Renewable Energy Action Plan for Lebanon

ADEME

Agence de l'Environnement et de la Maîtrise de l'Energie

ALMEE

Groundwork for the development of the National Renewable Energy Action Plan for LEBANON

PV	CSP	Wind	Biomass	Geothermal	Hydro

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ABBREVIATIONS AND ACRONYMS

AFD	Agence française de développement
ALMEE	Lebanese Association for Energy Saving and for Environment
BAU	Business As Usual
BDL	Banque du Liban
CAS	Central Statistics Administration
CBC	Cross Border Cooperation
CDR	Council for Development and Reconstruction
CEDRO	Country Energy Efficiency and Renewable Energy Demonstration Project for the Recovery of Lebanon
CFL	Compact Fluorescent Lamp
CoM	Council of Ministers
CNRSL	National Lebanese Council for Scientific Researches.
CSP	Concentrated Solar Power
EdL	Electricité du Liban
EdZ	Electricité de Zahlé
EE	Energy Efficiency
EIA	Environmental Impact Assessment
EIB	European Investment Bank
ENPI	European Neighbourhood Partnership Initiative
EU	European Union
EUR	Euro, official currency of the Eurozone
GDP	Gross Domestic Product
GEF	Global Environment Facility
GHG	Greenhouse Gases
GHI	Global Horizontal Irradiation
GoL	Government of Lebanon
GWh	Gigawatt·hour
KTOE	Kilo tons oil equivalent
kWh	Kilowatt·hour
LCA	Life Cycle Analysis
LCEC	Lebanese Centre for Energy Conservation
LGBC	Lebanon Green Building Council
LIBNOR	Lebanese Standards Institution
LSES	Lebanese Solar Energy Society
MASEN	Moroccan Agency for Solar Energy
MEDSTAT	Euro-Mediterranean Statistical Co-operation
MoE	Ministry of Environment
MoEW	Ministry of Energy and Water
MoF	Ministry of Finance
MoU	Memo of Understanding
MW	Megawatt
NEEAP	National Energy Efficiency Action Plan

NEEREA	National Energy Efficiency and Renewable Energy Account
NGO	Non-Governmental Organisation
NREAP	National Renewable Energy Action Plan
OEA	Order of Engineers and Architects
O&M	Operation and Maintenance
PGEF	Power Generation Emission Factor
PPA	Power Purchase Agreement
PV	Photovoltaic
R&D	Research and Development
RCREEE	Regional Center for Renewable Energy and Energy Efficiency
RE	Renewable Energy
REDZ	Renewable Energy Development Zones
SWOT	Strengths, Weaknesses, Opportunities and Threats analysis
TPES	Total Primary Energy Supply.
UfM	Union for the Mediterranean
UNDP	United Nation Development Programme
US	United States (of America)

ABSTRACT

Faced with demand for electricity and energy, Lebanon has tremendous potential for developing clean, renewable sources of energy. The appeal for developing these resources combined with energy efficiency and cleaner technologies goes beyond meeting growing electricity demand and energy security. On a national and regional scale the market potential is promising for new industries, new businesses and new jobs.

The Groundwork for the Development of the National Renewable Energy Action Plan (NREAP) is in the scope of the Directive[1] 2009/28/EC and in coherence with the Pan-Arab Strategy for the Development of Renewable Energy 2030. It presents an important milestone in forging regionally coherent commitments towards developing renewable sources of energy.

However, in order to leverage the regional scale effect of markets, more coordinated efforts will be required in moving forward on these commitments.

In this context, this study, while providing a roadmap for the development of the Lebanese NREAP, identifies key actions and initiatives on a national scale that can make better use of the resources available for the benefit of the country.

In depth analysis of the national energy context show that Lebanon is very dependent on fossil energy imports (more than 98%). Electricity subsidies are a heavy burden on the Lebanese public budget (18% of government expenditures in 2012). Subsidy to EdL (Electricité du Liban) electricity raised 20.7 USC/kWh in 2012. Electricity subsidies from 2006 to 2014 were around **$15.2 billion** without interest, equivalent to the cost of construction of **3500 – 4500 MW** renewable energy electricity plants and equivalent to the triple of the existing operational electricity generation capacity. If we consider the interest, EdL deficit represents near **1/3 of the total government debts**. Annual subsidy to EdL represents **54%** of the annual government debts.

Lebanon has many favorable solar resources for a variety of solar energy technologies and applications. According to several studies a Power Purchase Agreement (PPA) tariff from 12 to 23 USC/kWh would give an internal rate return (IRR) of 16% for a solar electricity mature market and a payback period of 6 years. Therefore, a transition to alternative energy resources, including renewable, will be a matter of necessity sooner or later.

The report describes to a big extent the actual and potential contribution of renewable energy to the country energy supply. It is initiated with a review of the energy- related policies and legislations, presents a SWOT analysis, highlighting the ecological, economic and social impacts of adopting solar power in Lebanon, and suggests a set of

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[1] Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources.

recommendations and actions for implementing sustainable energy policies in the country that can be considered in the development of the Renewable Energy Strategy and the National Renewable Energy Action Plan.

Finally, this study argues that renewable energy – most importantly solar power, with its particular national climatic advantage – could play a significant role as a cost-competitive alternative to conventional fossil fuels. The absence of cost-reflective electricity tariffs in Lebanon today currently conceals this potential cost advantage; and leaves renewable energy deployment subject to further, economically distorting, policies such as renewable targets and fiscal incentives. Systematically opening up the economic opportunities offered by renewable energy to Lebanon will hence **require structural reform of electricity market and pricing mechanisms**, thereby rationalizing the use of different energy sources in the country.

Key words: Energy Policy – Solar energy – PV cells – Lebanon – sustainable energy roadmap.

This report is mainly based on ALMEE's studies and reports, the "Viable roadmap for the promotion of solar energy in Lebanon[2]", the studies on RE potential in Lebanon prepared by Adel Mourtada under the project SHAAMS ENPI CBC and for WWF, the studies on renewable energy potential in Lebanon (Solar, Wind, Geothermal, Biomass, Hydro) prepared under the project CEDRO and by the UNDP and the LCEC and the work for the preparation of the Strategic Environmental Assessment of Lebanon's Renewable Energy Sector conducted by the Ministry of Environment.

[2] Mourtada, A.; Jouni, A., "Roadmap for the promotion of PV electricity in Lebanon," in Renewable Energies for Developing Countries (REDEC), 2014 International Conference on , vol., no., pp.102-107, 26-27 Nov. 2014 doi: 10.1109/REDEC.2014.7038539.

1. What is National Renewable Energy Action Plan (NREAP)?

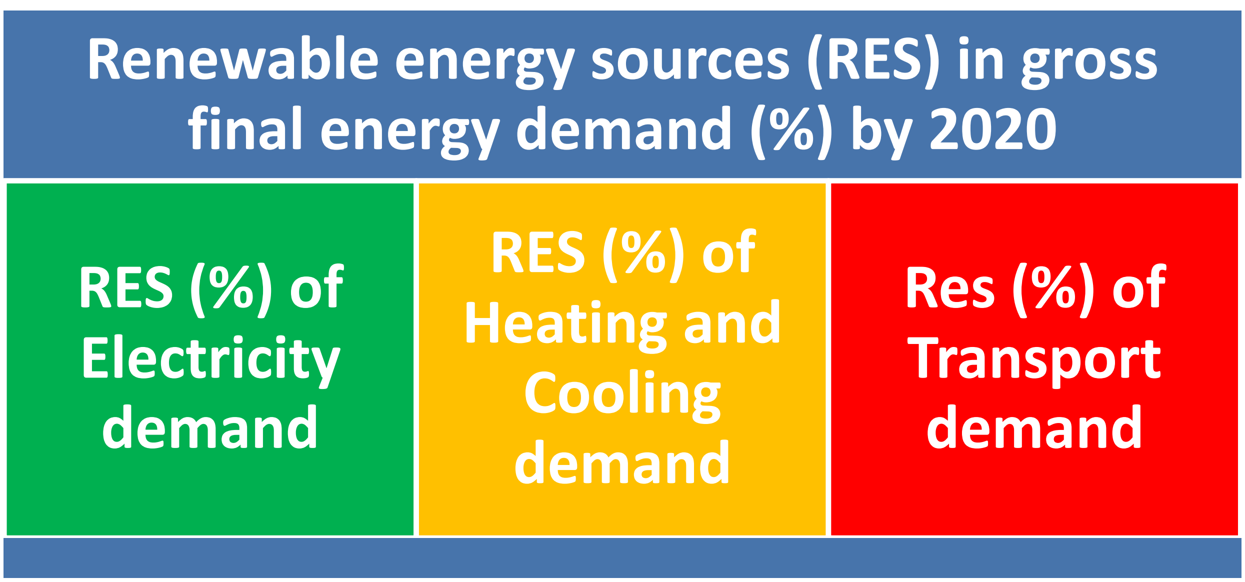
1.1. Introduction

A **"NREAP"** is a National Action Plan on Renewable Energy that all Member States of the European Union were obliged to notify to the European Commission by 30 June 2010. The plan provides detailed road map of how the Member State expected to reach its legally binding 2020 target for the share of renewable energy in their total energy consumption, as required by Article 4 of the Renewables Directive[3]. In the plan, the Member State sets out sectoral targets, the technology mix they expect to use, the trajectory they will follow and the measures and reforms they will undertake to overcome the barriers to developing renewable energy.

The RES Directive transposes the European target of a 20% renewable energy sources (RES) in **gross final energy demand** by 2020. It has set differentiated binding national targets for all EU member states. The RES target share is based on the following formula:

$$\mathrm{RESTargetShare} = \frac{\mathrm{RESelectricity} + \mathrm{RESheating/cooling} + \mathrm{REStransport}}{\mathrm{GrossFinalEnergyConsumption}}$$

As the formula shows, the RES[4] target is a relative target that can be reached by a combination of RES capacity expansion with reduction of final energy demand.



[3] Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources.
[4] Including solar water heating.

The RES Directive therefore allows countries the use of "**cooperation mechanisms**" for reaching the national 2020 targets for renewable energy in a cost-effective manner. Countries with relatively expensive RES potentials can thereby meet their targets by purchasing RES shares from countries with relatively cheap RES potentials.

Incentivising the development of renewables can be justified on a number of grounds, principally as follows:

- Reduction of carbon emissions – through displacing fossil -fired generation, heating and transport fuels;
- Increasing security of supply – by deferring imports of fuels needed for energy production, especially gas and oil;
- Economic growth – through creating an export driven RES industry in Europe, and also by creating jobs in installation, operation and maintenance (although in some cases such employment will displace that in other forms of energy production).

1.2. National Renewable Energy Action Plan (NREAP)

By the end of 2010 the EU member states had to submit National Renewable Energy Action Plans (NREAPs) demonstrating pathways and policies to meet their RES targets (figure 1). The contracting parties of the Energy Community are also developing NREAPs, of which some were final while others were still in a draft stage as of December 2015. NREAPs set forth their sectoral targets, expected generation technology mix, and intended renewable development trajectories for the years to come. The plans are also to include detailed descriptions of the measures, policies and reforms the parties will implement to overcome the barriers to renewable energy development (Energy Community, 2013). Prior to issuing NREAPs, contracting parties are expected to publish forecast documents on which the NREAPs are based.

It should be clearly indicates how the delivering target (%) renewable energy by 2020 is feasible through domestic action and with which proportion of energy consumption in each sector coming from renewable could be achieved. For example the 15% RES target of UK will be achieved through NREAP as following:

- RES around 30% of electricity demand, including 2% from small-scale sources;
- RES around 12% of heat demand;
- RES around 10% of transport demand

It is important to stress that these figures are purely illustrative of how the overall 15% target for the UK could be met. They should not be taken as an upper limit to the UK ambition for renewables deployment. Given the dynamic nature of the energy market and the advances in technology that are being made, it is likely that the balance between different sectors could change as we go forward. Whatever the precise breakdown may be, we are putting in place the framework and taking the actions necessary to ensure that we meet our renewable goals. This is also valid for all the 27 EU countries

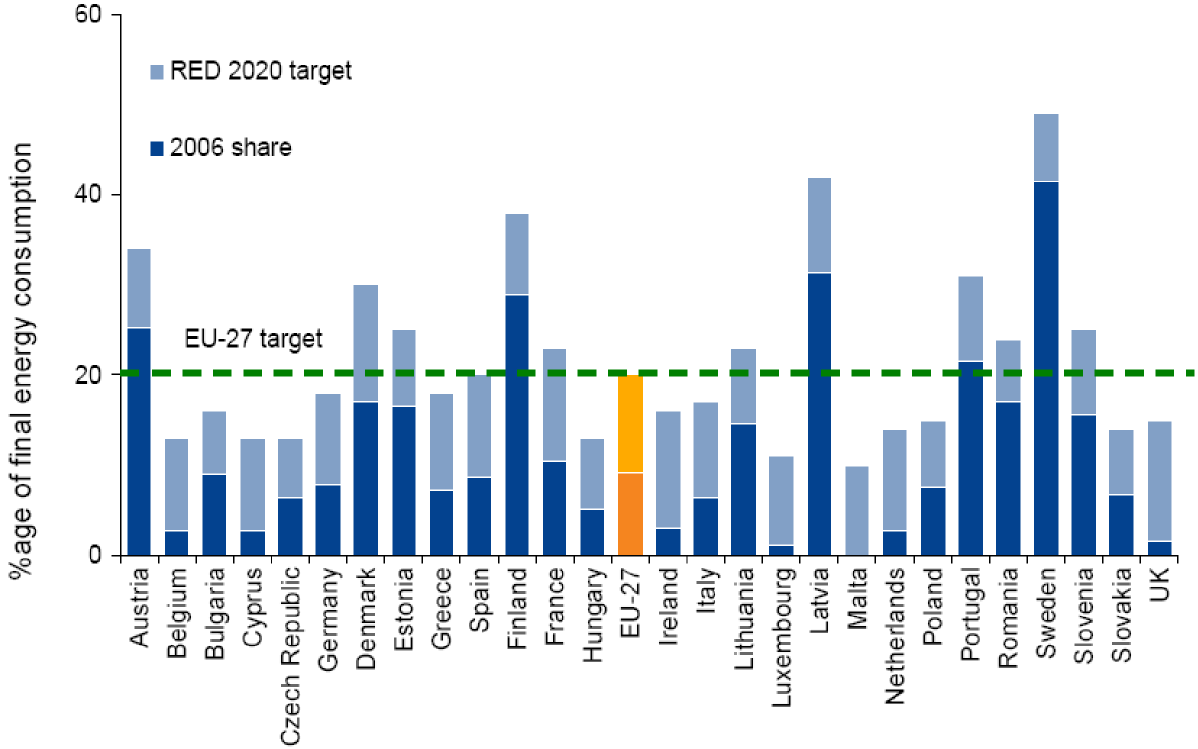


Figure 1: Comparison of National Renewable Energy Targets with overall EU-27 target and national RES shares in 2006 (Source: Pöyry & Eurelectic[5])

1.3. RES Lebanon target by 2020

The Renewable Energy Lebanon target is 12% of thermal and electricity supply by 2020 without any national plan demonstrating pathways and policies to meet this RE targets.

We can consider that this target concerns only electricity demand. And no RE targets are set nor for transport demand and neither for cooling and heating demand.

Finding 1	
	• National Renewable Energy Strategy do not exist in Lebanon • RES targets cover only electricity sector • NREAP do not exist

5 John Scowcroft , Susanne Nies,« Renewables Action Plan (RESAP) », EURELECTRIC, 2011.

2. National Energy Policy Context

2.1. Socio-economic context

The Lebanese population amounted to 4.4 million inhabitants in 2014 (without Syrian refugees). According to UN population prospects, the increase in population should slow down compared to past trends, to reach more than 5 million inhabitants by 2030 and 5.2 million by 2040. The share of the population living in the urban area would be approximately 90%.

GDP is around USD_{2005} 67 billion (PPP) and GDP per capita reached over 14,100 USD/cap. in 2014.

2.2. Energy Policy

Energy Strategy: At the beginning of 2010, the Lebanese Government adopted an objective of gradually increasing the share of renewable energies in the energy consumption from 2% in 2010 to 12% in 2020 as part of its energy plan. It seems that the objective of 12% still unclear for policy makers (will RE cover 12% of total Energy Needs or 12% of electricity generation as stressed recently by the MoEW?). *The difference between the two options is 8% of Primary Energy*.

Finding 2

- It seems that the objective of RE 12% still unclear for policy makers (will RE cover 12% of total Energy Needs or 12% of electricity generation as stressed recently by the MoEW?).

We wonder if RE cover 12% of primary or final energy in Lebanon and we think that this target is realistic.

From the other side the Strategy assumes that energy efficiency will contribute to reduce the energy consumption by 5% in comparison to the base line scenario (business as usual, BAU - trend or reference) by 2020. However, at present, more than five years later, action plans and programs that have been developed (as the distribution of 3 millions lamps (CFL) that were distributed to households throughout the country and incentives programs for SWH) still not sufficient to translate this strategy into sustainable projects.

Finding 3

- After 5 years of the launching of the RE strategy, EE Action plan and programs that have been developed still not sufficient to translate the RE strategy into sustainable projects.

Institutional framework: Law 462/2002 [6] forms the institutional framework of the energy sector. It allows the restructuration of the company Electricité du Liban (EdL). According to this Law a Regulatory Authority should be established and the role of the Ministry of Energy and Water (MoEW) is to provide planning and implementation of sector strategies and energy regulation in the country [3]. The amendment 288 to the law 462, has set legal basis for independent power producers and three IPPs are now approved (one of them is the Electricity of Zahlé, EdZ).

Finding 4	• Feed-in tariffs [4] do not exist and the recent net-metering applied by EdL allows excess energy fed to the network in summer to be credited and balanced during winter months. But the experiences didn't success.

Policy Paper for the Electricity Sector [1]: During 2010-2011, the Council of Ministers adopted the comprehensive reform plan submitted by MoEW regarding the electricity sector. The plan claims giving priority to the types of energy which cause the lowest damage to the environment, depending mainly on gas and renewable energy and is aiming to create an electricity sector with a 5,000 MW capacity by the year 2015. The Policy Paper commits to launching, supporting and reinforcing all public, private and individual initiative to adopt the use of renewable energies to reach **12% of electric and thermal supply**. But table 1 shows that the initiatives don't allow realisation of this target. RE will cover only 3.2 of primary energy and 6.9 of electricity generation according to this plan.

The Policy Paper includes a preliminary estimate of the resources requirements (recurrent and capital expenditure). But there are many weak elements in the Policy Paper which are: (i) The planned reform of electricity tariffs required to assure the financial balance of electricity sector is still under discussion; (ii) It is not properly linked to a coherent national strategy and capital investment and operational costs plans; (iii) It requires a high public expenditure not properly justified; and (iv) It does not contain any clear mechanisms for monitoring implementation and updating of the policy paper.

This plan supposed to be finalised at the end of 2014 and promised the end of the blackout program. But the deficit in electricity generation passed from 21,7% in 2010 to rich more than 33% in 2014 (figure 2) and the deficit in electricity supply is near 50% in July 2014 (supply 1500 MW, demand 2900 MW)[6] .

The Policy Paper tackled also the renewable energy sector where it insisted (among others) on the development of a wind atlas and a feasibility study for photovoltaic's farms, and the large promotion of the "clean energy" concept among the public. The energy efficiency component also entailed the awareness raising about:

[6] Adnan Al Hajj, Al Safir, 21 July 2014.

- the interest of using solar water heaters, compact fluorescent lamps, and energy efficient street lighting;
- the creation of a financing mechanism by the Central Bank of Lebanon (Banque du Liban; "BDL") entitled NEEREA: National Energy Efficiency and Renewable Energy Action;
- the adoption of the energy conservation law and the institutionalization of the Lebanese Centre for Energy Conservation (LCEC).

Five years after the adoption of the Policy Paper, little progress has been noted on the main pillars of this national initiative, mainly due to an already complex political, economic and social situation – later on aggravated by a massive influx of refugees from Syria since 2013 (more than 1,1 million refugees in mid-2015). However the energy efficiency and renewable energy components of the Policy Paper did reach some substantial achievements.

Finding 5	• In 2015 after 5 years of the launching of the Policy Paper of the Electricity Sector no main objective was realised: black out is increasing, no additional electctricity capacity generation was installed, RE and EE targets still far to be realised but reached some substantial achievements and electricity tariffs reforms do not start.

Since 2010, the Lebanese Government has shown some increasing support to the development of energy efficiency measures in Lebanon. It has approved the first National Energy Efficiency Action Plan for Lebanon for the period 2011-2015. The Ministry of Energy and Water is currently working on a second NEEAP of the Republic of Lebanon for the period 2016-2020.

Moreover, in the past decade the Lebanese authorities increasingly highlighted the necessity to address environmental challenges and to mitigate consequences of climate change, as well as to develop energy efficiency measures and the use of alternative sources of energy. In that context, BDL launched several circulars to encourage investments in projects related to "environment", through exemptions to commercial banks of their minimum reserves at the Central Bank if an equivalent of these reserves was provided as loans to clients for such purposes.

This initiative was mainly based on the fact that investments in energy savings and renewable energy technologies often represent for Lebanese SMEs a huge cost with long payback periods. In addition, Lebanon has a huge potential to increase energy efficiency but there is a lack of access to appropriate financing mechanisms. Thus, the development of specialised energy efficiency financing windows in appropriate financial institutions was required, as well as the development of skills for energy efficiency project appraisal and the design of specialised financial products.

For more than a decade, the European Union has supported the development and reinforcement of the Lebanese private sector. Encouraging achievements have been recorded in the areas of legislation, access to finance (through Kafalat[7]), assistance to enterprises, as well as quality management.

Within this promising and dynamic "energy savings context", the EU committed in 2010 a EUR 15 million budget envelope (for a 6-years implementation period) through a "Facility in support of Small and Medium Enterprises' energy efficiency investments".
The EU offered to:

- Complement the NEEREA scheme (implemented by BDL) and making it more attractive by subsidizing the loans that SMEs might request from commercial banks to finance these investments. This commitment was formalized within a dedicated EU-BDL grant contract (worth EUR 12.2 million).
- Complement a guarantee mechanism proposed by Kafalat for environment oriented investments needs. This commitment was formalized within a dedicated EU-Kafalat grant contract (worth EUR 2.5 million).

Besides these financing facilities, the EU also offered some technical assistance in order to support both direct beneficiaries institutions to (i) specify eligibility criteria of the investment project for the subsidy/guarantee to apply in the frame of this facility, (ii) set the amount of the subsidy/guarantee to be granted and (ii) monitor the implementation of the selected projects. This technical assistance is currently being executed by the LCEC (through a contract signed with BDL).

Table 1: Share of RE in electricity generation and in primary energy according to the Policy paper for Electricity sector

Electricity generation from Installed and new Electricity plants	2009	After 2015
The installed capacity of all old hydro plants (MW)	274	274
The actual generation capacity of the existing Hydro plants (MW)	190	190
Annual generation of electricity of existing hydro plants (estimated in 2015 = 2013) (GWh)	469	1034
New hydro plants according to the Policy Paper (MW)		40
New Wind farms according to the Policy Paper (60-100 MW), average 80 MW		80
Demonstration PV plant - Beirut River -(MW)		10
New Electricity Plants Energy to Waste 15-25 MW - Average 20 MW		20
Total capacity of existing and new RE plants according to Policy Paper (MW)	274	424
The installed capacity of old thermal power plants (MW)	2038	2038
The operational capacity of old thermal power plants (MW)	1685	1500

[7] Kafalat is a Lebanese financial company with a public concern that assists small and medium sized enterprises (SMEs) to access commercial bank funding.

Annual generation of existing thermal plants - (estimated in 2015 = 2013) (GWh)	9938	9218
Total Installed capacity according to the Policy Paper (MW)	2312	5000
Estimated electricity generated from new hydro-plants (GWH)		218
Estimated electricity generated from new PV plants (GWH)		22
Estimated electricity generated from new wind plants (GWH)		192
Estimated electricity generated from waste to energy plants (GWH)		80
Total electricity generated from RE – (after 2015 estimated) (GWh)	469	1546
Share of RE electricity plants in the total installed capacity (%)	11.9	5.5
Total electricity demand – (estimated for 2015) (GWh)	15000	22510
Expected Share of RE electricity in total EdL electricity generation and purchase (%)	**4.1**	**6.9**
Total Primary Energy Consumption [4]–(Estimated in 2015) (ktoe)	6000	8341
Primary energy from biomass and other RE ktoe [5]	42	92
Expected Share of RE electricity in total primary energy demand (%)	**1.3**	**3.2**

Estimation for 2015 is based on values for 2012 increased by the average of the annual raise calculated from previous years.

National Energy Efficiency Action Plan [7]: The National Energy Efficiency Action Plan for Lebanon NEEAP 2011-2015 has been adopted by the Government in November 2011. It includes 14 independent but correlated activities. The activities are described but the estimated financial means for their achievement are not assured. The financial aspect mentioned in the NEEAP report is considered through the indication of the necessary budget, the required investment and the gained benefit for each activity. Nevertheless, this financial issue is missing accuracy since it gives sometimes financial figures within a margin between 50% and 100%. Moreover, there is no program for implementation and no indicators for follow up and no methodology of evaluation are indicated.

Unfortunately initiatives regarding PV proposed in the NEEAP are not sufficient to achieve the objective of 12% RE (of primary energy) by 2020. LCEC and MoEW are working on a 10MW PV farm (BRSS) all along with a 60-100MW wind farm bid in its advanced stages. The actual installed capacity of PV alone is above 6 MW. Moreover, the MoEW has launched a complete study for the restructuring of hydro power plants.

It should be mentioned that the energy efficiency law project is prepared but still not adopted by the Parliament.

National Renewable Energy Strategy: The NRES is currently under preparation and the mentioned target will only address the electricity sector. In March 2012 the Lebanese Government passed the Strategic Environmental Assessment Decree (SEA). In that context, the UNDP has commissioned a consultancy project for the preparation of the SEA of the national renewable energy sector in Lebanon in order to conduct a systematic assessment of the environmental consequence of the NRES to ensure that the claimed consequences are fully included and addressed appropriately at the earliest stage of decision making.

2.3. Electricity sector

A summary of the electricity sector situation for the year 2009 is presented in the "Policy Paper for the Electricity Sector, 2010" as following:

- ***Hydraulic power plants****: The installed capacity of all hydro plants is 274 MW but the actual generation capacity is 190 MW. The energy produced from the hydro plants (Litani, Nahr Ibrahim and Bared) constitutes 4.5% from the total production.*
- ***Thermal Power Plants:*** *The installed capacity of thermal power plants is 2038 MW but the capacity was 1685 MW. The fuel cost varies widely from 9 USC/kWh to 22 USC/kWh.*

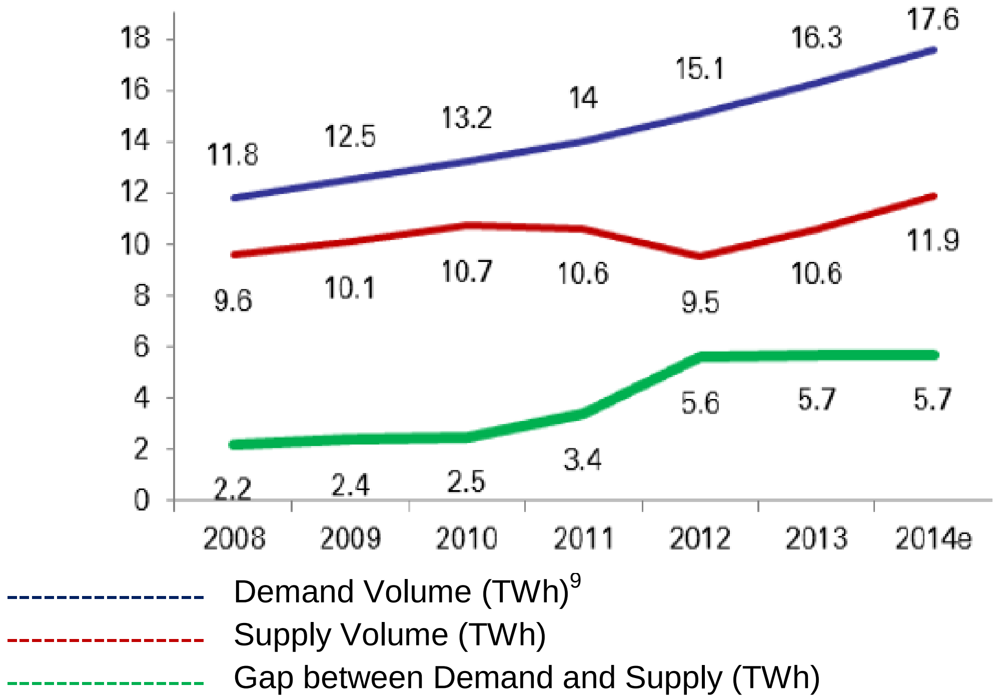
The average capacity and imports available in 2009 was 1500 MW; the average demand was 2000-2100 MW and the instantaneous peak in the summer was 2450 MW. The total energy demand in 2009 was 15,000 GWh (7% increase from 2008) whereas the total production and purchases was 11,522 GWh (6% increase from 2008) which resulted in energy not supplied (deficit) of 3,478 GWh (23%) (figure 2).
The total losses on the system are about 40% (more than $300 million): 15% technical losses; 20% non-technical losses and 5% uncollected bills.

The government since 2010 is taking action to improve the electricity services and to reach 24/24 services by 2014. This involved (and will involve) a large investment package for rehabilitation of old power plants and the construction of new ones, including the involvement of the private sector in power generation. As Government investments need a long breath to be realised (the law n° 181/2012 allocated around 800 MUSD to the MoEW for the construction of new plants and the rehabilitation of existing ones) the participation of the private sector and the international donors (in the finance of new electricity plants[8]) was not secured at the end of 2015, there are reasonable doubts whether this target will be achieved.

As a result frequent power blackout of 3 to 16 hours per day is currently occurring in all cities in Lebanon. Back-up generation at larger companies and informal neighbourhood generators (that work at damaging environmental conditions) secure the supply during power cuts. **The electricity tariffs (EdL) still unchanged since 1994**, although the costs for fuel rose almost fivefold.

[8] The participation of Private Finance Institutions and the International donors is expected to attend 6 billion USD by 2015 in The Policy Paper for Electricity sector (2010).

The average tariff of electricity is 7.7 USC/kWh for industry and 9 USC/kWh for residential use, which does not even cover the costs of fuel. The policy of fixing energy tariffs at a low rate in a social pricing context has inhibited the development of energy efficiency and renewable energy and encourages high consumption and wasting energy. This scenario is supported by high government subsidies.



(Source: EdL, World Bank , “Electricity in Lebanon: Negative Repercussions on the Economy”), 2014 only 11 months.

Figure 2: The Mismatch between Electricity Demand and Supply

EdL’s financial deficit: The financial deficit of EdL averaged $4.5 billion for 2006-2008 [1] and as showing in table 1 subsidy to EdL from 2009 to 2014 averaged $10.866 billion. Table 1 also shows the situation of electricity sector the last six years.

A serious step towards the participation of the private sector in generation is the Law 288 that was adopted by the Lebanese parliament in 2014 and that allows the government to license private electricity producers.

The continuous growth of the energy import bill [2] leads to increasing financial pressures, more and more difficult to bear. This financial pressure also constrains the

[9] Tera = 10^3 Giga = 10^6 Mega = 10^9 Kilowatts.

Lebanese government to invest in rational energy management and the development of renewable energies as an alternative to managing only the supply.

Table 2: Situation of the electricity sector of Lebanon for the period 2009-2014

Items	2014	2013	2012	2011	2010	2009
EdL Expenditures (MUS$)		2630	2920	2460		
Subsidy from the government to EdL (M USD)*	2104	2036	2272	1750	1198	1506
Annual Levies** (MUSD)		594	648	710		
Total oil bill* (including boats) (MUSD)	2151	2047	2131	1780	1299	
Total production and purchases of electricity (GWh) breakdown as** :	12524	12096	10965	12396	12574	11522
- hydro plants	194	1034	1178	805	956	468
- Thermal plants	9715	9218	9463	10751	10378	9938
- Electricity boats	2478	1322				
- Purchase from Syria	137	522	296	606	792	589
- Purchase from Egypt			28	234	448	527
Share of Electricity from renewable source in the total EdL (%)	1.5	8.5	10.7	6.5	7.6	4.1
Average kWh price collected by EdL USC/kWh		4.9	5.9	5.7		
Subsidies by the government to EdL USC/kWh	16.8	16.8	20.7	14.1	9.5	13.1
Calculated Electricity tariffs to insure the financial equilibrium of EdL USC/kWh		21.7	26.6	19.8		

* Ministry of Finance
** EdL

In fact, transfers to EDL were relatively low from 2003 to 2008. More than its half (53.8% of total EdL deficit)[10] was accumulated during the last 5 years (period of implementation of the "Policy Paper for Electricity Sector"). Transfers to EDL covering the electricity deficit in Lebanon severely impacted Lebanon's indebtedness and its economic growth. According to the BLOMINVEST Bank, by the end of 2014, the Lebanese gross debt is estimated to settle around $68B or 143% of GDP which means that transfers to EdL (including interests) constitute almost 40% of the GPD. Thus, abolishing those transfers would have resulted in a lower debt of $40.97B or 86.3% of GDP in 2014.

[10] Mirna Chami & Marwan Mikhael, Any hopes for Lebanese to Enjoy 24 Hours of Electricity Ever Again?, BLOMINVEST Bank, January 2015.

As for EDL's income, two sources exist: treasury transfers and annual levies from citizens. The former was the main contributor to EDL's resources with a stake of 77.2% in 2013; meanwhile the latter took the remaining share of 22.8%. Thus, the treasury transfers practically equals three quarters of EdL costs while residents' levies barely cover one quarter. It is also worth mentioning that **levies are following a declining trend since 2011** (table 2) despite the increasing number of subscriptions and the expected reforms in the billing system through the 3 service providers[11] (National Electrical Utility Company SAL, Butec Utility Services SAL, KVA SAL).

EDL contributed 3.2 percent (%) of the total oil bill in 2014.

In 2014 the electricity bill for private generators was 1.2 Billion USD the total electricity bill paid by the Lebanese customers was 3.9 Billion USD[12] (figure 3).

With primary expenditures of the Government at LBP 14,430 billion in Jan-Dec 2014, the share of transfers to EDL reached 21.9 percent, a slightly higher share than that paid in Jan-Dec 2013 which stood at 21.0 percent of total primary expenditures[13] (figure 4).

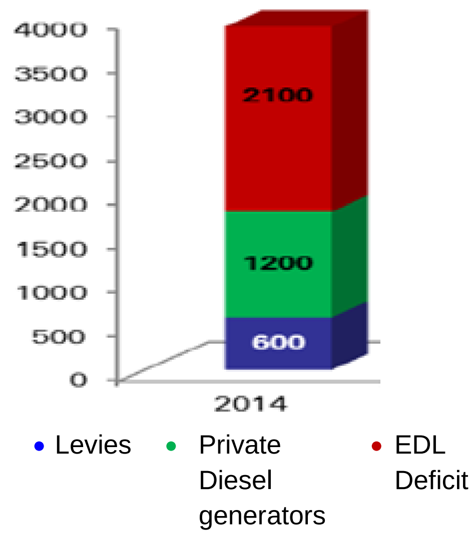


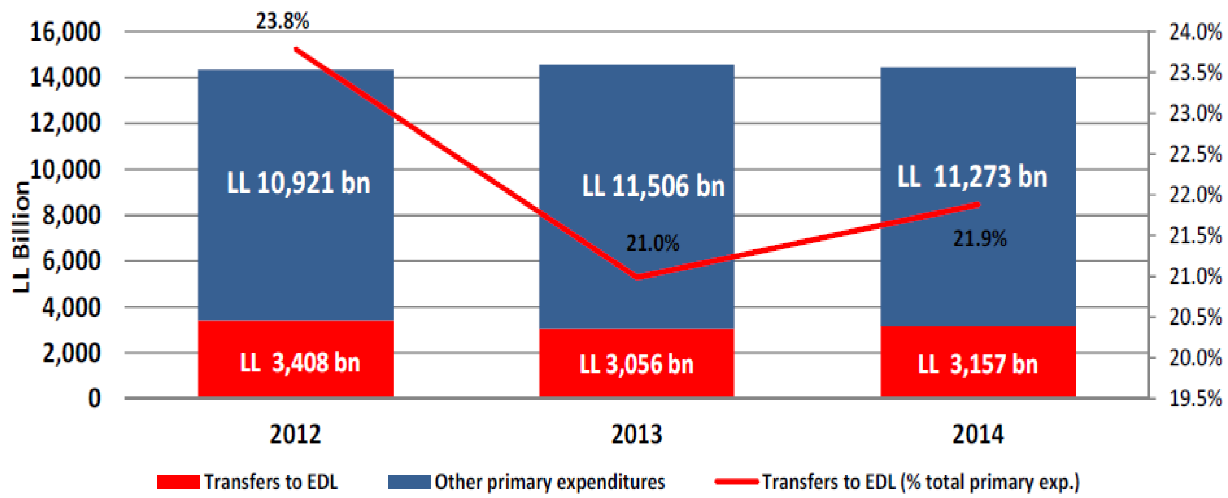
Figure 3: Total Electricity bill, 2014

This EdL deficit is caused primarily by the low tariffs of electricity. Figure 5 shows the average Electricity prices illustrating the MENA-wide policy of providing low-cost energy supplies to both households (see annex 2) and industries. Lebanon is between the countries with lowest prices.

Only Morocco and the Palestinian territories match European levels, thereby being exceptions to the otherwise low-cost environment for Middle Eastern electricity – both countries are reliant on international imports of oil for power generation, and Morocco imports Spanish power, being unable to supply its own market (a fate it shares with many of its MENA neighbours). Nevertheless, both the Moroccan government and the Palestinian authorities subsidize electricity prices, suggesting that actual generation

11 Service providers were assigned with distribution services from stations, securing efficient levying system and creating "the smart meters".
12 "Electricity in Lebanon: Negative Repercussions on the Economy", World Bank, 2015
13 Treasury Transfers to Electricité du Liban A Monthly Snapshot, Ministry of Finance, December 2014.

costs may well exceed these already high price levels – rendering their domestic electricity generation exceptionally expensive even by international comparison.



(Source: Ministry of Finance – 1 US$ = 1500 LL)

Figure 4: Transfers to EDL out of primary expenditures (Jan-Dec 2012 – Jan-Dec 2014)

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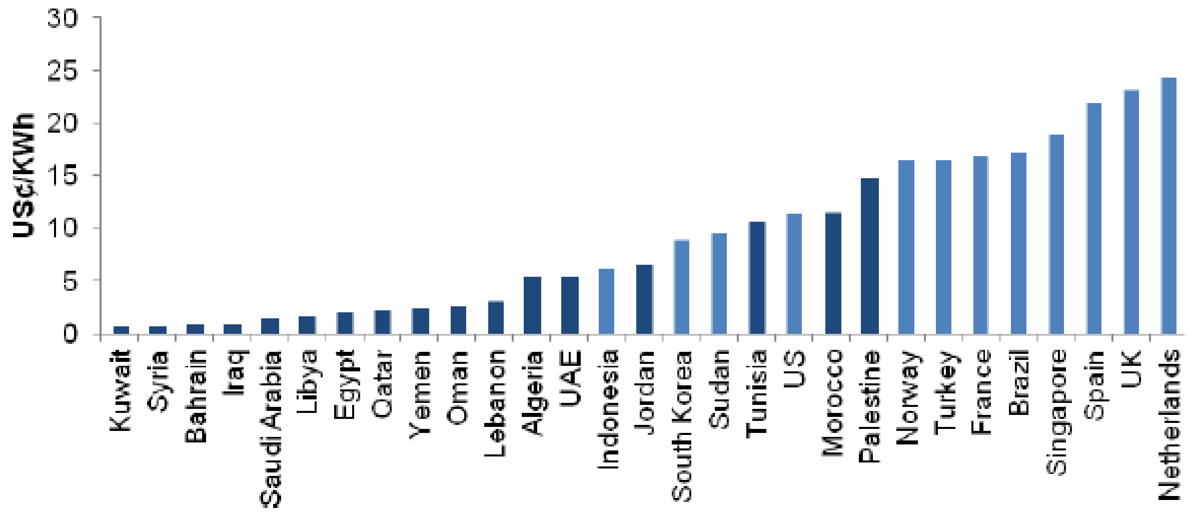


Source: El-Katiri, Fattouh and Segal (2011); EIA (2013)

Figure 5: Cross-Country Comparison of Average Residential Electricity Prices in Selected MENA and non-MENA Countries, 2008

EDZ initiative: Zahle city provided with 24/24 electricity starting January 2015. EDZ[14] Company succeeded to provide its 53,000 subscribers the electrical energy 24/24 with a regular stream of voltage. EDZ claims that her project is an eco-friendly project providing employment for about 50 Lebanese family and attenuating pollution due to 200 private generators working in Zahle, and therefore provides an integrated economic circle in the region, and will attract new investments to the Bekaa without costing the state a penny, and thus Zahle is the first Lebanese area to provide a full time electricity approved by the Ministry of Energy, and legalized by a law that allows the electrical production[15] for EDZ, issued by the parliament not long ago.

The tariff remains the same one of EDL (Electricite du Liban) in addition to the consumption generated from EDZ with a cost of 150 L.L. per kilowatt (10$c/kWh) and without any incremental value, with no need to install extra counters. On this basis, citizens are paying lower tariffs by 40% to 70% on the amount paid today to both EDZ and private generators; with a note that large enterprises and companies benefit from special prices and offers.

2.4. Environmental level

Lebanon ratified the climate change convention in December 1994 and is a non-annex 1 party to the Kyoto Protocol; hence it has no obligations for greenhouse gas emission reductions. Lebanon is the second most important emitter of GHG per capita in the region. It should be pointed out, that the GHG generation in Lebanon is 4.34 tCO2 per capita (2011), that is not far from the world average (4.50 tCO2 per capita) [8], double of Southern Mediterranean countries (2.43 tCO2 per capita) and less than the half of the developed countries.

[14] EDZ, founded in the early 1920s, is a private institution that generates and distributes electricity in east Lebanon's Zahle and other areas such as Saadnayel, Barr Elias, Riyaq, Ablah and Taanayel

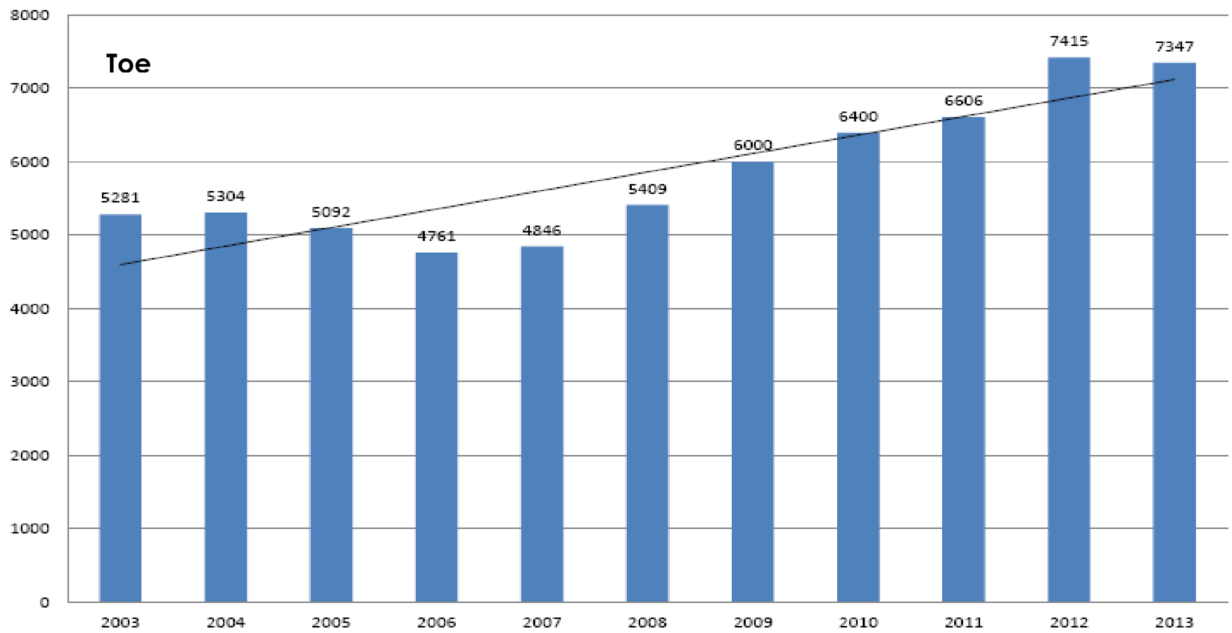
[15] EDZ electricity generation around 70 MW.

3. Energy efficiency potential by 2025

3.1. Energy consumption evolution

Energy consumption in Lebanon had an increase of over 60% between 2000 and today, reaching almost 8 Mtoe in 2014 (figure 6). The country is heavily dependent on imports, especially of oil. Its energy dependence rate in 2014 reached 98%. The only domestic resources available are renewable, and so far only hydropower has been exploited to a large extent for electricity generation, with other renewables (mostly biomass and solar) being traditionally used for heating purposes, mostly in the residential sector. In 2014, renewable energy represented only 2% of total primary energy supply.

If no aggressive policies are enacted, the picture is not likely to evolve that much, with renewables still accounting for only 4% of the energy mix by 2030 and 2040 under a business as usual scenario[16].



(source: ALMEE)

Figure 6: Primary energy consumption 2003-2013

3.2. Energy Efficiency Potential by 2025

The total Energy Efficiency potential[17] in 2012 for Lebanon was 1,818 ktoe, of which 41 percent was for the electricity sector and 59 percent for end-use sectors. In the end-use

[16] Source: OME database
[17] "MENA – Delivery Mechanisms and Institutions to Realize Energy Efficiency Potential", World Bank, RCREEE, 2015.

sector, the highest EE potential was estimated to be residential at 537 ktoe, followed by transport at 280 ktoe, industry at 157 ktoe, tertiary at 66 ktoe, and agriculture and fishing at 29 ktoe. The EE potential consisted of 25 percent of total primary energy supplied (TPES) in 2012.

The technical EE potential projected for 2020 and 2025 is 2,242 ktoe and 2,434 ktoe, respectively. Based on the projected values of 2025, the total EE potential represents 33 percent of TPES.

4. SWOT analysis

4.1. Pillars of a sustainable Energy Policy

Trends: The country has an interesting technical and financial potential capable of launching and supporting ambitious projects in the energy and environment domains. The banking sector is economically powerful with significant financial reserves and the moment could be opportune for financing energy efficiency, renewable energy and environmental projects.

Solar potential: Lebanon is geographically well situated to promote solar energy (the **yearly average** of solar radiation in Lebanon is 1900 kWh/m^2). In this framework, it is worthwhile to point out, in this framework, that the Directorate General of the weather forecast as well as some universities are equipped with a network of meteorological stations allowing measurements of the solar radiation for hourly periods in many sites of the country. However, there is no analysis of such data and no Solar Atlas is available.

Seasonal variability remains of solar radiation high, with a variation factor of more than 3 between December and July. These values are related to the only available measurements in three stations in Lebanon for the period 1968-1990 (table 3).

The medium temperature solar thermal for air conditioning or sea water desalination as well as concentrated solar power and PV are not yet developed in the country despite its potential for use in air conditioning and electricity generation.

Table 3: Global radiation in Wh/m^2.day

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Abde	2044	3089	3875	6095	6464	7344	7035	6822	5312	3588	2734	2115	**4715**
Ksara	2518	3625	4943	6214	7702	8840	8758	7949	6762	4849	3424	3507	**5683**
Beirut	2308	3191	4380	5496	6461	7208	7018	6424	5380	4247	3004	2317	**4793**

(Source: ALMEE based on Lebanon Meteorological Office data –available years means 1968-1990)

Arguments in favour of the development of RE: The arguments in favour of the development in Lebanon of renewable energies seem obvious and can be summarized as follow: (i) Energy bill control and balance of payments improvement, (ii) Reduction of the conventional energy system emissions to the local and global environment: SOx, NOx, CO2, etc… (iii) Reduction of the impact of future world energy pressures on national economy, (iv) Technical innovation promotion and technological progress dissemination, bypassing some development stages, (v) Reduction of investments for expanding the conventional energy production system, (vi) Optimization of economic costs, favourable to a sustained growth and rapid improvement of the country incomes, (vii) Reduction of risks linked to uncertainties in the world energy situation, (viii)Reduction of the electrical peak demand from the grid and improvement of the balance between generation and consumption.

4.2. Barriers to Renewable Energy Strategy Implementation

A survey was conducted under the project SHAAMS to assess Economic, market and financial barriers and facilitators to the strategy implementation during 2013. The results of the survey confirm the identified barriers below:

Legislations and regulations: These include: (i) The absence of effective policies, (ii) Private Sector is heavily constrained by regulations, (iii) Absence of regulations and standards that preclude new technologies.

Finding 6	• Regulatory measures are requested to stimulate market opportunities and support the introduction of innovative methodologies

.**Economic Barriers**: It includes: (i) High subsidies on electricity (that make the payback period of RE applications too high for end users), (ii) No preferential taxation for RE&EE equipment, (iii) RE&EE industry has no sufficient incentives to react to market demand, (iv) No efficient incentives to promote RE&EE investment in electricity sector: wind, CSP, PV, biogas, etc., (v) lack of financial mechanisms and instruments encouraging RE&EE manufacturing (despite the existing ones like NEEREA), (vi) High cost of capital and lack of access to capital & financial institutions (for high investments).

Technical Barriers: Adequacy of Resources: The transfer of new technologies requires the existence of supporting infrastructure. The major infrastructure constraint for RE electrical generation is at the level of the Lebanese electrical grid. This power network needs to be deeply restructured for an efficient penetration of RE generation. This restructuring process should be analyzed in terms of planning and budgeting. There is also lack of priority for national R&D programs and lack of training & education at university and professional or vocational level. Most RE&EE companies are small size with limited financial capacities.

Finding 7	
	• The power network needs to be deeply restructured for an efficient penetration of RE generation. • This restructuring process should be analyzed in terms of planning and budgeting.

Public Awareness: Lack of awareness is a major barrier hindering the widespread of cost-effective new technologies. Awareness about the benefits that new technologies offer as well as the provision of alternatives is very important for facilitating acceptance of new technological options. Cultural and societal barriers are also important and need to be addressed. Continuous Capacity Buildings and awareness programmes are needed.

4.3. Results of SWOT analysis

Below the results of SWOT based on analysis conducted by SHAAMS project [9]:

Table 4: SWOT analysis

	Strengths **HELPFUL** **(To achieving the objective)**	**Weaknesses** **HARMFUL** **(To achieving the objective)**
INTERNAL ORIGIN	• Strategy defined through the 2010 policy paper & NEEAP. • NEEREA. • Solar sector is still an emerging market in Lebanon. • Willingness for a public-private dialogue from both private and public institutions. • Many national players might be involved in actions that will help enhancing the policy. • SWH standards are available. • An energy conservation law is presently under preparation. It is envisaged that in the future this law will constitute the main regulatory framework for EE and RE.	• Lack of Funding. • Target of 12% RE by 2020 is not clear for stakeholders (12% of overall energy mix or from electricity supply?). • Weak dissemination of solar energy policies and strategies. • No specific law for Renewable Energy • Need for technical staff in public institutions. • Presently no tax support schemes exist for RES in Lebanon. • Decision making is centralized. • The private public cooperation is still limited • Most of the strategic functions in MoE and MoEW are covered by advisors (from outside the ministry), with as consequences instability and lack of continuity in the implementation plans. • Government is not stable • Not enough awareness for banking

		sector on solar energy market growth opportunities. • Decision making is related to politics more than economy.
	Opportunities **HELPFUL** **(To achieving the objective)**	**Threats** **HARMFUL** **(To achieving the objective)**
EXTERNAL ORIGIN	• Lebanon is represented in RCREEE and MEDENER • The UfM will launch in 2016 a platform for RE & EE that includes Lebanon • Four EU ENPI-CBC solar energy projects are running in Lebanon during 3 years • Prices of solar energy solutions are becoming more affordable.	• Geographical position of Lebanon • Lack of coordination with international programmes, institutions and initiatives related to renewable energy (IRENA, MSP, etc.)

	Strength **HELPFUL** **(To achieving the objective)**	**Weaknesses** **HARMFUL** **(To achieving the objective)**
INTERNAL ORIGIN	- Private sector operators are dynamic and quick to follow innovation in this domain. - Companies are usually aware of existing legislation. - Financing means are available (though limited). - Possibility to implement personalized services (connection to the grid + private generator). - Possibility to implement innovative solutions (such as sun shades over building frontages). - University curricula in renewable energies are available in Lebanon. - Good solar exposure for the country.	- Cooperation in research between enterprises and universities / research centres is almost inexistent. - Lack in testing facilities. - No economy of scale (small operators). - No distribution networks (small operators). - Lack of staff expertise within companies. - Regarding residential systems: lack of space over the roof, and potential problems with neighbours. - Barriers to the entry of competitors. - Business owners might be oriented towards the technological aspect of the business and might disregard the marketing / commercialization aspect. - The initial investment required from users

		is a barrier for choosing a solar system (Users tend to lack thinking on a long-term basis). - Feed-in-tariff not exist
	Opportunities **HELPFUL** **(To achieving the objective)**	**Threats** **HARMFUL** **(To achieving the objective)**
EXTERNAL ORIGIN	- PV prices are on a decreasing trend. - Possibilities of vertical integration.	- Traditional electricity is subsidised and still cheaper to obtain than PV or CSP electricity. - Political instability in the region affecting the country. .

5. Estimation of Renewable Energies Potential

Renewable energy is frequently portrayed as a catalyst for wider economic benefits such as industrial development around 'green' technology clusters, and the developing countries' all-important concern of skilled job creation. The frequently emphasized advantage of renewable energy technology lies, to some extent, in the relative ease of technology transfer between producing and newly producing countries, the comparatively low capital-intensity of renewable technologies vis-à-vis other energy industries, and thus in the significant opportunities for Lebanon to set up his own manufacturing and R&D industries.

A 2010 World Bank[18] study indeed suggests that nearly 50,000 new local jobs for manufacturing components could be created by 2025, if there were to be strong development of concentred solar plants (CSP) components factories in five MENA economies (Algeria, Egypt, Jordan, Morocco, and Tunisia) alone.

The renewable energies potential of Lebanon is discussed in the following sections.

5.1. Wind Potential

Lebanon has a reasonable wind potential as reported in studies and estimates until present - primarily the wind atlas which was finalized in 2011. Hence the study can be considered as the first essential step, practically indicating sites where further assessment including wind measurements would be followed up before investment decisions are made.

The key results from this study with regards to wind potential on the basis of various assumption scenarios are for the sites with average wind speed of 6.5 m/s and based on the identified technical potential, corresponding electricity generation from wind power amounts to approximately 12,139 GWh/y (table 5), and equivalent to 60% of the actual electricity demand.

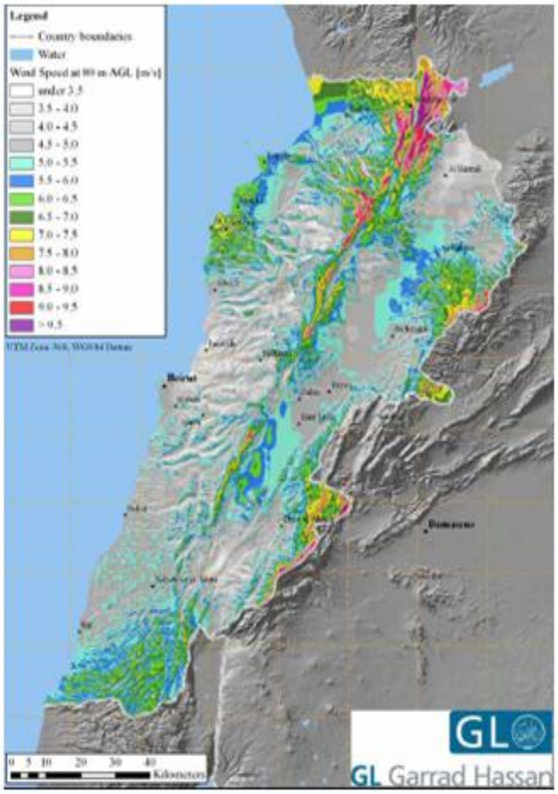
[18] World Bank/ESMAP (2011). For further discussion and simulations, see van der Zwaan et al. (2013). Simulating the effect of Moroccan RES plans under a baseline scenario, a 2010 study confirms the potential for trickle-down effects of renewable energy targets into the Moroccan economy, including the creation of some 269,000 jobs and a 1.21% share in GDP by 2040. De Arce et al. (2010, 341).

Table 5: Estimated electricity generation from wind vs wind speed range

Average annual wind speed (m/s)	Ass. Capacity factor (%)	Area in km2	App. Potential capacity (MW)	Approximate total potential power output (MWh
6.5 – 7	22.0	294.4	2,355	4,538,556
7 – 7.5	25.1	187.6	1,500	3,298,140
7.5 – 8	28.2	92.8	743	1,835,448
8 – 8.5	31.4	48.0	384	1,056,246
8.5 – 9	34.8	24.8	199	606,648
9 – 9.5	38.4	12.7	102	343,112
> 9.5 (assumed 10 m/s)	42.1	15.7	125	460,995
Total		**676**	**5408**	**12,139,145**

Consequently, preliminary estimates of the wind atlas are promising, however it should be noted that -as reported in the relevant deliverable – there is a certain level of uncertainty in the presented predictions arising from a number of sources such as:

- Low resolution of available monthly wind data;
- Poor agreement between the hourly and monthly data for specific masts;
- Absence of comprehensive data coverage for certain periods and sites;
- Low height of the measurements;
- Only one measurement height for the ML meteorological stations, preventing any measured estimate of wind shear;
- Large extrapolation distance from 10 m to heights of 50 m and 80 m and corresponding uncertainty in the modelled shear assumed;
- Grid resolution (5 km and 100 m); andInherent uncertainties in wind modelling over large distances



The previous map shows the areas identified as having high onshore wind energy potential. Although no natural areas or cultural heritage sites protected by legal texts were identified in high wind potential areas, the regions consist of forests and green cover predominantly.

The Wind Atlas indicated average wind speeds up to more than 9.5 m/s across varying areas in Lebanon and therefore, capacity factors for wind farms in the country can range from 22% to 42%. Based on a study by IRENA, CEDRO has estimated levelised costs of electricity generation from wind in Lebanon which range from $c6.9/kWh to $c17.9/kWh, depending on capital costs, O&M costs and the capacity factor adopted (table 6).

In every case though the levelised cost of energy (LCOE) from onshore wind farms in Lebanon is substantially lower than the current average generating costs of EdL.

Wind power in the country is at present practically non-existent. During 2013, MoEW launched a tender for the construction of a 50 to 100 MW wind farm, and the procedure is still on-going. The selected contractor will build, own and operate the wind farm that can sell electricity for 20 years to EdL (+ 5 years option).

Table 6: LCOE vs capacity factors, investment and O&M costs

Capacity factor	$C/kWh		
	Low capital - High O & M	Mean capital - Mean O & M	High Capital - low O & M
22.0%	13.4	14.9	16.4
25.1%	12.1	13.3	14.6
28.2%	11.1	12.1	13.1
31.4%	10.3	11.1	12.0
34.8%	9.6	10.2	10.9
38.4%	8.9	9.5	10.1
42.1%	8.4	8.9	9.3

5.2. Solar Photovoltaic Potential

Photovoltaic (PV) is a renewable energy technology that converts solar radiation directly into electricity. Solar energy is abundant; the energy that the Earth receives from the Sun every hour is equal to the world's annual energy needs [10].

The advantages of PV are manifold:

- Unlimited resource of solar energy
- Available in all regions of the world
- Modular, it varies from Milliwatts in consumers products to Gigawatts in utility-scale power stations
- No air emissions, no waste production during operation
- Virtually no maintenance
- Silent during operation
- Proven technical lifetime of 30 years

Lebanon has a significant potential for PV, backed by the high solar irradiance levels, the relative lack of dust or sand and a relatively mild climate that ensures a more optimal operation in terms of efficiency.

Current progress has focused only on several (about 70) small demo plants supported by CEDRO (e.g. 40-50 kW in schools), whilst one demonstration project for a 1 MW PV plant on a constructed ceiling over a stretch of the Beirut River by LCEC and MoEW.

The PV companies in Lebanon claim the installation of several small projects of a overall capacity of 10 MW.

Calculation of the economic potential for PV power in Lebanon has been conducted at a preliminary stage (CEDRO), taking into account relevant constraints to ensure technical viability, environmental sustainability, and social security. In that context constrained use, i.e. areas excluded from PV sites referred to;

- Agricultural land
- Forest areas
- Historic sites
- Wetland and water bodies
- Slopes of more than 35°
- Slopes not facing south (when land is not flat)
- Areas with a surface below 8,000 m2 (based on a PV potential capacity of 8,000 m^2/MW).

In that context, it has been concluded that there is a potential for PV in Lebanon that could reach up to 110 GW (table 7), with candidate areas shown in the map below. This amount corresponds to annual electricity generation of 180,000 GWh, almost 15 times present generation from the TPPs (Thermal Power Plants) of the country.

Table 7. Solar PV Potential in Lebanon

GHI	Area in km2	Assumed App. Capacity Factor (%)	Potential capacity in MW(assuming 8000m2/MW)	Potential power output (MWh)
1700 – 1800	36.6	16.6	4,575	6,633,750
1800 - 1900	124.3	17.3	15,537.5	23,632,537.5
1900 - 2000	187.3	18	23,412.5	34,884,625
2000 – 2100	188.7	19.5	23,587.5	40,240,275
2100 – 2200	269	20.1	33,625	59,247,250
2200 - 2300	70.46	20.8	8,807.5	16,029,650
Total			**109,545**	**180,668,088**

CEDRO has conducted a financial analysis to extract LCOE for different scenarios pending on the maturity of the PV market. Results indicated LCOE ranging from 12 to 23 $-cents/kWh. In that context assuming a Power Purchase Agreement (PPA) tariff of 0.25 USD/kWh would give an internal rate of return (IRR) of 15.7% for a PV mature market. Some key results from the analysis of a hypothetical plant of 1.3 MWp performed by CEDRO are shown below (table 8):

Table 8: Results from the financial modelling of a 1.3 MW PV plant in Beirut

Financial parameters	Scenario I - not mature market	Scenario II - not mature market rebate	Scenario III - mature market
Financing	100% equity	70% equity, 30% rebate	100% equity
CAPEX	3.9 MUSD	2.75 MUSD	3.03 MUSD
O&M Costs	94,800 USD/y	94,800 USD/y	46,300 USD/y
Energy production	2,070 MWh/y	2,070 MWh/y	2,070 MWh/y
LCOE	0.23 USD/kWh	0.23 USD/kWh	0.23 USD/kWh

Payback period (for FiT=0.25 USD/kWh)	10 y	7y	6y
IRR (20y) (for FiT=0.25 USD/kWh)	7.8%	13.2%	15.7%

Studies were conducted by ALMEE and the Lebanese University for a 40 MW solar plants in the Bekaa near Zahle [12][13][14]. Different technologies of solar plants were designed to deliver all their production to the national Lebanese grid. In this feasibility study, simulations were performed with the help of the System Advisor Model software (commonly known as SAM). Unfortunately, there is no clear strategy in Lebanon for the incorporation of power plants that utilize renewable energies. Input data (interest rate, taxes, possible incentives etc.) were used as given by the Lebanese market if available or according to previously established similar plants when data weren't available. The results were divided into two categories; Technical and Financial Results. Changes related to technology costs and possible incentives are estimated for 20 years loan term. According to assumptions considered the PPA prices still less than 23 US cents/kWh and fall down to 14 US cents/kWh and still achieve a good profitability of the plant (an IRR=16 %). This is shown in the table 9.

However any further development of additional PV plants or similar investments in renewable energies will require the introduction of smart grids for better synchronizations between different power plants for improving the balance between production and demand.

The financial study for large PV plants should consider the land price and should be compared to other renewable energy and conventional sources used in Lebanon.

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Table 9: Results from the financial modelling of 40 MW PV plant in Zahle – Lebanon

Financial parameters	Scenario I – not mature market	Scenario II – Mature market
Financing	100% equity	100%equity
CAPEX	108 MUSD	84 MUSD
O&M Costs	2.8 MUSD	1.8 MUSD
Electricity Production	68000 MWh/y	68000 MWh/y
Payback period (for FiT =0.23 USD/kWh the first 6 years and 0,14 USD/kWh for 14 years)	10 years	6 years
IRR (20Y) (for FiT =0.23 USD/kWh the first 6 years and 0,14 USD/kWh for 14 years)	8.5%	16%
Jobs creation in Lebanon	480	800

5.2.1. Recommended projects in PV sector

PV applications for the commercial and industrial sectors

The first recommended activity of PV applications will target institutions not yet targeted sufficiently in Lebanon, particularly in the commercial and industrial sectors. It is recommended to encourage the use of PV connected to the grid and supplying the load in case of grid interruptions, synchronizing with the diesel self-generator. When the grid is available, the PV (after local due diligence) will be injected to the grid when a surplus in power exists. The targeted sites can have the power capacity of between 50-200 kW each. Objective is to attend 20 MW in commercial and industrial sector by 2020.

PV for the residential sector

The residential sector has not yet been targeted by any substantial initiative to promote electricity-producing PV systems, although it is the potentially the most important sector for PV penetration in terms of potential. The proposed objective will focus on installing approximately 5000 PV systems, standardized to approximately 2-3 kWp. This initiative will strive to leverage the maximum amount of PV systems within this scheme, while trying to promote the use of any financial mechanisms available in the Lebanese market. This objective will be efficiently achieved once the Lebanese Grid is all the time available and the feed in tariff is applied instead of the net metering.

The implementation of PV plants should take into consideration the architectural point of view.

The Order of Engineers and Architects has to setup new rules for the PV implementation on buildings taking into consideration the maximum allowable roof height.

PV for micro irrigation system in agriculture sector

The third initiative is related to the use of PV in agriculture sector for irrigation. It is common to the use of diesel to power generators in agricultural operations. There are some significant drawbacks, including:

• Fuel has to be transported to the generator’s location, which may be quite a distance over some challenging roads and landscape.
• Fuel costs add up, and spills can contaminate the land.
• Generators require a significant amount of maintenance and, like all mechanical systems, they break down and need replacement parts that are not always available.

For many agricultural needs, the alternative is PV pumping systems. Modern, well-designed, simple to- maintain PV systems can provide the energy that is needed where it is needed, and when it is needed. These are systems that have been tested and proven around the world to be cost-effective and reliable, and they are already raising levels of agricultural productivity worldwide when used to power a micro irrigation system as compared to an overhead sprinkler system. Photovoltaic power for irrigation is cost-competitive with traditional energy sources for small, remote applications, if the total system design and utilisation timing is carefully considered and organised to use the solar energy as efficiently as possible. In the future, when the prices of fossil fuels rise and the economic advantages of mass production reduce the peak watt cost of the photovoltaic cell, photovoltaic power will become more cost-competitive and more common.

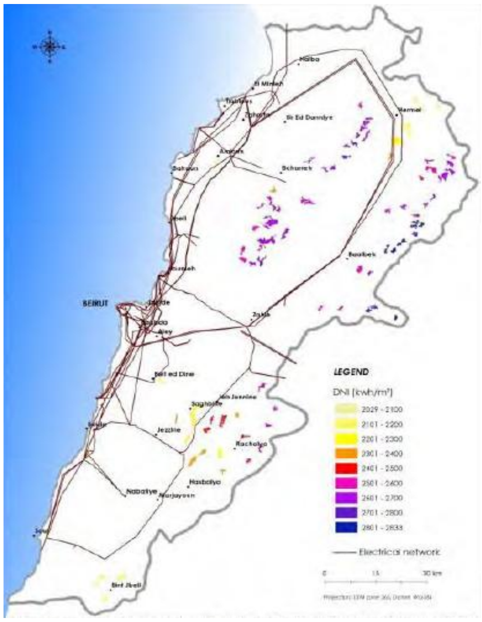
A pumping site for agriculture purpose is also implemented with success in Lebanon needing just 0.3% of the agriculture land.

The proposed objective will focus on installing approximately 100 PV systems, standardized to approximately 5-10 kWp. These systems could operate as standalone small irrigation plants or distributed coordinated subsystems for the irrigation of large fields.

Utility-scale PV farms

The fourth proposed initiative is related to utility scale power, and in particular is focused on implementing an approximate 370 MW PV farms projects (40-100 MW each plant) and a Power Purchase Agreement (PPA) tariff of 0.23 USD/kWh the first six years and 0.15 USD/kWh from next 14 years.

5.3. Concentrated Solar Power Potential



Concentrating solar power (CSP) technology uses direct normal irradiation (DNI) to generate power. The CSP plants use parabolic mirrors to concentrate the incident DNI to raise the temperature of a transfer fluid in the receiver and run turbines to generate electricity.

The map below shows the land use of the areas identified as having high solar CSP potential. The area includes a section of the Upper Mountains of Akkar which are part of the Akkar National Park designated in the NPMPLT, and the Semi-Desert of Ras Baalback considered as an important birds' area.

The potential for CSP in Lebanon was estimated in a dedicated study by CEDRO taking the following criteria into account;

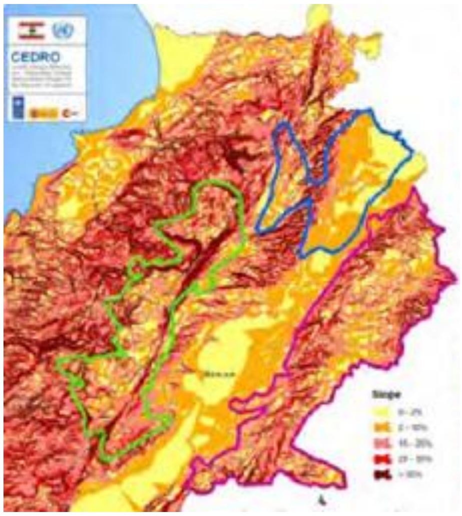
- Direct Normal Irradiance (DNI) above 2,100 kWh/m2/year;
- Solid and unpopulated land;
- Land slope less than or equal to 3%;

- Water availability;
- Minimum land surface of 1km2.

The CSP technology that was used for the purpose of this assessment was the parabolic trough (which is currently the most mature technology with over 90% of the currently installed capacity), whereas the use of central receiver (solar towers) might lead to different results due to different topography requirements. This work demonstrated a significant technical potential for CSP, which surpasses total levels of electricity demand, as shown in the table 10 below:

Table 10: CSP Potential in Lebanon

DNI in kWh/m2	Surface Area in km2	Capacity in MW	Annual Yield in GWh
2100-2200	18.5	925	1,790
2200-2300	17.2	860	1,741
2300-2400	10.9	545	1,153
2400-2500	8.9	445	981
2500-2600	30.9	1,545	3,545
2600-2700	50.8	2,540	6,058
2700-2800	16	800	1,980
2800-2833	8.1	405	1,027
Total		**8,065**	**18,275**



Assuming that only 15% of the total land area is used, then the potential for electricity generation from this reduced area corresponds to 1,210 MW and a subsequent power supply of 2,741 GWh.

Note: assuming a level for the total energy demand of 15,000 GWh (2009 estimate), then the above contribution of CSP reflects more than 18% of this total demand on aggregate.

Subsequently a categorization of potential areas with respect to proximity to existing transmission network has been performed and is shown schematically in the next figure and in table 11 below:

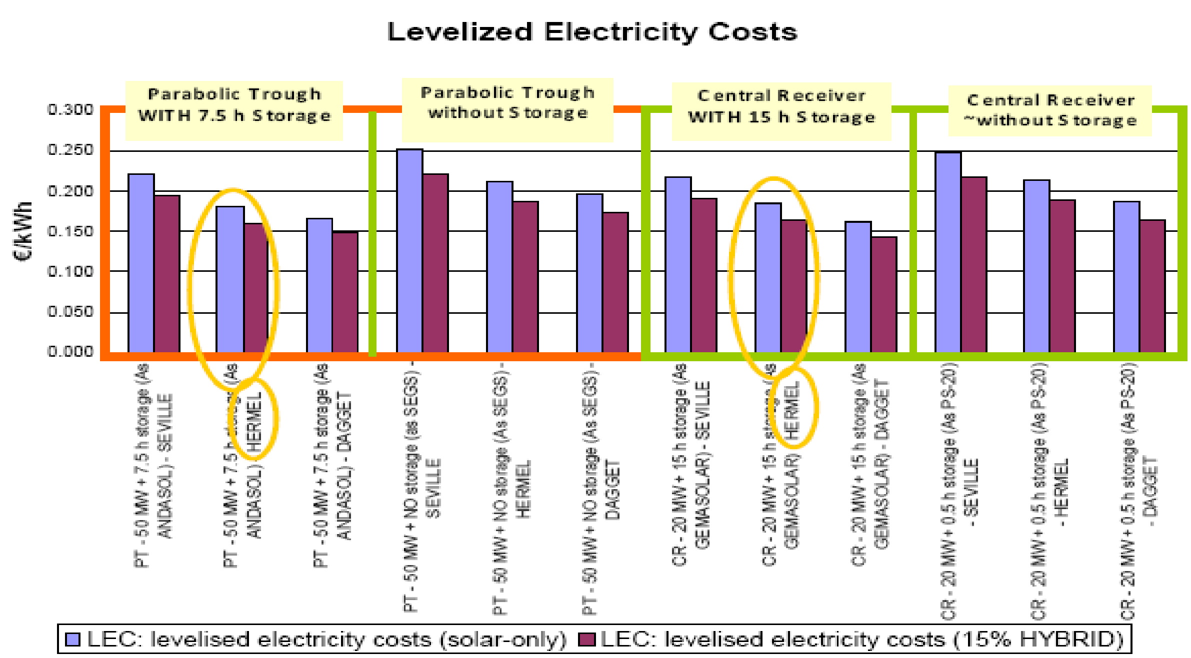
Table 11: potential areas with respect to proximity to existing transmission network

	Closest distance to the electrical network (in Km)		
DNI (kWh/m2)	10	10-20	20-30
2029-2300	95	5	0
2300-2600	67.9	32.1	0
2600-2833	31.7	65.8	2.5

Levelised electricity costs from the performed analysis range from 17 to 25 $-cents/kWh, and depend mostly on the quality of the solar resource. The same study by CEDRO also includes a financial analysis of various scenarios for the location of Hermel, selected due to its very high DNI (2,450 kWh/m2/y) for two types of technology and two cases each:

- Parabolic Trough with 7.5 hours of heat storage
- Parabolic Trough without heat storage
- Central Receiver CSP using molten nitrate salts and large heat storage;
- Central Receiver CSP using saturated water steam with negligible heat storage.

Results indicated LCOE of $-cents 16-21/kWh depending on the use of hybrid technology or solar only and heat storage, as shown in the figure 6below:



(Source: CEDRO)

Figure 6: LCOE for different scenarios of CSP plants

5.4. Hydro Power Potential

The installed capacity of hydropower plants in Lebanon today is about 280 MW but the actual generation capacity is 190 MW, since many of the plants have been in service for several decades, some of them for 50-100 years. Therefore, potential for new capacity from hydropower generation exists either from the rehabilitation of existing or the construction of new plants, which within the electricity sector policy paper (2010) has been quantified to range between 40 and 120 MWe.

The energy produced from hydropower plants has been variable in the last years, ranging from 4.5% of the total production (Litani, Nahr Ibrahim and Bared)10 to 8.7% in 2012 primarily due to the rehabilitation of TPPs in place.

Potential for development of hydro in Lebanon refers to either rehabilitation of existing plants or construction of new ones[19].

It has been estimated that at least 15% of additional generation capacity is possible from rehabilitating hydropower plants, which corresponds to additional electricity generation of about 129 GWh/y and an increase of the average capacity factor of all plants to 42.3% (from current 37.2%).

Master Plan Study for the hydroelectric potential of Lebanon along the main river streams has been prepared by Sogreah, which identified the potential arising from 32 new sites (non mini-Hydro - a special study is to be launched in 2014), split into two categories:

- Run of river schemes: potential capacity of 263 MW (1,271 GWh/y);
- Peak schemes (with dams): potential capacity of 368 MW (1,363 GWh/y).

In brief, this analysis concluded that additional 250 MWe of new hydro power plants, producing about 1200 GWh/y, can be financially viable:

- Approximately 125 MW of new hydropower supply is viable at exceptionally
- favourable locations with low environmental impact and relatively low levelised costs;
- 100 MW are additionally available and viable, yet relatively less favourable than the first trench;
- 25 MW that also exist require special attention to the environmental impacts.
- All three trenches have levelised costs lower than current average generation costs of EDL.

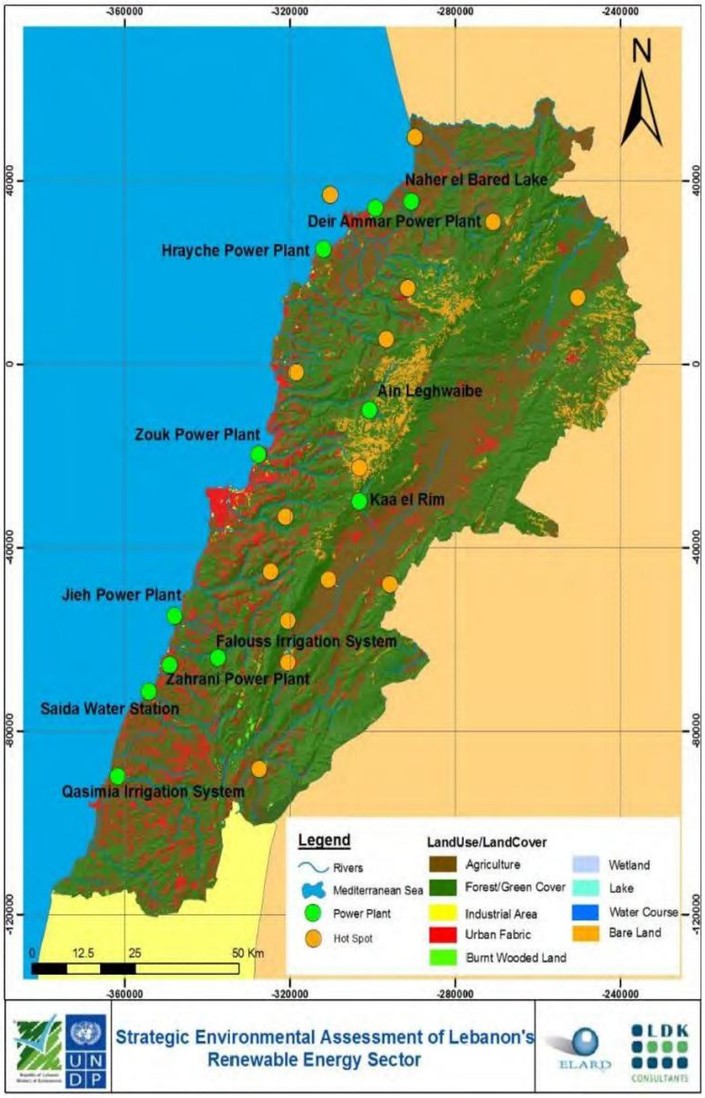
The potential for hydropower from non-river sources has been studied recently (CEDRO projects). Candidate sites for such schemes are:

- Irrigation channels and conveyors

[19] UNDP, Hydropower from Non-River Sources, the potential in Lebanon, 2013

- Wastewater treatment plants
- Thermal power plants' outfall pipes
- Distribution networks of drinking water

The relevant potential has been calculated to reach 8-15 MW. The study performed a site assessment for 20 sites and selected 13 of them with a potential amounting to 5 MW and electricity production of about 25,000 MWh/y that can be financially viable, half of which refers to existing thermal power plants.



The next map shows the location of the main identified locations for hydropower generation and their surrounding land uses. The map also shows biodiversity "Hot Spot" which include:

- Nature Reserves
- Important Birds Areas
- Himas and other Protected Areas

The study on river-sourced hydropower plants in Lebanon, conducted (as aforementioned) by Sogreah[20] (2012) for MoEW, indicated the positive financial viability of several potential hydropower plants to be developed in the country. The number and associated costs for these Lebanese power plants are shown below (table 12):

[20] MoW, Schéma Directeur Hydroélectrique du Liban, Sogreah, 2012

Table 12: Economics and tariffs for hydropower plants in Lebanon (Sogreah, 2012)

	Level 1	Level 2	Level 3	Total
	Minimum Selling Total Tariff < $c8.1/kWh	Minimum Selling Tariff > $c8.1/kWh & < $c12/kWh	Minimum Selling Tariff > $c12/kWh	
Number of Sites	13	12	4	**29**
Power (MW)	139	94	17	**250**
CAPEX (M$)	273	287	78	**638**
Production (GWh)	713	413	68	**1,194**
Average cost ($) of installed kW	**2,070**	**3,220**	**4,310**	

5.5. Biomass Potential

Biomass can be used in a number of ways: it can be burnt directly, used to produce gas or used to produce ethyl alcohol. It accounts for about one seventh of world production of fuel, and is the third most important source of energy produced (with gas). Various biomass power generation technologies exist today, at a varying status of development. An overview of most important biomass technology options and corresponding end-uses, together with an indication of the technology status, is shown in the table 13 below.

The technologies involved are generally well-developed and commercially available so that development of projects depends mainly on the availability of raw materials. For enterprises using their own waste materials, project lifetimes are certain while the enterprise continues its own production.

An overall evaluation of the biomass[21] potential has been performed by CEDRO in 2012, including on ground surveys and ranking of the ten most promising streams of biomass (table 14):

[21] UNDP-CEDRO, The National Bioenergy Strategy for Lebanon, 2012

Table 13: Biomass – Key Technology Options

Type of resource	Raw materials	Conversion technology	Product	End-use
Solid biomass	Wood logs, chips and pellets, agricultural residues	Combustion (thermal)	Combustible fuel	Heat, electricity
Solid biomass	Wood chips and pellets, agricultural residues	Bioengineering (gasification, pyrolysis etc.)	Biogas or Biofuel	Heat, electricity, transport fuels
Wet biomass	Manure, sewage sludge, animal litter	Anaerobic fermentation (biological)	Biogas	Heat, electricity, transport fuel

Table 14. Ranking of most important biomass resources

Rank	Feedstock	Potential GWh/y
1	Residues from forestry felling	460-600
2	Residues from olive trees	230-270
2	Residues from fruit trees	500-750
3	Residues from cereals	580-750
4	Energy crops on currently unused land	990-2,800
5	Olive cake by-products	128-301
6	Waste wood	162
7	Municipal sewage sludge	185
8	Animal fat and slaughterhouse residues	210
9	Yellow grease	137-156
10	Landfill gas recovery (specifically Naameh landfill)	162

In conclusion, for electricity generation, waste incineration of MSW, use of landfill gas as well as co-firing of forest and agricultural residues appear to be the two most promising cases for CHP installations.

A land use map was also developed in the referred CEDRO-Biomass study that shows the location of the main identified locations for bioenergy production including:

- Energy crops and olive mills (same geographic location at the caza level)
- Municipal Sewage Sludge

- Slaughterhouses
- Landfill Gas

The map (see the CEDRO- biomass study for the map) also shows biodiversity “Hot Spot” which include:

- Nature Reserves
- Important Birds Areas
- Himas and other Protected Areas

Concerning electricity, four scenarios have been developed, depending on political/economic trends to explore various bioenergy perspectives over time, contributing to the RES. The scenarios reflect an installed capacity of biomass electricity generation plants from 9-119 MWe.

The main elements of these scenarios (table 15) and key results are shown below. From the figures it appears that, with the exception of scenario I, contribution of biomass to the achievement of the RES target will be small. Under scenario I production of electricity could reach 8.3% of the total electricity produced based on 2009 data.

Table 15: Outline of four scenarios for bioenergy development

	Scenario I	Scenario II	Scenarion III	Scenarion IV
Title	Well-being and development	Economic crisis	Underdevelopment and poverty	Political challenges
Description	Peace and growing economy/ promotion of bioenergy with sustainability	Incidental unrest and low growth/ min sustainability levels in bioenergy	Political turmoil/ limited to no priority on bioenergy/ no sustainability on bioenergy	Strong economy/ political social unrest lead to underdevelopment of some regions/ some utilization of bioenergy. Min sustainability levels
Primary energy (GWh)	6,953	2,354	517	1,543
Final Energy				
Electricity	934	475	73	261

(GWhe)				
Electricity (MWe)	**119**	**62**	**9**	**33**
Heat (ktoe)	131	78	14	39
Heat (MWth)	222	134	23	66
Transport (ktoe)	271	28	14	39

In more detail, scenario I encompasses:

- Waste to energy plants (incinerators): 301 GWh/y – capacity 38 MW. It is worth noting that solid waste management is a major problem in Lebanon – there are more than 700 open dumps in operation15.
- Up to 930 GWh/y of electricity can be produced form the combustion of waste from forestry wood and paper industries.
- With regards to electricity production, the key options refer to direct combustion and a small share from biogas plants. Promising technologies refer mainly to advanced technological options for biofuels production.

The share of each bioenergy source per scenario is schematically illustrated below (figure 7):

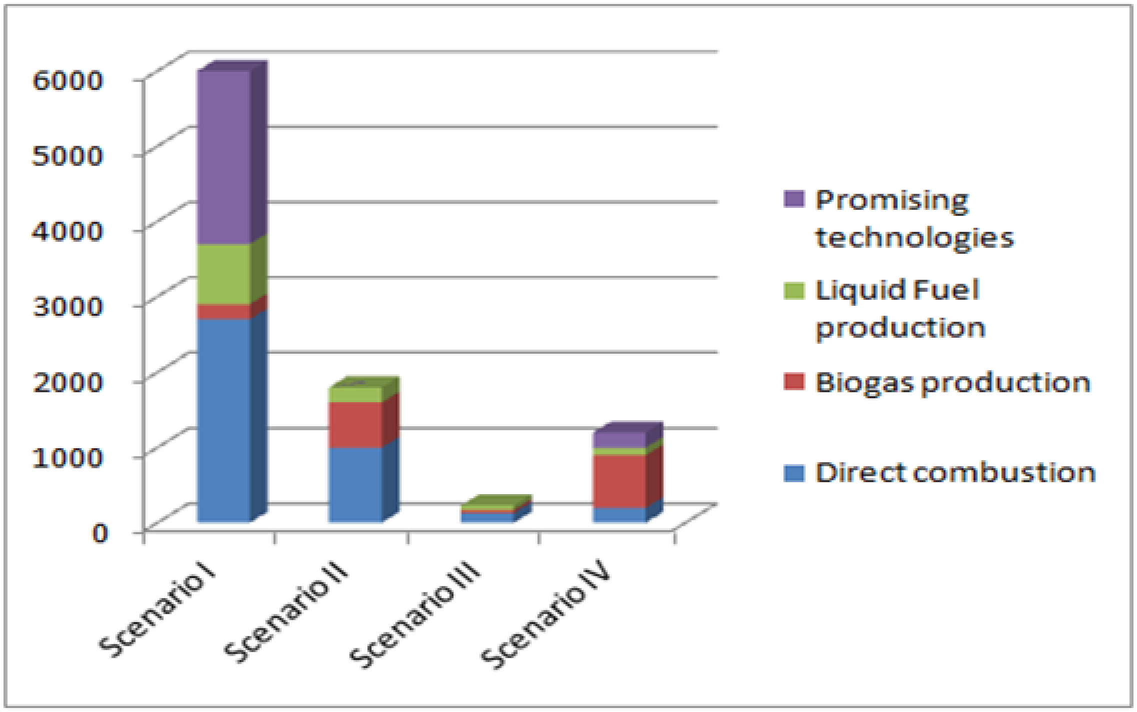


Figure 7: Share of each bioenergy source per scenario

Common barriers to the deployment of biomass in Lebanon are considered to be:

- Ensuring security of feedstock supply at predefined costs over the mid-long term;
- High costs of investments, non-presence of experienced suppliers and technicians to maintain relevant plants;
- Acceptance of technologies by local communities;
- Lack of financing instruments to support investments such as feed-in tariffs.

5.6. Geothermal Potential

A National Geothermal Resource Assessment[23] for Lebanon has been initiated by UNDP-CEDRO Project in collaboration with the Ministry of Energy and Water. The study started in May 2012. It has been performed by the company GEOWATT AG in Zürich, Switzerland. The geothermal resources have been assessed by collecting all the relevant


CEDRO | Country Energy Efficiency and Renewable Energy Demonstration Project for the Recovery of Lebanon

The National Geothermal
Resource Assessment of LEBANON

February 2014

[23] Vincent Badoux, Dieter Ollinger, Clément Baujard and Thom-as M
Resource Assessment of LEBANON, UNDP/CEDRO 2014.

geological, hydro-geological, structural and thermal information available for Lebanon.

Only a very small part of the geothermal heat can be economically exploited considering the present state of the technology. An optimistic but not unrealistic scenario could consider the implementation of 1 pilot installation of 1.3 MWel by 2020. In case of success and positive results, 4 additional power plants could be installed until 2025. Considering this scenario, it is concluded that the total electricity production by 2020 by means of geothermal energy can reach 6 GWhel. By 2025, the total production could be increased to 30 GWhel which corresponds to about 0.2% of the total energy demand.

This study identified two prospective areas suitable for the development of geothermal pilot projects. The most promising area is located in the Akkar region, where deep groundwater can be expected at a depth of 1,500 m and at a temperature up to 130°C. The second area is the Bekaa Valley, where the deep water can be estimated to be around 80-90°C and located at a depth of 2,800 m. Considering the degree of confidence of the available data, it cannot be excluded that water in the Bekaa Valley could be found at a temperature higher than 100°C, which would allow power generation as well. Other prospects have been identified in the Kaoukaba area and in the vicinity of Tyr, where evidences of thermal anomalies have been identified.

If the geothermal potential is confirmed, the completion of the first pilot installation could be achieved with another US$ 20 million, by drilling a second well and by constructing a geothermal power plant until the start of electricity production. This stage could then be financed by private investors.
As a key factor, the development of geothermal technology in Lebanon will require strong government incentives and concise permitting and licensing procedures during the 10 first years of an initial development phase of geothermal energy in Lebanon.

The main barrier is related the lack of geological and structural information at great depths. This lack of information leads to a relative high uncertainty of the estimations of the geothermal potential in Lebanon. The results of this study showed that the potential of geothermal energy for power generation is quite low (table 16). Because that Potential of geothermal will not be considered in the National Renewable Energy Action Plan.

Table 16: Cost breakdown (in Million US$) for power plants in four underground environments in Lebanon

Parameter	Akkar Hydrothermal	Akkar EGS	Bekaa Valley Hydrothermal	Beirut EGS
Heat generation MW (Thermique)	13	29	13	16
Geothermal Power	1,3	2,9	1,3	1,6

production MW_{el}				
Investment costs				
Well doublet				
Infrastructure drilling site	1.4	2.0	1.7	2.4
Energy supply	0.1	0.2	0.2	0.2
Well 1	2.6	11.1	6.7	20.0
Well 2	2.1	8.9	5.4	16.0
Planning & Test	0.7	3.0	1.8	5.4
Reservoir engineering	2.0	2.0	2.0	2.0
Geothermal fluid loop				
Production & injection pump	1.6	1.6	1.6	1.6
Heat Exc., filter, pipes	0.6	0.7	0.6	0.6
Binary cycle plant unit				
Turbine & generator unit	4.2	7.8	4.2	4.7
Building	2.5	3.4	2.5	2.6
Cooling unit	1.0	1.2	1.0	1.0
Infrastructure				
Pipes, valves, etc.	0.9	1.3	0.9	1.0
Energy supply	0.7	0.7	0.7	0.7
Fees	1.4	2.0	1.4	1.5
Incidentals	3.1	6.6	4.4	8.7
Total Investments (Millions US$)	**24.8**	**52.5**	**34.9**	**68.5**
Annual costs				
OPEX	**0.7**	**1.1**	**0.9**	**1.4**
CAPEX	**2.1**	**3.9**	**2.7**	**4.9**
OPEX/CAPEX %	**30**	**30**	**30**	**30**
Total annual costs (Million US$/year)	**2.8**	**5.0**	**3.6**	**6.3**

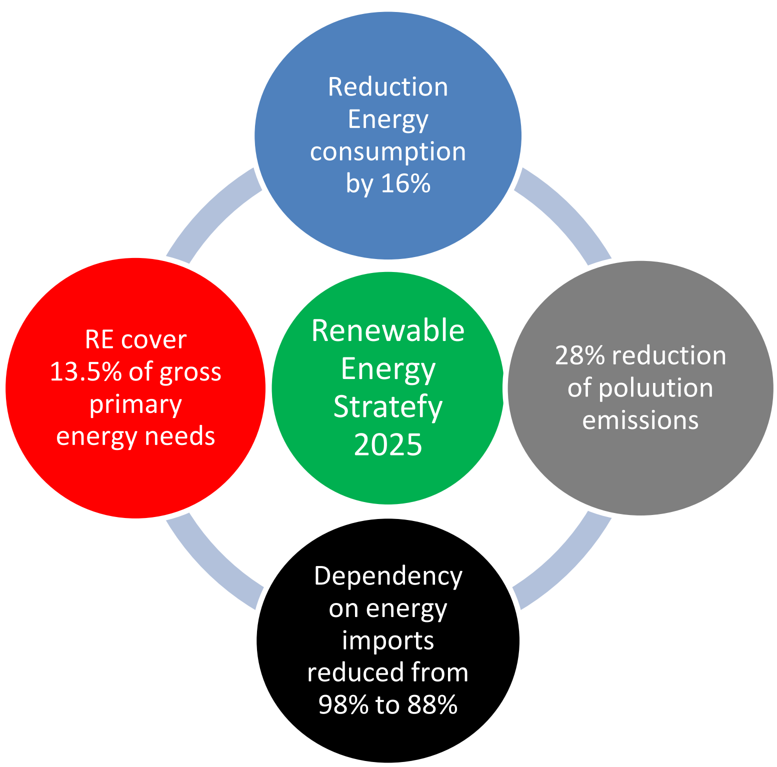
6. Roadmap for the development of RE by 2025 in Lebanon

The priorities of Lebanon's new energy policy should be based on three pillars:

- security of energy supply;
- economic performance;
- environmental performance.

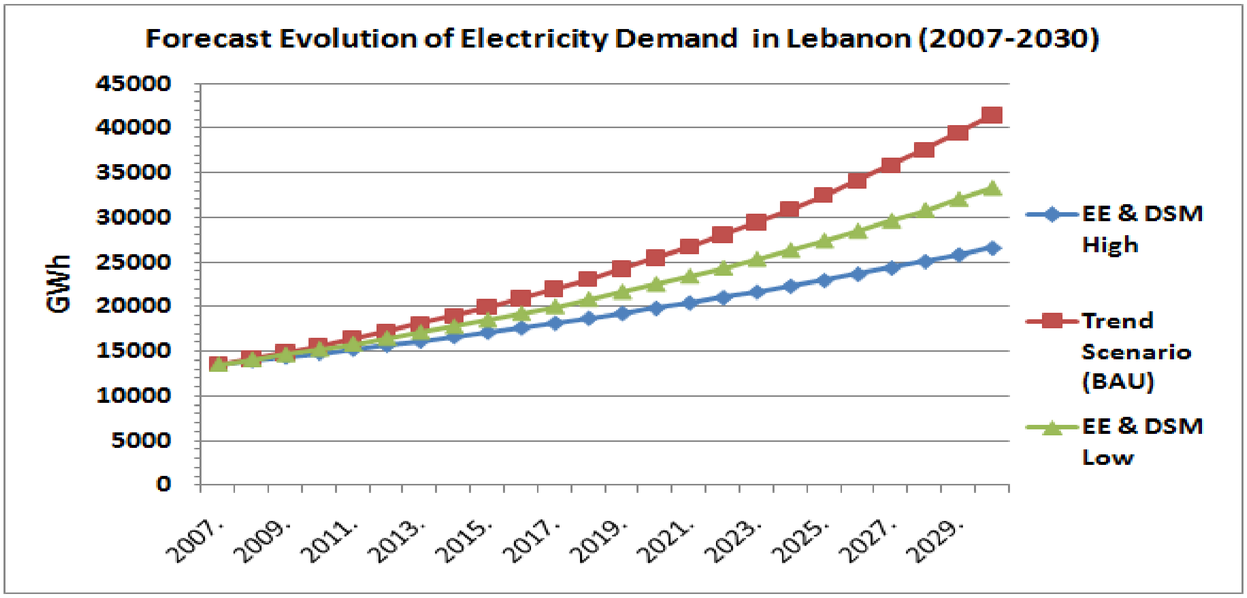
These pillars are themselves integrated and encompassed in the NegaJoule principle .

6.1. Lebanon 2025 objectives: a scenario of transition and a break with the past



- ➢ Reduction in consumption in comparison with the trend scenario (BAU) of 16% and energy intensity of 15%;
- ➢ Renewable energies cover 13.5% of energy needs (gross primary energy consumption) and 20% of electricity consumption (in GWh);
- ➢ Dependency on energy imports reduced from 98% to 88%;
- ➢ 28% reduction (compared with the trend scenario) in polluting emissions, in particular CO_2, as a result of energy and reforestation objectives.

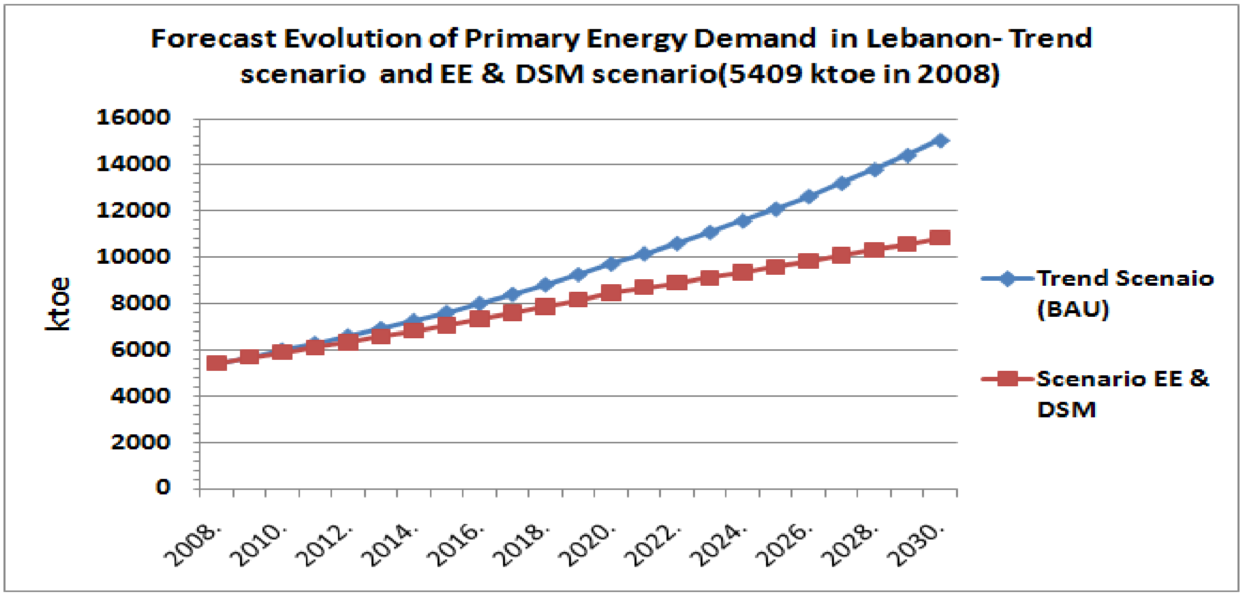
The impact of this NegaJoule strategy on the electricity demand is presented in figure 8.



(Source : ALMEE)

Figure 8: Forecast evolution of Electricity demand in Lebanon (2007-2030)

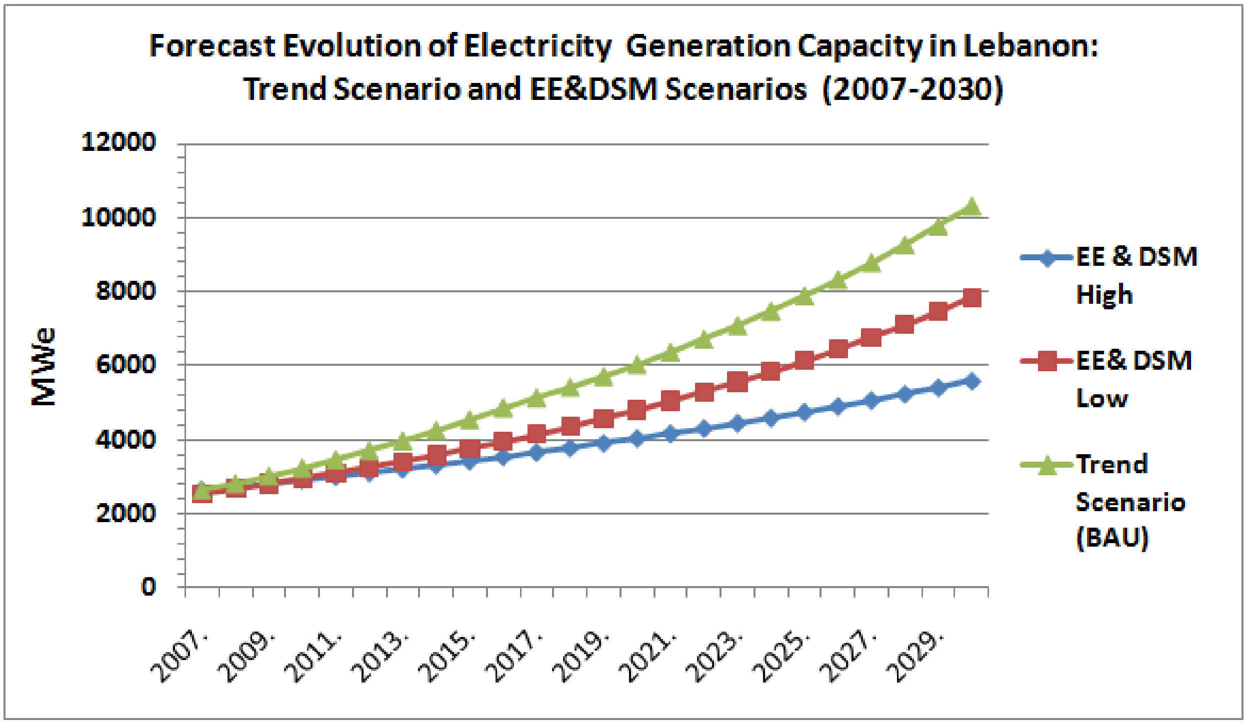
The impact of the proposed strategy on the forecast evolution of primary energy demand is presented in figure 9.



(Source : ALMEE)

Figure 9: Forecast evolution of Primary energy Demand in Lebanon – Trend scenario and EE&DSM scenario.

Figure 10 shows the impact of the proposed energy efficiency strategy on the electricity generation capacity.



(Source : ALMEE)

Figure 10 : Forecast evolution of Electricity Generation Capacity in Lebanon – Trend scenario and EE&DSM scenarios.

Multiple actions exists in Lebanon for promoting renewable energies projects and it is recommended that these actions to be coordinated and synchronized.

It is strongly recommended that a Committee formed of a wide number of actors coming from different sectors (Financial, Industrial, Environmental, Legal, Energy, Electrical,…) should be established in order to transmit to the government a think tank renewable energy policy.

Four recommendations to foster Sustainable Energy Policies in Lebanon were identified in the frame of the EU project "Paving the Way for the Mediterranean Solar Plan" [15]. Each of these recommendations is further analysed and adapted hereafter to our study according to four items: Objectives, Mechanisms, Expected impacts/benefits and anticipated barriers/challenges:

1. New Renewable Energy Strategy and National Solar Action Plan.
2. Institutional and capacity development.
3. Strengthening legal framework for EE&R.E
4. EE&RE financing schemes: EE&RE fund and FiT.

6.2. New Renewable Energy Strategy and National Solar Action Plan

Objectives: A new Renewable Energy Strategy and National Solar Action Plan aim to:

- Set the overall long-term vision, priorities and objectives of the Lebanese renewable energy policies in links with other public policies.
- Explicit strategy for sustainable energy broken down into concrete and realistic action plans for EE&RE.

Recommendation 1

- A new Renewable Energy Strategy and National Solar Action Plan should be developed and adopted.
- It is also recommended to work on setting a global strategy for energy before talking about a strategy for Renewable Energy

Mechanisms: Under the MoEW leadership with the support of other national entities and stakeholders, establish the responsibilities and timeframe to undertake the development of a detailed national renewable Energy Strategy and National Solar Action Plan. These documents shall determine the modalities of the implementation, institutions in charge (with possible external support), methodologies and implementation calendar to develop the Renewable Energy Strategy with realistic and ambitious goals.

Recommendation 2

- We wonder that theNational Solar Action Plan can set detailed implementation calendar, responsibilities, allocated human and financial resources, synergies and complementarities between programmes, performance indicators and monitoring and evaluation procedures.

During the preparation of the RES and NSAP, ensure an open, genuine and transparent debate and consultation with stakeholders and civil society before its adoption.

Expected impacts/benefits: The new RES and NREAP are to provide clear guidance and long-term orientations to be progressively reflected on the legal and regulatory framework (notably for energy prices and subsidies) as well as with an effective and operational implementation of the Solar Energy Action Plan to foster the effective deployment of RE technologies.

Anticipated barriers/challenges: Institutional structuring and the physical infrastructure preparing are necessary for an efficient penetration of RE.

Following the development of the strategy, the political instability could hinder its endorsement. Moving ahead would thus be subject to the negotiation skills of the MoEW minister.

6.3. Institutional and capacity development

Objectives: Ensure that the institutional set up of the Lebanese energy administration can effectively fulfil the mandates, missions and tasks assigned by the new Renewable Energy Strategy as well as by the National Solar Action Plan.

Mechanisms: The overall institutional organisation is to be set by the Renewable Energy Strategy while the organisation or re-organisation of each institution and associated capacity building is to be carried out within a work plan agreed and monitored by the MoEW as coordinating focal point.
Furthermore, the coordination of activities with relevant institutions as well as monitoring and evaluation should be set by clear and flexible procedures under the MoEW leadership.
The proposed institutional organisation and development include:
- The establishment of an independent electricity regulator with the objective to ensure promotion of RE resources (Regulation Authority according to the electricity law 462).
- The establishment of a think-tank entity (Universities, NGOs, CNRSL, IRI, LIBNOR, UNDP, EU Delegation, NGO etc.) working as a main advisor on renewable energy policies and regulations.
- The institutionalisation of the LCEC as National Agency of EE.
- The creation of institution for big scale RE project "Lebanese Agency for RE" Like MASEN in Morocco.

Recommendation 3

- Establishment of an independent electricity regulator.
- Establishment of a think-tank entity working as a main advisor on renewable energy policies and regulations.
- Establishment of a National Energy Efficiency Agengy.
- creation of institution for big scale RE project "Lebanese Agency for RE" Like MASEN in Morocco.

Expected impacts/benefits: An effective and relevant institutional set-up, capacities and coordination should contribute to effectively deploy RE technologies and increase EE.

Anticipated barriers/challenges: Internal organisation resistance to changes and reforms is usual but can be overcome and even be turned over thanks to anticipated consultation and putting forward a clear long-term vision and work-plan for each institution broken down into progressive steps.
Political instability and delays in decision making with political power struggle given the current deep division of the Lebanese political entities into two main groups can hinder the establishment of entities.

6.4. Strengthening legal framework for EE&RE

Objectives: Translate the policy objectives and targets of the Renewable Energy Strategy and NREAP into coherent, solid and articulated legal framework for EE&RE covering promotion and investment with enforcement and control modalities.

Mechanisms: amend and adopt the currently existing electricity law (Law 462). Develop Renewable Energy Law.

Expected impacts/benefits: To provide more legal security for stakeholders, in particular RE developers and EE&RE service providers.

Anticipated barriers/challenges: Revising or preparing regulations has to go through multiple steps and time-consuming processes within the government and the parliament, including consultations with stakeholders. A lack of information on energy policies and awareness on EE&RE by stakeholders and actors of the legislative process may be an issue, possibly generating misunderstanding and bottlenecks. On the other hand, the political instability and tensions in Lebanon could lead to delays in endorsing new laws and regulations. The negotiation skills of the MoEW minister as well as the endorsement of the president of the parliament would be crucial to push the laws forward.

Recommendation 4	• Translate the policy objectives and targets of the Renewable Energy Strategy and NREAP into coherent, solid and articulated legal framework for EE&RE covering promotion and investment with enforcement and control modalities.

6.5. EE&RE financing schemes: EE&RE fund

Objectives: Ensure that for viable EE&RE investments, adapted financing schemes are in place for investors/developers (RE) and users (EE, small RE).

Mechanisms: Establish financial mechanisms for big RE projects.

Expected impacts/benefits: Boost RE investment to develop the national market for EE&RE services and equipment, attract manufacturing and services, and contribute to economic development and growth.

Anticipated barriers/challenges: Lack of awareness and information of the financial sector, low electricity administrated prices and high subsidies for all customers.

Some stakeholders indicated that Feed In Tariff couldn't be considered as a good approach for Lebanon since the government objective is to reduce subsidies allocated to EDL. But FiT can be less than the actual subsidies of electricity.

A technical bottleneck for the connectivity to the grid is at the EDL Level since the grid is not available 24/24.

Recommendation 5	• Ensure that for viable EE&RE investments, adapted financing schemes are in place for investors/developers (RE) and users (EE & small RE). • Emprouve the existing financial shems (Kafalat, BDL)

6.6 Implementation of EE & DSM Measures and Programmes

According to the EDL and the Electricity Paper, Lebanon needs to significantly increase its total generation capacity[24] in future years from 1680 MW (in 2009) to 5,000 MW after 2015 (plants relying on heavy fuel, diesel and imported gas) to meet the increased demand in the absence of a demand management policy (the most cost-efficient way of satisfying growing needs). However, a combination of increased production equipment imports and fuel imports has a very unfavorable impact on the country's investment capacity and balance of payments.

[24] Actual maximal operational plants capacity is 1649 MW (including 120 MW from Syria and 266 MW from boats: Zouk 164 MW, Jiyeh 130 MW, Hraycheh 33 MW, Zahrani 431 MW, Deir Amar 431 MW, Baalbeck 30 MW, Tyr 30 MW, Litani 14 MW) – Actual Supply 1500 MW, Actual Demand 2990 MW - Adnan Al Hajj, Al Safir, July 21, 2014.

The implementation of EE&DSM measures and programs could reduce the need of generation capacity to 4600 MW by 2025 (figure 10). The NEEAP actually under revision should take in consideration this target horizon 2025.

Recommendation 6

- Implement EE&DSM measures and programs with target to reduce the need of generation capacity to 4600 MW by 2025 .
- The NEEAP actually under revision should take in consideration this target horizon 2025.

6.7 Smart grid

The electricity grid in Lebanon should be redesigned according international standards to permit the connexion of PV systems and Wind systems.

Recommendation 7

- Adopt Standards for smart grid.
- Design and implement smart grid

6.8 Evaluation of the technico-economic potential of RE in Lebanon (2016-2025)

The potential of electricity generation from RE and the investment needs (period 2011-2020) are estimated in table 17.

The potential of thermal solar water heaters and the investment needs are estimated in table 18:

Table 17: Potential of generation electricity from RE and investments needs (2011-2025)

Technology	Installed capacity	Share of production in Primary Energy needs in 2025 (%)	Investment needs in M€	Electricity production costs (in €cents/kWh)
Existing Hydropower	235 MW	1.5	100	3
New Hydro plant	80 MW	0,4	240	6
PV residential + commercial + micro irrigation	30 MW	0.3	75	16.3
PV plants	500	3.7	1070	15.5
Wind power	250 MW	1.6	400	8
CSP* (Concentred Solar Power)	600 MW	4.0	1900	17.3
Biogas	35 MW	0.50	76.0	5
Total	**1247 MW**	**12**	**3.861**	

1 € = 1.12 US$ (October 201)

*CSP : Concentred solar power plants without storage system

Table 18: Potential of generation of thermal energy from solar and investments needs (2016-2025)

Technology	Installed capacity	Share of production in Primary Energy needs in 2020 (%)	Investment needs in €
Installed solar water heaters in 2010	350 000 m²	0.40	0
New solar water heaters by 2020	1 000 000 m²	1.1	300
Total	**1 350 000 m²**	**1.5**	**216.4**

Source: RESSOL/ALMEE

6.9 Cooperation With neighbouring countries

This balanced mix of energy efficiency and renewable energy projects, including decentralised and centralised, small and large scale projects will benefit the country's inhabitants and companies. To ensure the relevance of "Lebanon 2025" in an international context linked to major projects, grid connections and major project objectives should be drawn up not only for 2025, but also for 2030, 2040 and 2050 [17] [18] since the networks and major solar and renewable installations are planned on a long term basis.

Lebanon could share this plan with the neighbouring countries and institutions, IRENA and EU in order to identify areas of common interest. Cooperation with neighbouring countries would facilitate the planning of the grid and electricity production. Within the framework of the MSP, some major projects were intended, at least partially, for the export of electricity via Syria and Jordan.

Recommendation 8

- Renewable Energy Strategy should be drawn up not only for 2025, but also for 2030, 2040 and 2050 since the networks and major solar and renewable installations are planned on a long term basis
- Cooperation with neighbouring countries would facilitate the planning of the grid and electricity production.

6.10. Strategic Environmental Impact Assessment

The government must also carry out a prior national strategic Environmental Impact Assessment, in order to gain a clearer understanding of the combined impact of the various projects. In practice, the government should decide to go even further and optimise the selection of sites suitable for large solar power stations, while facilitating the work of industrialists, by designating Renewable Energy Development Zones (REDZ).

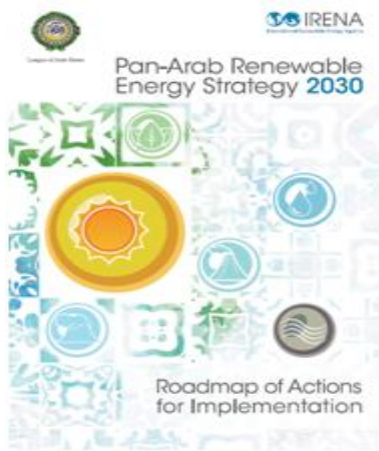
Recommendation 9

- carry out a prior national strategic Environmental Impact Assessment, in order to gain a clearer understanding of the combined impact of the various projects.
- select osites suitable for large solar power stations and designat Renewable Energy Development Zones (REDZ).

6.11. Pan-Arab Renewable Energy Strategy 2030

Lebanon participated in the drafting of the Pan-Arab Renewable Energy Strategy 2030. The Realisation of this strategy requires concerted efforts not only on the policy and regulatory levels, but also on the technical and financial support levels. Recognising the importance of regional coordination, IRENA collaborated with the Arab League[25] and RCREEE to create a regional process that will accelerate the implementation of the Pan-Arab Renewable Energy Strategy and support Member States with achieving renewable energy targets.

A course of action is proposed as a roadmap for different Arab countries to fill their gaps and fulfil national targets. These country-specific actions are based on recommendations from the Arab Renewable Energy Framework (AREF) and the template for the National Renewable Energy Action Plans (NREAP) and are specifically tailored to conditions in the Arab region. This represents the recipe for a regional framework of coordination among the various actors currently involved in the region, including but not limited to national authorities, regional and international institutions.



Recommendation 10

- Lebanon should take into consideration the recommendations of the Arab Renewable Energy Framework (AREF) to realise its owns obligations in the frame of the Pan-Arabe Renewable Energy Strategy.
- Lebanon should participate in regional framework of coordination of activities related to the Pa-Arab RES.

6.12. Strengthening of Research and Development in RE

Enhancement of the capacities of the Lebanese Universities (Doctorate Schools - Research Platforms on RE offering PhD program leading to development of research work in RE and graduates of high level able to manage RE projects in Lebanon) in order to engage in high quality research, implement research projects and provide scientific services in the fields of: a) technological integration of solar heating and cooling and PV technologies (grid-connected and stand-alone) in buildings, b) simulation models and optimization of solar heating and cooling systems CSP and PV technologies and c) energy modelling and decision support regarding the energy planning in municipal and regional scale emphasizing the adoption of PV, CSP and solar thermal technologies and oriented to support energy policy formulation. The capacity building will be provided by enhancing research equipments in RE, by improving scientific knowledge through secondments and training and by creating partnerships with EU and International

[25] Jamila Matar Director of the Energy Department, League of Arab States – Forward to the Pan-Arab Renewable Energy 2030, IRENA/RCREEE/AL, 2015

research institutions and Lebanese industries. It will contribute to the technology transfer and their adaptation to Lebanon circumstances.

6.13. Electricity Tariffs

The priority action is to gradually restructure (in 3 years) and increase the existing tariff to eliminate the financial deficit in the electricity sector and establish a balanced budget for EdL, on one hand; and reduce the financial burden on the citizens caused by the utilization of costly private generators, on the other hand.

- Gradually increase the tariff in conjunction with improvements in the electric service provision until reaching the goal of a sustainable 24/24 electric service (over 3 years) hence eliminating the need for private generators and abolishing the financial deficit.
- Adopt special tariffs and fees for low income consumers.
- Implement Time Of Use (TOU) tariffs (e.g., night-reduced) in conjunction with the implementation of Smart Meter Reading (SMR) schemes.

The tariff will be continuously reviewed in line with the budget for this sector, taking into consideration the diversity in conventional and renewable resources; without being a burden on consumers or the public purse; rather, it will be used as a flexible tool to enhance equity among various customer groups and provide the necessary revenues for the Treasury (table 19).

Table 19: Proposed planning for the restructuration of electricity tariffs.

	Actual Tariff	Year 1	Year 2	Year 3
Average tariffs for residential (500 kWh/month)	0.046 $c/kWh	0.069 $c/kWh	0.095 $c/kWh	0.126 $c/kWh

Recommendation 11

- Gradually increase the electricity tariff (over 3 years) and apply continual adjustment until abolishing financial deficit.
- Adopt special tariffs and fees for low income consumers.
- Implement Time Of Use (TOU) tariffs and Smart Meter Reading .

7. Conclusion

- Lebanon is very dependent on fossil energy imports. It imports about 96% [5] of its primary energy, and most of the electricity is produced with heavy oil and diesel oil. Despite an average annual solar radiation of 4.8 kWh/m²/day it only has less than 0.5% solar energy in the total energy mix.
- The power sector in Lebanon is suffering from inefficiencies and blackouts.
- Electricity subsidies are a heavy burden on the public budget (18% of government expenditures in 2012).
- Growing energy consumption and growing energy prices are increasing this financial pressure.

International and Mediterranean context [19] [20] should be favourable to start a discussion on renewable energy and work on increasing the share of renewable energy in the Lebanese energy mix. There are some barriers hindering the uptake:

- electricity tariffs do not reflect the real cost of generation, transmission and distribution,
- absence of adequate political decisions in favour of renewable energy and energy efficiency (that can boost the change),
- no adequate consideration of negative energy externalities,
- no effective legislation.

Main recommendations are:

- Sustainable energy requires the right energy context & strong national **energy policy & reforms** and the right international support [21].
- Overall energy **reforms rely on** strategy, institution and regulation (balanced prices & elimination of subsidies for electricity and oil) to reach economic fundamentals and social balance.
- **Focus on EE (regulation)** to limit impact of demand increase.
- **Ownership** and national institution/capacity building are necessary.
- **Financial support** dispersed and little adapted to small and medium EE & RE projects are not sustainable: need for a EE & RE Fund.

The position paper adopted by Lebanese stakeholders during the meeting of 18 march 2015 is a valuable document to be presented as guideline for policy makers (annex 1).

In Lebanon the solar technologies presents a good opportunity, due to national climatic conditions that can be found and wind technology offers an existing cost-competitive technology option, with significant cost saving potential vis-à-vis conventional fossil fuels. The case is likely to be even stronger once long term social benefits – so-called 'positive externalities' – such as lowered environmental pollution, rising quality of life, and clean electricity. While renewable energy targets in Western, industrialized economies are frequently associated with emissions targeting and climate change considerations, Lebanon and MENA countries may actually consider renewable energy technologies as an economic solution for the supply of their rapidly expanding domestic energy markets.

Raising the share of renewable energy in Lebanon in the time period up to the 2025 will, nevertheless, require the involvement of highly policy solutions based on Lebanon economy, and these are likely to entail some form of electricity market restructuring. Under current market mechanisms – which include a lack of competition between electricity producers and a mere infant private sector inside power generation (hampered by decades of public utility provision) – the pricing mechanisms of electricity will be unable to render transparent those cost advantages that some renewable energy technologies are likely to offer to Lebanon.

The most important element in assessing and realizing any cost advantage of renewable energy vis-à-vis fossil fuels to country's economy will undeniably require the reform of the domestic energy markets, particularly their pricing schemes, alongside greater private access at utility production level under a more liberalized market-based system. The political fragility of the country, following the political protests that have start in 2015 and the entree in Lebanon of 1.1 Million Syrian' refugees undoubtedly complicates such (likely) unpopular electricity market reform; however, there are mechanisms at hand that should help the Lebanese economy move towards market based utility systems. These include the option of redistributing savings made via dedicated social safety systems (thereby strengthening welfare while reducing economic waste). In this way, deadweight loss and resource waste would be reduced, saving valuable funds for better use towards alleviating poverty, and truly allowing all citizens to benefit from countries' resource wealth. If renewable energy were to be a triggering factor in the consideration of such price reforms, their value for the Lebanese economy would undoubtedly exceed that of any other policy target.

Change, including in the areas of energy and technology, is frequently said to be driven either by desperation, or by inspiration. In Lebanon, both factors appear to have been mostly absent from national policymaking agendas for many decades. Rising global prices for oil and electricity tariffs and adaptation of energy market mechanisms that reflect costs can help Lebanese economy build long-term sustainable welfare systems that create and preserve, rather than destroy, value. The overall considerations related to the Lebanese NREAP are summarized in the following box

NREAP Lebanon

The energy policy of Lebanon should be formulated by the Ministry of Energy and Water (MoEW) in cooperation with all ministries and bodies involved and should be approved by the Council of Ministers. The Ministry of MoEW will examine the country's energy requirements, takes into account the obligations arising from international treaties and agreements and defines the main axes which in turn determine the targets to be implemented. At the same time, the energy model to be applied in Lebanon will focus also on the social dimension of energy saving. The energy policy should be based on the following main pillars:

- Security of energy supply
- Competitiveness
- Protection of the environment

The above national energy policy goals will be translated into specific quantitative, binding targets for the country for the 2025 milestone:

- 13.5% contribution from renewable energy sources in the primary use of energy;
- 2% contribution from renewable energy sources in the road transport consumption (biofuel and electrical cars charged by a part of green electricity;
- 5% contribution from renewable energy sources in heating and cooling demand (SWH and part of green electricity used for heating and cooling).

Security of Energy Supply

Actions aiming to achieving this target are:

- Diversification of energy sources through implementation of the strategic goal for introduction of natural gas into the country's energy mix.
- Increasing the country's energy self-sufficiency and strengthening of its geostrategic role in the greater area through the development of research actions related to the country's fossil fuel energy potential.
- Maximization of efficient utilisation of renewable energy sources aiming to replace energy from imported sources.
- Energy saving both in the primary form and its final use.
- Ensuring sufficient electric power supply potential.
- Development of the country's self sufficiency in relation to the import of primary fuels by maintaining sufficient security stocks.

Competitiveness

Measures contributing to the creation of a healthy competitive energy market include:

- Liberalisation of electricity market aiming to increase the productivity and competitiveness of the domestic economy and to improve the services provided to consumers.
- Elimination of Electricity and oil prices subsidies
- Development of energy infrastructures and improvement of electric power transmission infrastructures.
- Effective development of RES plants, based on spatial planning.
- Adoption of investments in the energy sector based on the maximum resource utilization criterion and overall benefit.
- Simplification of all licensing procedures.

Protection of the Environment – Sustainable Development

Protection of the environment and sustainable development are ensured through:

- Promotion of renewable energy sources for the generation of electricity and heat contributing to a significant reduction of pollutant and greenhouse gas emissions.
- Efficient and rational use of energy.
- Substitution of petrol with biofuels in the transport sector as much as possible.
- Promotion of high efficiency electricity and heat cogeneration in industries and large commercial plants.
- Application of stricter specifications on transport fuels and the type of fuel in the electricity generation sector.
- Promotion of the use of natural gas (when this becomes available in the domestic market) for public transport.
- Preparation of a study on the environmental impact assessment strategy through implementation of this Scheme.

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Annex 1: Position Paper

Beirut, 18/03/2015

POSITION PAPER

WE, the signatory stakeholders, endorse the following points as a mean to pave the way for the development of a viable roadmap for the promotion of renewable energy, in particular solar (mainly PV), in Lebanon.

Considering the fact that

- Lebanon is highly dependent on fossil energy imports; it imports approximately 98% of its primary energy where most of the electricity is produced with heavy oil and diesel oil;
- Despite an annual average solar radiation of 4.8 kWh/m²/day, Lebanon has less than 0.5% solar energy in its total energy mix;
- The power sector in Lebanon is suffering from inefficiencies, difficulties and weaknesses in addition to brown and blackouts.
- Electricity subsidies are a heavy burden on the public budget (18% of government expenditure in 2012);
- Growing energy consumption and increasing energy prices are heightening this financial pressure;
- PV in Lebanon can generate up to 8,000 new jobs by 2020 if a Renewable Energy Strategy and a National Action Plan are adopted and implemented in the short term.
- Existing studies and suggestions on Legislation/ Regulations for RE penetration are missing important issues such as:
    - A dynamic process for updating regulations and standards according to the continuous advancement of technologies;
    - The stimulation of market opportunities and support for the introduction of innovative methodologies;
    - The reduction of subsidies on electricity production in order to reduce payback period of RE applications for end users;
    - The lack of preferential taxation for RE&EE equipment; and insufficient incentives to answer to market's demand;
    - The lack of efficient incentives to promote RE&EE investments in the electricity sector: wind, CSP, PV, biogas, etc.;

- The fact that existing financing mechanisms and tools need to be optimized and made more effective.
- The high cost of capital and lack of access to capital and financial institutions (for high investments);
- Major infrastructure constraint for RE electricity generation at the level of the Lebanese electrical grid, which needs to be profoundly restructured (in terms of planning and budgeting) for the efficient penetration of RE generation;
- The lack of priority for national R&D programmes;
- The lack of training and specialized education in universities and professional or vocational institutions;
- The small and limited financial capacities of most RE&EE companies;
- The lack of awareness about the benefits of new technologies which turns into a major barrier hindering the spread of cost-effective new technologies;
- The cultural and societal barriers;
- The lack of capacity-building and awareness-raising programmes.

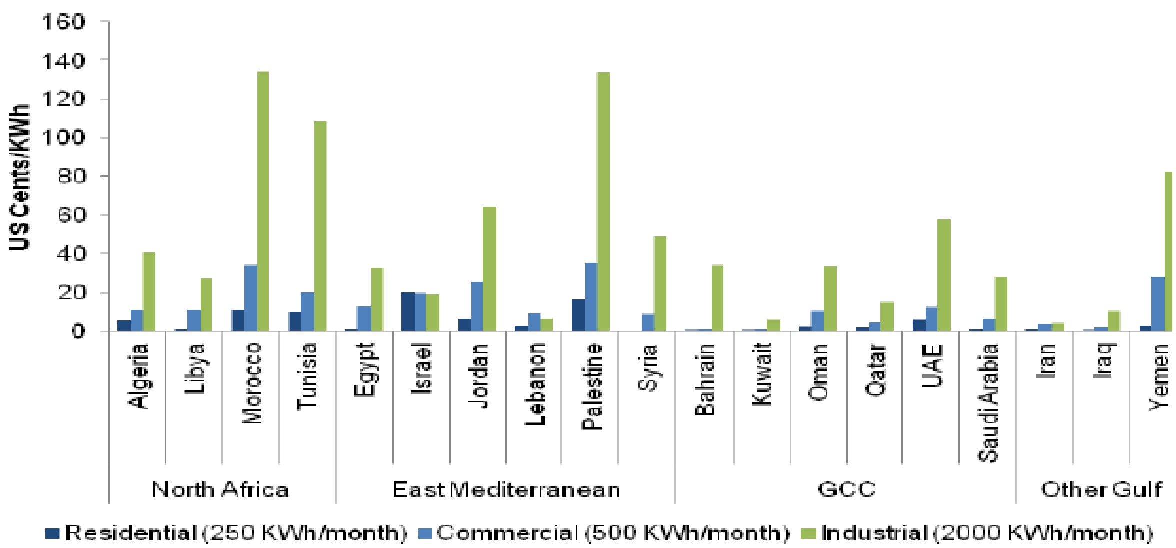
WE recommend the relevant authorities to:

- Draft a National Energy Strategy to cover the economic sectors in Lebanon.
- Draft a Renewable Energy Law to englobe the Strategy as to define, in association with other public policies and in consultation with civil society, an EE&RE national long-term vision, priorities and objectives; it should provide more legal security for stakeholders, particularly RE developers and EE&RE service providers;
- Break down the strategy into a concrete, realistic, and time-bound National Solar "Action Plan" including the setup of a sustainable financial plan;
- Progressively reflect both the Renewable Energy Strategy and the National Action Plan in the legal and regulatory framework (notably regarding energy prices and subsidies) and to ensure the effective and operational implementation of both for the effective rolling out of RE technologies;
- Consider that the institutional set-up of the Lebanese energy administration should be able to effectively fulfill the mandates, missions and tasks assigned to it by the Renewable Energy Strategy and the National Solar Action Plan by, for instance:
    - Establishing an independent electricity regulator aimed at ensuring the promotion of RE resources (Regulation Authority according to the Electricity Law No. 462/2002 last updated by Law No. 288 in 2014);
    - Establishing a multi-actors think-tank body (e.g. universities, NGOs, national public/private bodies, UNDP, EU Delegation, etc.) working as a main advisor on RE policies and regulations;
    - Developing capacity building activities , " Research & Development" programs and awareness raising campaigns;

- Translate policy objectives and targets of the Renewable Energy Strategy and National Solar Action Plan into a coherent, solid and articulated legal framework for EE&RE; it should cover promotion and investment with enforcement and control mechanisms; all this by amending and adapting the existing Electricity Law (Law No. 462 last updated by Law No. 288 in 2014).
- Ensure that the adapted financing schemes are in place for PV investors/developers and users (e.g. feed-in tariffs for PV projects); this will boost PV investment, develop a national market for EE&RE services and equipment, attract manufacturing and services, and contribute to the national economic development and growth,
- Promote PV field projects, especially in the following sectors: commercial/industrial, residential, micro irrigation systems in agriculture, and utility-scale PV farms.
- Establish a dynamic process for updating regulations and standards according to the continuous advancement of technologies;

Annex 2: Residential, Commercial, and Industrial Electricity Prices in Selected MENA Countries

A look at disaggregated data[26] for residential, commercial, and industrial power use for 2012 nevertheless opens up some material for thought: prices for industrial and residential/commercial users differ significantly in many MENA countries, for varying reasons including cross-subsidies for residential and commercial users, or a simple tendency to shield industrial electricity prices less against rises in electricity generation costs than residential users (see figure 11). While still tame in some larger oil and gas producing countries, such as the GCC economies and Algeria, the size of these industrial tariffs could provide some economic opportunities for renewable energy technologies in industrial use or, conversely, allow for more generally adjusted electricity tariffs. In Morocco, for instance, (one of the MENA region's highest priced markets for electricity) average residential electricity tariffs stand at ¢11/kWh, but the price for commercial customers is more than three times as high, at ¢35/kWh, while industrial consumers pay a high ¢133/kWh. At these prices, even high-cost CSP technology could deliver a cost-effective electricity supply when this is compared with the high cost of Morocco's oil-fired power plants. This data also offers an important indication of where electricity prices in the MENA region could be, if subsidies on direct electricity and on input fuels were transparently removed.



Countries, 2012 (source : Oxford Institute[27] for energy)

Figure annex: Residential, Commercial, and Industrial Electricity Prices in Selected MENA countries

[26] Notes: Prices are averaged between (where applicable) dynamic night- and day-tariffs
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The Lebanese Association for Energy Saving & for Environment (ALMEE)

The Lebanese Association for Energy Saving and for Environment is involved in a wide range of activities related to sustainable practices and other "green" issues. Known by its French-language acronym, ALMEE (Association Libanaise pour la Maitrise de l'Energie et pour l'Environnement), the group describes itself as "a non-political & non-profit association" committed to better handling of multiple issues and technologies associated with **Energy and Environment**, not just in Lebanon but also across the Mediterranean Basin and worldwide.

Specifically, ALMEE's overriding goal is to develop, increase and promote scientific methods and means contributing to better management of energy and related economic policies, including the following:

- Renewable energy sources like solar, wind, biomass, hydraulic, wood, etc.;
- Technical issues designed to improve energy efficiency, such as insulation, glazing, and the latest heating/air-conditioning and lighting technologies;
- Techniques like cogeneration that lessen the waste associated with power generation and industrial processes.
- Energy Building codes, Rating System for Green Buildings, Energy Performance Label an Certificate.

For more than 2 decades, ALMEE has pursued a philosophy of sustainable and harmonious development for Lebanon and the region, gaining a wealth of experience from cooperation with some of the world's leading organizations.

In short, ALMEE has worked with local, regional and international partners – from governments and multilateral institutions of civil society and the private sector – to buttress calls for more sustainable policies and practices related to energy and environment. ALMEE's main goal is building awareness and support for better management – and to keep the business community apprised of the tremendous growth potential exhibited by this new and exciting sector.

As the public becomes more and more concerned about environmental issues, the marketplace continues to reflect changing attitudes, opening up significant opportunities for forward-thinking companies to increase sales and revenues and be good corporate citizens at the same time. ALMEE constitutes an excellent venue to communicate these and other possibilities tied to the use of renewable energy and other means of better and more sustainable environmental practices.

ALMEE worked on developing proposed mechanisms for green house gases emissions in several projects.

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