	550	550	550	550	550	550
TOTAL	**1,849**	**1,849**	**1,803**	**2,163**	**2,233**	**2,713**	**3,733**	**3,923**	**4,113**	**4,113**	**4,113**	**4,113**	**4,113**

INTERIM POWER

	Current	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Added Capacity (MW)													
Zouk Barge	195				-195								
Jiyeh Barge	195				-195								
Zouk Interim			100				-100						
Jieh Interim			250				-250						
Zahrani Interim			600				-600						
Deir Amar Interim			450				-450						
Private Generators	*750*		-750										
TOTAL	**1,140**	**0**	**650**	**0**	**-390**	**0**	**-1,400**	**0**	**0**	**0**	**0**	**0**	**0**
Cumulative Installed Capacity (MW)													
Zouk Barge	195	195	195	195	0	0	0	0	0	0	0	0	0
Jiyeh Barge	195	195	195	195	0	0	0	0	0	0	0	0	0
Zouk Interim	0	0	100	100	100	100	0	0	0	0	0	0	0
Jieh Interim	0	0	250	250	250	250	0	0	0	0	0	0	0
Zahrani Interim	0	0	600	600	600	600	0	0	0	0	0	0	0
Deir Amar Interim	0	0	450	450	450	450	0	0	0	0	0	0	0
Private Generators	750	750	0	0	0	0	0	0	0	0	0	0	0
TOTAL	**1,140**	**1,140**	**1,790**	**1,790**	**1,400**	**1,400**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

ELECTRICITY IMPORT

	Current	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Capacity (MW)													
Import from Syria	69		*-69*										
TOTAL	**69**	**0**	**-69**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Cumulative Capacity (MW)													
Import from Syria	69	69	0	0	0	0	0	0	0	0	0	0	0
TOTAL	**69**	**0**	**-69**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

LANDFILL POWER

	Current	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Added Capacity (MW)													
Naameh Landfill	7												
TOTAL	**7**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Cumulative Installed Capacity (MW)													
Naameh Landfill	7	7	7	7	7	7	7	7	7	7	7	7	7
TOTAL	**7**	**7**	**7**	**7**	**7**	**7**	**7**	**7**	**7**	**7**	**7**	**7**	**7**

HYDROELECTRIC POWER

	Current	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Added Capacity (MW)													
Richmaya	3												
Litani	47												
Nahr Irahim	17												
Bared	6												
Kadisha	15												
Other						*100*							
TOTAL	**88**	**0**	**0**	**0**	**0**	**100**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Cumulative Installed Capacity (MW)													
Richmaya	3	3	3	3	3	3	3	3	3	3	3	3	3
Litani	47	47	47	47	47	47	47	47	47	47	47	47	47
Nahr Irahim	17	17	17	17	17	17	17	17	17	17	17	17	17
Bared	6	6	6	6	6	6	6	6	6	6	6	6	6
Kadisha	15	15	15	15	15	15	15	15	15	15	15	15	15
Other	0	0	0	0	0	100	100	100	100	100	100	100	100
TOTAL	**88**	**88**	**88**	**88**	**88**	**188**	**188**	**188**	**188**	**188**	**188**	**188**	**188**

RENEWABLE ENERGY

	Current	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Added Capacity (MW)													
Distributed PV	44	*24*	*24*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*	*20*
Wind			220			400			400		400		400
Solar PV	1		*187*							*500*		*500*	
Solar + Storage					300								
TOTAL	**45**	**24**	**431**	**20**	**320**	**420**	**20**	**20**	**420**	**520**	**420**	**520**	**420**
Cumulative Installed Capacity (MW)													
Distributed PV	44	68	92	112	132	152	172	192	212	232	252	272	292
Wind	0	0	220	220	220	620	620	620	1,020	1,020	1,420	1,420	1,820
Solar PV	1	1	188	188	188	188	188	188	188	688	688	1,188	1,188
Solar + Storage	0	0	0	0	300	300	300	300	300	300	300	300	300
TOTAL	**45**	**69**	**500**	**520**	**840**	**1,260**	**1,280**	**1,300**	**1,720**	**2,240**	**2,660**	**3,180**	**3,600**

Annex 2: Optimal Scenario Details

THERMAL POWER PLANTS

	Current	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Added Capacity (MW)													
Zouk 1	440				-440								
Zouk 2	157				-157								
Jieh 1	180				-180		360						
Jieh 2	63				-63								
Zahrani 1	420												
Zahrani 2					360	190							
Deir Amar 1	430												
Deir Amar 2				360	190								
Baalbeck	57												
Tyr	56					*100*							
Hrayche	46		-46				300						
Selaata 1					360	190							
TOTAL	**1,849**	**0**	**-46**	**360**	**70**	**480**	**660**	**0**	**0**	**0**	**0**	**0**	**0**
Cumulative Installed Capacity (MW)													
Zouk 1	440	440	440	440	0	0	0	0	0	0	0	0	0
Zouk 2	157	157	157	157	0	0	0	0	0	0	0	0	0
Jieh 1	180	180	180	180	0	0	360	360	360	360	360	360	360
Jieh 2	63	63	63	63	0	0	0	0	0	0	0	0	0
Zahrani 1	420	420	420	420	420	420	420	420	420	420	420	420	420
Zahrani 2	0	0	0	0	360	550	550	550	550	550	550	550	550
Deir Amar 1	430	430	430	430	430	430	430	430	430	430	430	430	430
Deir Amar 2	0	0	0	360	550	550	550	550	550	550	550	550	550
Baalbeck	57	57	57	57	57	57	57	57	57	57	57	57	57
Tyr	56	56	56	56	56	156	156	156	156	156	156	156	156
Hrayche	46	46	0	0	0	0	300	300	300	300	300	300	300
Selaata 1	0	0	0	0	360	550	550	550	550	550	550	550	550
TOTAL	**1,849**	**1,849**	**1,803**	**2,163**	**2,233**	**2,713**	**3,373**	**3,373**	**3,373**	**3,373**	**3,373**	**3,373**	**3,373**

INTERIM POWER

	Current	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Added Capacity (MW)													
Zouk Barge	195				-195								
Jiyeh Barge	195				-195								
Zouk Interim			100				-100						
Jieh Interim			250				-250						
Zahrani Interim			600				-600						
Deir Amar Interim			450				-450						
Private Generators	*750*		-750										
TOTAL	**1,140**	**0**	**650**	**0**	**-390**	**0**	**-1,400**	**0**	**0**	**0**	**0**	**0**	**0**
Cumulative Installed Capacity (MW)													
Zouk Barge	195	195	195	195	0	0	0	0	0	0	0	0	0
Jiyeh Barge	195	195	195	195	0	0	0	0	0	0	0	0	0
Zouk Interim	0	0	100	100	100	100	0	0	0	0	0	0	0
Jieh Interim	0	0	250	250	250	250	0	0	0	0	0	0	0
Zahrani Interim	0	0	600	600	600	600	0	0	0	0	0	0	0
Deir Amar Interim	0	0	450	450	450	450	0	0	0	0	0	0	0
Private Generators	750	750	0	0	0	0	0	0	0	0	0	0	0
TOTAL	**1,140**	**1,140**	**1,790**	**1,790**	**1,400**	**1,400**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

ELECTRICITY IMPORT

	Current	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Capacity (MW)													
Import from Syria	69		*-69*										
TOTAL	**69**	**0**	**-69**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Cumulative Capacity (MW)													
Import from Syria	69	69	0	0	0	0	0	0	0	0	0	0	0
TOTAL	**69**	**0**	**-69**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

LANDFILL POWER

	Current	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Added Capacity (MW)													
Naameh Landfill	7												
TOTAL	**7**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Cumulative Installed Capacity (MW)													
Naameh Landfill	7	7	7	7	7	7	7	7	7	7	7	7	7
TOTAL	**7**	**7**	**7**	**7**	**7**	**7**	**7**	**7**	**7**	**7**	**7**	**7**	**7**

HYDROELECTRIC POWER

	Current	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Added Capacity (MW)													
Richmaya	3												
Litani	47												
Nahr Irahim	17												
Bared	6												
Kadisha	15												
Other						*100*							
TOTAL	**88**	**0**	**0**	**0**	**0**	**100**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Cumulative Installed Capacity (MW)													
Richmaya	3	3	3	3	3	3	3	3	3	3	3	3	3
Litani	47	47	47	47	47	47	47	47	47	47	47	47	47
Nahr Irahim	17	17	17	17	17	17	17	17	17	17	17	17	17
Bared	6	6	6	6	6	6	6	6	6	6	6	6	6
Kadisha	15	15	15	15	15	15	15	15	15	15	15	15	15
Other	0	0	0	0	0	100	100	100	100	100	100	100	100
TOTAL	**88**	**88**	**88**	**88**	**88**	**188**	**188**	**188**	**188**	**188**	**188**	**188**	**188**

RENEWABLE ENERGY

	Current	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030

Added Capacity (MW)													
Distributed PV	44	*24*	*24*	*50*	*50*	*50*	*50*	*50*	*50*	*50*	*50*	*50*	*50*
Wind			220			400		400			400		400
Solar PV	1		*187*		400	400			400			400	
Solar + Storage					300			400					
TOTAL	**45**	**24**	**431**	**50**	**750**	**850**	**50**	**850**	**450**	**50**	**450**	**450**	**450**
Cumulative Installed Capacity (MW)													
Distributed PV	44	68	92	142	192	242	292	342	392	442	492	542	592
Wind	0	0	220	220	220	620	620	1,020	1,020	1,020	1,420	1,420	1,820
Solar PV	1	1	188	188	588	988	988	988	1,388	1,388	1,388	1,788	1,788
Solar + Storage	0	0	0	0	300	300	300	700	700	700	700	700	700
TOTAL	**45**	**69**	**500**	**550**	**1,300**	**2,150**	**2,200**	**3,050**	**3,500**	**3,550**	**4,000**	**4,450**	**4,900**

Annex 3: Reference Material

The main report used for the analysis is the “Updated Policy Paper for the Electricity Sector – March 2019”, issued by the Ministry of Energy and Water on March 18th, 2019, and published on the official website on April 18th, 2019.

The policy paper presents the expansion plan and the proposed energy mix all the way until 2026, with an explicit target of achieving 30% of electricity consumption through renewable energy by 2030.

In addition, official national resources are used and listed in the following table:

	Reference	Publisher	Date	Information Acquired
[1]	التقرير السنوي حول الإنجازات والمعوقات خلال العام 2017	Electricté du Liban	2018	- Capacity by plant (2016-2017) - Generation by plant (2016-2017) - Fuel by plant (2016-2017) - Generation cost by plant (2016-2017)
[2]	Thematic time series Electricté du Liban (EDL) 1995-2018	Central Administration of Statistics	2019	- Generation by plant (2016-2018) - Electricity Imports (2016-2018)
[3]	2017 Solar PV Status Report for Lebanon	DREG-UNDP	2018	- Decentralized PV capacity (2017) - Decentralized PV generation (2017)
[4]	Optimal renewable energy mix of the power sector by 2020	UNDP – Climate Change Unit	2015	- Energy yield for renewable energy
[5]	Power Plant Performance in 2015	Energy Information Administration (EIA)	2016	- Energy yield of natural gas plants
[6]	Power to Change 2016	IRENA	2017	- Solar PV and Wind LCOE forecast