



Energy-Food-Ecosystems Nexus SAFETY IN RENEWABLE ENERGY INTEGRATION

Presentation of

Eng. Ramzi Dobeissy, PhD. candidate

Head of High Voltage Transmission Networks Department

Head of Transmission Master Plan Committee

Electricité du Liban (EDL)

BEIRUT 24 August 2022



Electricity Sector in Lebanon

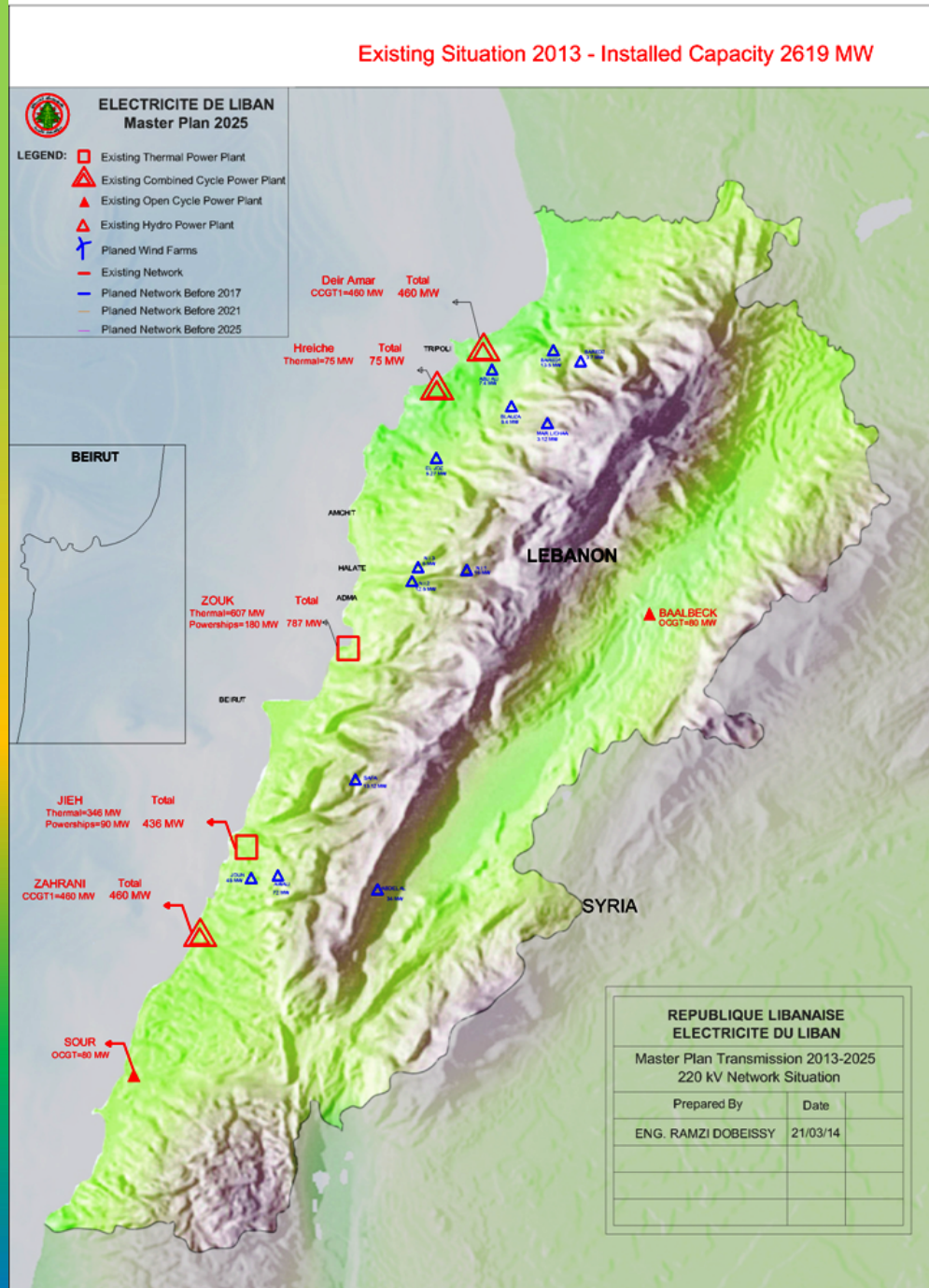
Historical Overview-Before 1990 Period

- Before the beginning of the nineties and during the war period the Electric Power sector was suffering from severe damages due to military operations.
- The Grid was consisting of two main thermal Power Plants in Zouk and Jeih with an installed capacity of around 950 MW for both evacuating their produced power via a 150 kV network limited between both of them, in addition to the Hydro power Plants of Litany with a total installed capacity of around 200 MW and several other micro plants of total installed capacity of around 80 MW representing all the renewable energy sources in the country with a percentage of 20%.



Historical Overview Before 1990

Power Generation plants



**Total
Installed
Capacity
2349 MW**

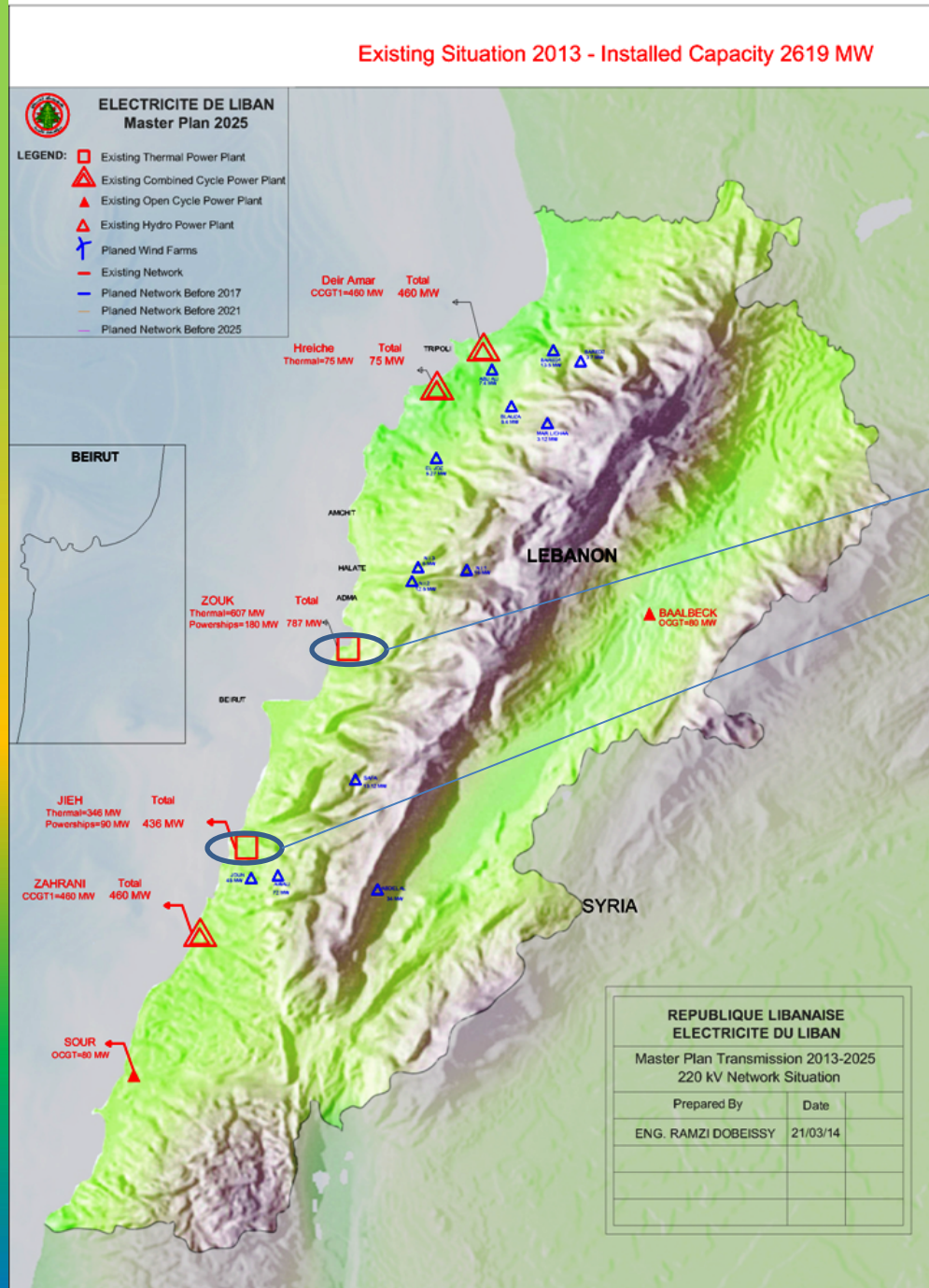
Zouk : 607 MW

Jeih : 346 MW



Historical Overview Before 1990

Power Generation plants



**Total
Installed
Capacity
2349 MW**

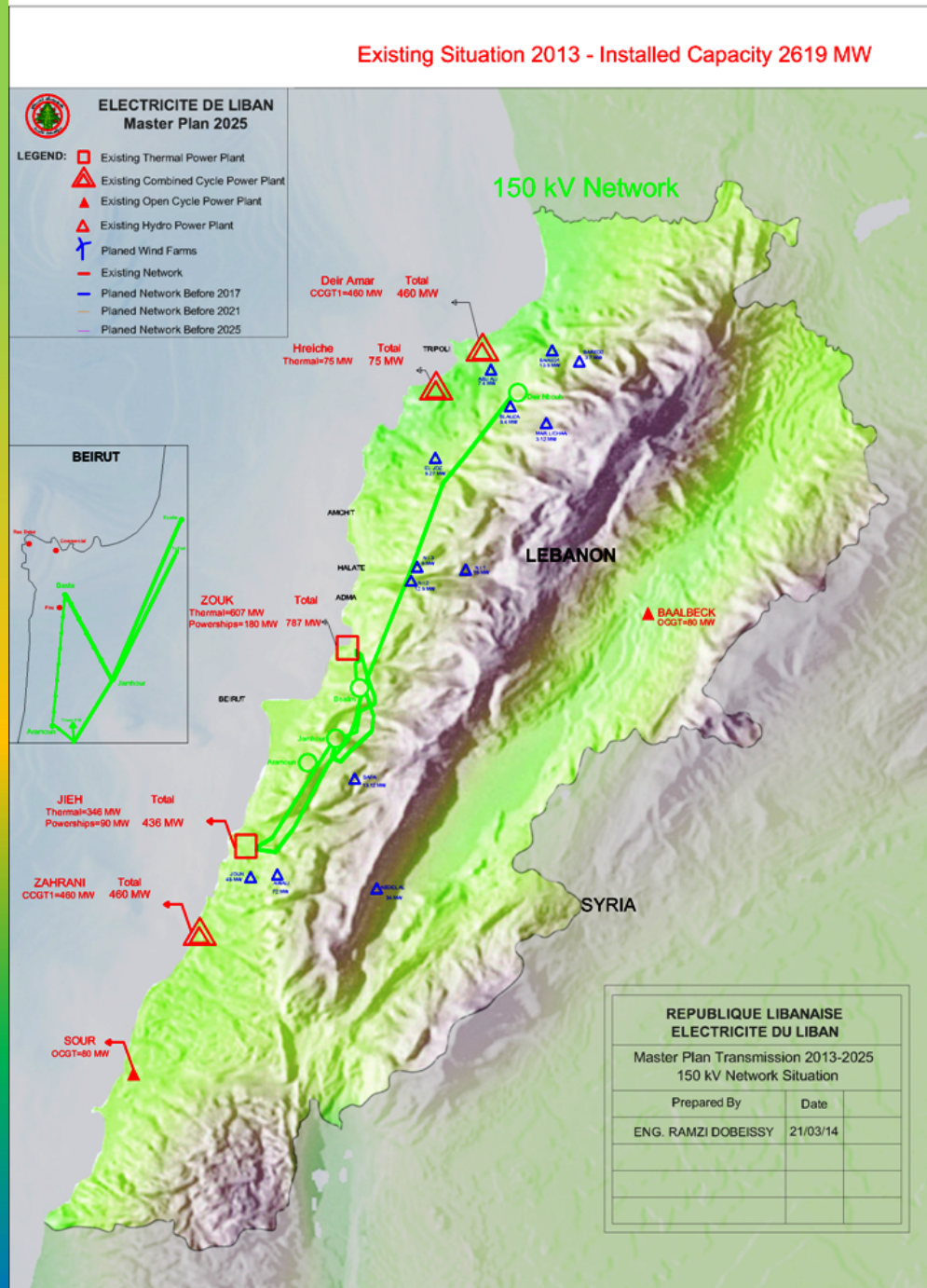
Zouk : 607 MW

Jeih : 346 MW



Historical Overview Before 1990

150 KV transmission network

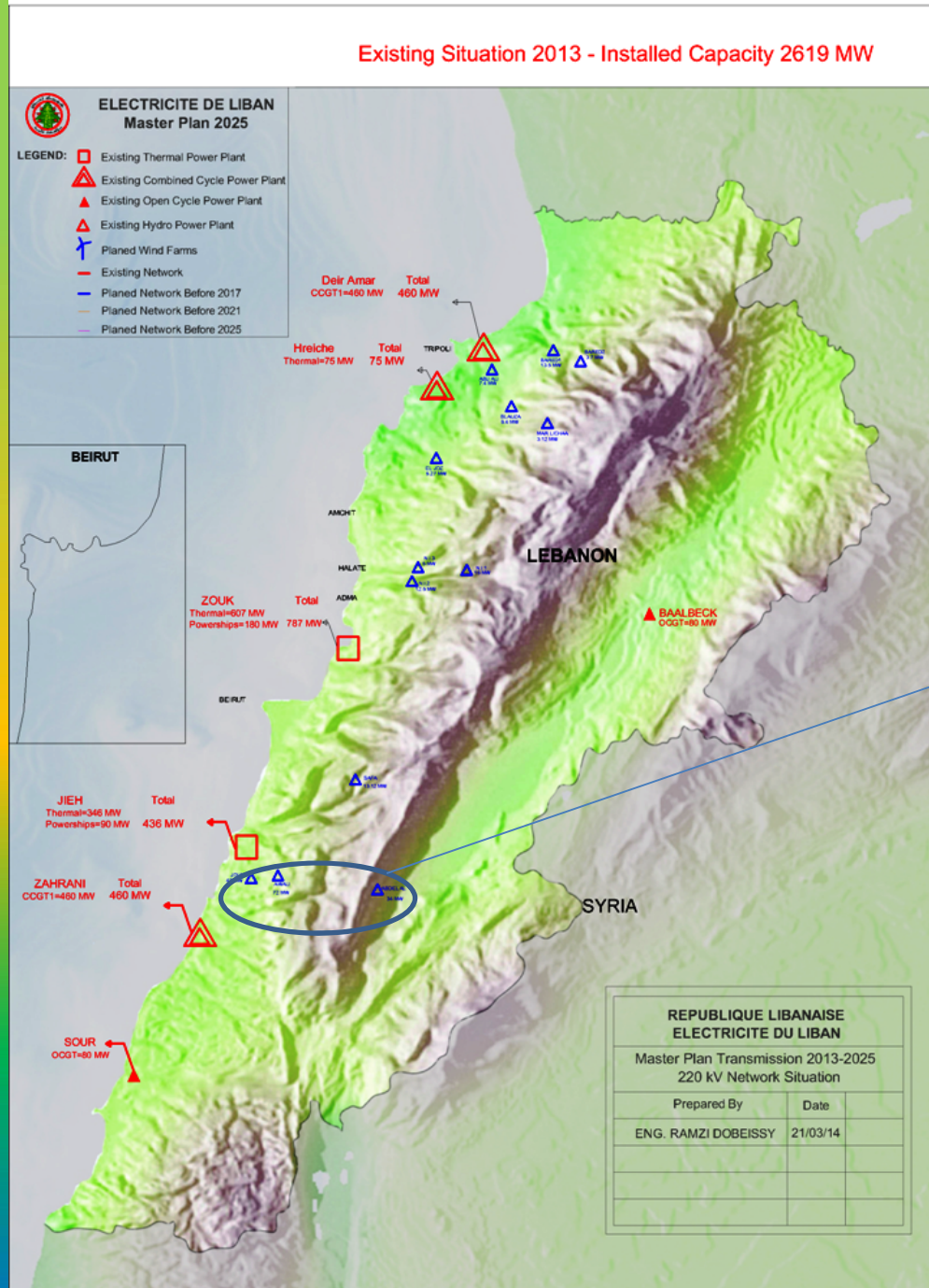


Total Installed Capacity 2349 MW



Historical Overview Before 1990

Power Generation plants



**Total
Installed
Capacity
2349 MW**

Litany : 199 MW

**Micro plants :
80 MW**



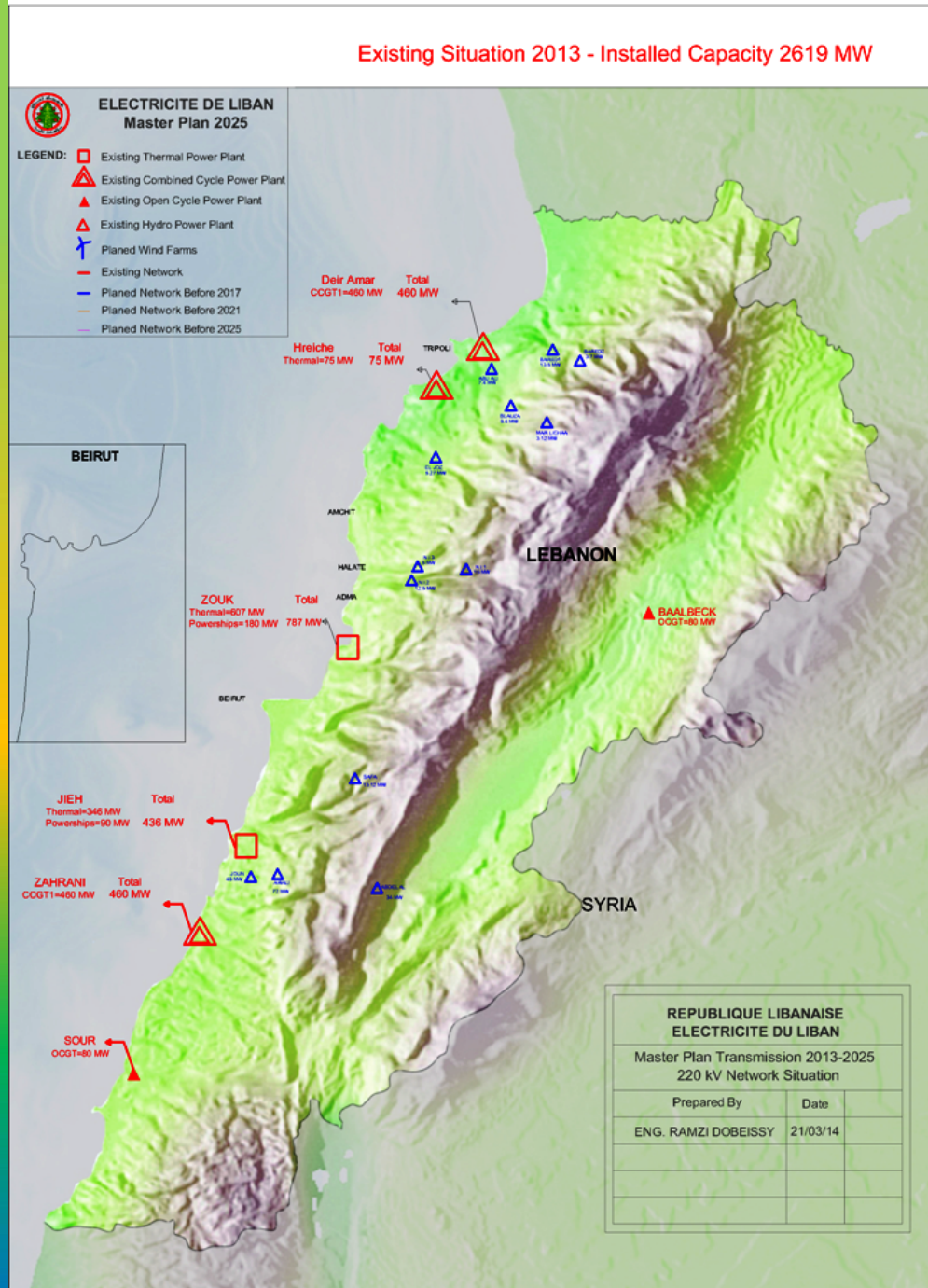
Electricity Sector in Lebanon

Historical Overview-Before 1990 Period

- The 66 kV Network was spread all over the country but was very old with a limited power carrying capacity.
- A single Thermal Power Plant in Hraichy with an installed capacity of around 75 MW was connected to this 66 kV network.
- A major reconstruction and rehabilitation plan was required to overcome the catastrophic situation of the whole network and to meet the increasing demand.



Historical Overview Before 1990

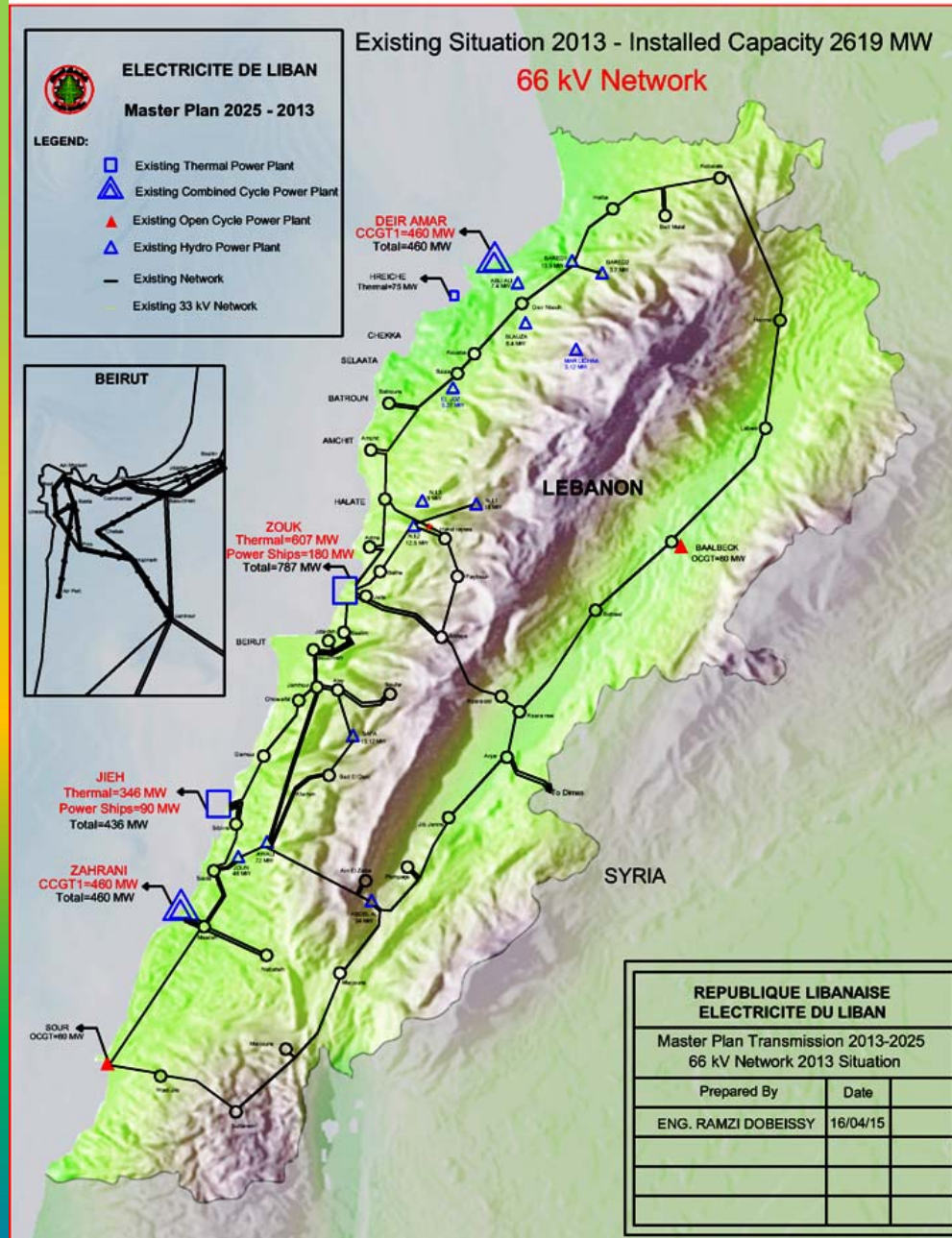


**Total
Installed
Capacity
2349 MW**



Historical Overview Before 1990

66 KV transmission network

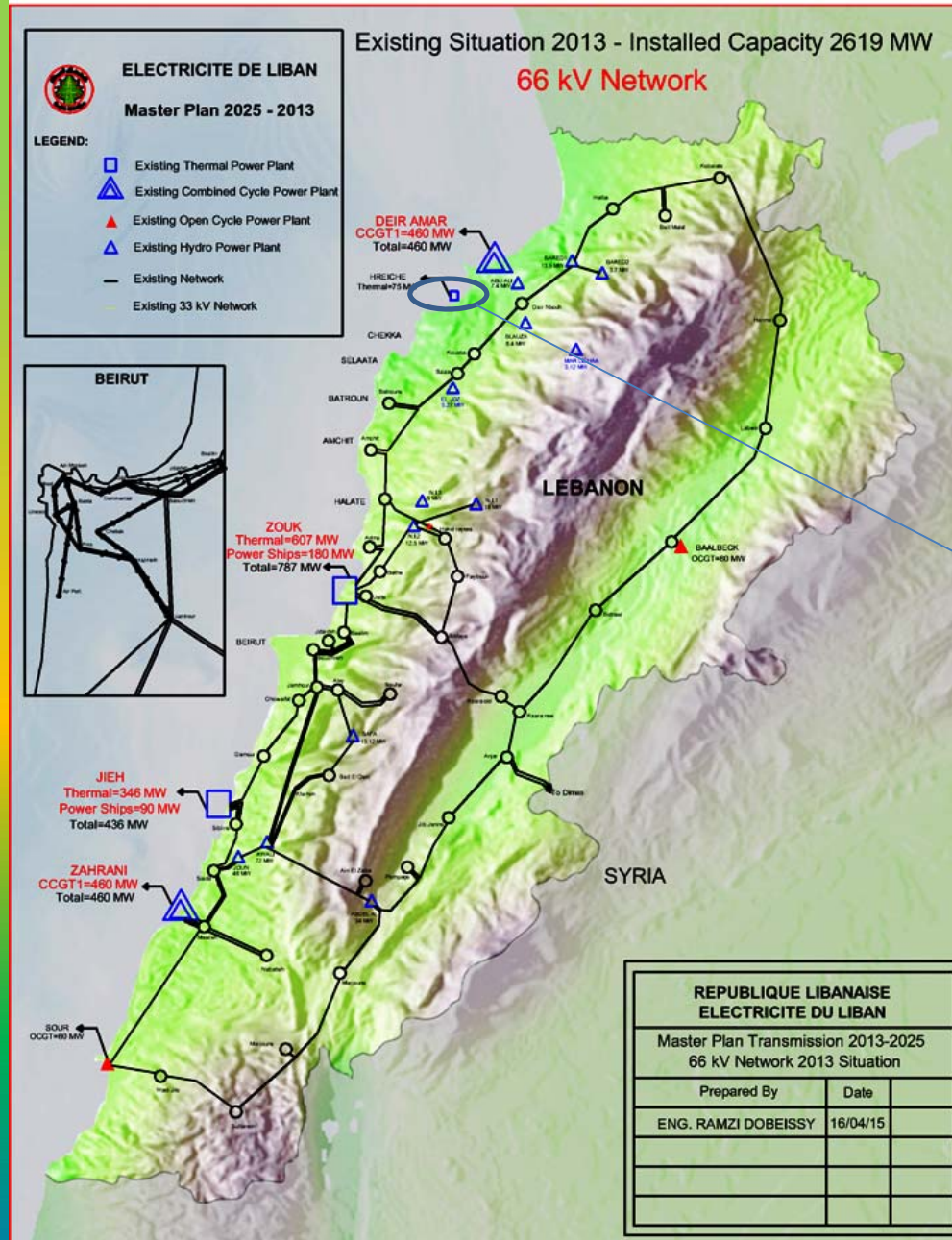


**Total
Installed
Capacity
2349 MW**



Historical Overview Before 1990

Power Generation plants



**Total
Installed
Capacity
2349 MW**

Hraishe: 75MW



Electricity Sector in Lebanon

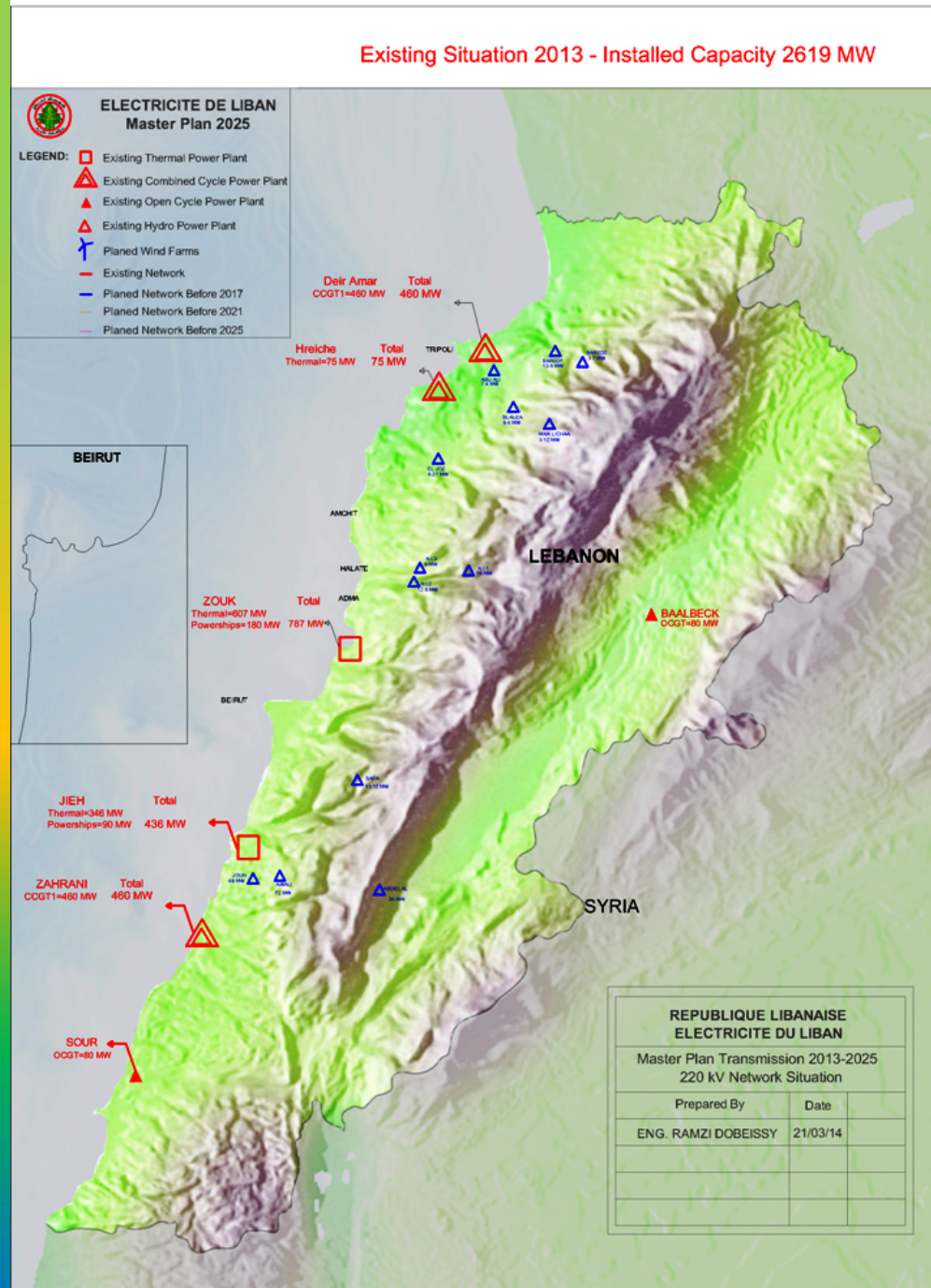
Historical Overview, 1990-2000 Period

- Two major Power Plants were built in Deir Amaar and Zahrani with a total installed capacity of 900 MW for both and connected to the new 220 kV network.
- The 220 kV network was created to take the role of the network backbone. This network covered most of the country's regions with a capability to transmit between 1500 to 2000 MW.
- A Tie line 400 kV was constructed to connect the Lebanese Grid with surrounding eight electrically connected countries through a regional sub-station in Ksara.



Historical Overview 1990-2000

Power Generation plants

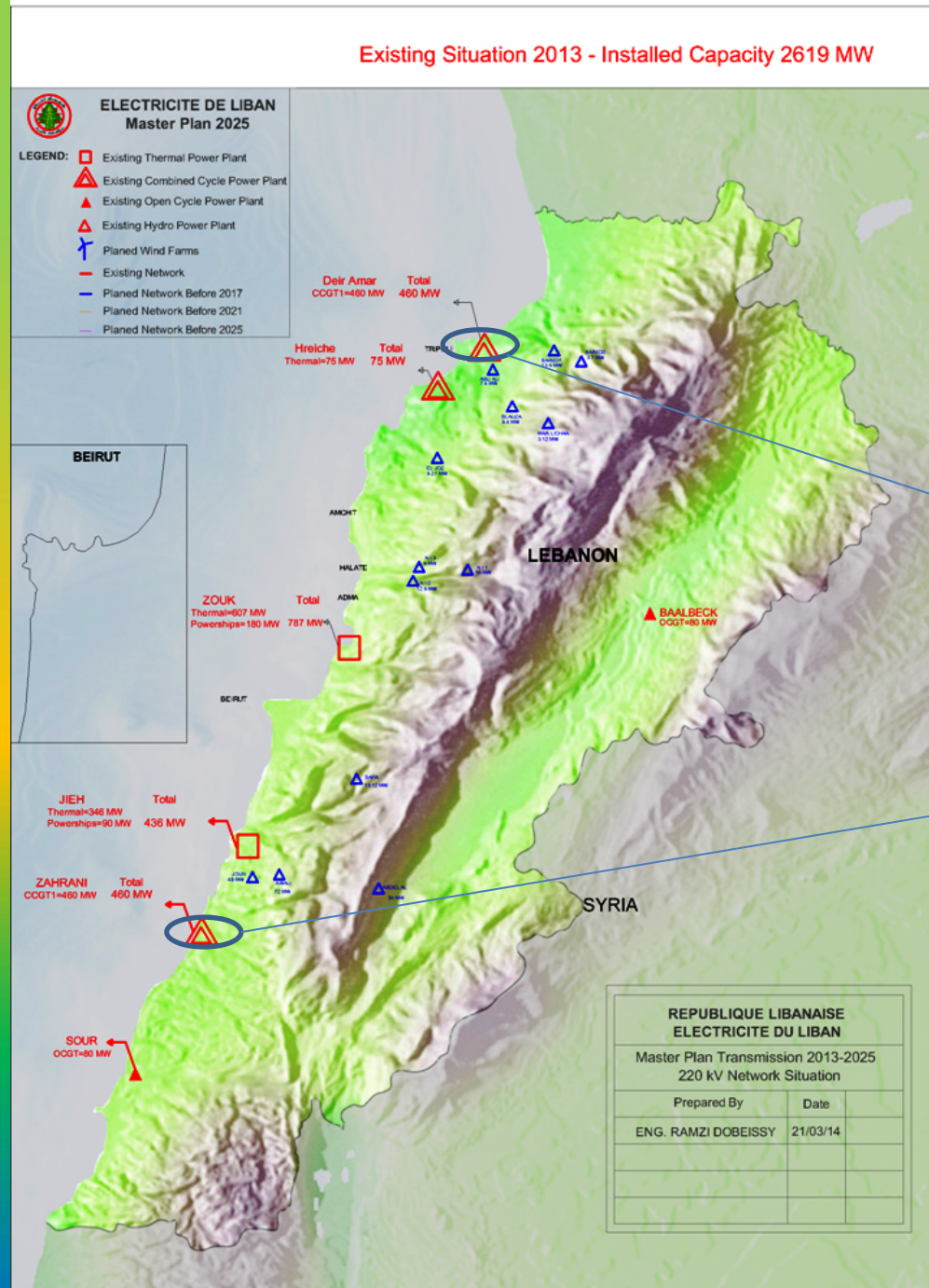


**Total
Installed
Capacity
2349 MW**



Historical Overview 1990-2000

Power Generation plants



**Total
Installed
Capacity
2349 MW**

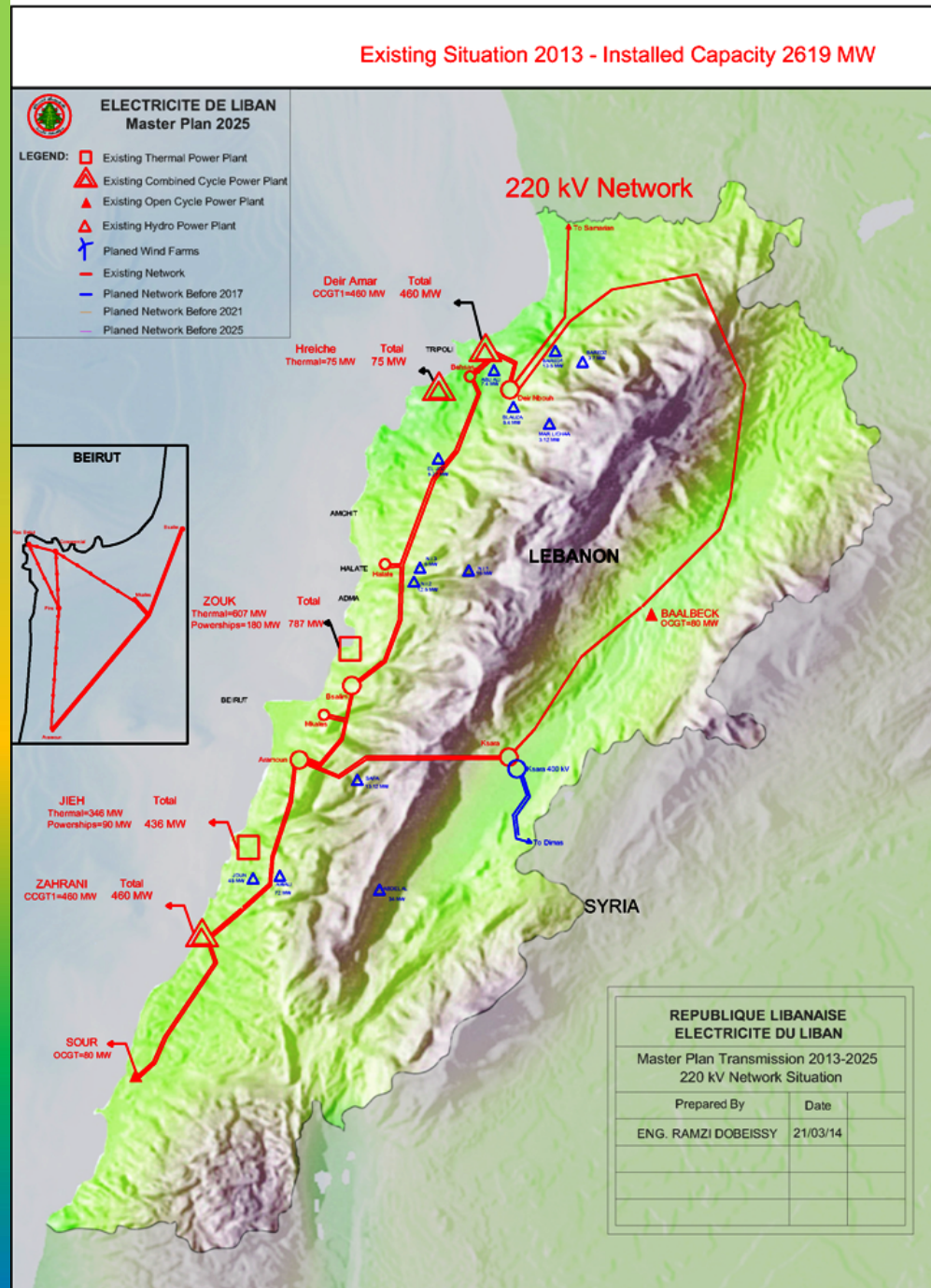
**DeirAmar:
460 MW**

Zahrani:460 MW



Historical Overview 1990-2000

400 & 220 KV
transmission
networks

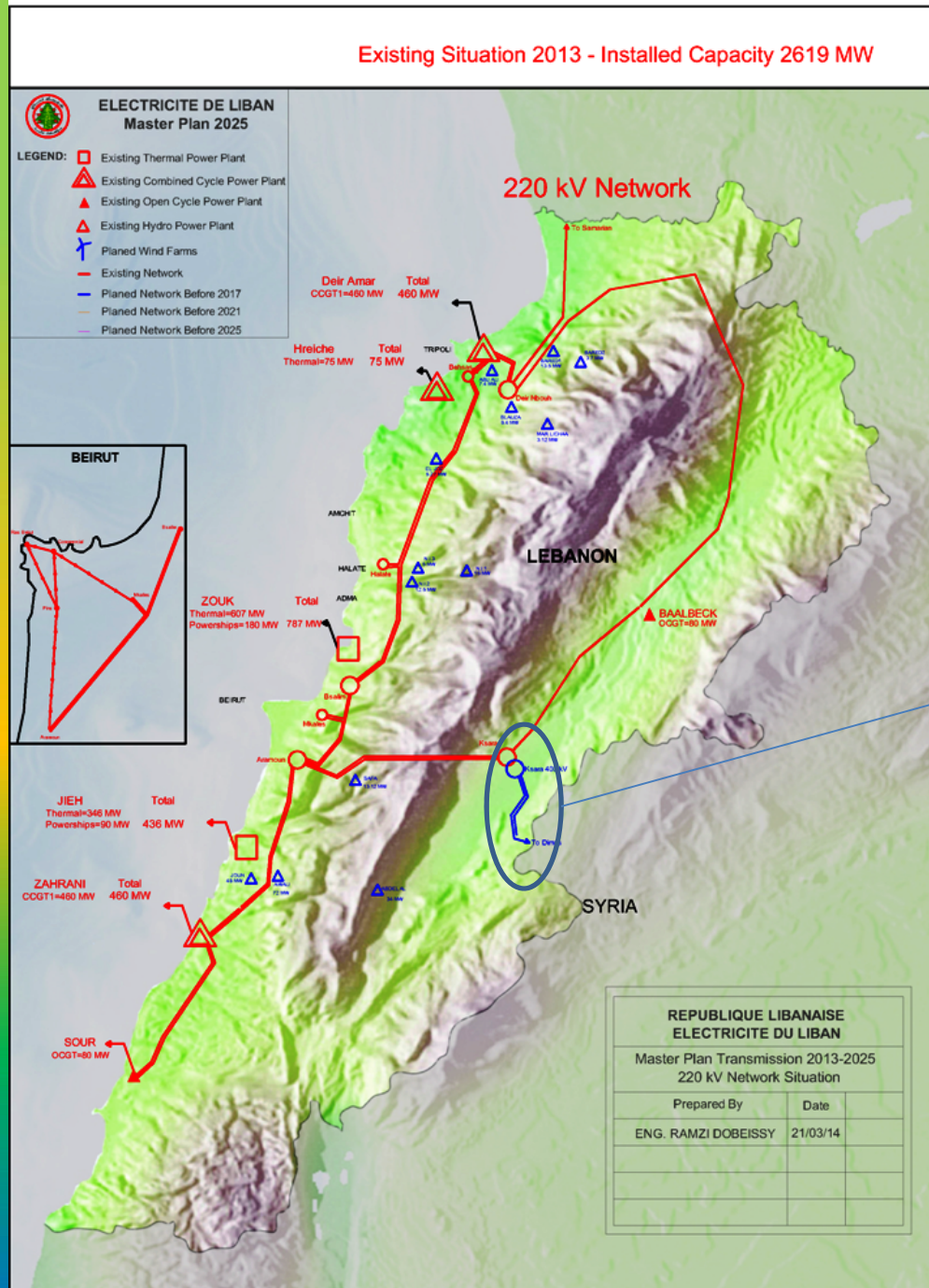


**Total
Installed
Capacity
2349 MW**



Historical Overview 1990-2000

400 & 220 KV
transmission
networks



**Total
Installed
Capacity
2349 MW**

Tie Line 400 kV



Main problems the Sector was facing

❑ Administrative due:

- The complicated laws and regulations dating from 1972.
- The strategy of the Lebanese government to stop recruiting in the public sector that has been adopted since 1985 till now with a little exceptions.
- The lacking of qualified human resources.

❑ Financial:

- A fixed tariff set in 1994 and has not been modified since.
- The inability to reduce non-technical losses on our distribution network due to political and security concerns.

❑ Technical:

- the lack of major investments in the production, transmission and distribution sectors between 1998 and 2010.



Policy Paper 2010

❑ The policy paper- way to improve the Electricity Sector in Lebanon:

The roadmap policy paper was developed in the year 2010, it presents a realistic implementation program for the fundamental rehabilitation and development of the electric sector in Lebanon to respond to the economic and social needs and objectives of the country. The roadmap represents the foundation of the integrated national energy program that aims to modernize, restructure and rehabilitate the utility in an attempt to make it technically stable and economically profitable.



Policy Paper 2010

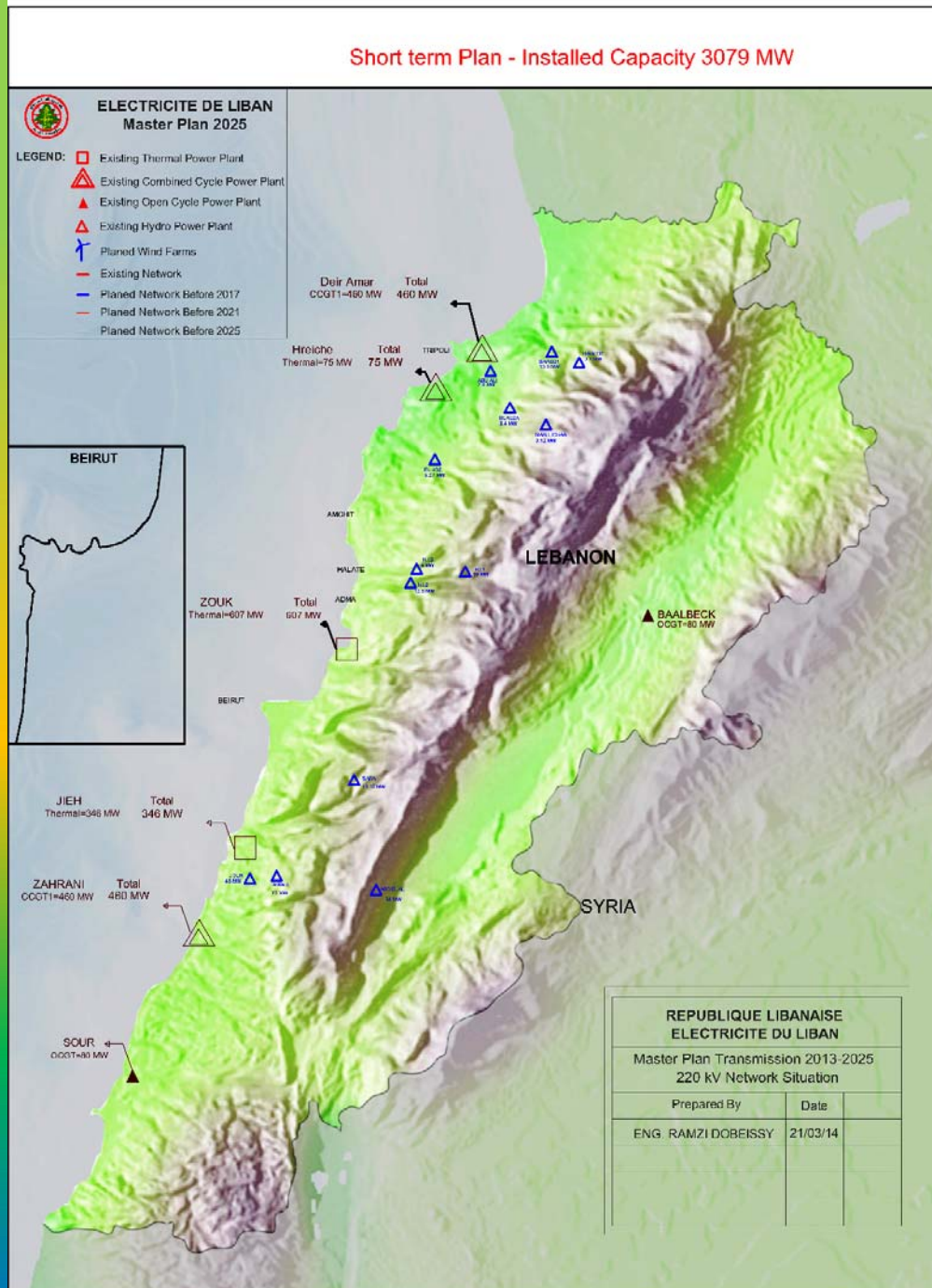
Short Term Plan

- ❑ The short term plan or the emergency plan that was issued in the year 2010 and financed by the Lebanese government through the law # 181, was a must to increase the production by 700 MW with all the corresponding investments in the transmission sector.



Short Term Plan

Power Generation plants

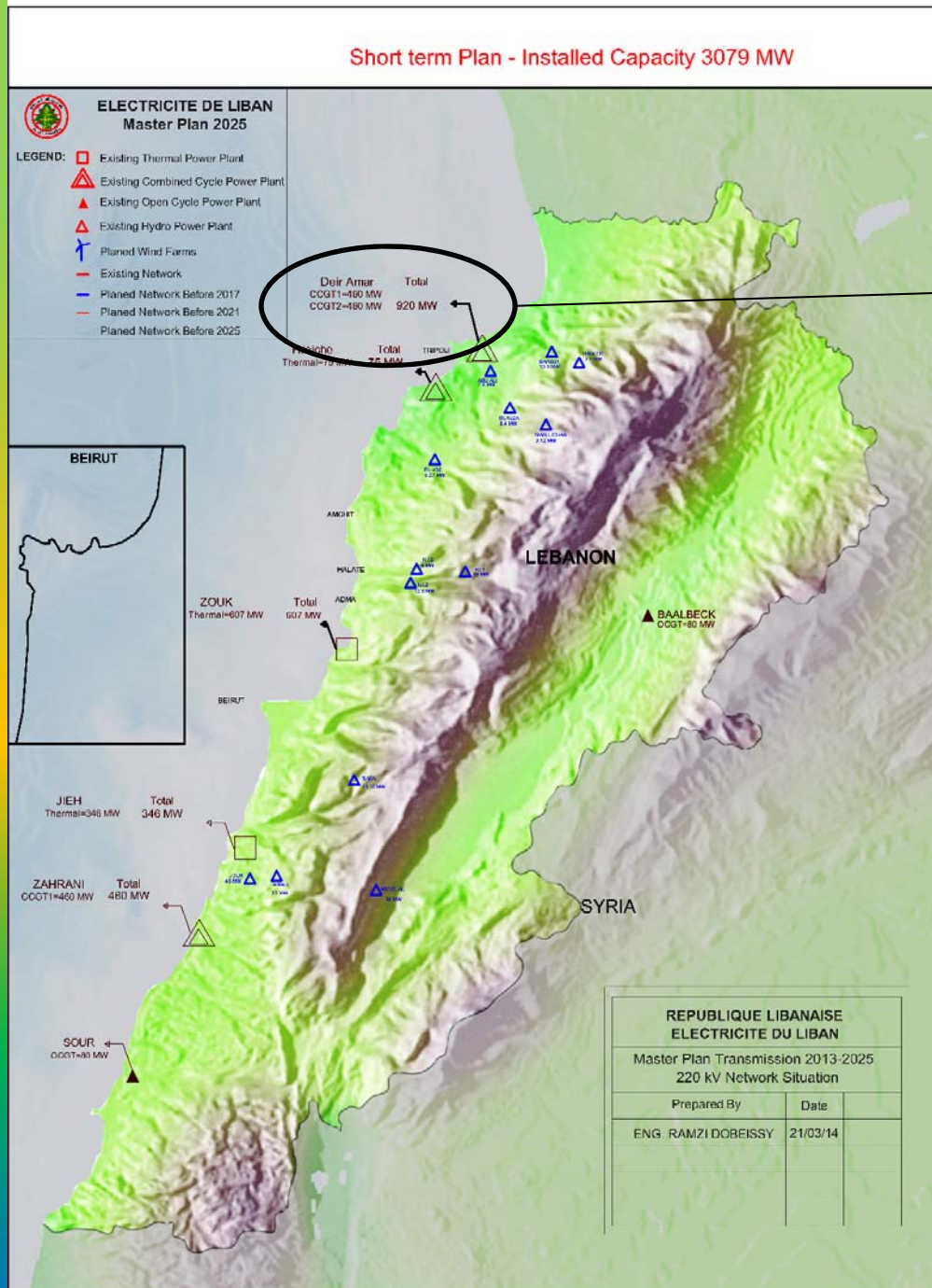


Installed Capacity 2619 MW



Short Term Plan

Power Generation plants



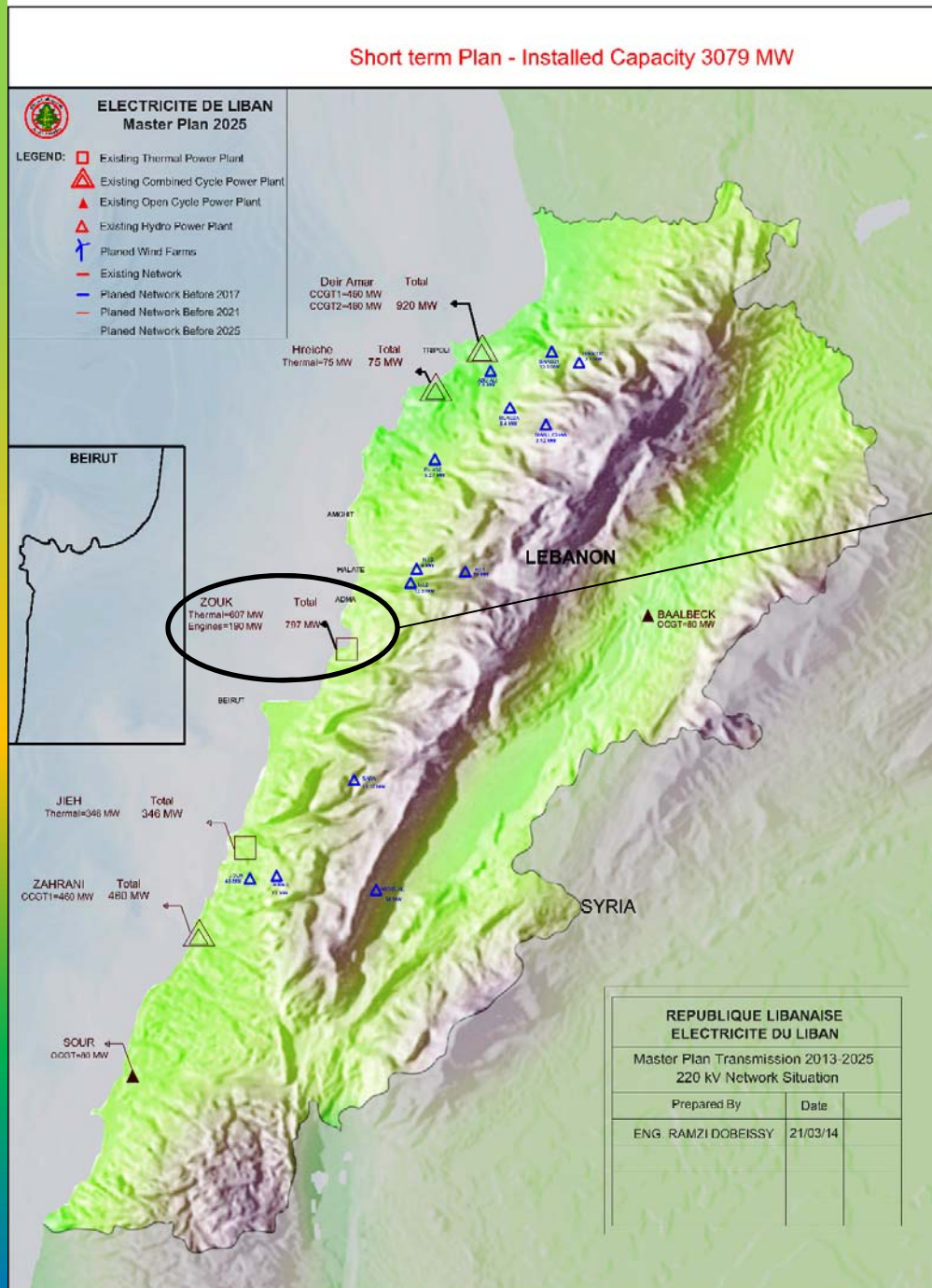
**Installed Capacity
2619 MW**

**DEIR AMAR 2
CCGT 530 MW**



Short Term Plan

Power Generation plants



**Installed
Capacity
2619 MW**

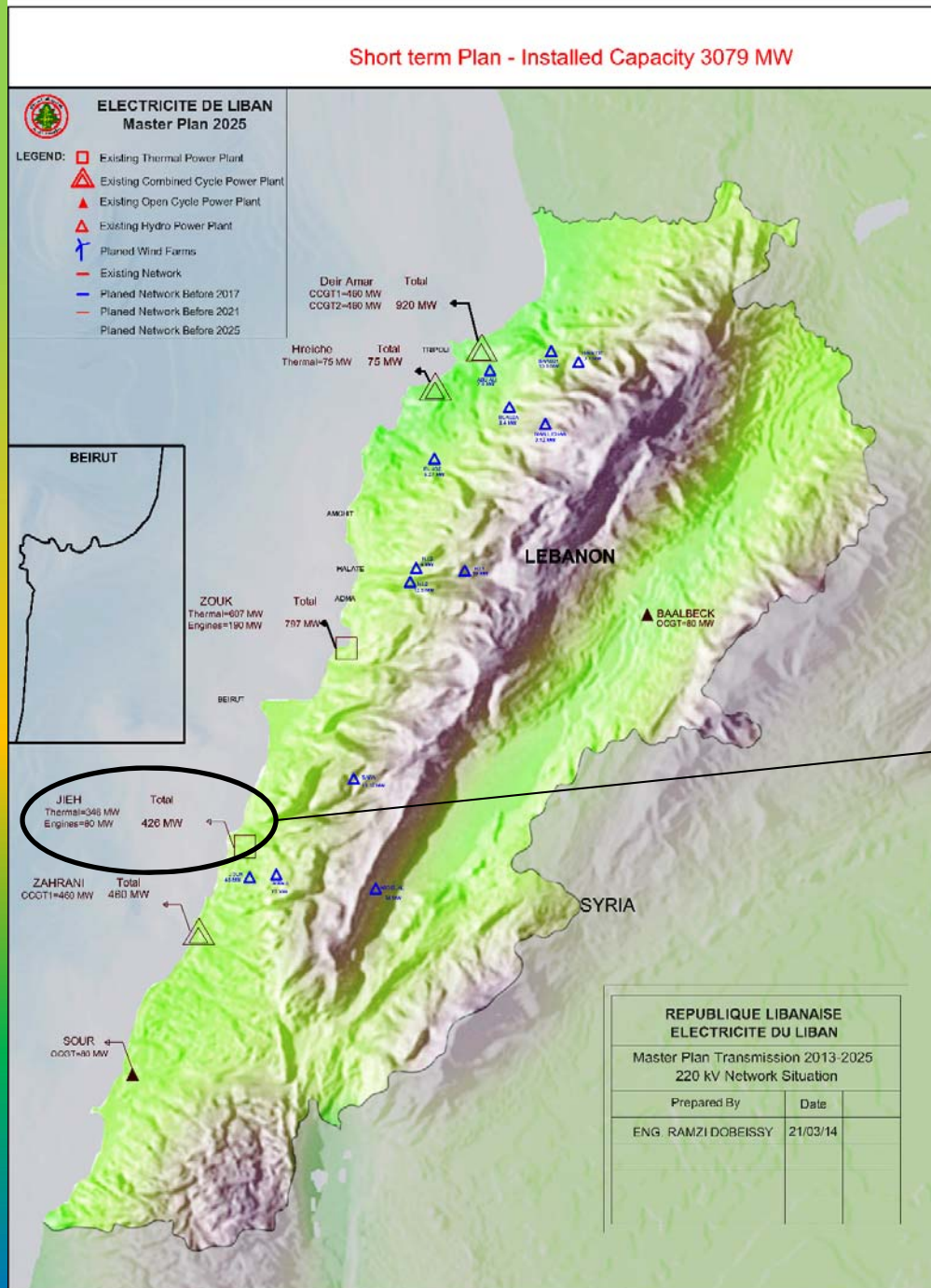
**DEIR AMAR 2
530 MW**

**ZOUK
reciprocating
engines
190 MW**



Short Term Plan

Power Generation plants



**Installed Capacity
2619 MW**

**DEIR AMAR 2
530 MW**

**ZOUK
reciprocating engines
190 MW**

**JIYEH
reciprocating engines
80 MW**

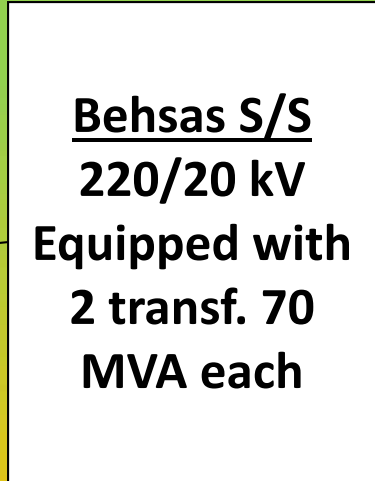
**Installed Capacity
after the
short term
plan will be
3079 MW**



**Main
Substations
220 kV**



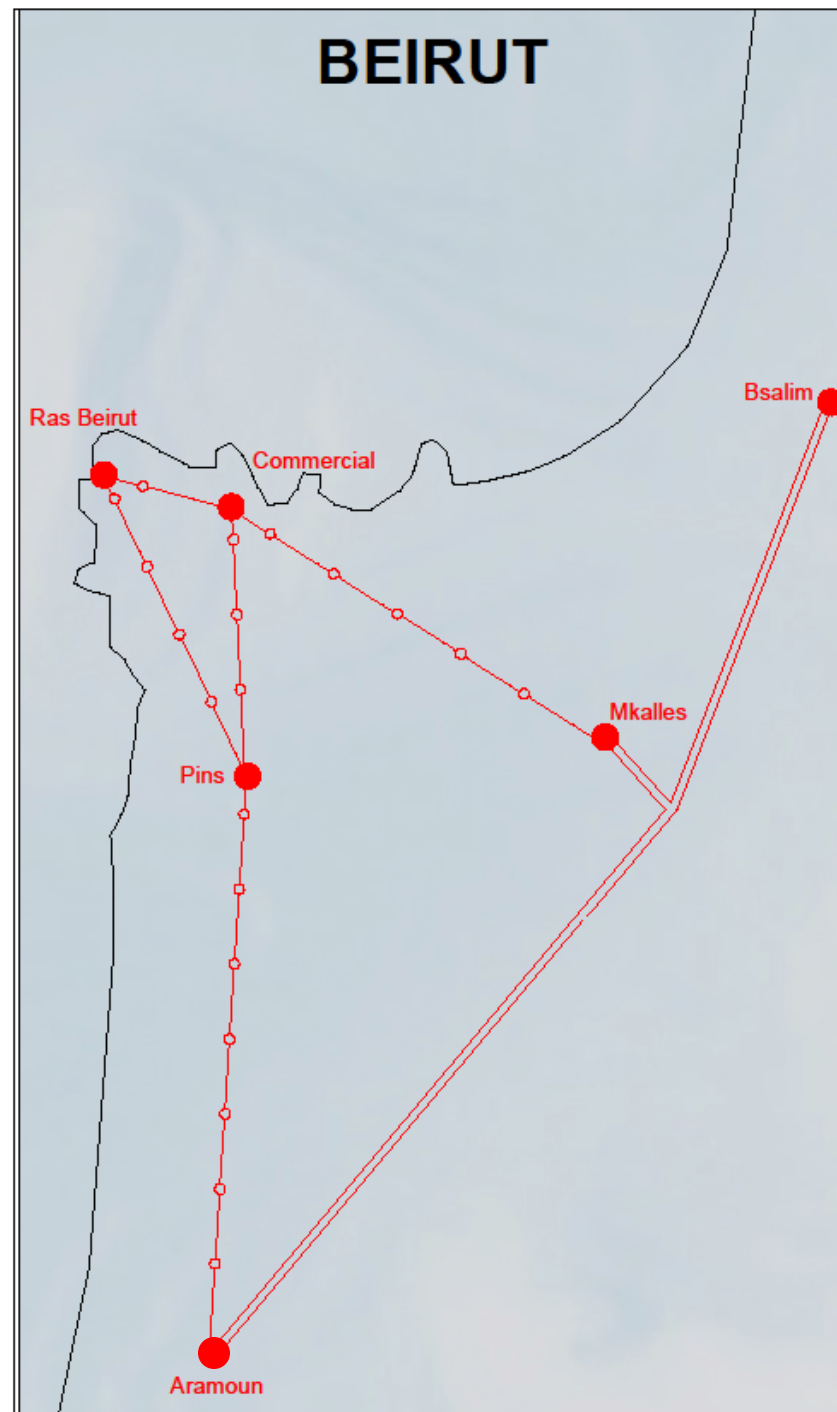
**Main
Substations
220 kV**





Short Term Plan

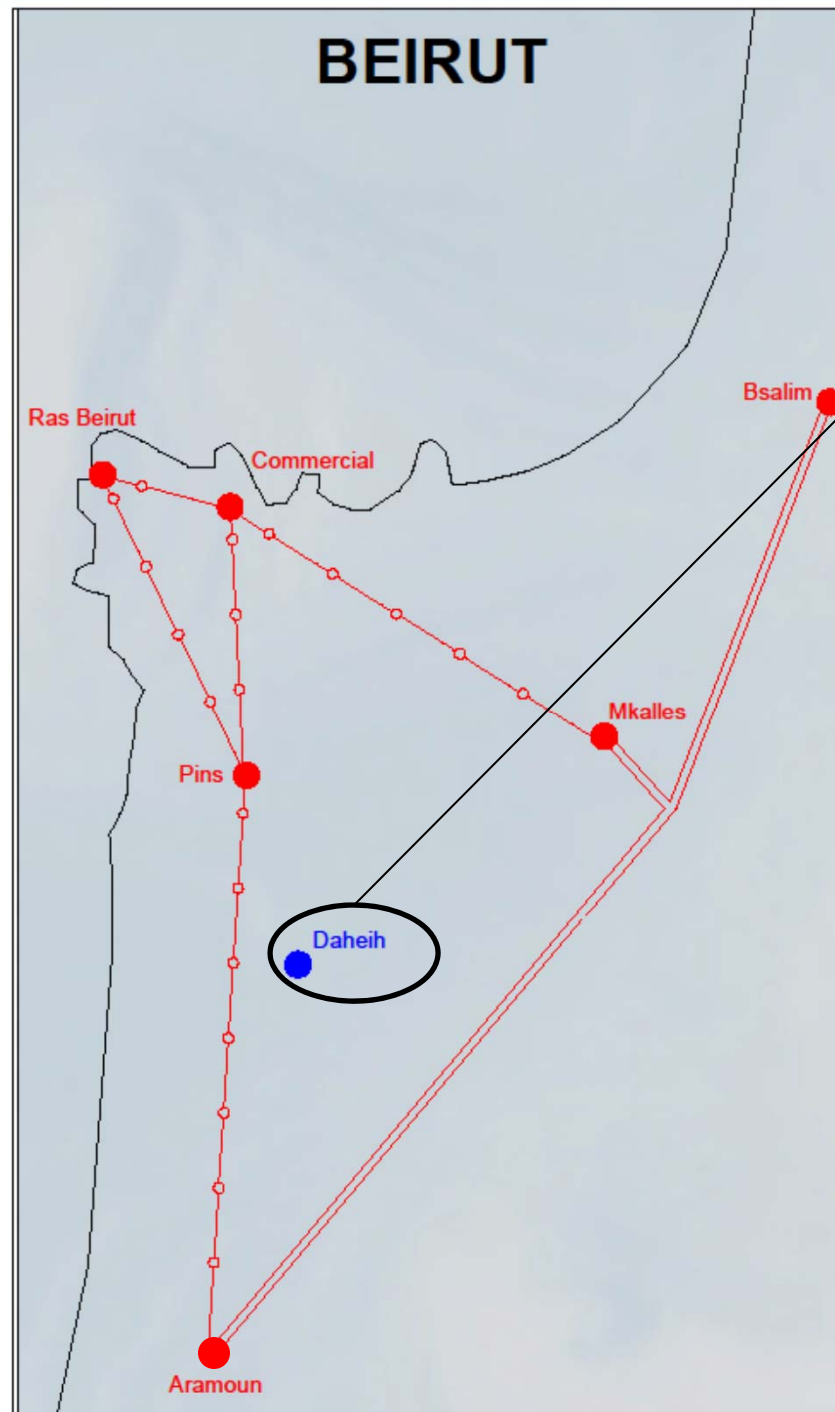
Main
Substations
220 kV





Short Term Plan

Main
Substations
220 kV

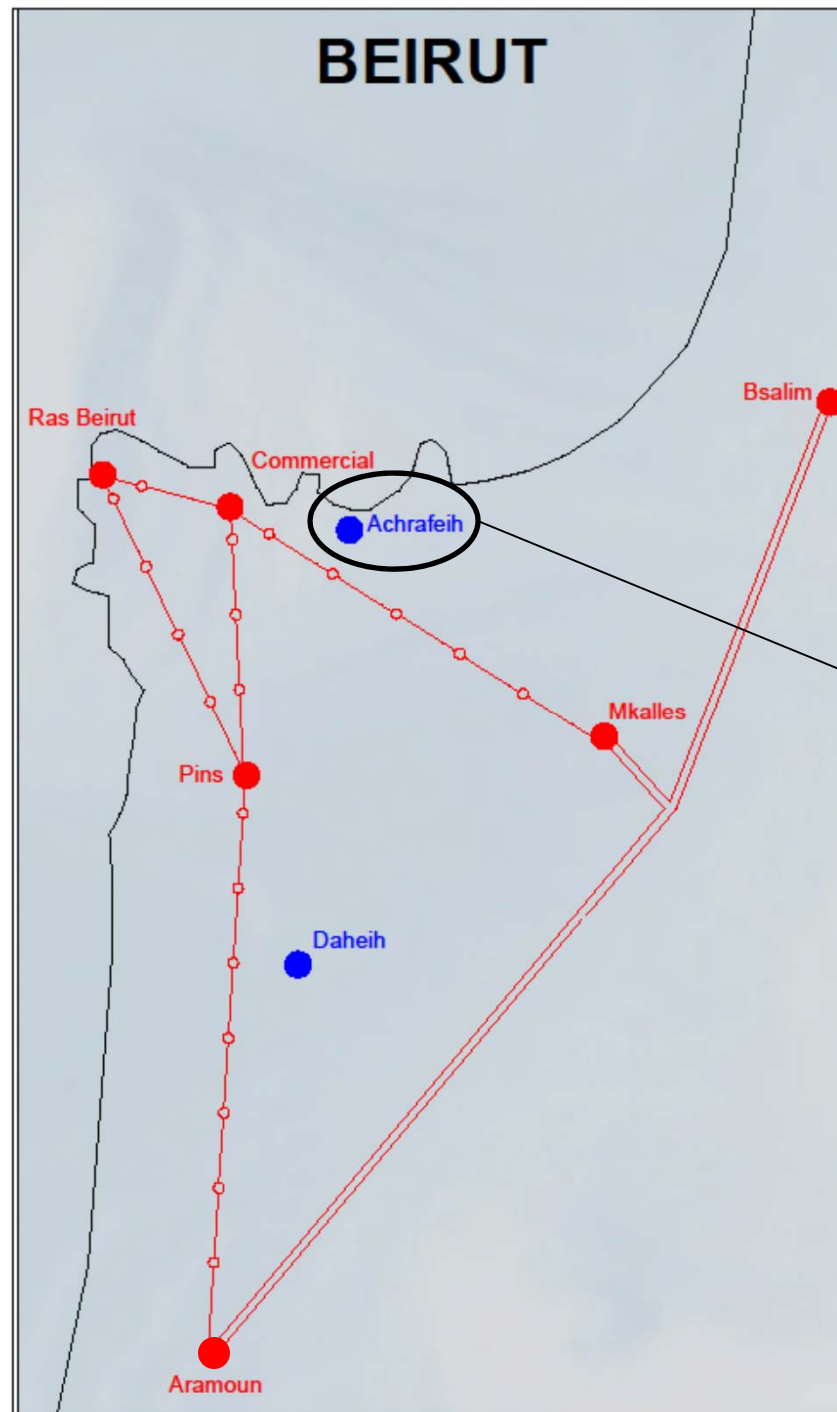


Dahieh S/S
220/20 kV
Equipped with
3 transf. 70
MVA each



Short Term Plan

Main
Substations
220 kV



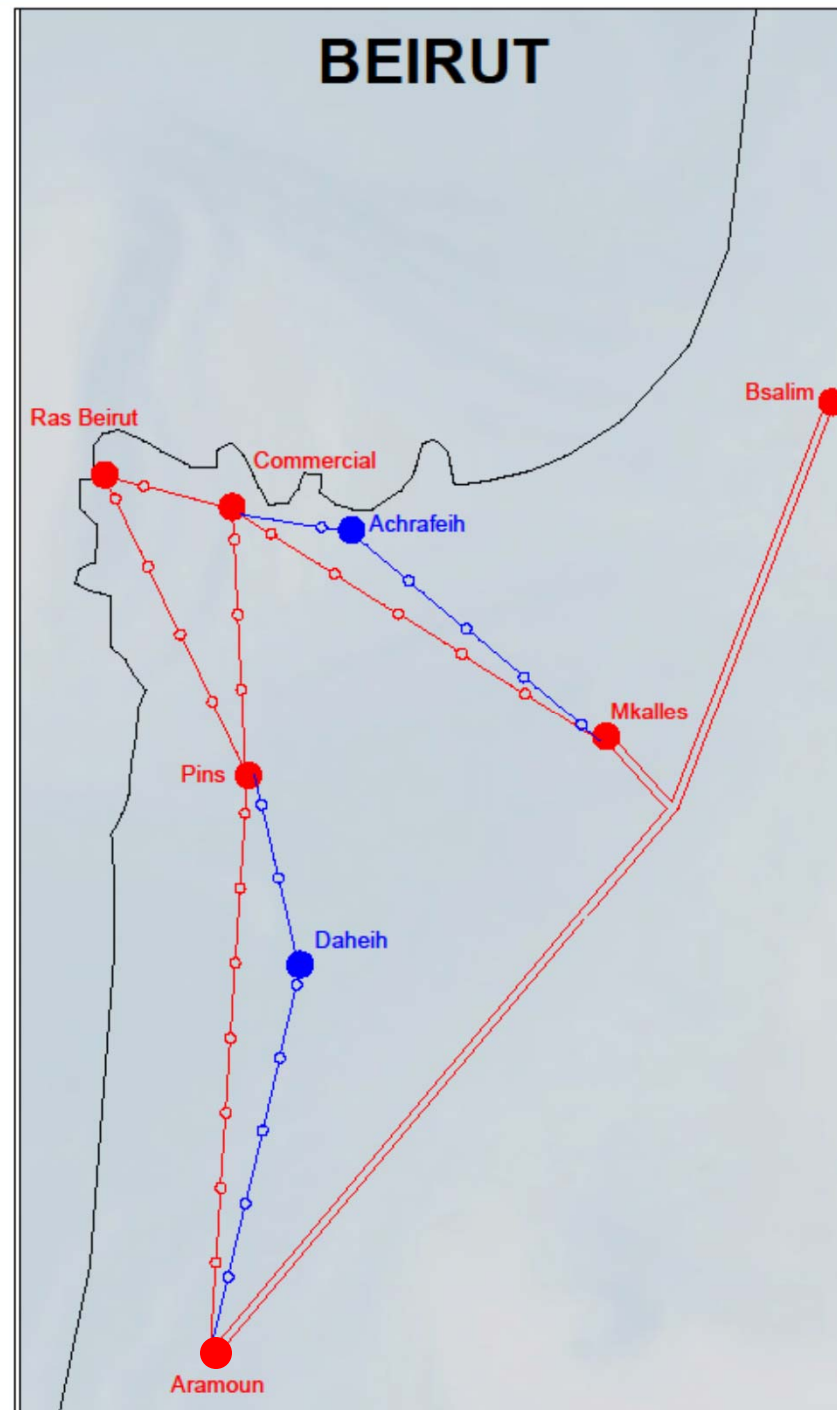
Dahieh S/S
220/20 kV
Equipped with
3 transf. 70
MVA each

Achrafeih S/S
220/20 kV
Equipped with
2 transf. 70
MVA each



Short Term Plan

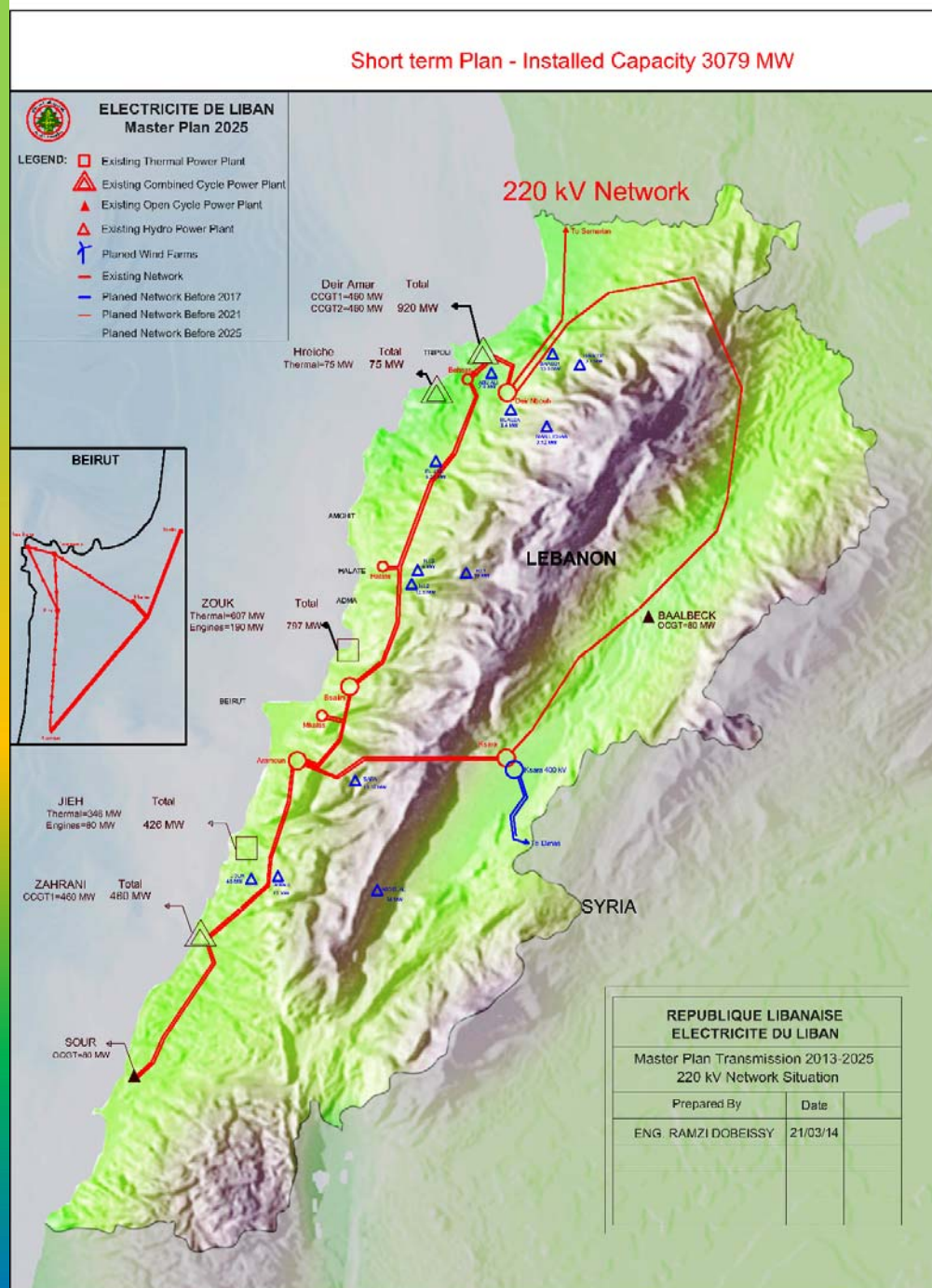
High Voltage
Underground
Cables 220 kV





Short Term Plan

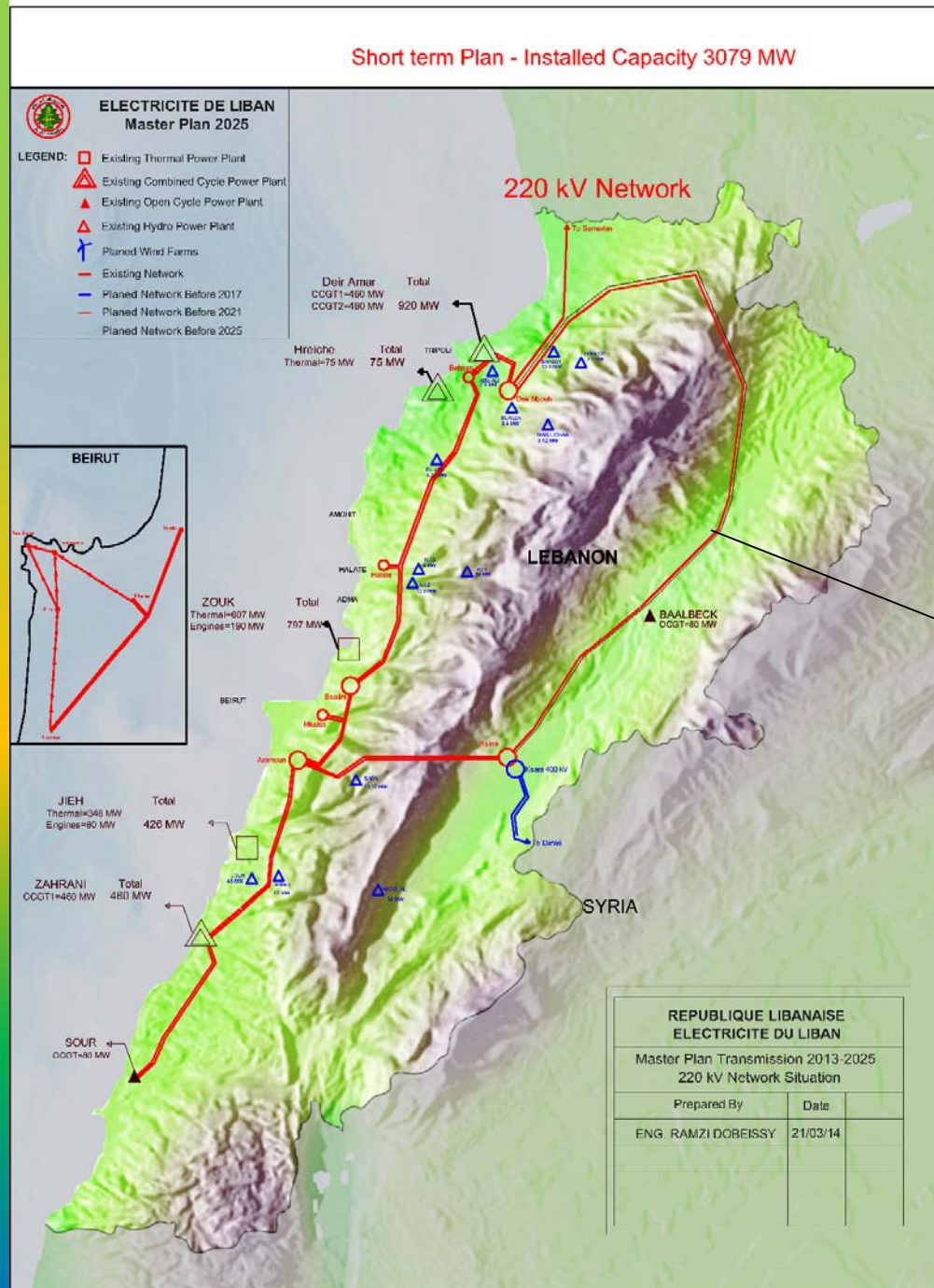
Overhead Transmission Lines 220 kV (OHTL)





Short Term Plan

Overhead Transmission Lines 220 kV (OHTL)

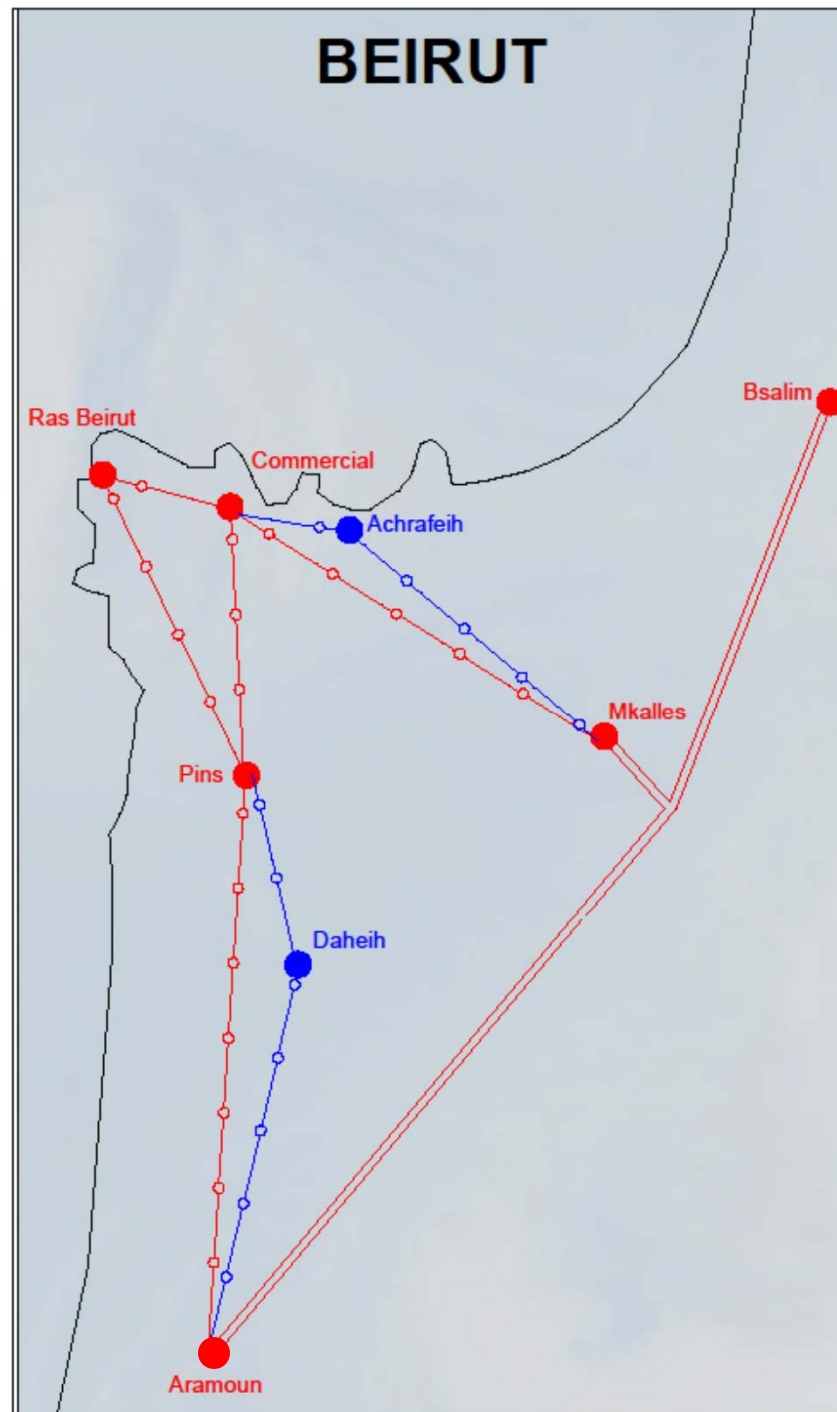


Operate again the second circuit of line Ksara – Deir Nbouh under 220 kV , this will happen soon after the renovation of the 66 kV line which in the last stages. Ksara-Deir Nbouh Length = 152 km Voltage= 66 kV Conductor=366mm² Almelek No of circuits=2



Short Term Plan

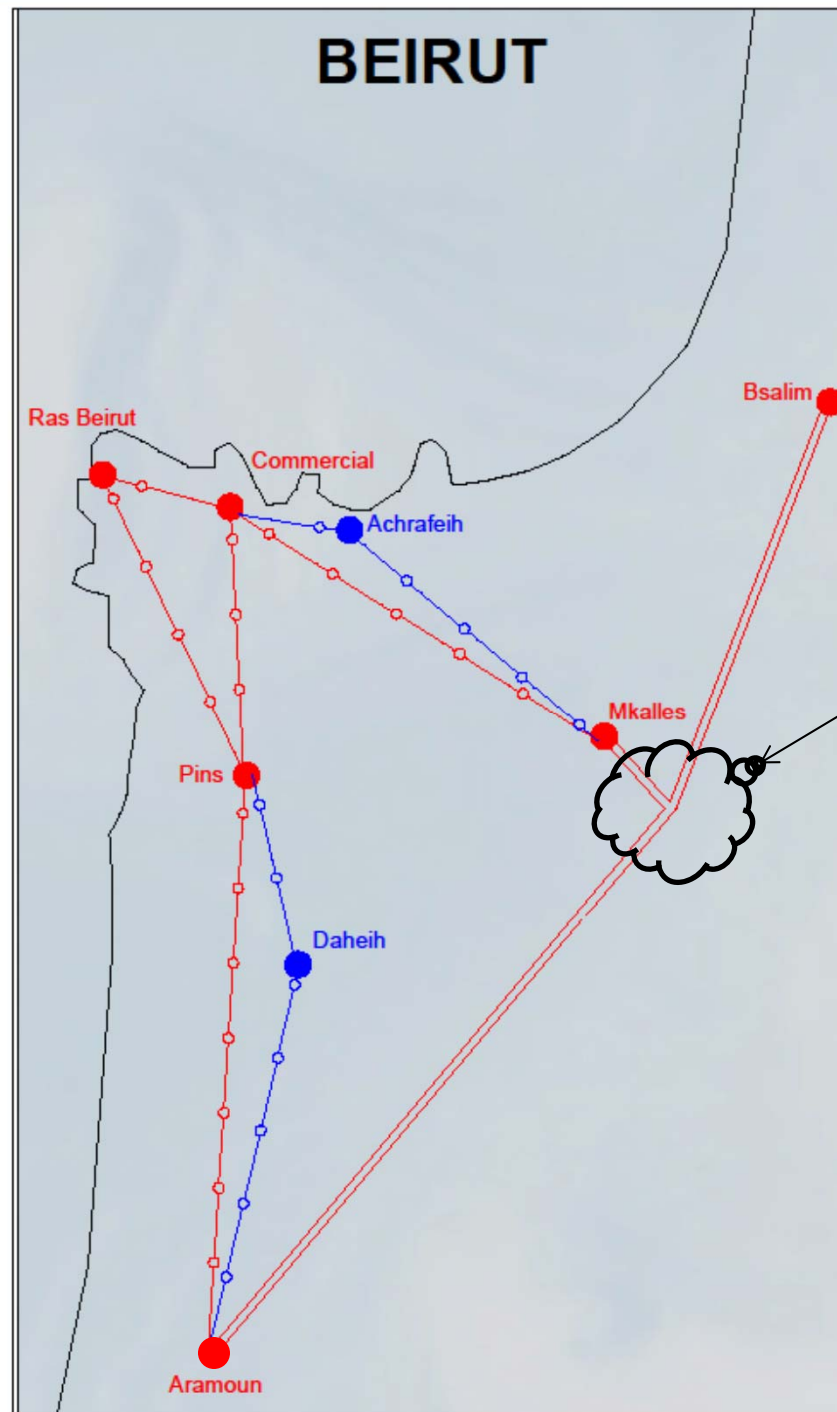
Network connection in Mansoureih





Short Term Plan

Network connection in Mansourieh



Execution of Mansourieh connection on Bsalim – Aramoun 220 KV line



Policy Paper Update 2019

- ❑ The Ministry of Energy and Water in collaboration with EDL issued this updated policy paper which was settled after coordination with the World Bank and was lately approved by the Council of Ministers.
This policy paper aims to achieve three major cornerstones which will work in parallel;
- Reducing the technical and non-technical losses and increasing the bill collections.
- Increasing the Generation capabilities with higher efficiencies relaying on Natural Gas to reduce the cost.
- Increasing the Tariff.
- This roadmap is the last chance to overcome the major problems that the sector has been facing for the last four decades.

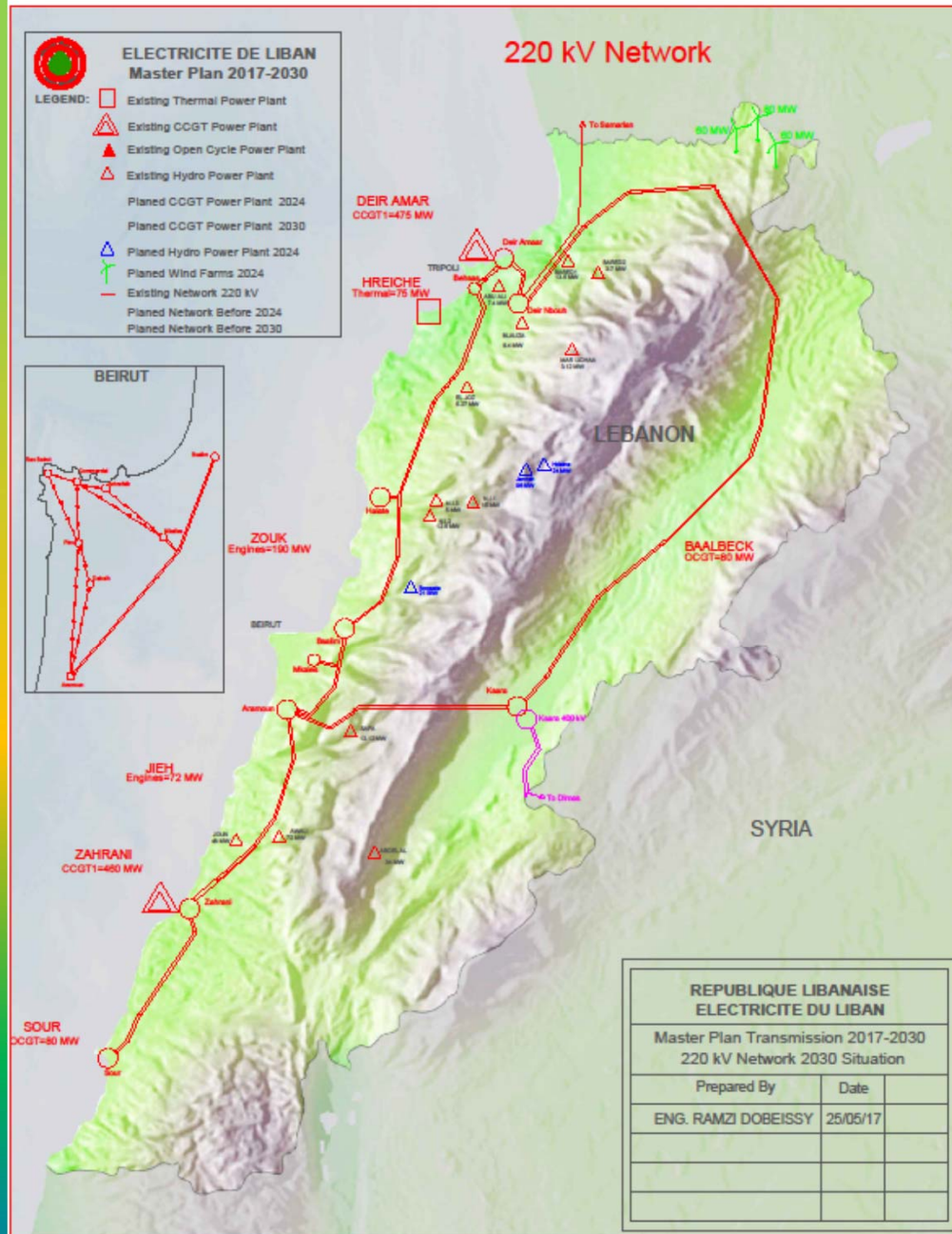


Master Plan Transmission 2017-2030

- ☐ **EDL requested EDF to prepare the Transmission Master 2017-2030 based on the existing Power Plants location in addition to a new location in Selaata.**
- ☐ **The Transmission Master Plan designated all the necessary investments in Transmission that are required to evacuate the additional generated power from the new power plants to reach the demand centers, it's divided into two periods 2017-2023 & 2024-2030.**
- ☐ **The Council of Ministers adopted the transmission Master Plan in September 2017.**



Master Plan (2017-2023) Power Generation plants

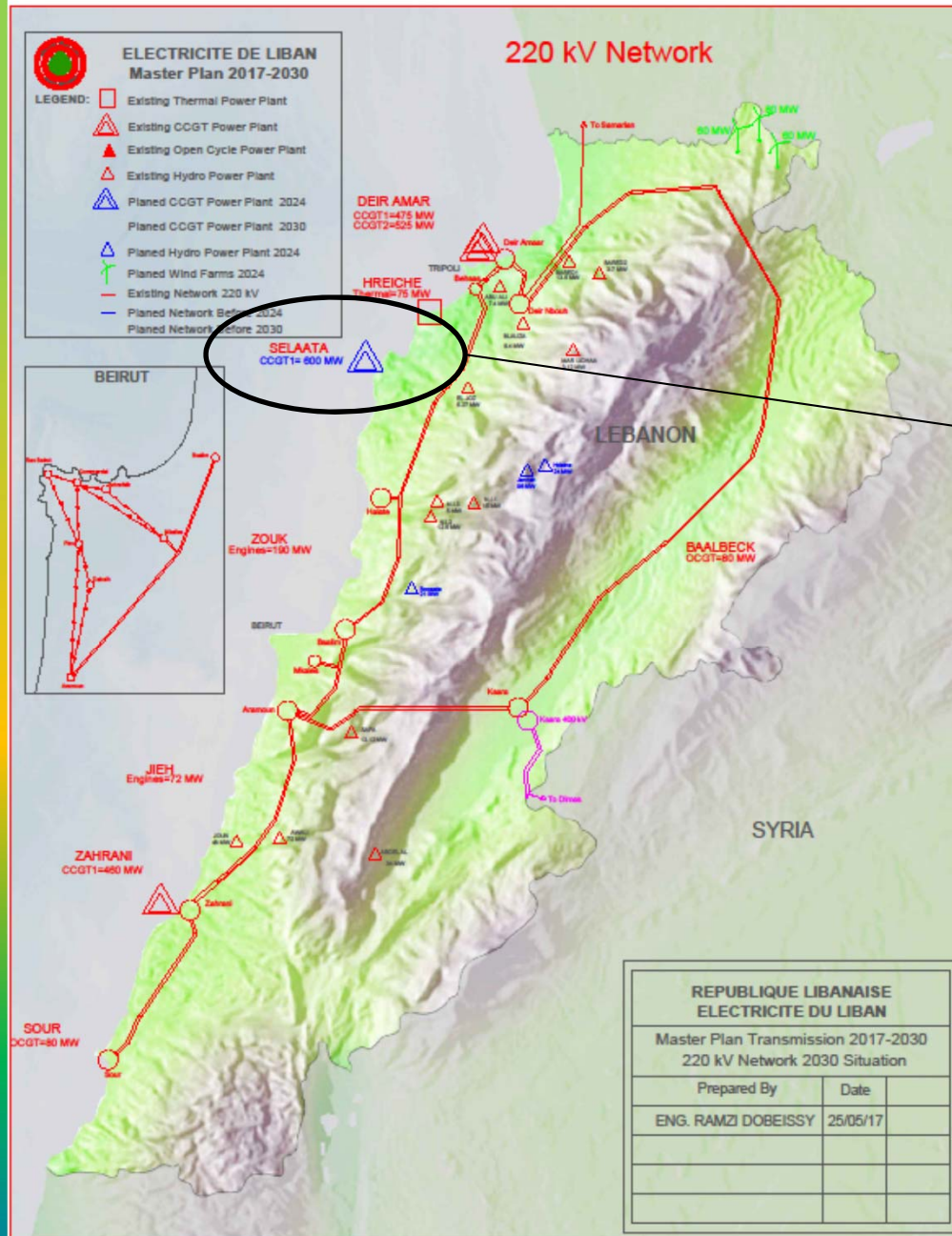


**Installed
Capacity
Will be
4925 MW**



Master Plan (2017-2023)

Power Generation plants



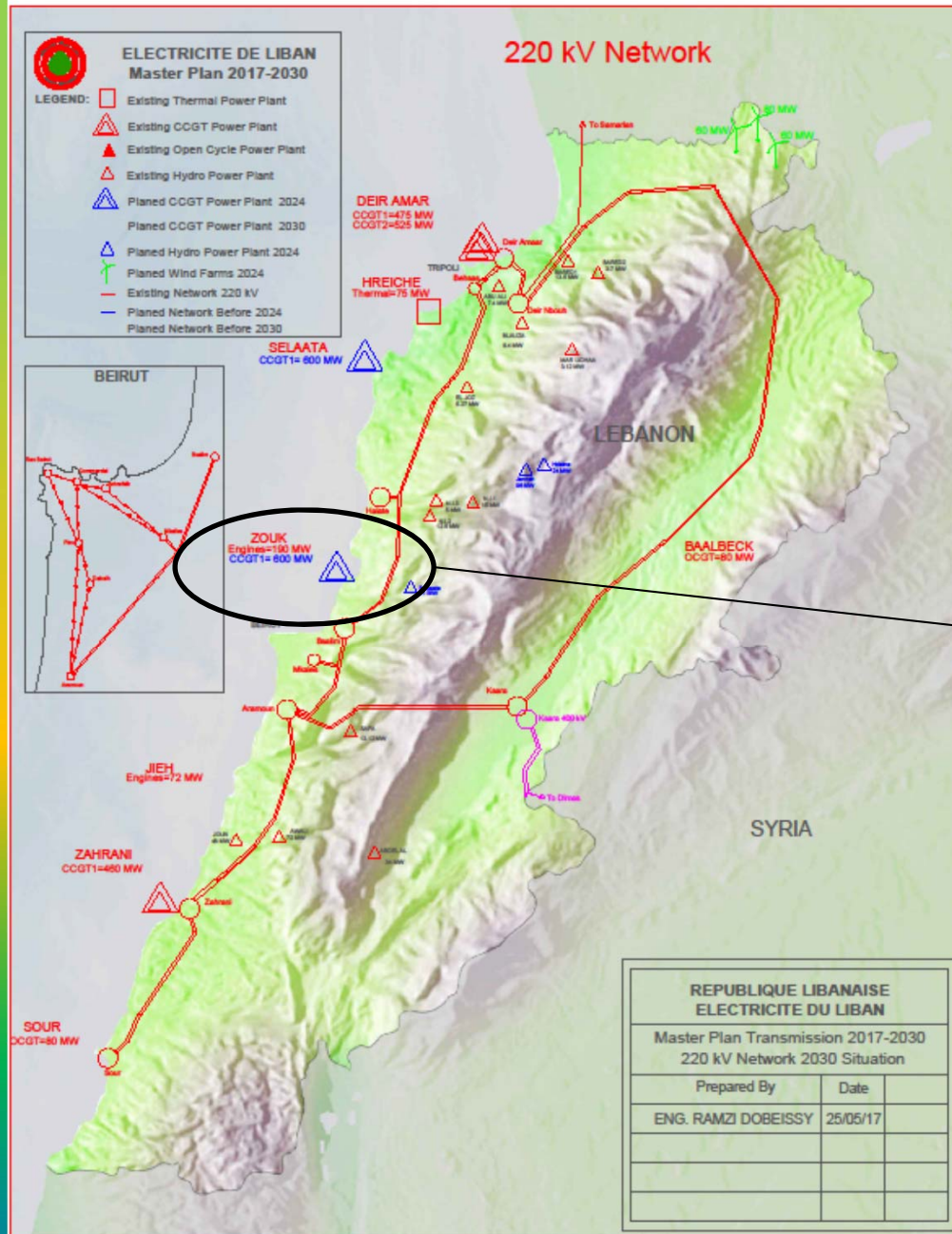
**Installed
Capacity
Will be
4925 MW**

**SELAATA 1
CCGT
600 MW**



Master Plan (2017-2023)

Power Generation plants



Installed Capacity Will be 4925 MW

SELAATA 1 CCGT 600 MW

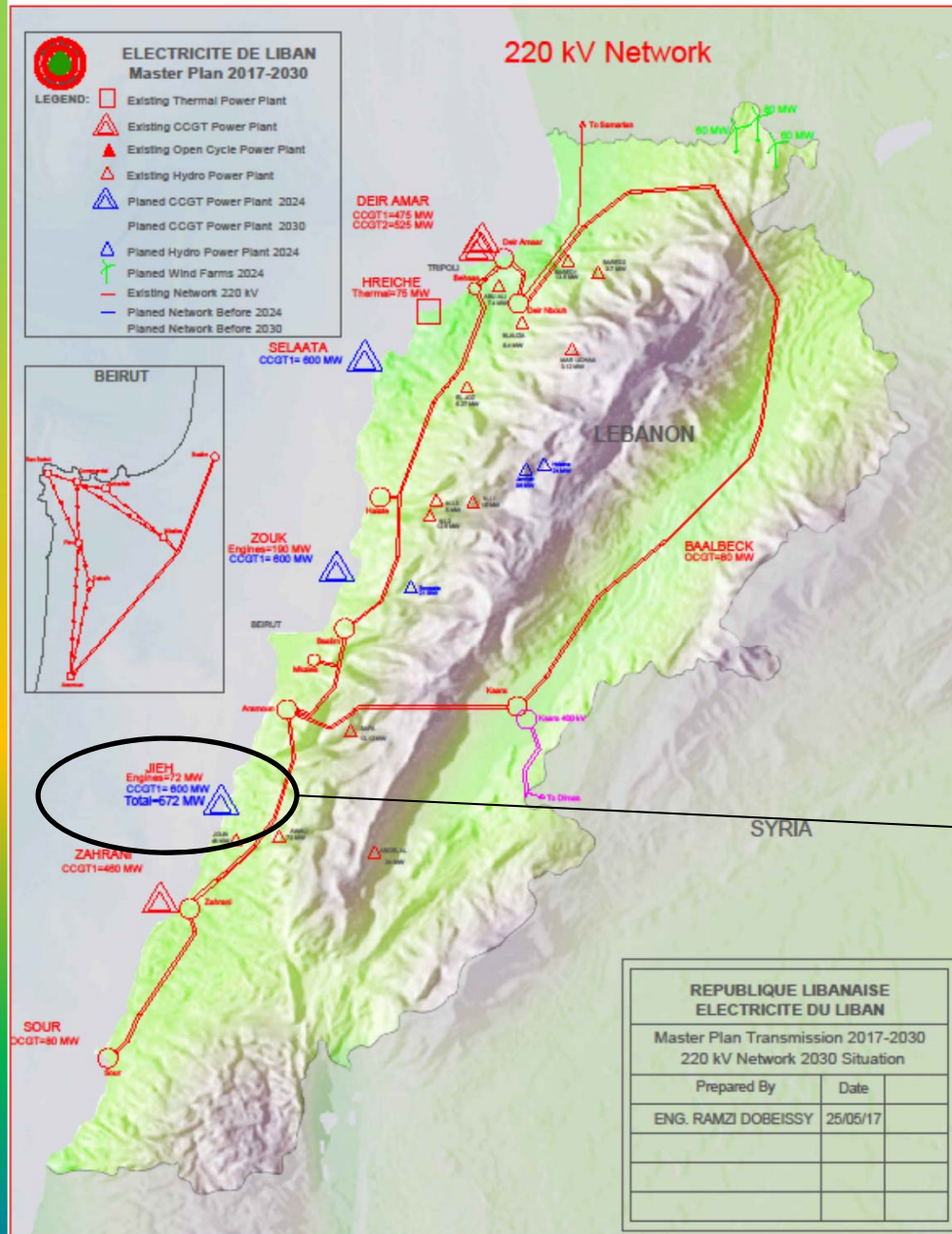
ZOUK 1 CCGT 600 MW



Master Plan

(2017-2023)

Power Generation plants



Installed Capacity Will be 4925 MW

SELAATA 1 CCGT 600 MW

ZOUK 1 CCGT 600 MW

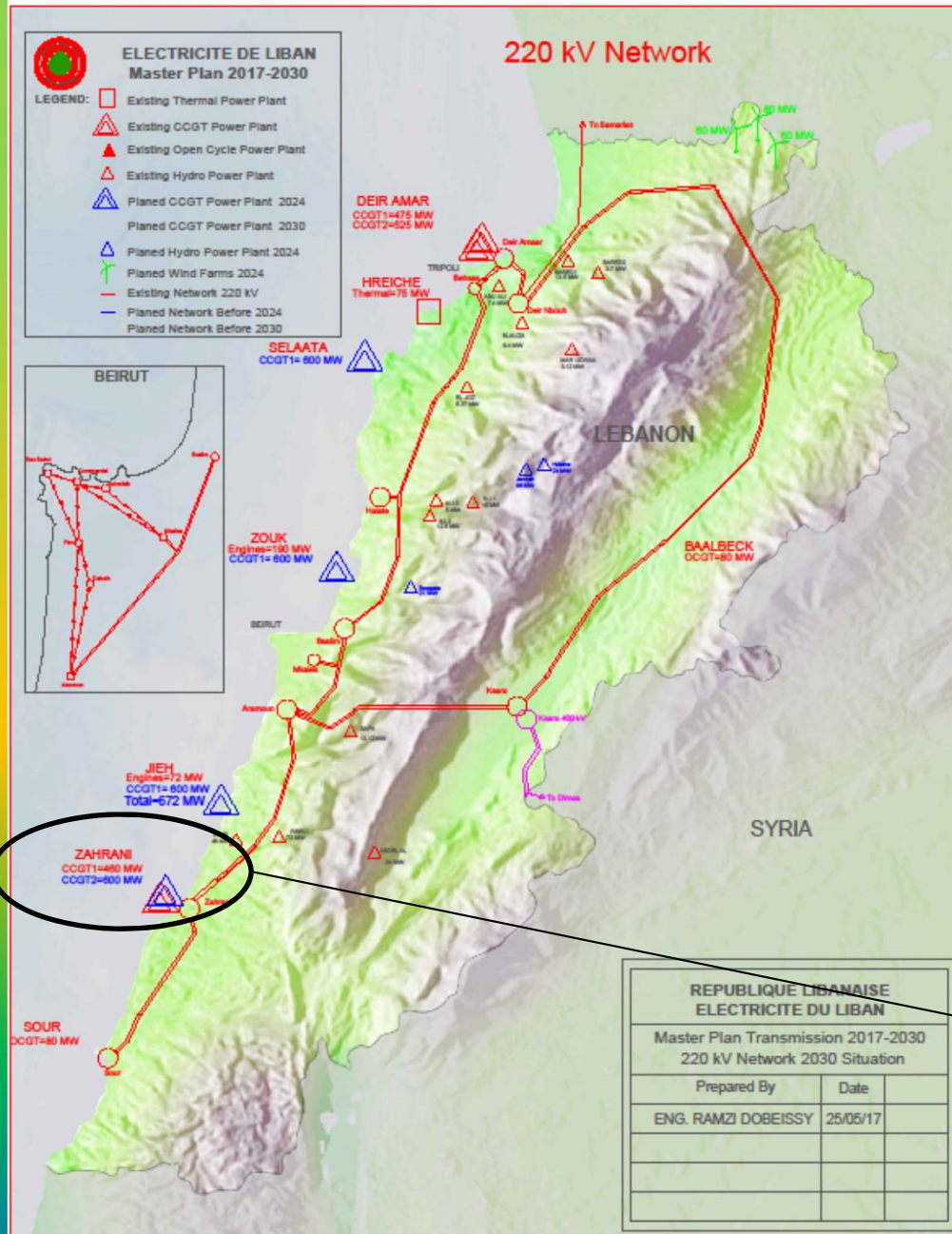
JIEH 1 CCGT 600 MW



Master Plan

(2017-2023)

Power Generation plants



Installed Capacity Will be 4925 MW

SELAATA CCGT1 600 MW

ZOUK CCGT1 600 MW

JIEH CCGT1 600 MW

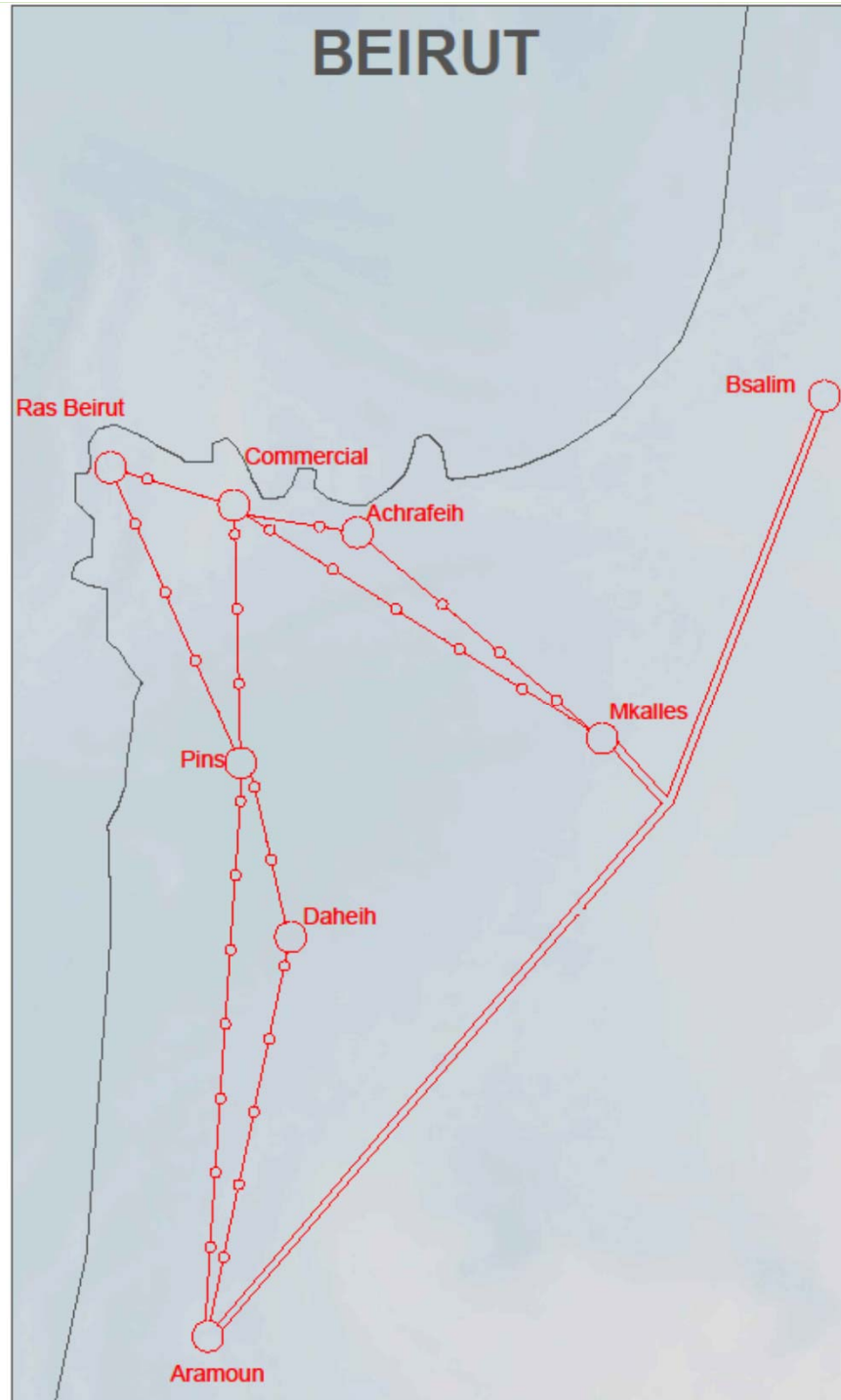
ZAHRANI 2 CCGT 600 MW



Master Plan

(2017-2023)

Substations
220 kV



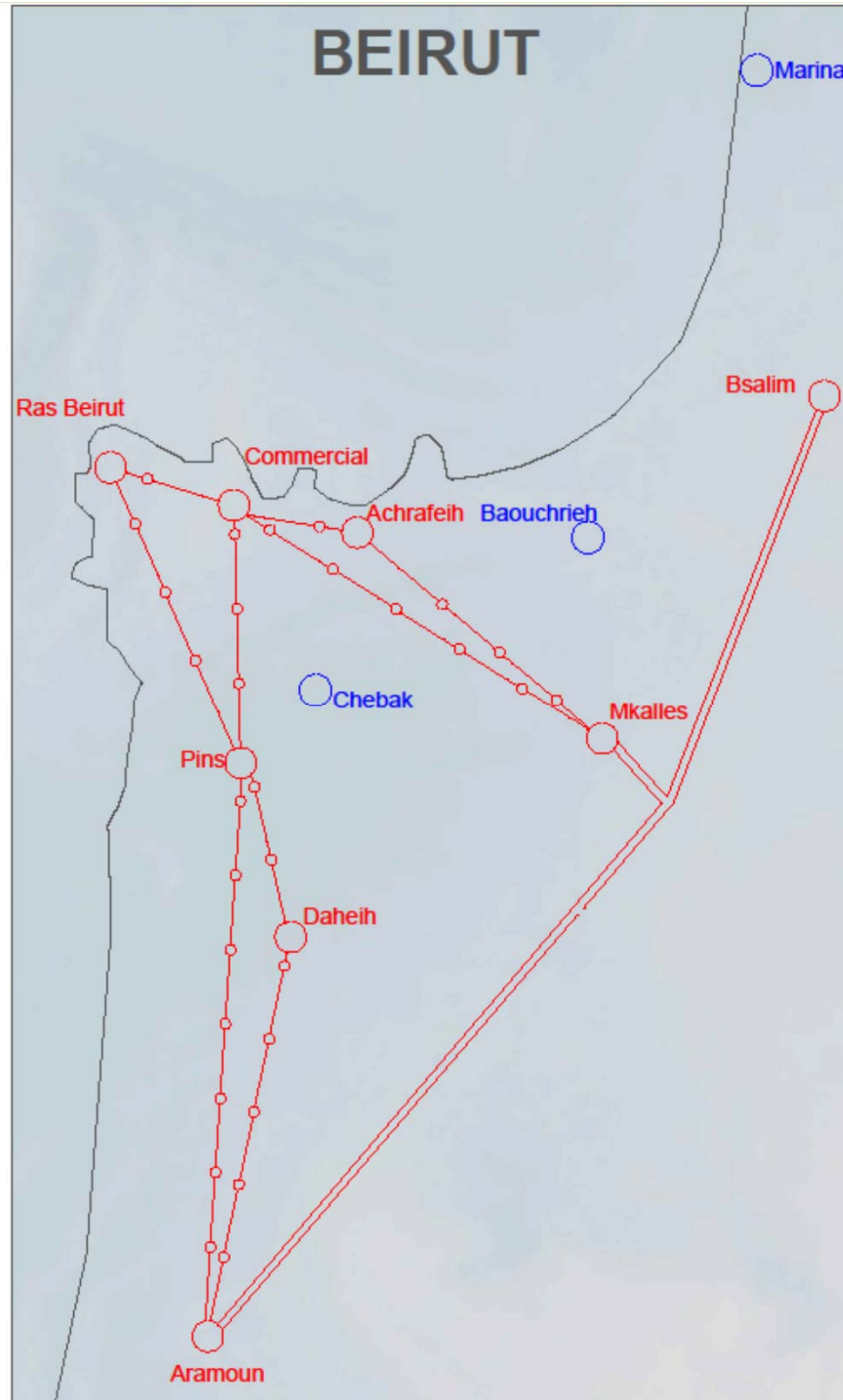
Installed
Capacity
Will be
4925 MW



Master Plan

(2017-2023)

Substations
220 kV



Installed
Capacity
Will be
4925 MW

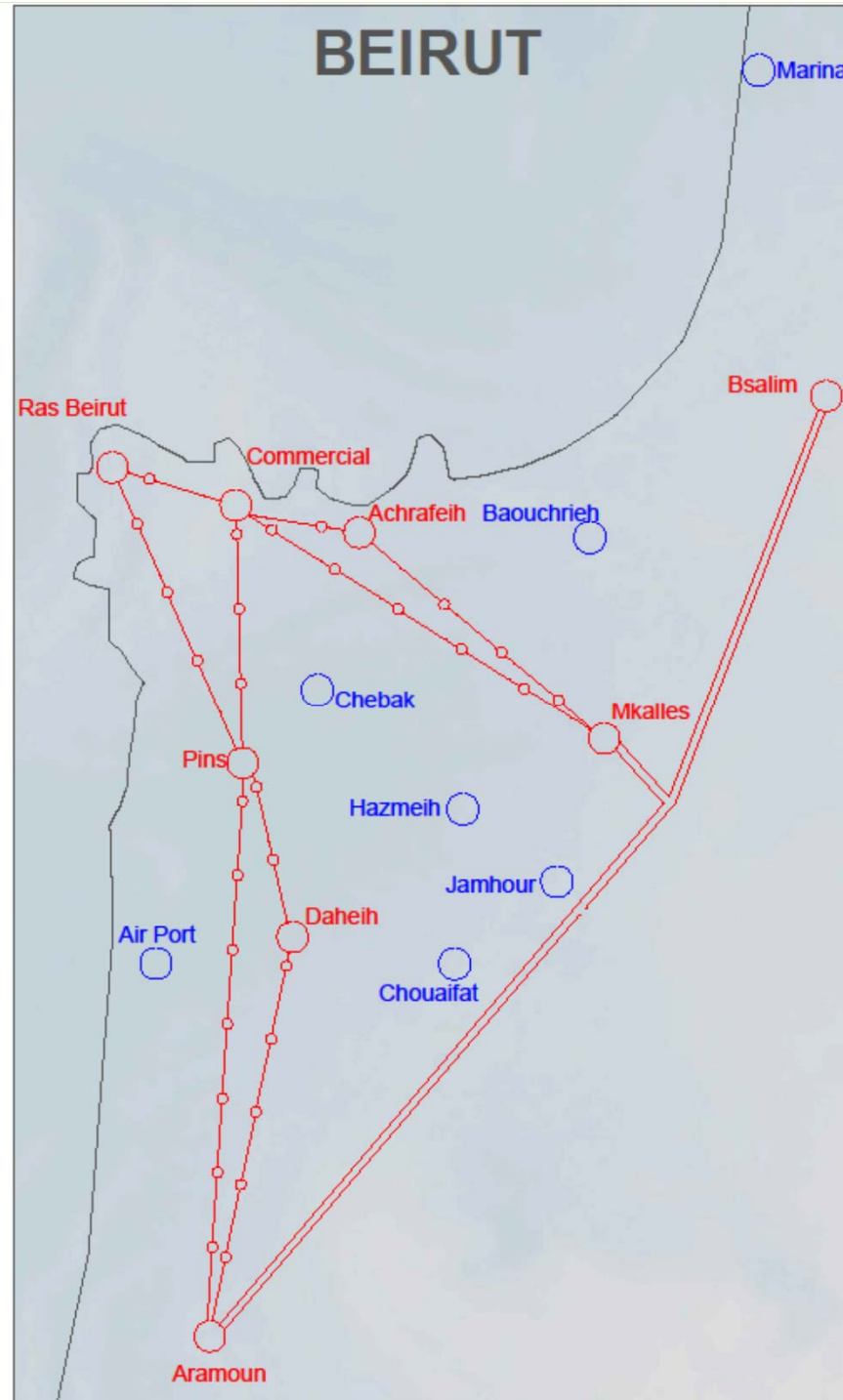
North Loop of
Beirut



Master Plan

(2017-2023)

Substations
220 kV



**Installed
Capacity
Will be
4925 MW**

**North Loop of
Beirut**

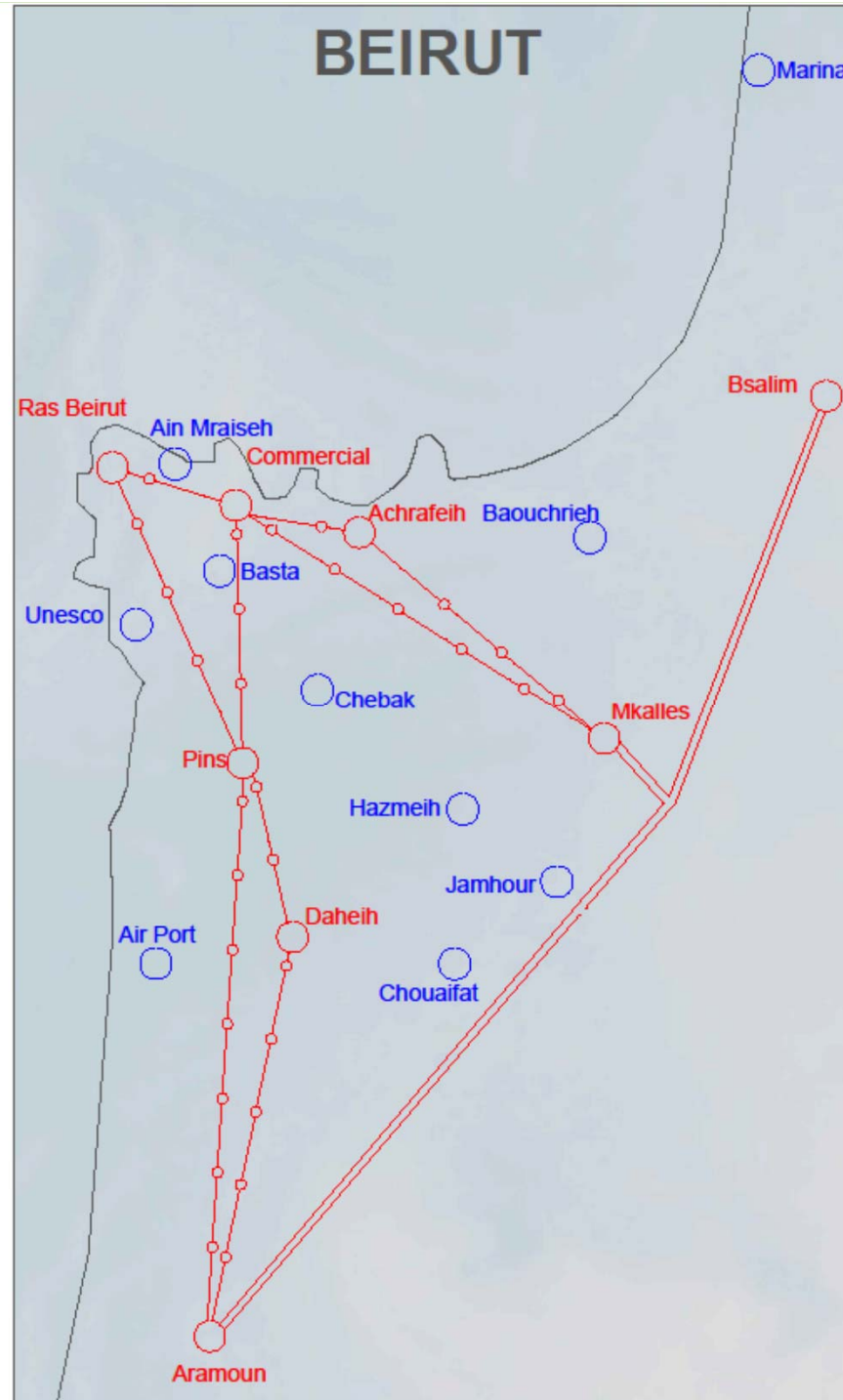
**1st South
Loop of Beirut**



Master Plan

(2017-2023)

Substations
220 kV



**Installed
Capacity
Will be
4925 MW**

**North Loop of
Beirut**

**1st South
Loop of Beirut**

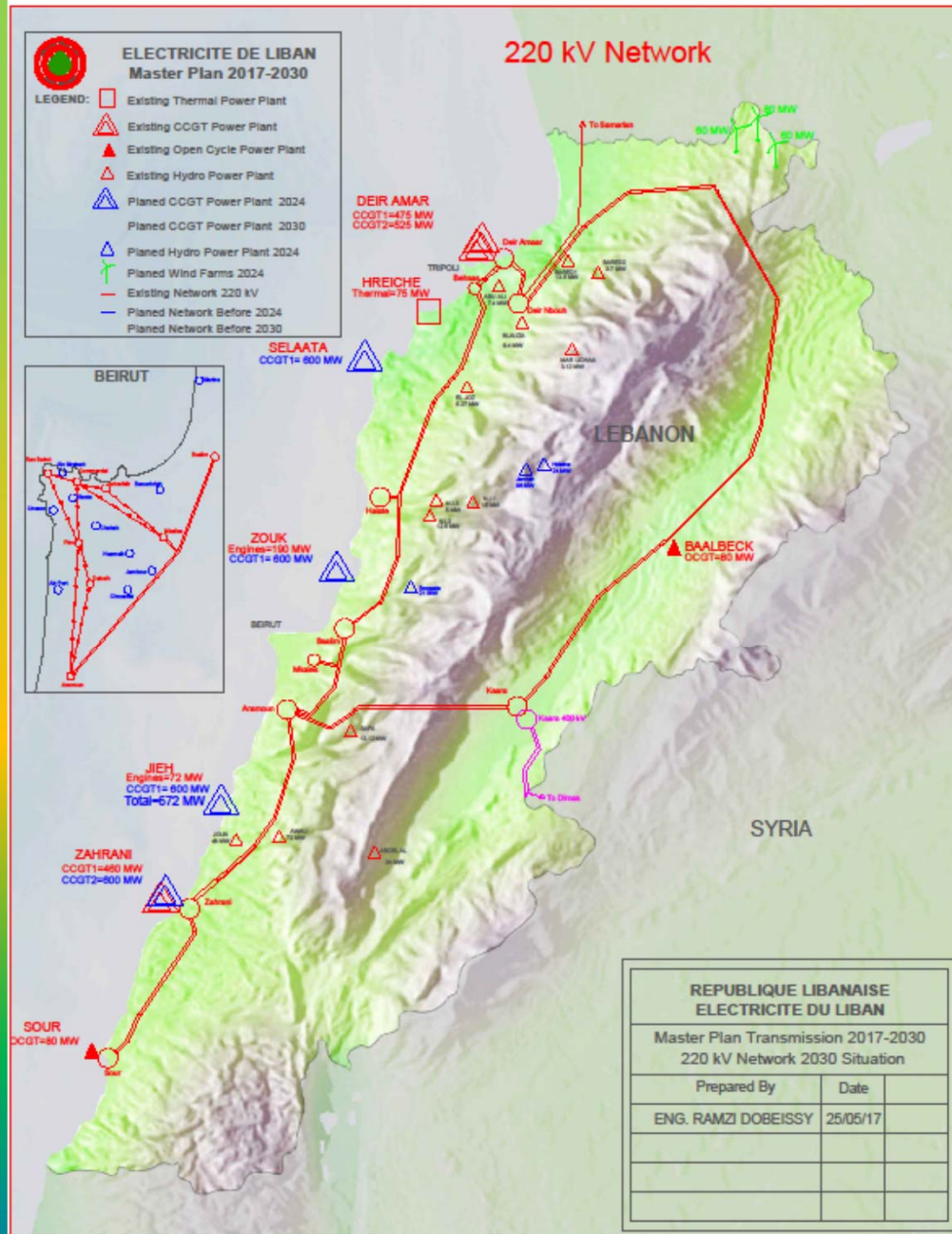
**2nd South
Loop of Beirut**



Master Plan

(2017-2023)

Substations
220 kV



**Installed
Capacity
Will be
4925 MW**

**North Loop of
Beirut**

**1st South
Loop of Beirut**

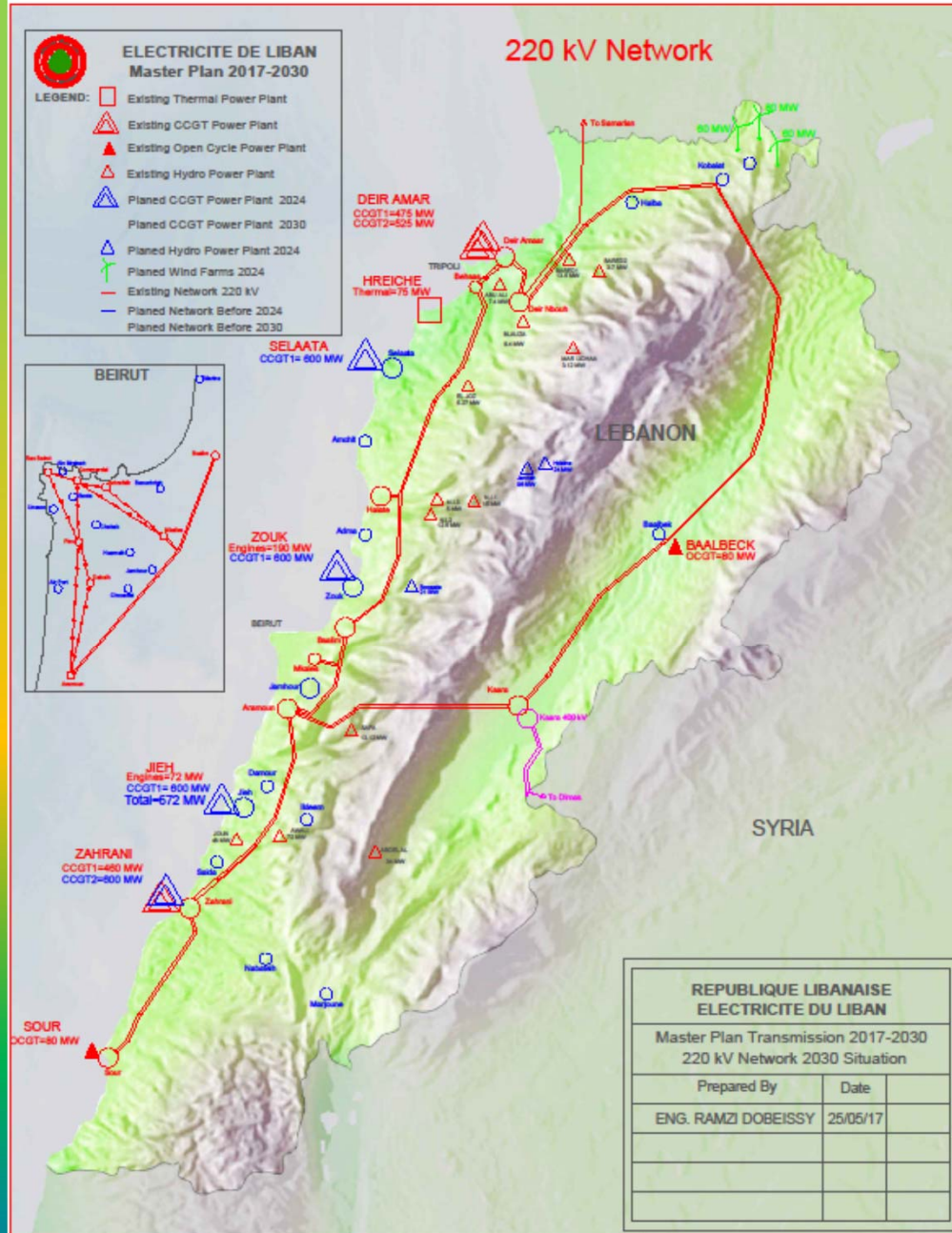
**2nd South
Loop of Beirut**



Master Plan

(2017-2023)

Substations
220 kV



Installed
Capacity
Will be
4925 MW

North Loop of
Beirut

1st South
Loop of Beirut

2nd South
Loop of Beirut

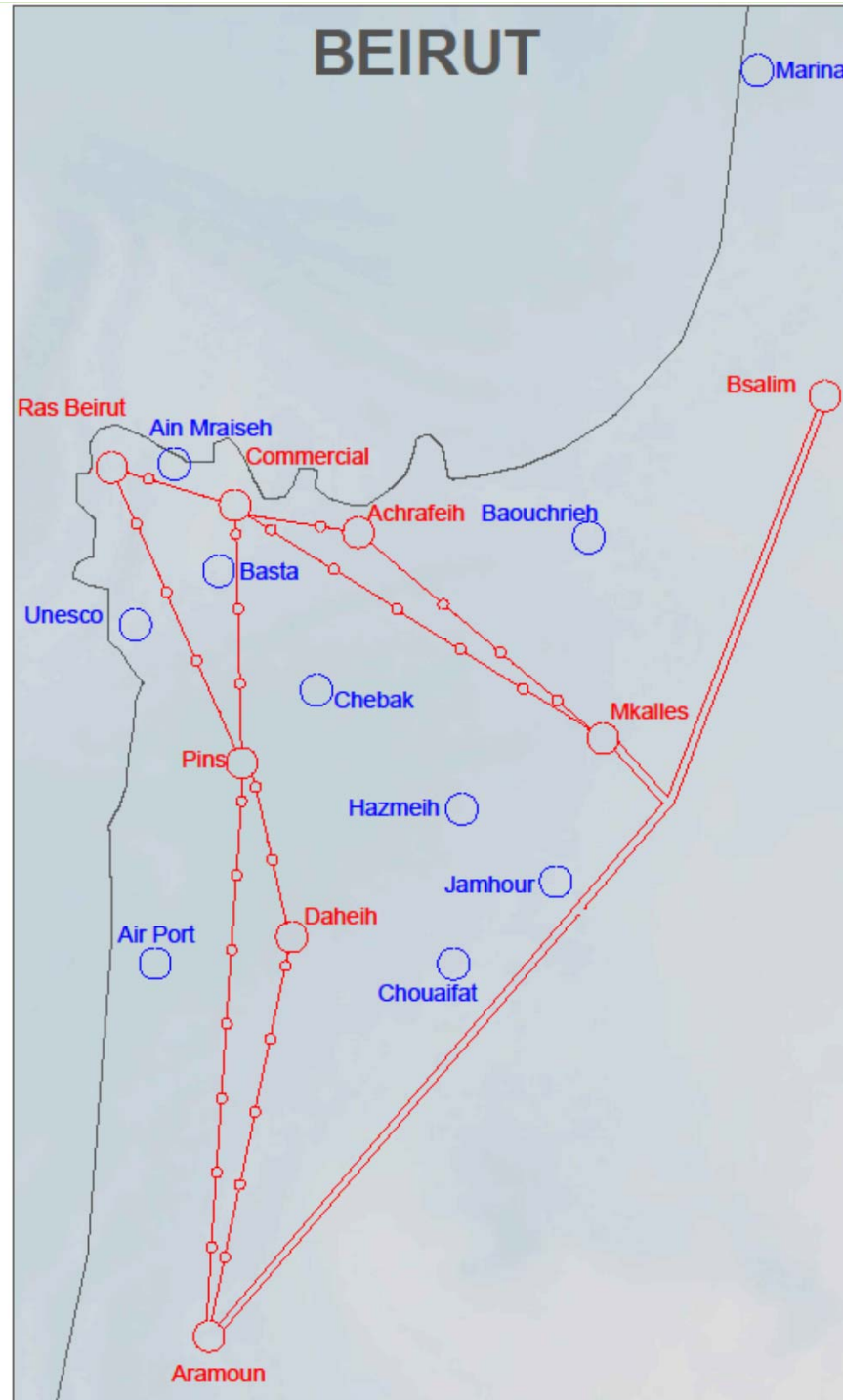
Other
Substations



Master Plan

(2017-2023)

Substations
220 KV



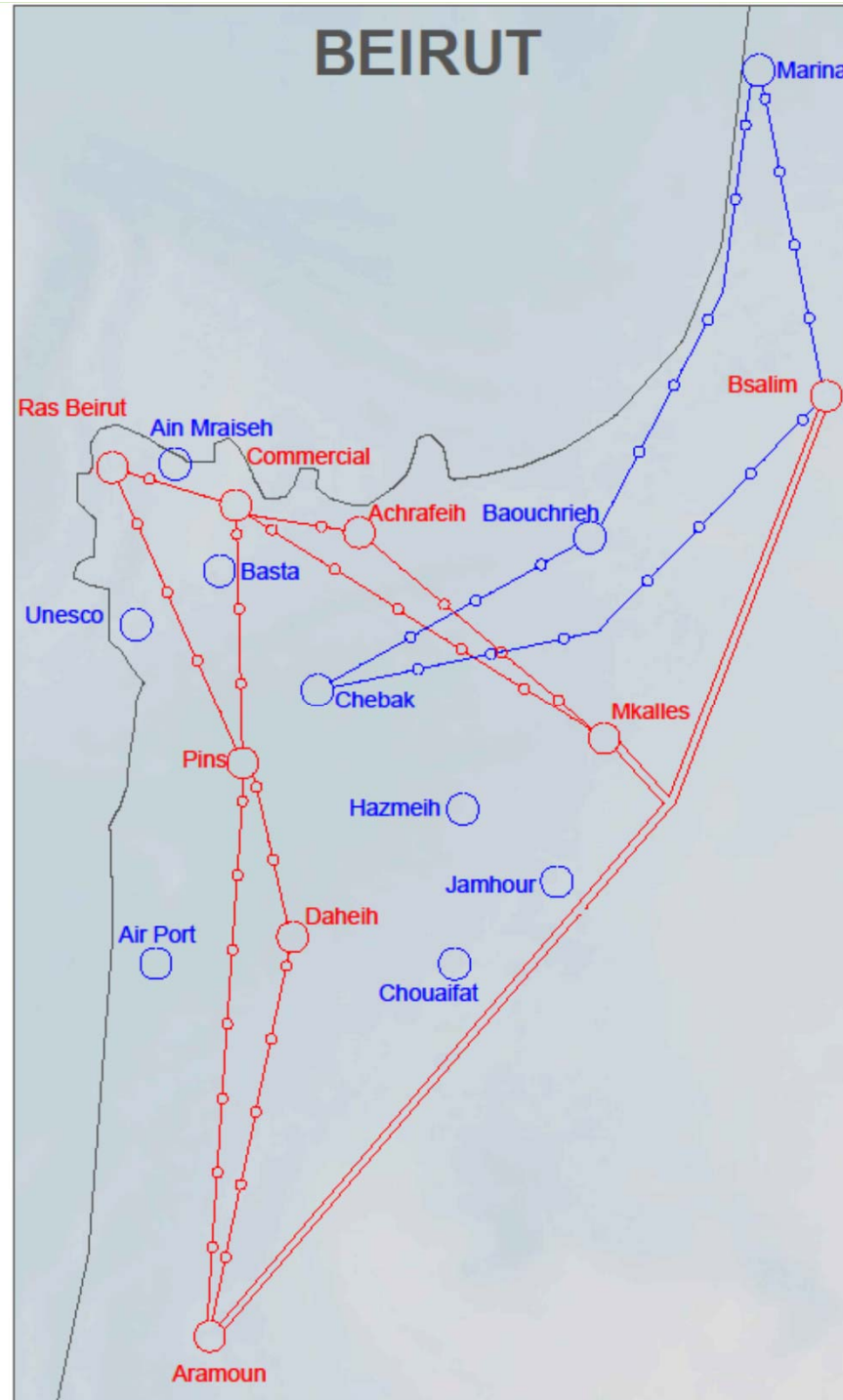
**Installed
Capacity
Will be
4925 MW**



Master Plan

(2017-2023)

High Voltage
Underground
Cables 220KV



Installed
Capacity
Will be
4925 MW

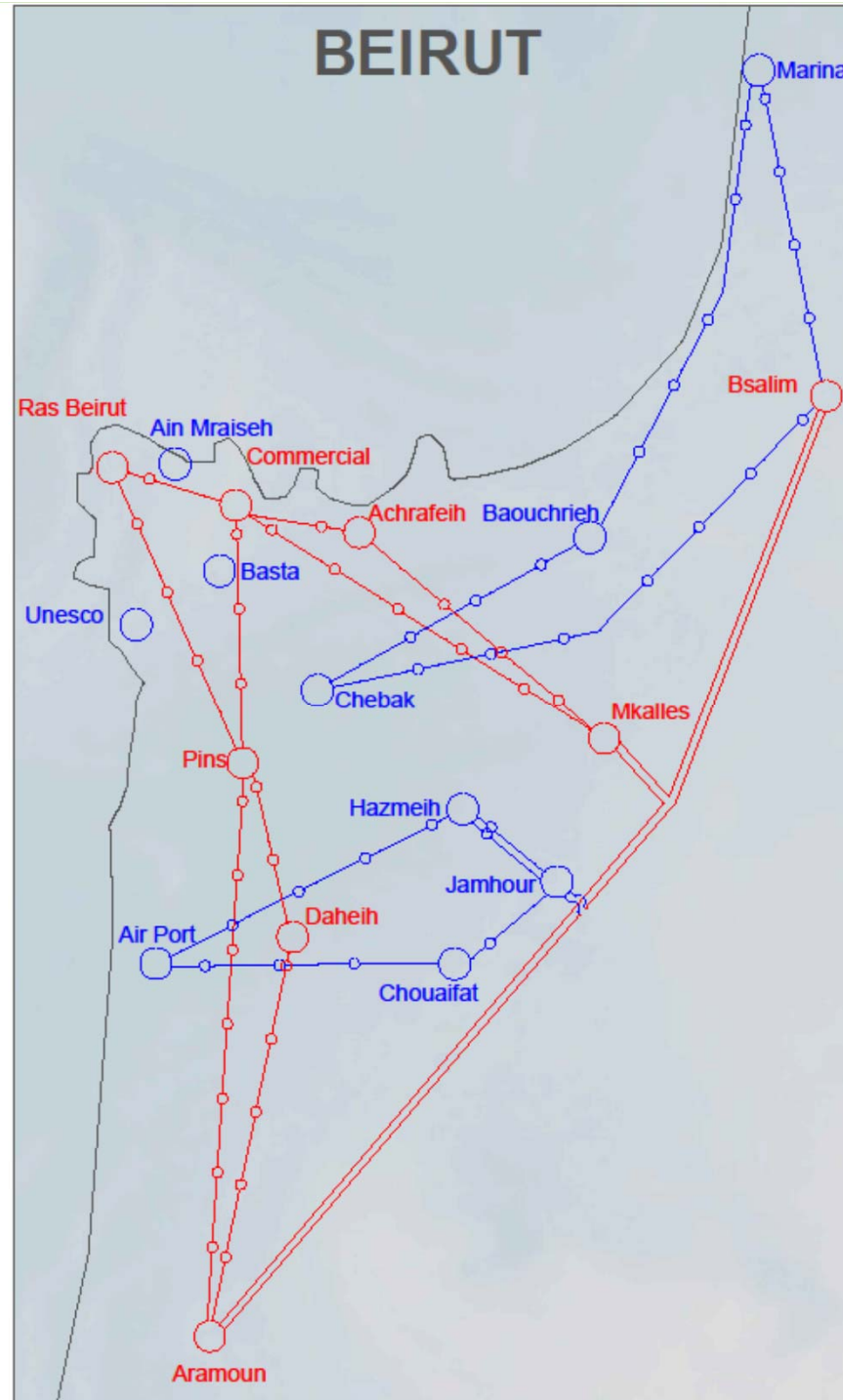
North Loop of
Beirut



Master Plan

(2017-2023)

High Voltage
Underground
Cables 220KV



Installed
Capacity
Will be
4925 MW

North Loop of
Beirut

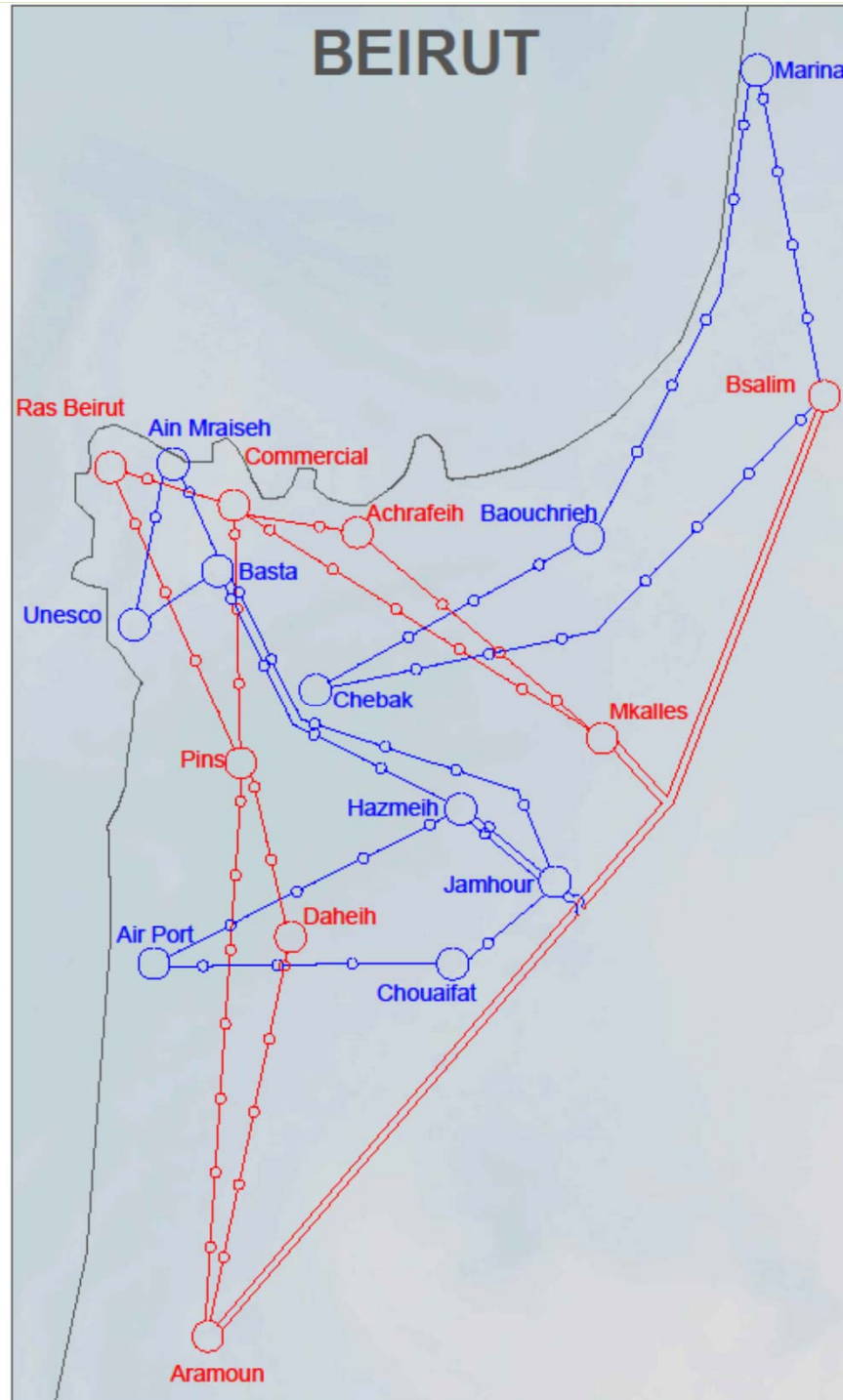
1st South
Loop of Beirut



Master Plan

(2017-2023)

High Voltage
Underground
Cables 220KV



**Installed
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**North Loop of
Beirut**

**1st South
Loop of Beirut**

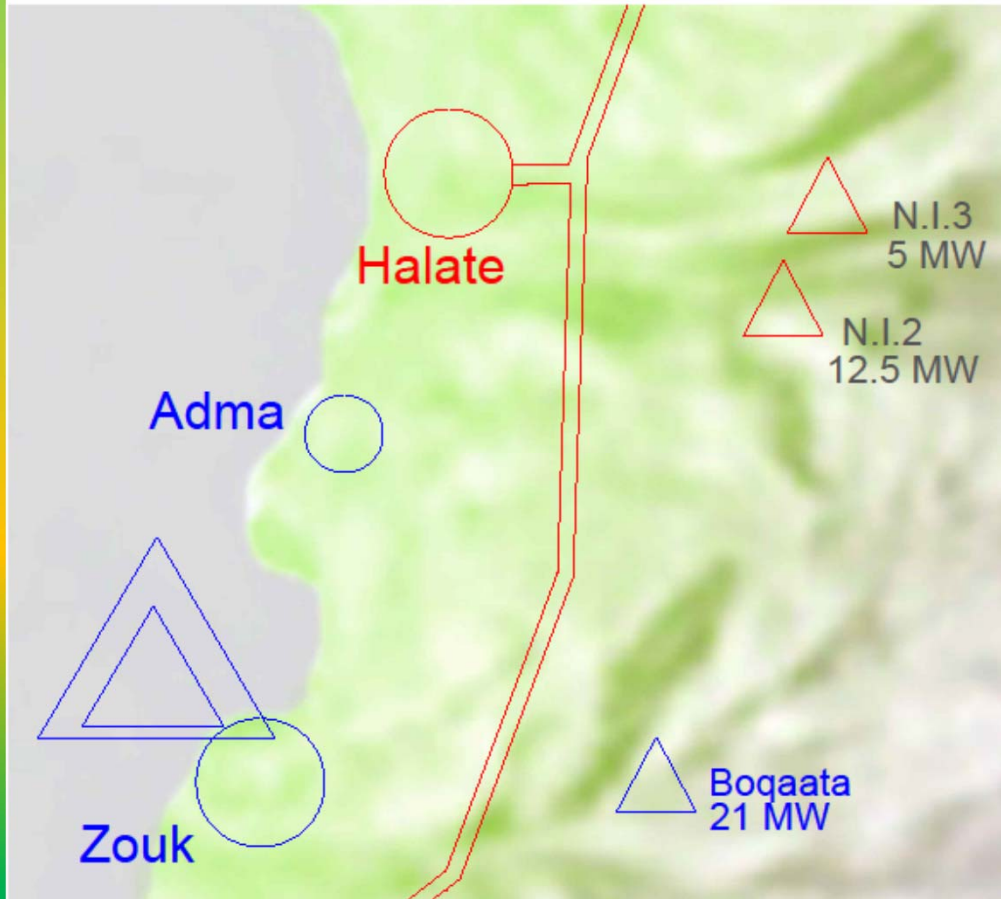
**2nd South
Loop of Beirut**



Master Plan

(2017-2023)

High Voltage
Underground
Cables 220KV



**Installed
Capacity
Will be
4925 MW**

**North Loop of
Beirut**

**1st South
Loop of Beirut**

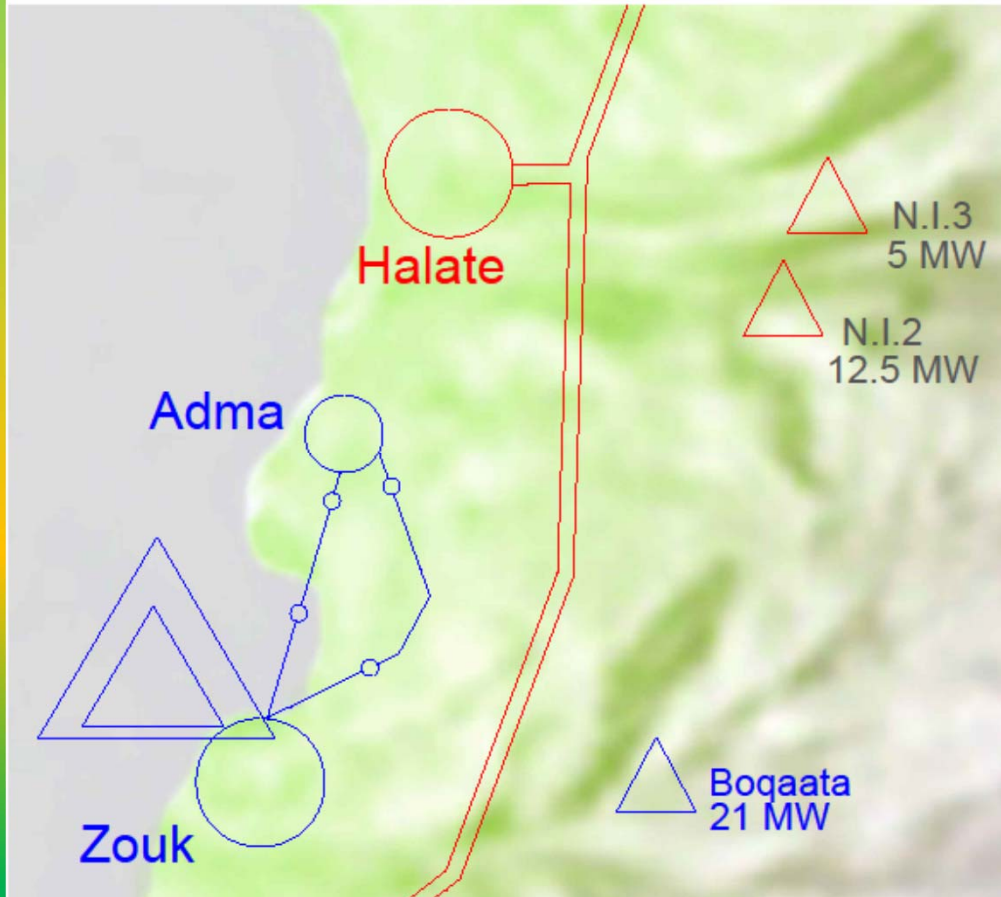
**2nd South
Loop of Beirut**



Master Plan

(2017-2023)

High Voltage
Underground
Cables 220KV



**Installed
Capacity
Will be
4925 MW**

**North Loop of
Beirut**

**1st South
Loop of Beirut**

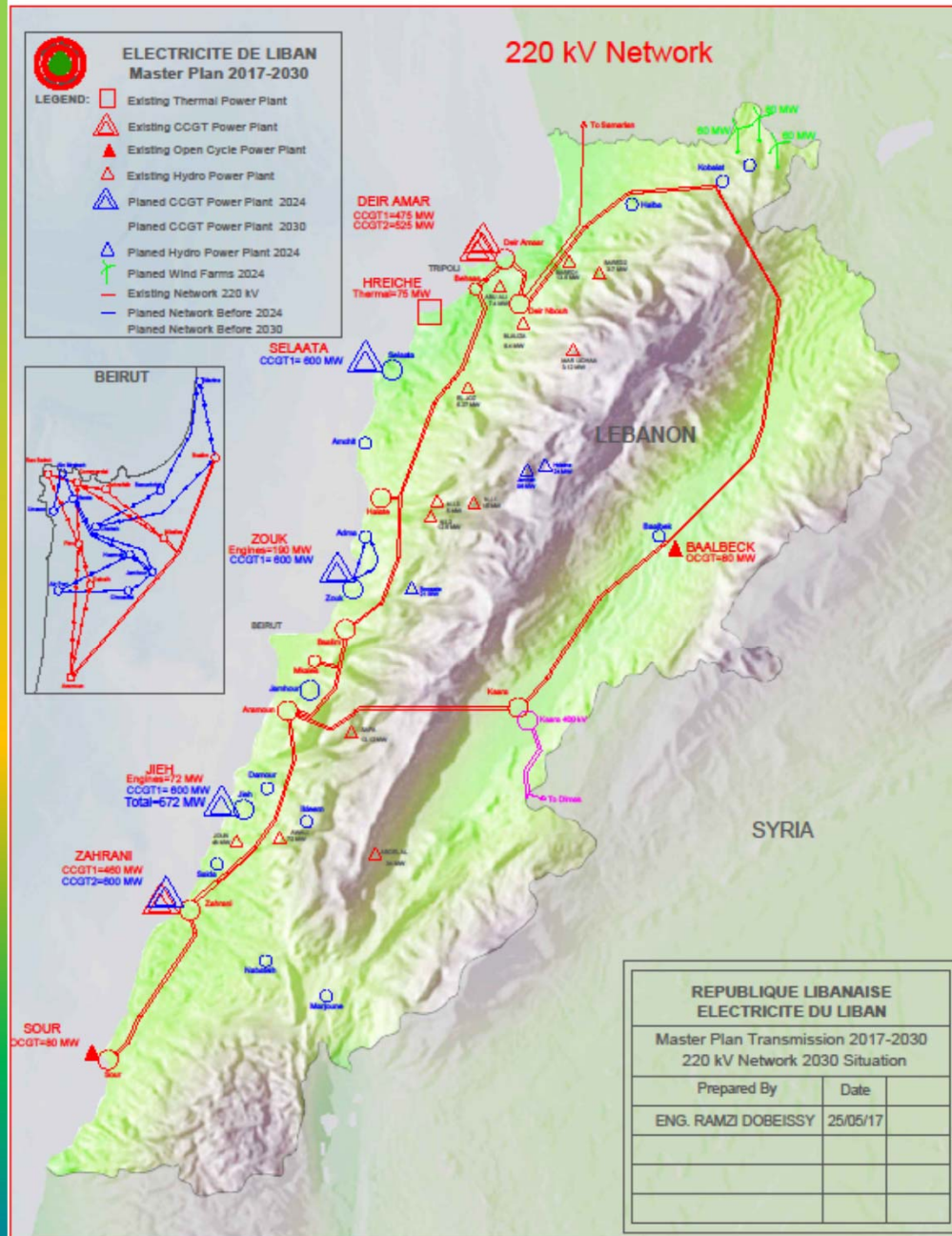
**2nd South
Loop of Beirut**

**Zouk – Adma
– Jounieh
(future) Loop**



Master Plan (2017-2023)

220KV
network



Installed
Capacity
Will be
4925 MW

North Loop of
Beirut

1st South
Loop of Beirut

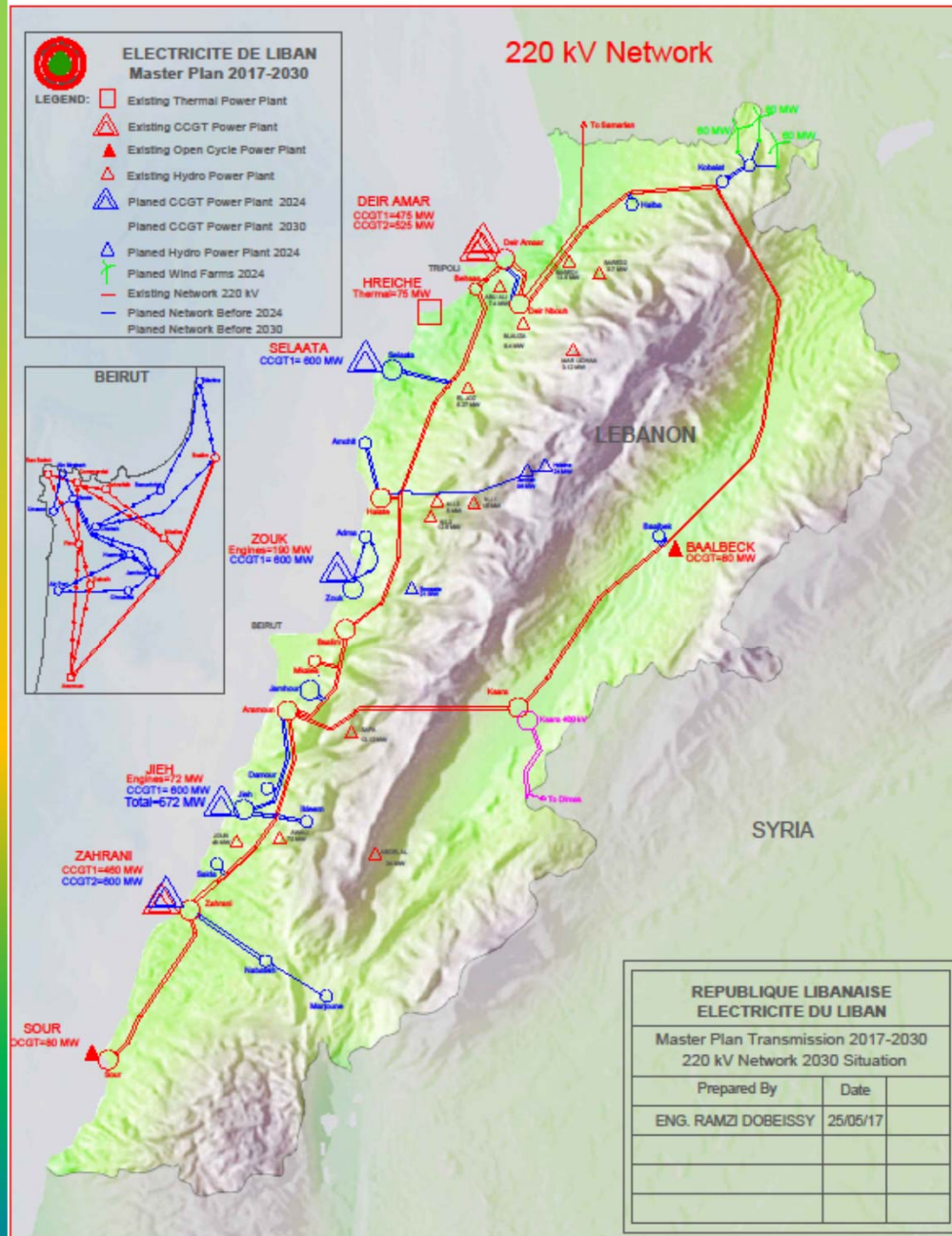
2nd South
Loop of Beirut

Zouk – Adma
– Jounieh
(future) Loop



Master Plan (2017-2023)

220KV
network
OHTL



**Installed
Capacity
Will be
4925 MW**

**North Loop of
Beirut**

**1st South
Loop of Beirut**

**2nd South
Loop of Beirut**

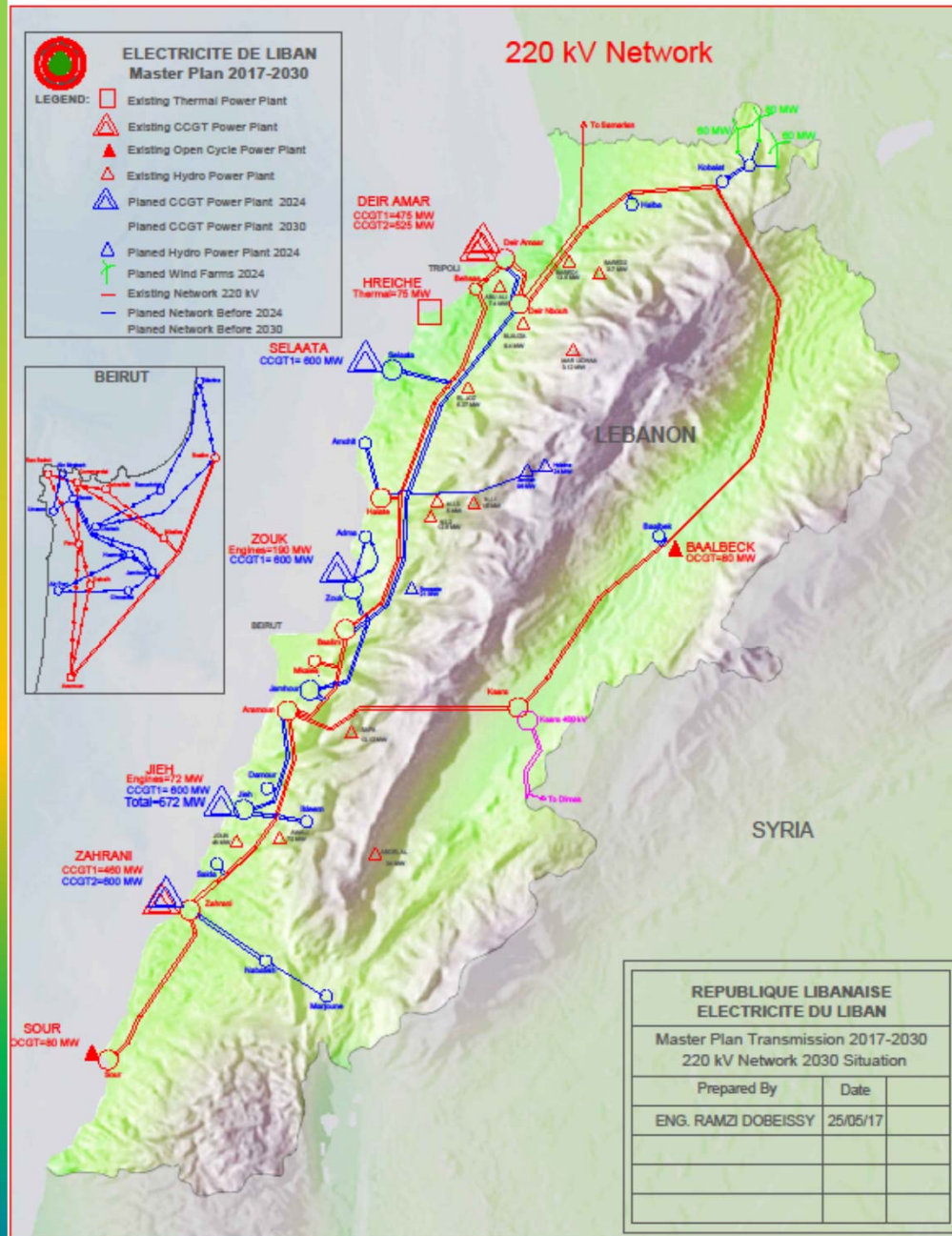
**Zouk – Adma
– Jounieh
(future) Loop**

Other lines



Master Plan (2017-2023)

220KV
network
OHTL



**Installed
Capacity
Will be
4925 MW**

**North Loop of
Beirut**

**1st South
Loop of Beirut**

**2nd South
Loop of Beirut**

**Zouk – Adma
– Jounieh
(future) Loop**

Other lines

Lines upgrade



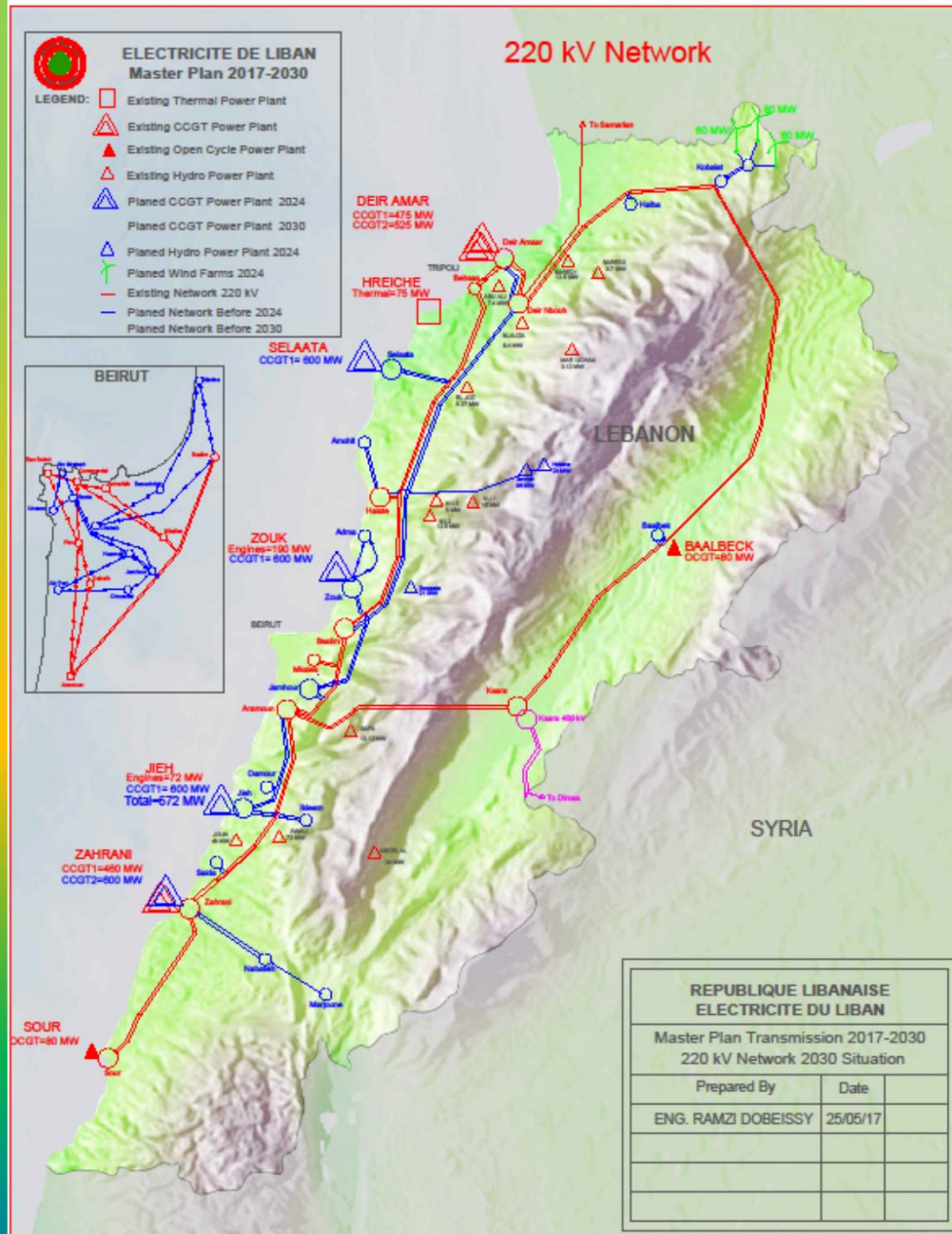
Master Plan (2024-2030)



Master Plan

(2024-2030)

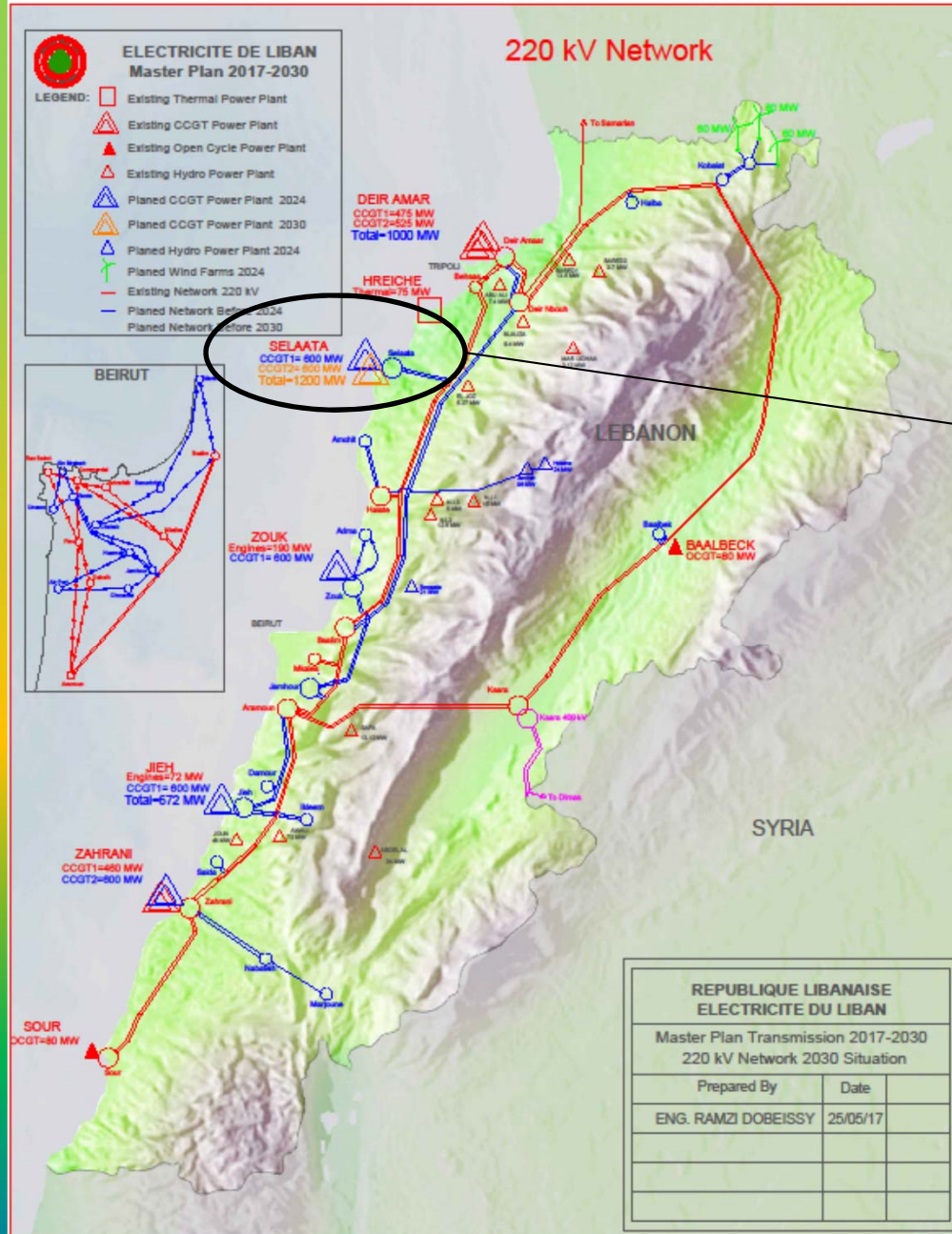
Power Generation plants



Installed Capacity Will be 6725 MW



Master Plan (2024-2030) Power Generation plants



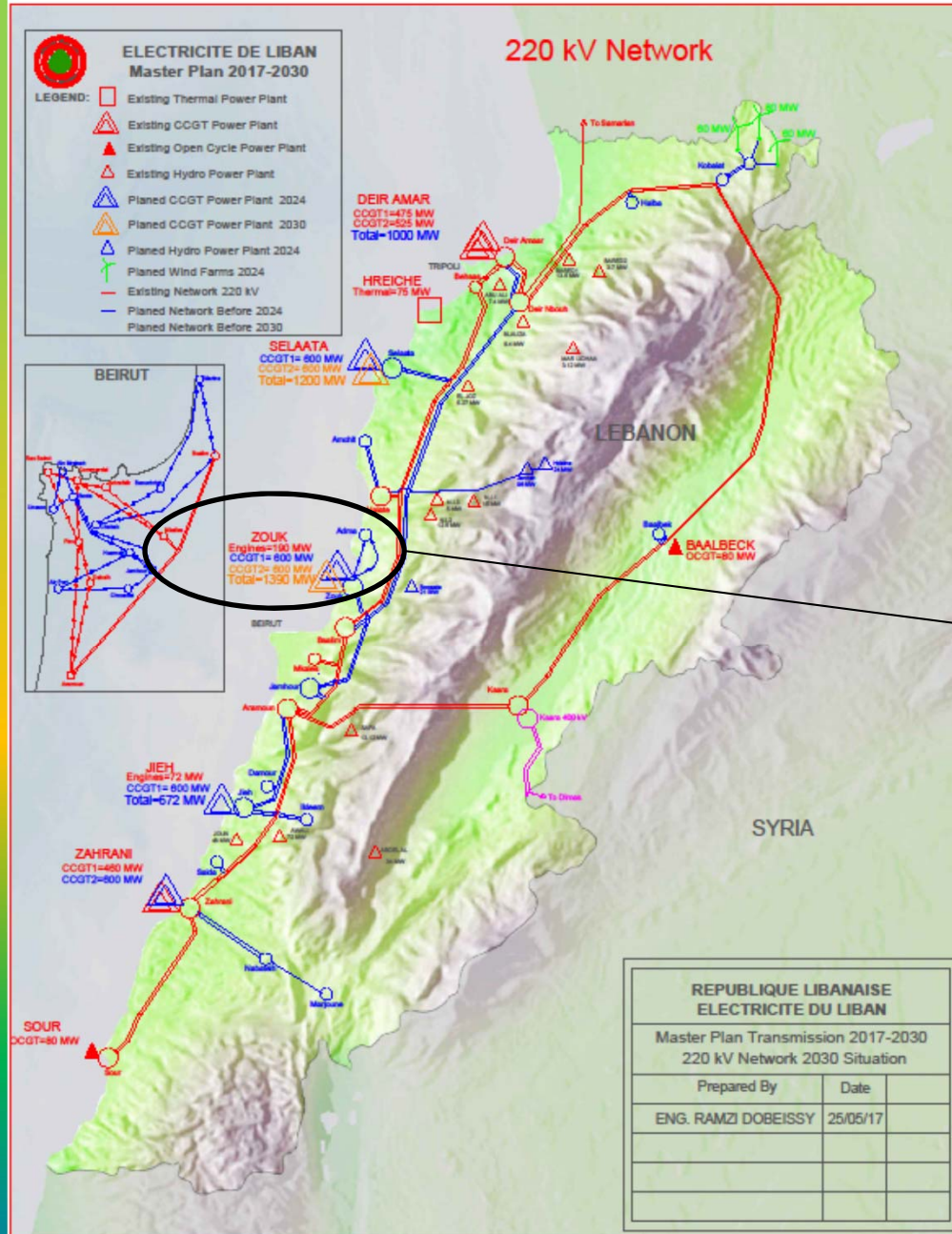
**Installed
Capacity
Will be
6725 MW**

**SELAATA 2
CCGT
600 MW**



Master Plan (2024-2030)

Power Generation plants



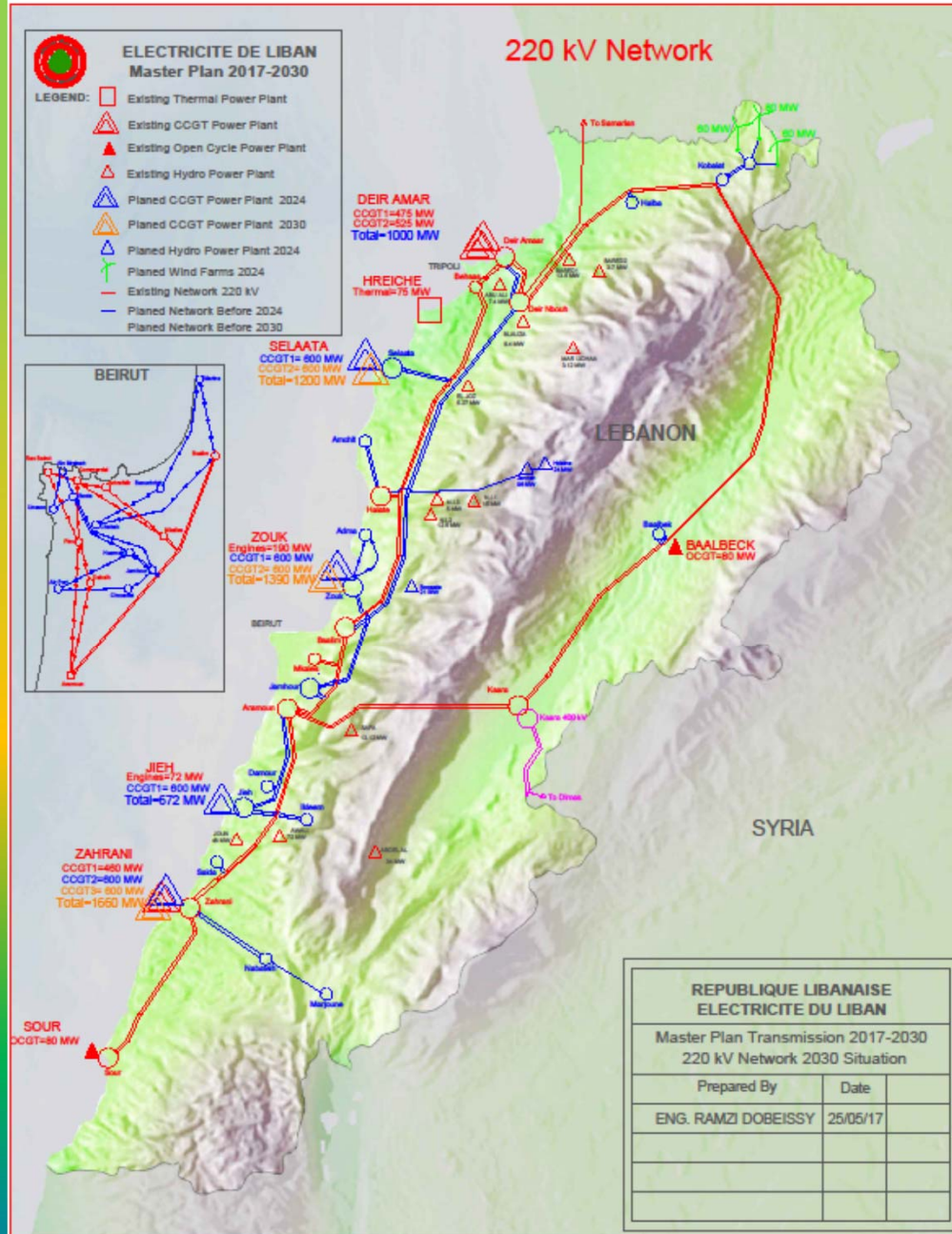
**Installed
Capacity
Will be
6725 MW**

**SELAATA
CCGT2
600 MW**

**ZOUK 2
CCGT
600 MW**



Master Plan (2024-2030) Power Generation plants



Installed Capacity Will be 6725 MW

SELAATA CCGT2 600 MW

ZOUK CCGT2 600 MW

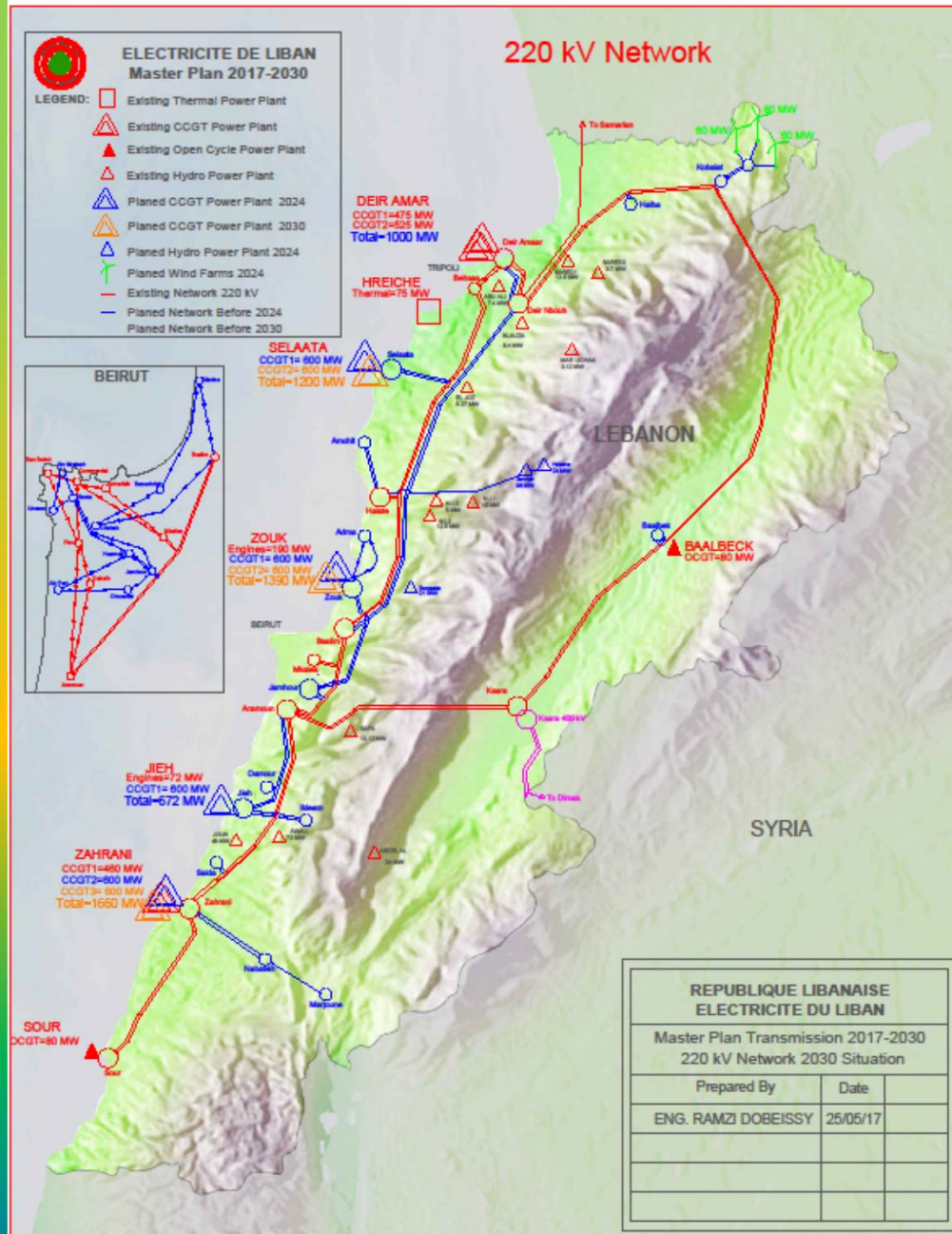
**New CCGT 600 MW
Location to be determined latter**



Master Plan

(2024-2030)

Substations
220 kV



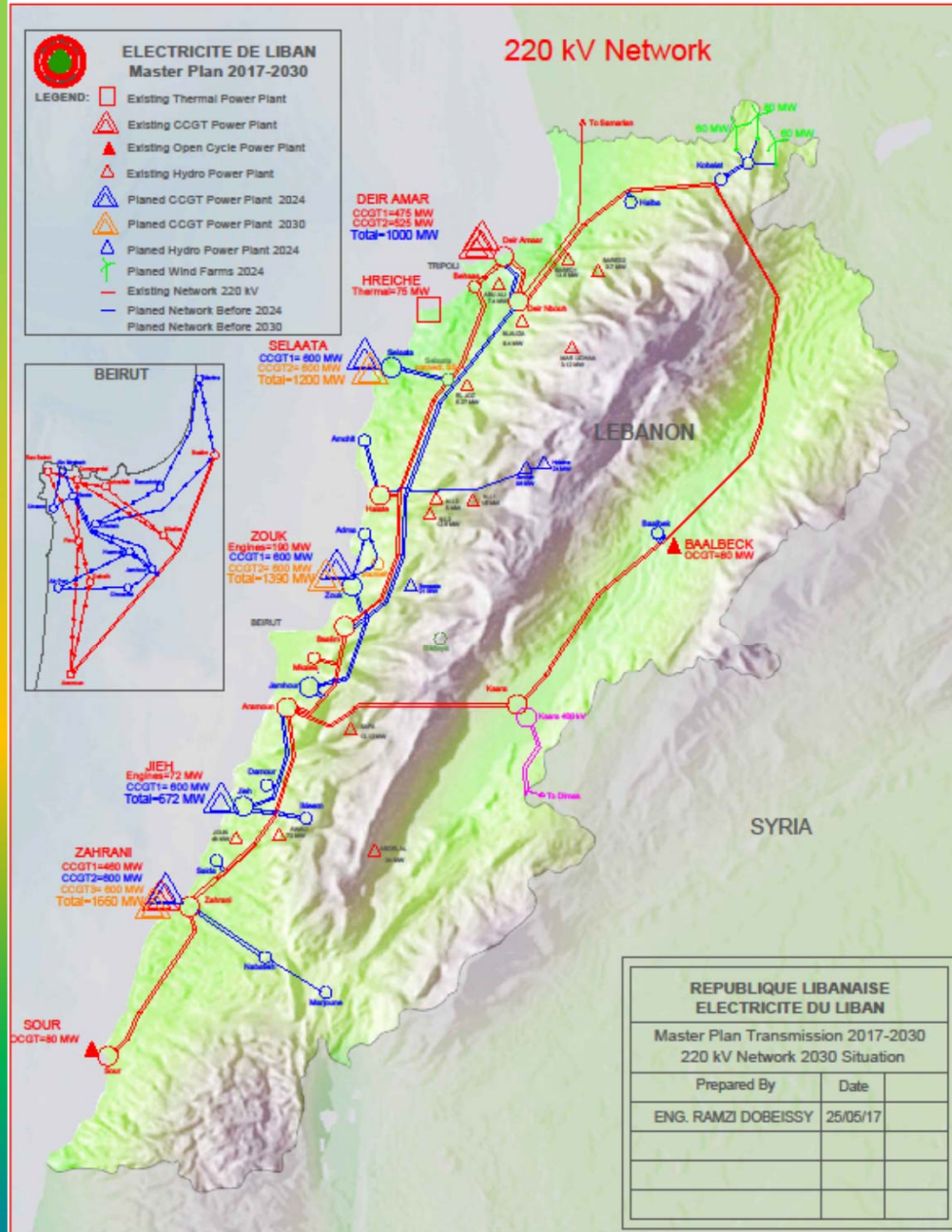
**Installed
Capacity
Will be
6725 MW**



Master Plan

(2024-2030)

Substations
220 kV



Installed
Capacity
Will be
6725 MW

Selaata
connection
S/S

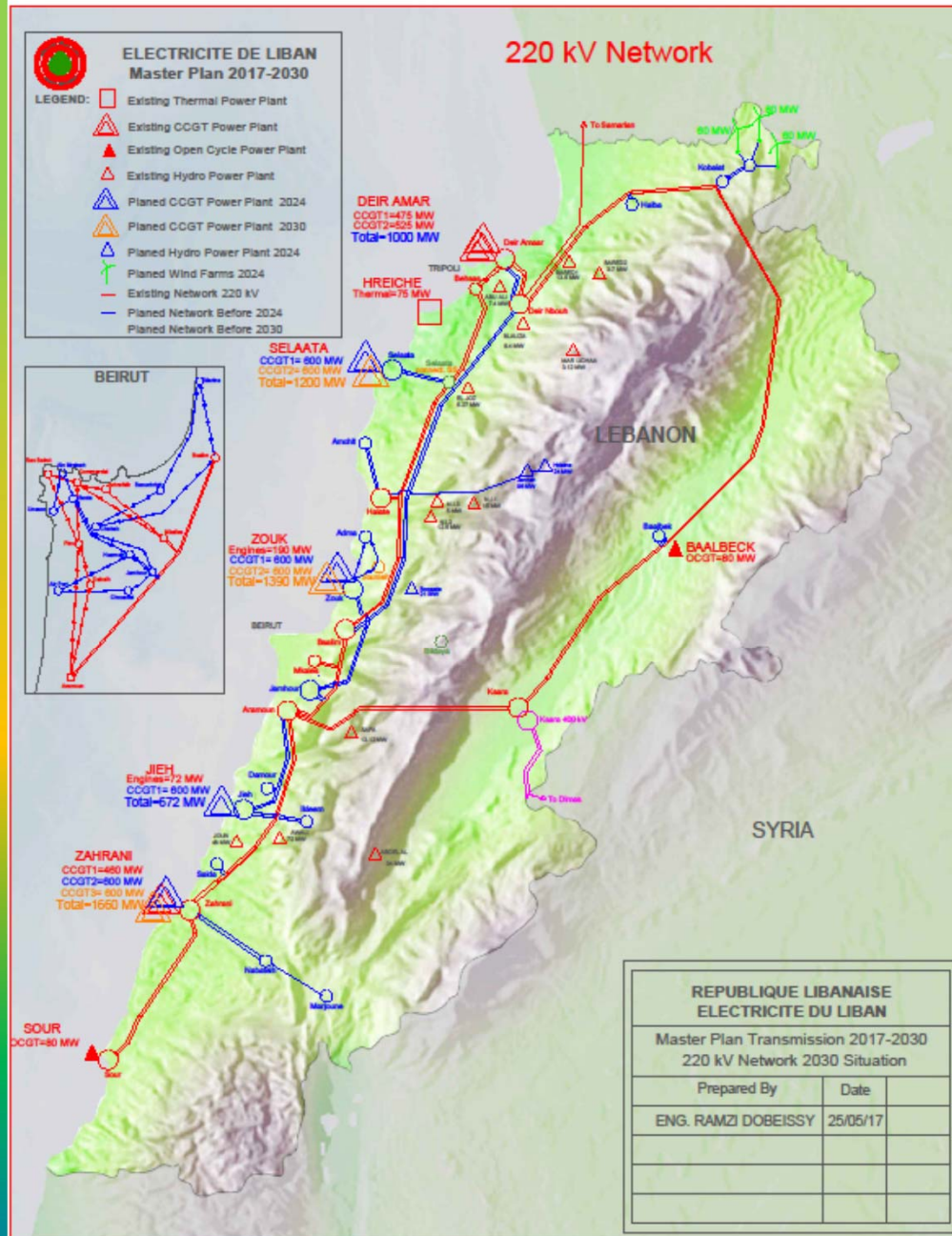
Jounieh S/S

Bikfaya S/S



Master Plan (2024-2030)

220KV network

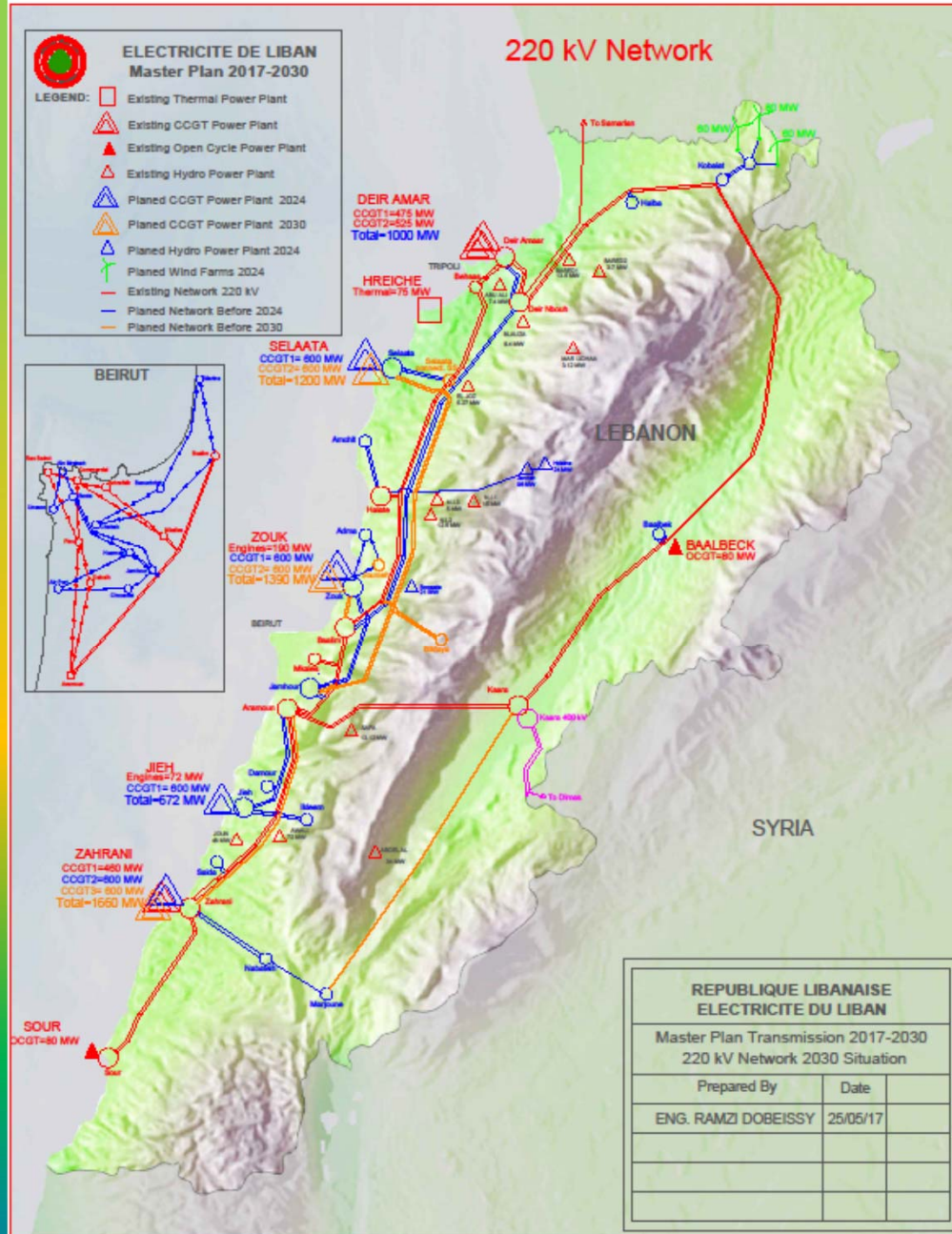


**Installed
Capacity
Will be
6725 MW**



Master Plan (2024-2030)

220KV
network
OHTL



Installed
Capacity
Will be
6725 MW

Selaata –
Jamhour
220KV

Bikfaya
connection
220KV

Aramoun –
Zahrani
220KV

Marjeoun –
Ksara 220KV



Renewable Energy

- The Lebanese government committed to adopt the utilization of renewable energies to reach;
- 12% of electric supply by the year 2020.
- 30% by the year 2030.

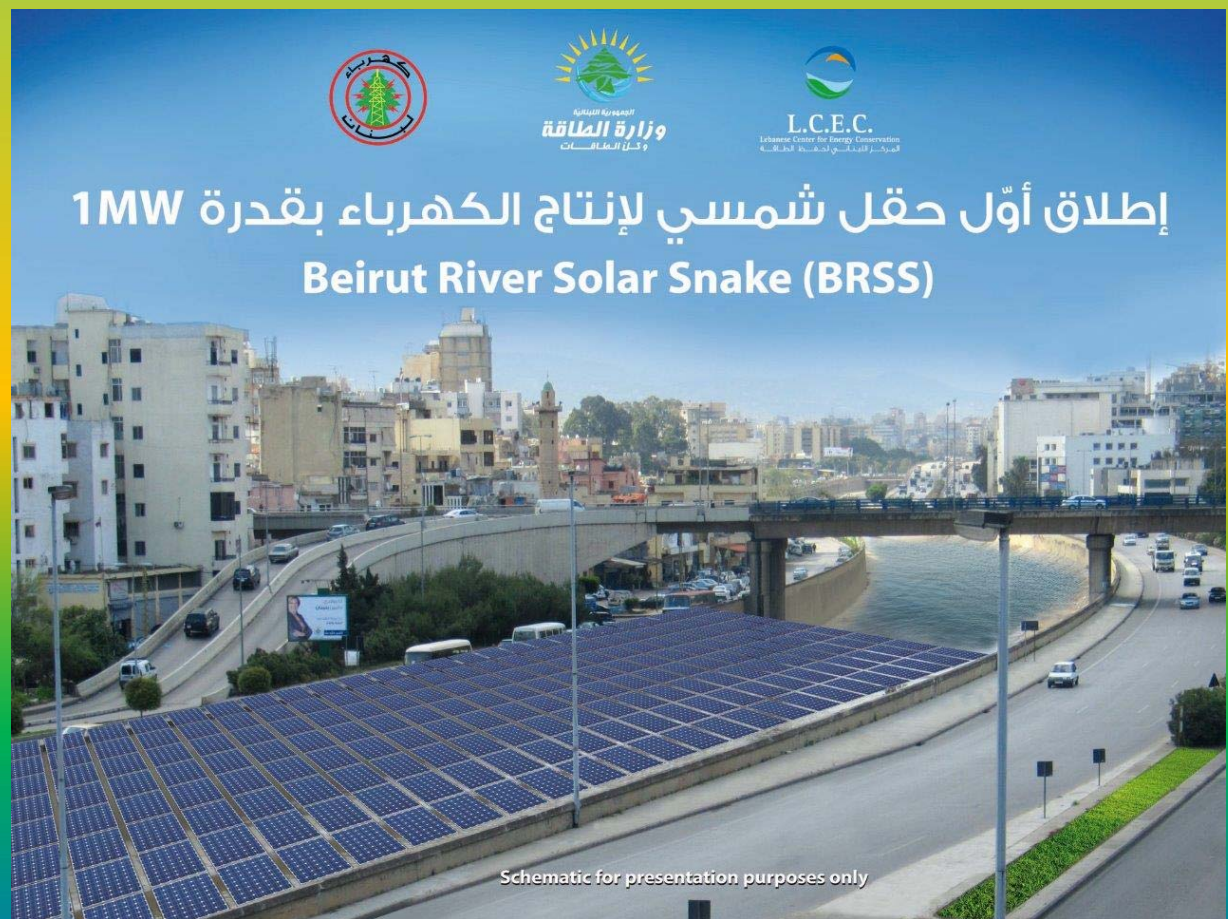




Renewable Energy

Beirut River Solar Snake

A Photovoltaic PV farm of 1 MW is in operation now, It's planned to extend the farm to reach 7 MW, (Bids are under evaluation).





Renewable Energy

Electricity from waste

**Landfill Power
Plant in
Naameh
7 MW**





Renewable Energy

Electricity from waste

-Incinerators-

Planned Incinerator in Beirut 60 to 70 MW, In addition to several 5 to 10 MW Incinerators are planned in several places of the country.





Renewable Energy

Round one:

- 220 MW of wind farms in Kobaiyat – contracts were signed in the year 2018.
- 12 PV farms 10 to 15 MW each with a total capacity of 180 MW, still under technical evaluation.





Renewable Energy

Round two:

- 200-400 MW of wind farms
- 3 PV farms 100 MW each with a storage capacity of 70 MW for each one, could be 6 farms 50 MW each.
- Several hydro power plants, the 4 major plants are:
Janeh Dam ~ 100 MW
Boqaata Dam ~ 21 MW

.....

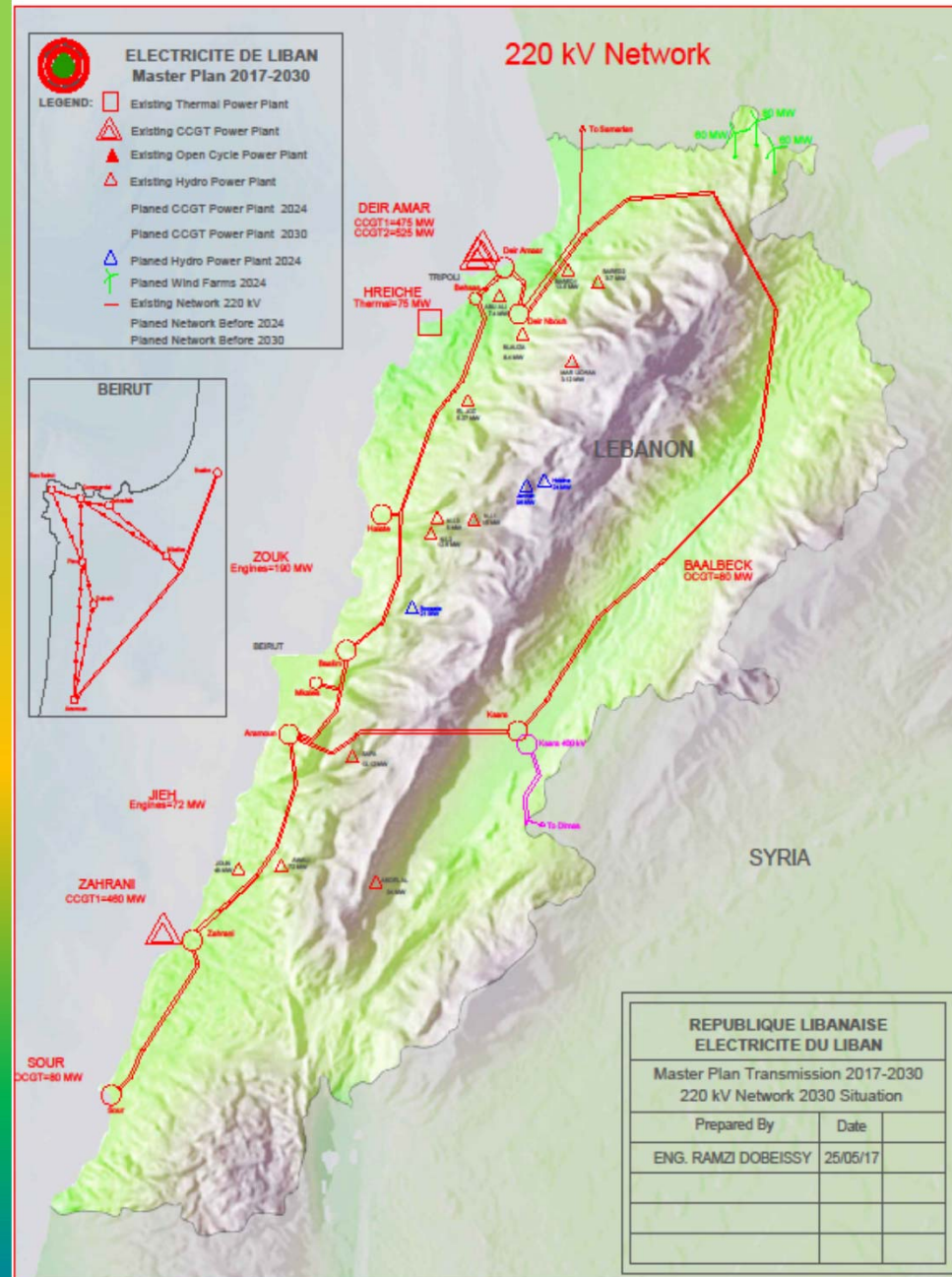
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Renewable Energy Hydro Power plants

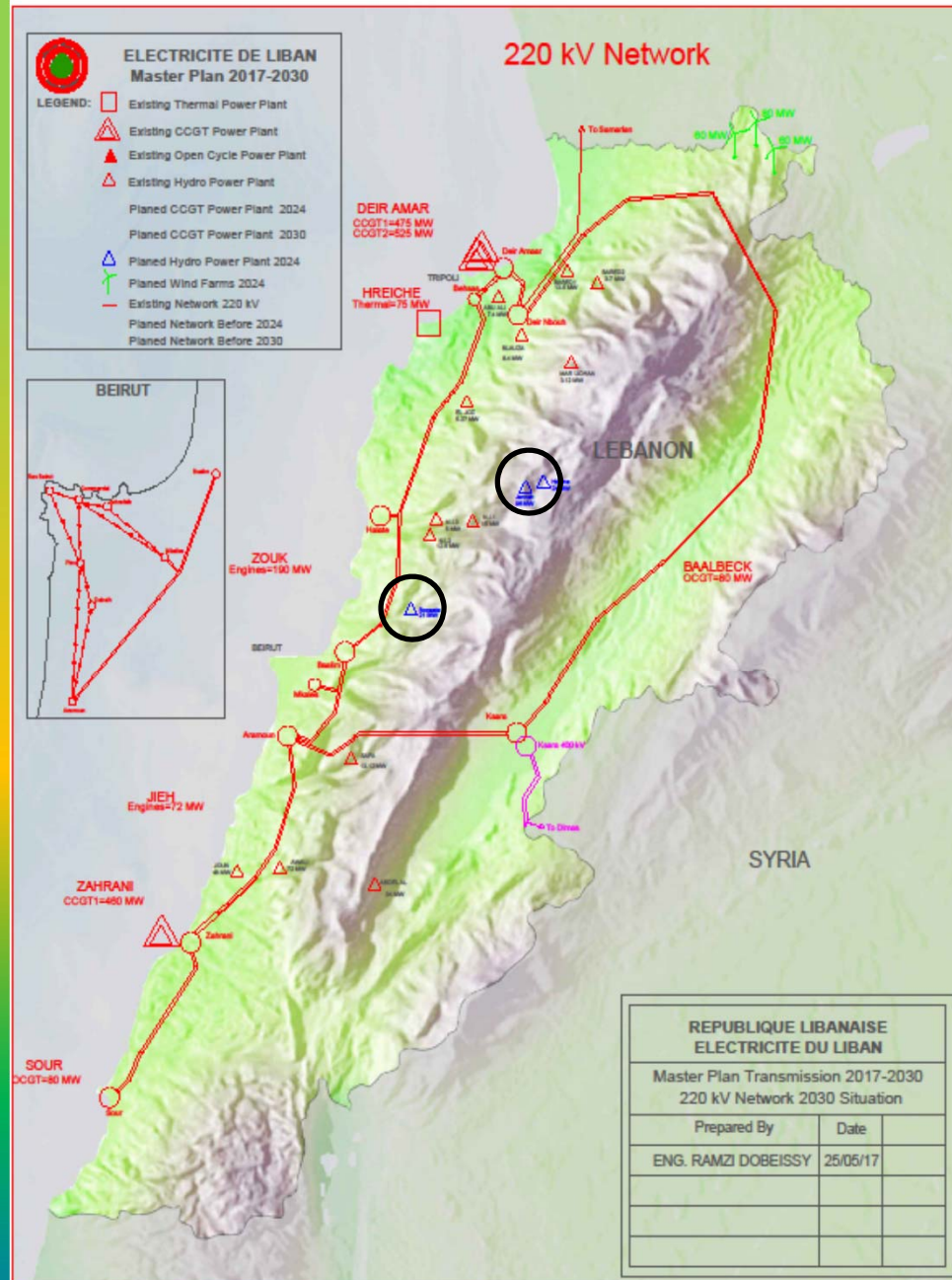
The expected power generated from the planed four major hydro power plants is around 162 MW.





Renewable Energy Hydro Power plants

The expected power generated from the planed four major hydro power plants is around 162 MW.

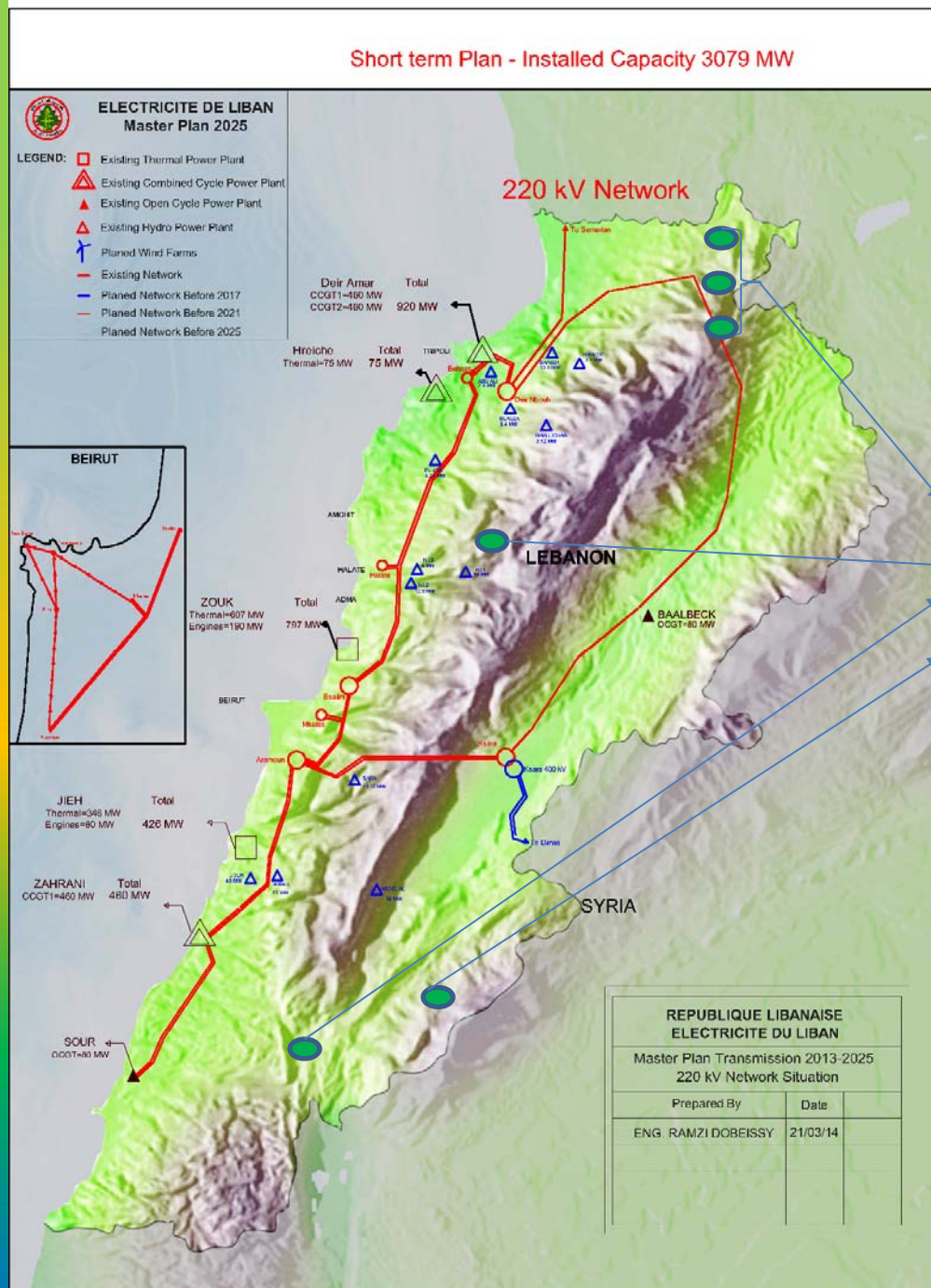






Safety in Integration Renewable Energy into the Grid

Wind Farms “Round two”

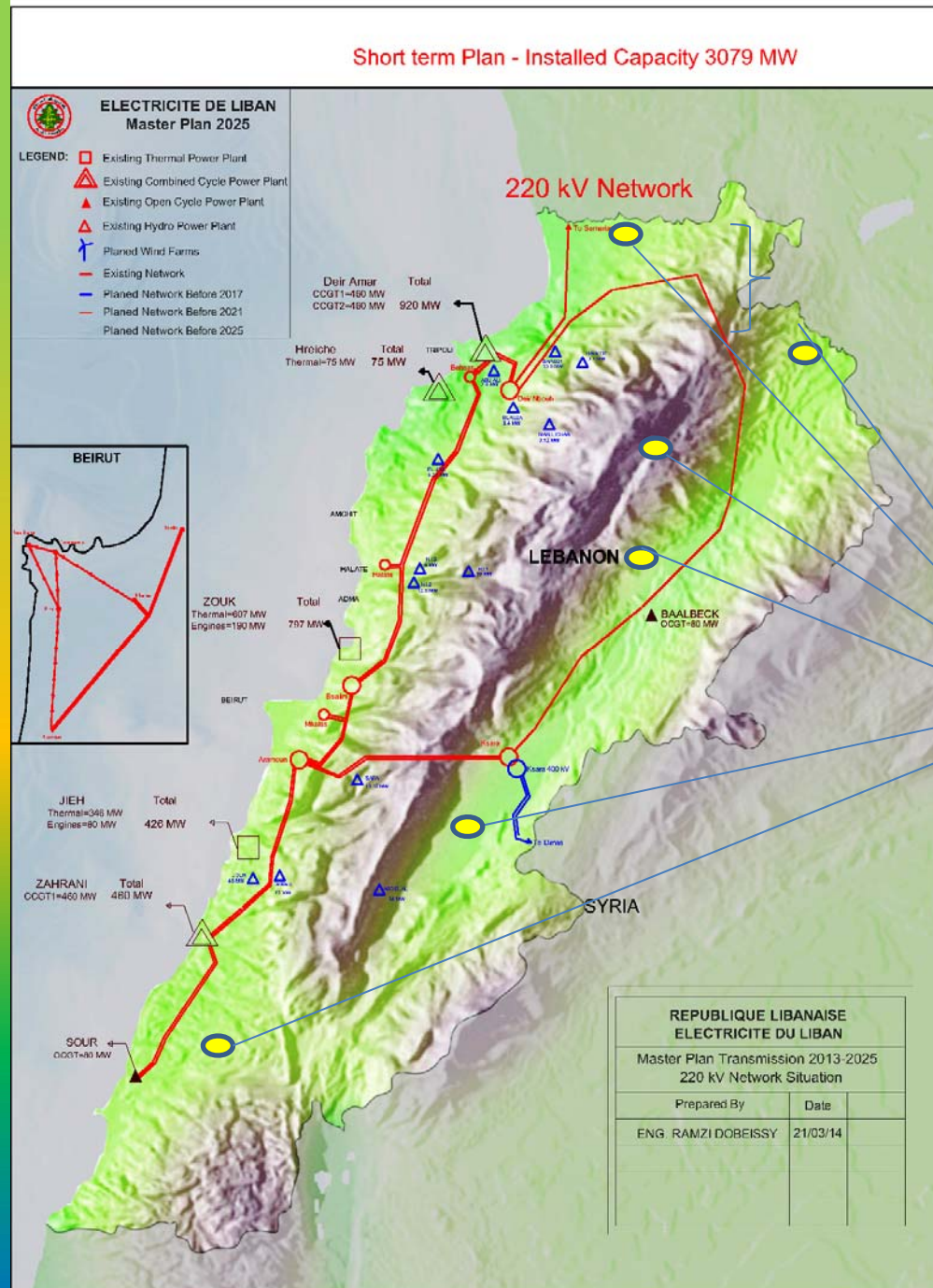


Expected locations of “Round Two” Wind Farms based on the wind atlas with an expected installed capacity between 200 to 300 MW , in addition to the three signed Wind Farms contracts with an installed capacity of 220 MW in Akkar region.



Safety in Integration Renewable Energy into the Grid

**PV Farms
with Storage
300 MW**

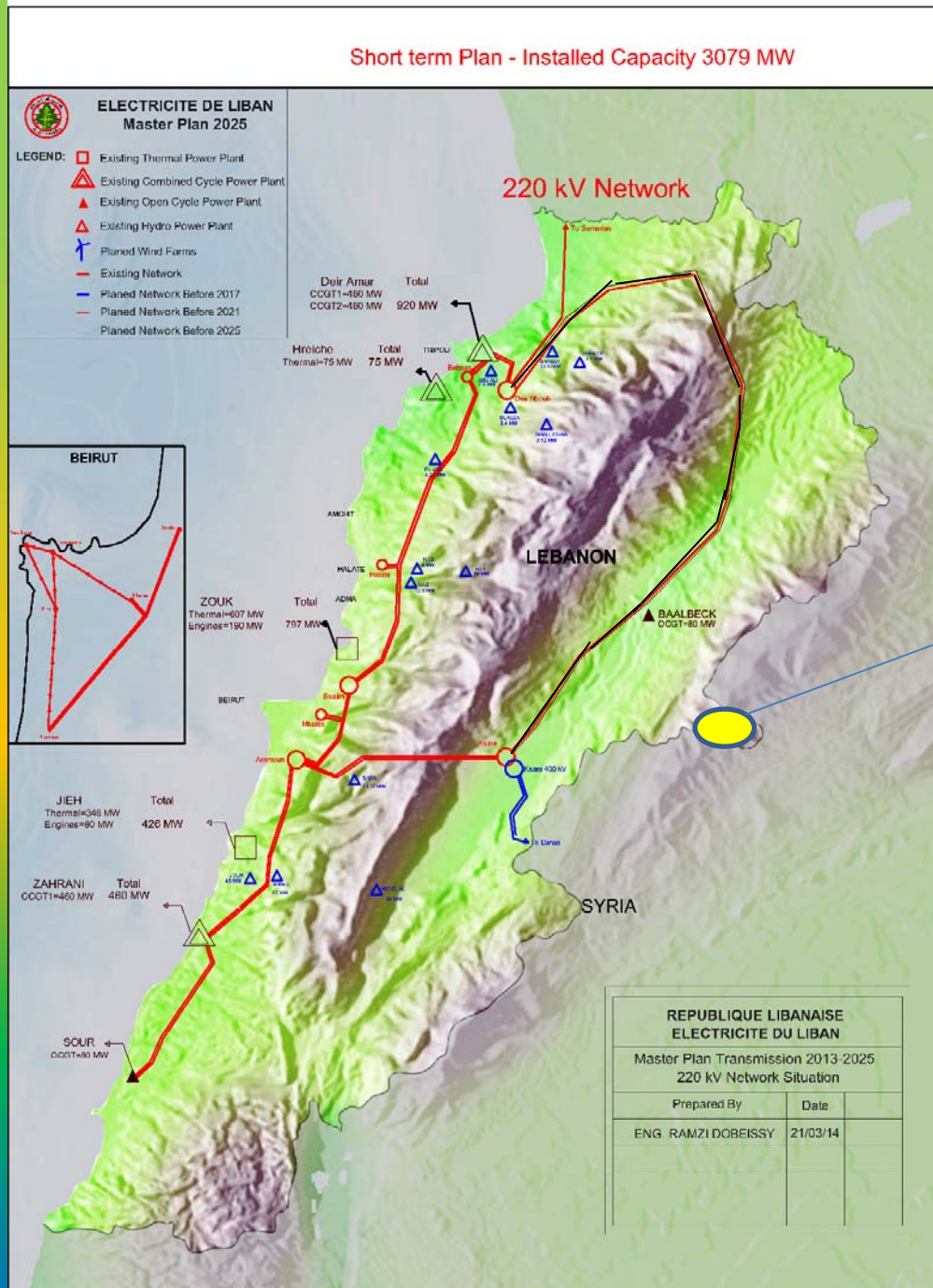


**Expected
locations of PV
farms with
Storage with
total capacity
of 300 MW
210 MWh**



Safety in Integration Renewable Energy into the Grid

Expected PV
Farm in Tfail
Exceeding 500
MW

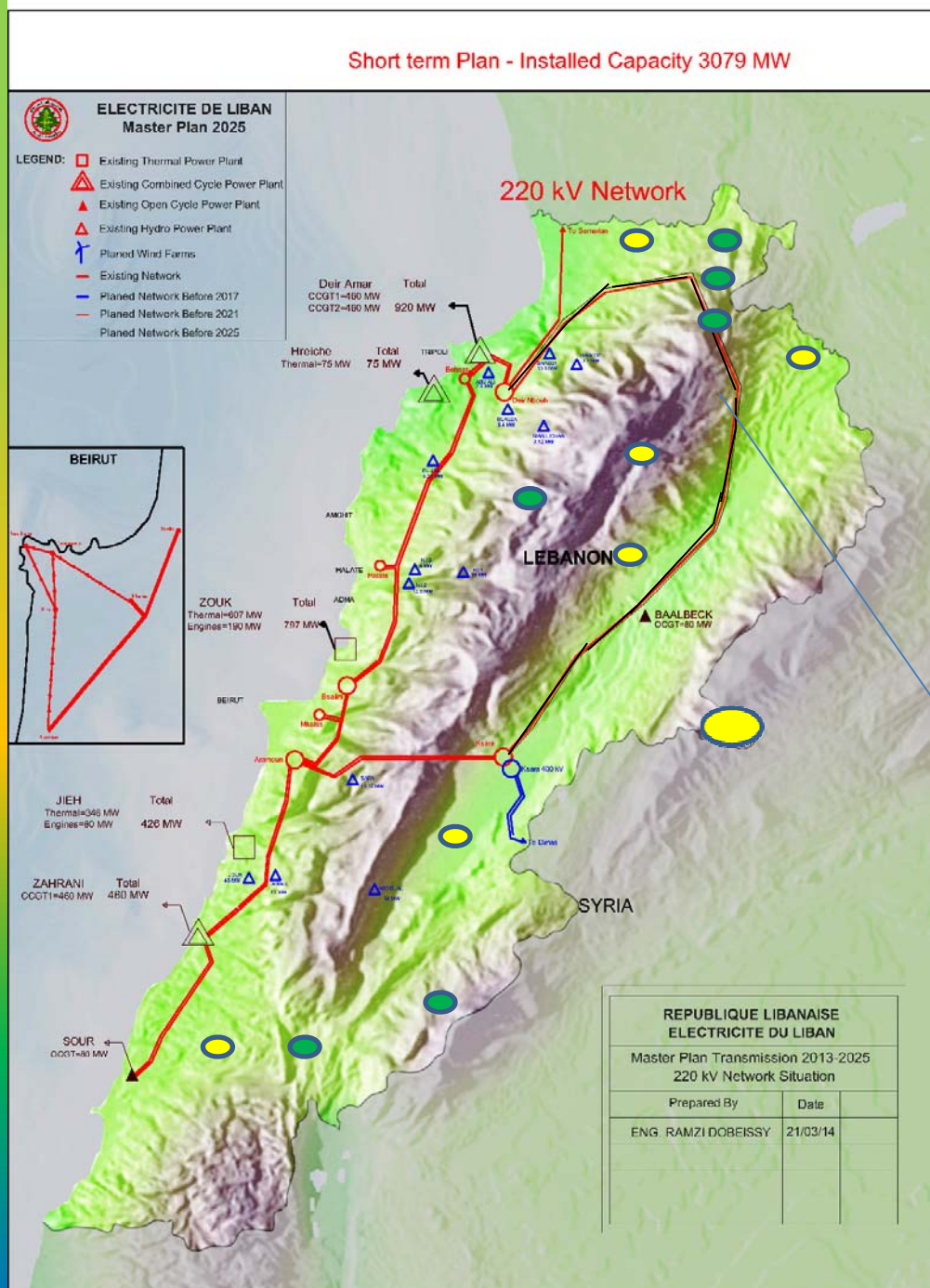


This PV farm is relatively far from the Grid, it's installed capacity could exceed 500 MW



Safety in Integration Renewable Energy into the Grid

**Reinforcement
of the
Transmission
Network for
power
evacuation**



**All these additional
Renewable energy
sources requires
reinforcement in
the Grid and
specially in middle
and north Bekaa to
increase the
evacuation capacity
of the network
where the expected
additional installed
capacities could
exceed 1000 MW in
the future.**

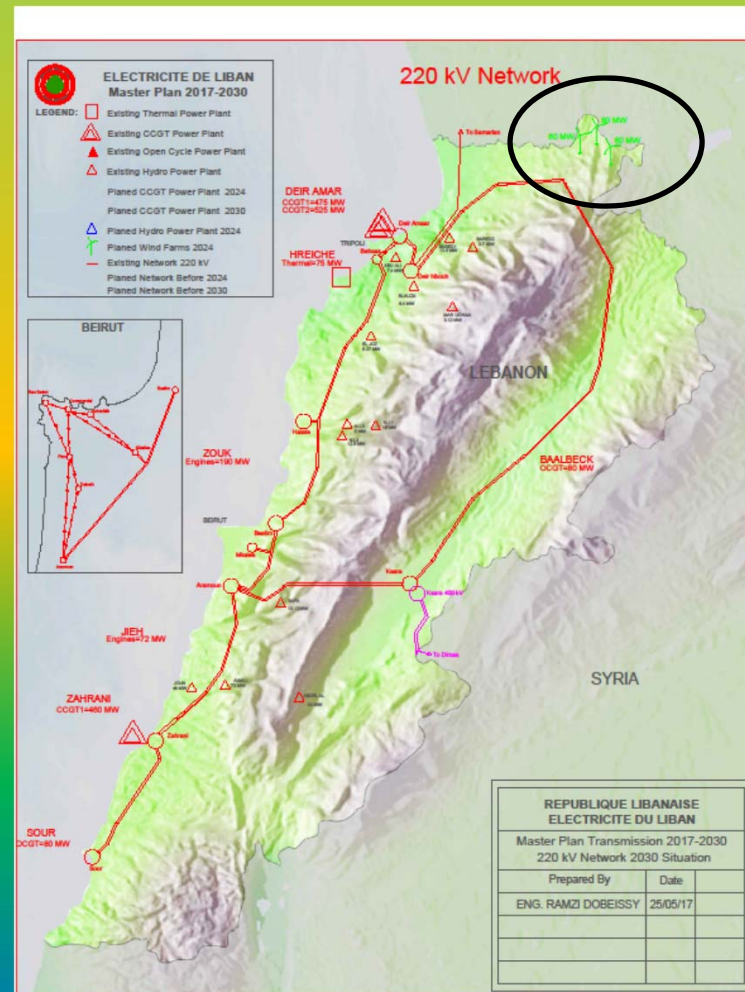
**Accordingly EDL will
lunch soon an
addendum on the
Transmission
Master Plan which
was approved by
the council of
Ministers in 2017.**



Safety in Integrating Wind Farms into the Grid

1-The Three Wind Farms will be connected on 220 kV network in Kobaiat substation.

2-The integration should be done by the construction of a common step up substation to be built by the developers in Kobaiat area.





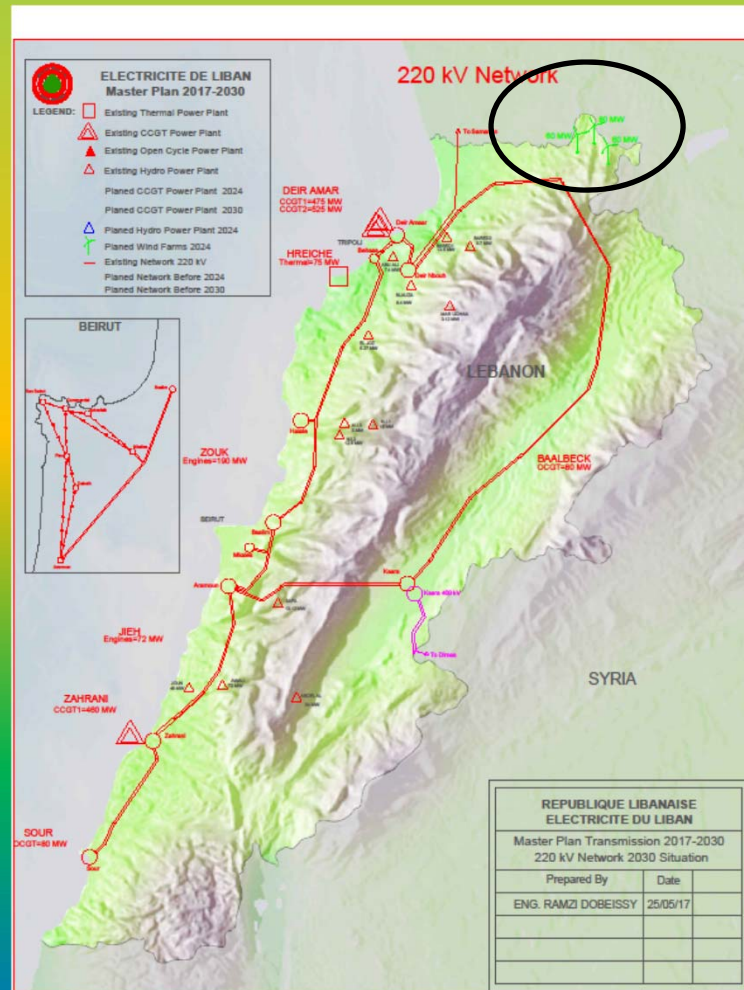
The influence of Connecting the Wind Farms to EDL's existing Grid

1-Voltage Variation

2-Steady-State Voltage

3-Voltage Fluctuation

4-Harmonics





The influence of Connecting the Wind Farms to EDL's existing Grid

1-Voltage Variation

Voltage variations are the main problem associated with wind power. This can be the limiting factor on the amount of wind power which can be installed. In normal operational condition, the voltage quality of a wind turbine or a group of wind turbines may be assessed in terms of the following parameters:

- Steady state voltage under continuous production of power
- Voltage fluctuations
 - o Flicker during operation
 - o Flicker due to switching



The influence of Connecting the Wind Farms to EDL's existing Grid



The influence of connecting a wind farm on a Grid on a certain voltage level is directly related to the short circuit power level. The short circuit power level in a given point in the electrical network represents the system strength.

It is clear that the variations of the generated power will result in the variations of the voltage at the point of common coupling of a wind Farm. If the equivalent short circuit impedance is small then the voltage variations will be small (the grid is strong). On the other hand, if the equivalent short circuit impedance is large, then the voltage variations will be large (the grid is weak).



The influence of Connecting the Wind Farms to EDL's existing Grid

2-Steady-State Voltage

The voltage should be maintained within utility regulatory limits. Operation of wind turbines may affect the voltage in the connected network. Appropriate methods should be taken to ensure that the wind turbine installation does not bring the magnitude of the voltage outside the required limits. It is recommended that load-flow analyses be conducted to assess this effect to ensure that the wind turbine installation does not bring the magnitude of the voltage outside the required limits.



The influence of Connecting the Wind Farms to EDC's existing Grid

3-Voltage Fluctuation

Fluctuation in the system voltage may cause perceptible light flicker depending on the magnitude and frequency of the fluctuation. This type of disturbance is called voltage flicker. There are two types of flicker emissions associated with wind turbines, the flicker emission during continuous operation and the flicker emission due to generator and capacitor switching's. The allowable flicker limits are generally established by individual utilities.



The influence of Connecting the Wind Farms to EDL's existing Grid

4-Harmonics

Harmonic disturbances are a phenomenon associated with the distortion of the fundamental sine wave and are produced by non-linearity of electrical equipment. Harmonics causes increased currents, power losses and possible destructive overheating in equipment. Harmonics may also rise problems in communication circuits. Power electronic converters are used in variable speed wind turbine systems where the harmonics can be easily removed by smaller filters. In general harmonic standards can be met by modern wind turbines.



Requirements for safe connection of wind farms into a power system

Integration of large scale wind power may have severe impacts on the power system operation. Traditionally, wind turbines are not required to participate in frequency and voltage control. However, in recent years, attention has been increased on wind farm performance in power systems. Consequently, some grid codes have been defined to specify the steady and dynamic requirements that wind turbines must meet in order to be connected to the grid. Examples on such requirements are capabilities of contributing to frequency and voltage control by continuous modulation of active power and reactive power supplied to the transmission system, as well as the power regulation rate that a wind farm must provide.



Requirements for safe connection of wind farms into a power system

- Integration of large scale wind power may have severe impacts on the power system operation.
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- Recently, attention on wind farm performance in power systems increased.
- Some Grid Codes have been defined to specify the steady and dynamic requirements that wind turbines must meet in order to be connected to the Grid like :
 - Capabilities of contributing to frequency and voltage control by continuous modulation of active and reactive power supplied to the transmission system.
 - Power regulation rate that a wind farm must provide.



Existing situation of EDL's Network And its weak points towards integrating Wind Farms on large scale

- Deficiency in generation which is leading to load shedding, where there is no dedicated plants to participate in voltage and frequency control.
- Operating one 220 kV circuit out of two between Ksara and Deir Nbough substations.
- Most of the power plants are working in Base load regime , hence the ability to over come the rapid variations of wind power production is very limited (Speed of Ramping up of generators in conventional power plants).
- Lacking the Network stability.



The steps to be taken to overcome the influence of Wind Farms integration on EDL's Grid

- Achieving the balance between Generation and demand and extra reserve power and that by implementing the Ministry Plan for Generation, Hence achieving the capability to overcome the full or partial unavailability of the expected integrated renewable energy Wind Farms and PV farms.
- Interconnection with the neighboring electric power systems (7 connected countries) where the power exchange could be available on larger scales ,hence reducing the percentage of renewable resources in comparison with the volume of the unified network where the influence of voltage Fluctuation caused by wind farms will be very limited .



The steps to be taken to overcome the influence of Wind Farms integration on EDL's Grid

- Renewable energy challenges conventional methods of dealing with contingency. Contingencies are traditionally defined as the loss of the largest generation unit. Renewable energy generation is spread over many wind turbines, solar farms so that a “largest generation unit” cannot be identified. The largest loss that can occur is 100% of the wind generation; if this is 20 to 30% of the total capacity and it occurs during peak demand, the loss cannot be handled by ramping up conventional reserves.



The steps to be taken to overcome the influence of Wind Farms integration on EDL's Grid

Energy Storage

- Additional methods of ensuring reliability of the grid need to be developed. These include energy storage and long distance transmission.
- As renewable energy penetration grows, the increasing mismatch between variation of renewable energy resources and electricity demand makes it necessary to capture electricity generated by wind, solar and other renewable energy generation for later use. Storage can help smooth fluctuations in generation inherent in wind or solar energy.



**And finally,
I am ready to answer your
questions and discuss any
recommendations**



Thank You