PRIORITIZATION AND ASSESSMENT OF VALUE CHAINS WITHIN THE RENEWABLE ENERGY SECTOR IN LEBANON

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Acronym	Definition
ALI	Association of Lebanese Industrialists
CAS	Central Administration for Statistics
CEDRO	UNDP program being implemented in Lebanon and focused in RE
CSP	Concentrated Solar Power
DREG	Small Decentralized Renewable Energy Power Generation project
EDL	Electricité Du Liban
EE	Energy Efficiency
FDI	Foreign Direct Investment
FiT	Feed-in Tariff
FTE	Full-Time Equivalent
IEA	International Energy Agency
ILO	International Labor Organization
IPP	Independent Power Producer
IRENA	International Renewable Energy Agency
LCEC	Lebanese Center for Energy Conservation
LCR	Local Content Requirements
MENA	Middle East and North Africa
MOEW	Ministry of Energy and Water of Lebanon
MW	Megawatt
NEEREA	National Energy Efficiency & Renewable Energy Action
NREAP	National Renewable Energy Action Plan
O&M	Operations and Maintenance
PPA	Power Purchase Agreement
PV	Photovoltaic
RE	Renewable Energy
SWH	Solar Water Heaters
UNDP	United Nations Development Programme
WTO	World Trade Organization

EXECUTIVE SUMMARY

The "Prioritization and assessment of value chains within the renewable energy sector in Lebanon" has conducted a full-fledged value chain assessment of different renewable energy technologies and offers an action plan to harvest the job creation potential in Lebanon for these specific sectors.

CHAPTER 1: BACKGROUND

The Lebanese Electricity Sector is highly dependent of imported fossil fuels. Fuel expenses for power generation and thermal use account for a very significant portion of the national GDP. With electricity tariffs heavily subsidized, these expenses substantially contribute to the country's national debt through the financial deficit of the state-owned power utility Electricité Du Liban (EDL). This situation has been exacerbated with the continuous influx of refugees in the wake of the Syrian crisis, which has increased the pressure to the already deteriorated power infrastructure.

Furthermore, the country suffers a serious shortage of power supply that requires EDL to conduct load shedding, causing daily black outs of up to 16 hours per day. EDL cannot to provide uninterrupted electricity across Lebanon, mainly because of their constant budgetary deficit. This situation led to supply from informal private diesel generators who sell electricity to third parties on local level using this polluting and costly power generation option. From a legal standpoint, the legality of these private generators is controversial, as EDL is supposed to hold a monopolistic role in power generation (decree 16878).

Renewable energy (RE) can contribute to a potential solution to overcome some of these challenges. The government of Lebanon has been active in setting targets for the improvement of the country's energy efficiency and the increase of the RE capacity through the National Energy Efficiency Action Plan (NEEAP), and the National Renewable Energy Action Plan (NREAP), respectively.

Low and not cost-reflective electricity tariffs are a barrier for the deployment of RE because of their long amortization periods. EDL cannot increase the power tariffs until the grid does not become more reliable, but at the same time EDL cannot easily improve the systems reliability due to its poor financial situation, thus creating a vicious circle. Moreover, RE is expected to provide employment opportunities for people at all qualification levels. Experiences from other countries in the region and elsewhere has shown that this is possible under a stringent regulatory framework, ambitious plans and support for building the respective capacities. For Lebanon, this can help to alleviate a strained situation on the labor market and in the economy.

The Economic Situation in Lebanon has also been impacted by the Syrian Crisis. While the Lebanese economy grew at strong rates between 2004 and 2010, the impact of the Syrian crisis has, among other effects, slowed down growth to around 2% or below. The Lebanese economy is primarily service oriented. The main contributing sectors to GDP in the year 2015 are wholesale and trade, real estate and financial and other services. Construction contributes with 7%, followed by education with 5%. Total manufacturing contributes as much as the public sector and twice as much as the construction sector. Given the large education sector, the country has opportunities and advantages in science based technology development.

While GDP and its components are well documented in national and international statistics, data on population and the labor market are scarce. Furthermore, data on the structure of the labor market and the work force are even scarcer. This situation challenges any possible assessment of the labor market. From the analysis of the economic structure, the following conclusions are drawn for employment opportunities from RE deployment:

• The Lebanese economy is strong in services, therefore the service components of all renewable energy technologies exhibit opportunities for domestic provision.

• In terms of production, the metal and machinery industry can contribute to all renewable energy, because despite small, it already exists.

CHAPTER 2: VALUE CHAIN SELECTION AND PRIORITIZATION

The following value chains have been analyzed in an initial assessment to prioritize for deeper analysis:
• Solar Water Heaters
• Solar Photovoltaic (PV)
• Wind Energy
• Bioenergy
• Energy Efficiency in Buildings
• Concentrated Solar Power
• Hydro power
• Geothermal energy

They have all been evaluated based on namely their technical, their economic and their institutional potentials. Each technology has been assessed according to a list of indicators, which led to the selection of the three following value chains:

• **Solar Photovoltaic (PV).** Solar PV is already an established sector in Lebanon with a decent number of competitive private companies (around 100). However, the sector still has a large growth potential. This assumption is underpinned by the government's plans to upscale the installed capacity of this technology. Government's intentions are confirmed by the recent processes to sign Power Purchase Agreements (PPA) for the installation of large solar farms. Additionally, it is considered that solar PV can contribute towards the decentralization of power supply. The market trends show an increasing interest in the installation of this kind of facilities. For all these reasons, solar PV has been prioritized and selected for deeper assessment in this study, as a value chain with good opportunities for job creation in the future. The assessment looks both into large solar farms as well as distributed solar plants with, and without batteries.

• **Wind Energy.** The wind energy sector is new in Lebanon. There are no previous experiences of wind farms in Lebanon. However, the government is currently in the final negotiation stages to sign PPAs with private developers for the installation of the first 200 Megawatt (MW) wind farm in the northern and mountainous district of Akkar. This process has been followed by an additional bidding process currently under evaluation to install additional capacity between 200 and 400 MW. In this context, wind energy has been selected for deeper assessment as it is deemed necessary to prepare the local workforce for these future developments.

• **Bioenergy.** Bioenergy has neither been developed extensively in the past in Lebanon nor has a privileged treatment in the government's long term plans. Nevertheless, bioenergy offers very good potential synergies with other sectors such as forestry, water treatment or waste management. That is why it was decided to select bioenergy for further assessment and specifically to narrow the focus to biomass (briquettes) and biogas.

CHAPTER 3: METHODOLOGY

The methodology of the assessment of employment from renewable energy has been developed over the past years and the consensus about the methods of choice is rather high. The scientific community developed methods to deduct and transfer information from existing studies to new estimates. International agencies such as IRENA or the ILO contributed to the comprehensive picture of jobs estimates in relation to green energy, energy efficiency and green jobs in total.

The literature on employment in renewable energy distinguishes direct and indirect employment. In the case of **direct jobs,** employment factors are used to measure the number of jobs created per unit of produced of product or service. The data for calculating employment factors can in principle be derived from a number of sources: data from a industry surveys; from specific enterprises or projects; from feasibility studies and technical literature specifications. Employment factors differ along the value chain: construction and installation is usually more labor intensive than manufacturing or operation and maintenance (O&M). Each phase has its own basic employment factor in terms of jobs/installed capacity. Likewise, countries differ in their economic structure, their capabilities as well as the speed and size of the economic development. Therefore, adjustment with regional factors for productivity, economic development and different stages of the value chain are applied.

In terms of **indirect employment,** the estimation of indirect effects is based upon the renowned economic analysis tool based on Input-Output-Tables. For Lebanon, up-to-date Input-Output-Tables of good quality exist. Input-Output tables provide information about the production and consumption of intermediate and final goods and disclose the cost structure of each economic sector. These tables capture the circulation of products within an economy for a given period. They condense the complexity of economic action with all its effects, counter-effects, actions and re-actions. The manufacturing, installation, and operation of renewable energy technologies are cross-cutting economic activities, which involve several economic sectors and need inputs from several economic sectors. This led to the development of RE-technology specific input vectors, which are compatible in their classification with the European standard classification system NACE. From these vectors, it is possible to know how additional installations of e.g. PV modules translate into additional demand in all economic sectors and into additional employment.

CHAPTER 4: VALUE CHAIN ASSESSMENT

The methodology described in Chapter 3 is used for the in-depth value chain assessment of the three selected technologies. To forecast the impact of PV, wind and bioenegy in terms of employment creation, two different scenarios were defined for each technology. These scenarios determine a specific installed capacity in MW for each year within the assessments considered timeframe (3 years). The scenarios have been defined considering feedback received during interviews with relevant sector stakeholders as well as using the NREAP targets and tendering processes publicly announced.

• **Optimistic scenario.** This scenario is based in the projections of the recent developments for each specific technology. Bidding processes that have already started are considered in this scenario, and the government due dates for their completion are assumed to be achieved as planned.

• **Conservative scenario.** Under this scenario, only those processes that are well advanced are considered to be completed within the assessment timeframe.

The following table shows the cumulative capacities for both scenarios by technology:

Table 1. Cumulative installed capacities considered under each scenario.

	Cumulative Capacity (MW):			
	2018	2019	2020	2021
SCENARIO A: Optimistic				
SOLAR	73	283	738	1198
Large Solar	*0*	180	*450*	*720*
Large Solar with Storage	*0*	*0*	*150*	*300*
Distributed Solar	*73*	*103*	*138*	*178*
WIND	0	0	200	500
BIO	0	3	6	9
Total	73	286	944	1707
SCENARIO B: Conservative				
SOLAR	61	80	280	599
Large Solar	*0*	*0*	*180*	*180*
Large Solar with Storage	*0*	*0*	*0*	*300*
Distributed Solar	*61*	*80*	*100*	*119*
WIND	0	0	200	200
BIO	0	3	6	9
Total	61	83	486	808

These two scenarios aim to set the optimistic and pessimistic boundaries of the wide range of developments that can occur in the coming years. While the high level of uncertainty makes it difficult to forecast the specific installed capacity of each technology in the coming years, it is considered that any future development should fall within these two scenarios.

The results from the value chain assessment model indicate that **more than 20,000 jobs could result from the deployment of the selected renewable energy technologies by 2021** under the optimistic scenario. The bulk of this number is found in the PV sector, from distributed as well as from large PV installation. It is noteworthy to mention that the calculation of the employment effect results in full-time equivalents. This means that the number of persons actually working in and for the renewable energy sector can be even larger.

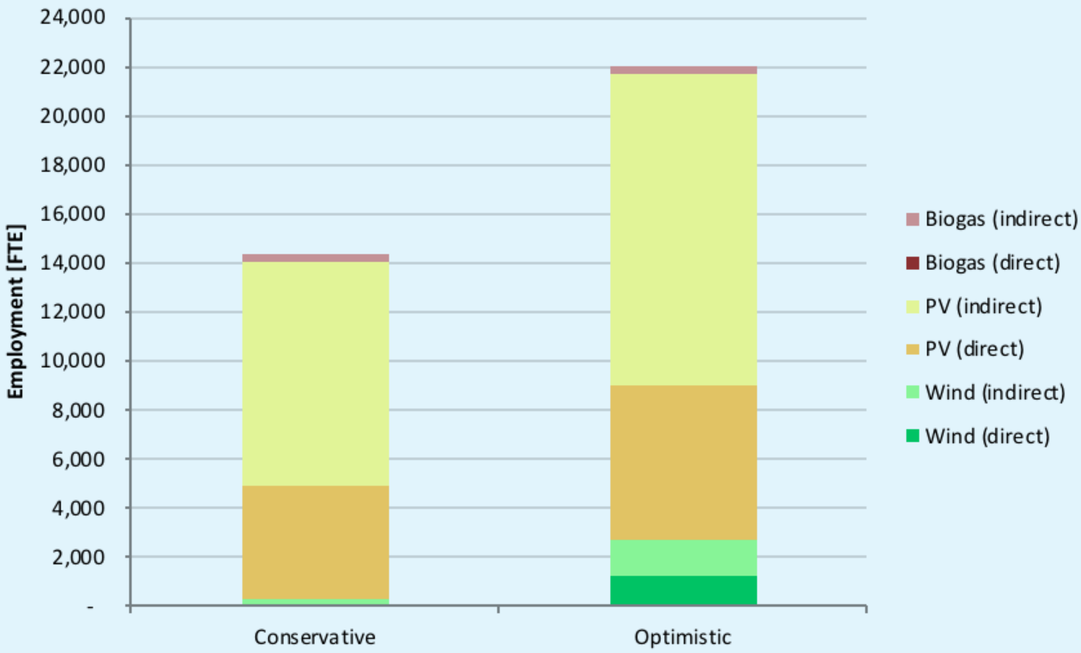

Figure 1. Employment from PV, wind and biogas, by value chain phase for 2021 under the conservative and the optimistic scenario

For the year 2021, the last year in the scenarios, a total of 21,976 jobs are created under the optimistic scenario and compares to the 14,323 jobs under the conservative scenario. Wind energy would represent a total of 2,753 people from these jobs under the optimistic scenario, roughly half of them in direct jobs.

In case the installed capacity happens to finally be lower than expected, then the necessity for expertise will be much smaller and the relation between direct and indirect jobs would favor indirect jobs in administration, law, real estate, etc. For PV, the learning curve is not as steep, because there are already experts and companies for PV in Lebanon. Therefore, the relation between direct and indirect jobs does not develop as rapidly as with wind energy. Biogas stays the same under both scenarios.

Wind energy creates jobs in installation and operation and maintenance. Again, the largest number of jobs is in the service sector and in construction. For the transport of wind energy, infrastructure is needed, be it at the port or along the roads. Roads have to be widened, the area around the roads has to be cleared, and these activities are part of the construction works. However, they need planning, and supervision, which also is part of the service sector. The services are relevant for operation and maintenance of a wind farm. Jobs in operation and maintenance are permanent over the life time of the renewable energy system.

The largest share of permanent jobs can be found in technologies which need fuel. Therefore, the biogas deployment can lead to high shares of permanent jobs. However, since the waste management strategies in Lebanon are not fine-tuned between incineration, waste to biogas and other uses, employment from waste collection has not been explicitly modeled.

Based on the interviews, the economic data and the model results, it is concluded that the Lebanese industry has a big potential to foster growth of renewable energy and its associated jobs.

CHAPTER 5: ACTION PLAN

The employment figures presented in the previous chapter will only be achieved if the capacities foreseen in the scenarios become a reality. The 35 actions proposed in the strategic action plan aim to support the deployment of RE as well as the creation of jobs in Lebanon. It takes into consideration the experience from other jurisdictions that the establishment of a thriving RE industry can only be achieved with a strong domestic market. It therefore combines the requirements of a Renewable Energy Strategy with the ones of an Industrial RE Strategy.

A number of actions are valid for all RE technologies. These include actions that require determined government action like the update of the NREAP especially in terms targets and assumptions. The current targets are not only unambitious, but they are also do not seem to be realistic anymore as they underrepresent the actual developments. This represents a planning risk for the sector: Companies will not be able to plan their capacity needs for the years to come appropriately, hence the full domestic employment potential in the RE sector – for both direct and indirect jobs – may not be realized.

Government action is also required to review existing RE support policies and regulations, the energy sector reform including the introduction of a regulatory body and the acceleration of the NEEREA (subsidized loans) process. Interviews with sector stakeholders reveal a slowdown in the distributed PV projects, and NEEREA has been identified as one of the potential reasons behind. This mechanism, described by many within the distributed solar PV sector as one of its cornerstones, requires long administrative process. While NEEREA mechanism has undoubtedly helped in the establishment of the solar PV sector in Lebanon, it must be highlighted that an extend slowdown can irreversibly damage the sector. Is in this context when public support is most needed in order to maintain the value generated throughout the past.

While the larger reforms of the energy sector may need time and are complex, there are several actions that can be taken that will not tackle the energy sector problems but that will enable the creation of new economic sectors and their associated employment creation.

Due to the peculiarities of the three technologies and their value chains, a number of technology-specific actions have been proposed which could be driven forward by the private sector, even though governmental and external support is helpful and in certain cases also needed. Each technology requires a specific approach regarding their implementation strategy: As solar energy resource is available across the country, it needs a decentralized approach but with central support in order to allow the uptake of many distributed PV installations. The wind sector has most potential in the North of Lebanon and due to its complexity and mostly large scale projects, a centralized approach is recommended. The bioenergy sector will require a centralized approach to allow the build-up of the specific knowledge but it will also need local project support.

Among the 35 proposed actions, a number of key actions can be highlighted as they could be chosen by UNDP to provide specific support:

• **Establishing a central RE knowledge hub that provides general RE but also technology-specific support and services:** This hub would become the central focal point for both companies and customers, driving the development of the RE sector and support the uptake of jobs by carrying out several of the actions proposed in this action plan.

• **Promoting R&D and companies working on hybrid systems:** The specific situation of Lebanon with EDL and private generators as energy providers which rely on diesel generation provides an opportunity for PV hybrid systems. Research and innovation in technological terms but also terms of implementation will require collaboration between energy companies and research institutes. In that unique area, Lebanon may even be well positioned to play a role on an international level.

• **Implementing a quality assurance framework for PV:** It is crucial that especially customers of distributed PV systems can rely on high-quality products and installations. A system that includes the application of international standards and certification of project developers and installers will ensure that PV projects deliver as planned.

• **Providing education and training, especially for PV installers and wind service engineers:** In these parts of the value chain a large number of jobs is expected to be created. Therefore a timely training and capacity building is needed to ensure quality and reliability of RE installations.

The implementation of the proposed actions will require time, dedication and appropriate funding. However, compared to the potential employment effects that can be expected, the costs and efforts are expected to be rather low. It is important though to start with the implementation of the actions very soon so that the sector is well prepared to execute the planned RE projects.

1. Background

1.1. The Project and Objectives

This report is the third and final deliverable of the **"Prioritization and assessment of value chains within the Renewable Energy Sector in Lebanon".** The overall objective of this consultancy was to provide detailed understanding of the current situation and potential future development of different technologies of the renewable energy sector in Lebanon. The result has been an assessment that compares the sub-sectors and identifies three key renewable energy value chains within these that have relatively larger potential for growth and job creation with a limited need for investment. Once three key renewable energies have been identified, a full-fledged value chain analysis has been carried out for their respective value chains.

1.2. Electricity Sector in Lebanon

1.2.1. General Overview

According to the statistics for 2016 from the International Energy Agency (IEA), up to 99% (4,107 ktoe) of the total primary energy demand for power generation in Lebanon was satisfied by oil products, and only 1% (41 ktoe) came from hydro resources. The National Renewable Energy Action Plan (NREAP) 2016-2020, which uses as baseline the year 2010, describes a similar situation. It also provides information about the very significant portion of power demand being covered by private generators (P.G.), which are estimated to cover 77% of the blackout demand.

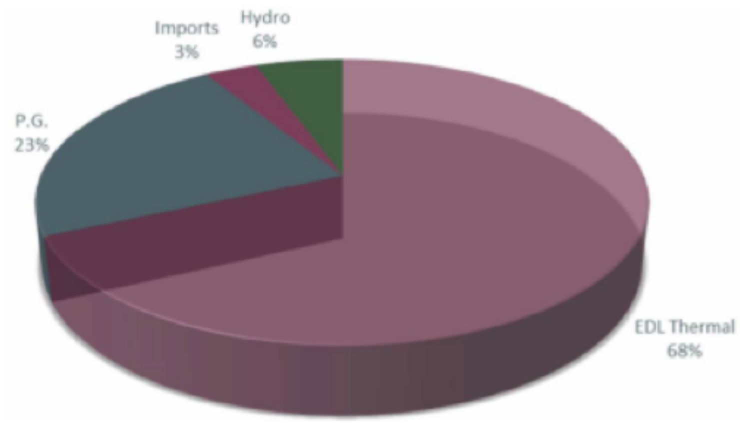

Figure 2. Approximated shares of electricity generation based on primary energy conversion for 2010 (Source: NREAP 2016-2020)

Taking into consideration the data for 2010 from the NREAP, almost 97% of the country's energy needs are covered from imported sources. This is a very relevant aspect that confirms Lebanon's enormous energy dependence from the exterior.

The NREAP estimates that in 2010 the power demand was approximately 15,934GWh, while the total electricity generation by Electricité Du Liban (EDL) was 12,089GWh, thus leaving an electricity deficit of 3,845GWh, which is partially covered by electricity generated from private sector generators (estimated at 2,950GWh). According to the Policy Paper for the Electricity Sector, 76% of EDLs customers have an average monthly consumption of less than 500kWh.

The legal framework to privatize, liberalize and unbundle the sector exists in Lebanon but it is not applied (law 462). The decree 16878/1964 and 4517/1972, which gives EDL the monopoly in generation, transmission and distribution is still being applied.

According to the Policy Paper for the Electricity Sector, the average cost of electricity including EDL's fixed costs was 17.14 US$ cent/kWh in 2009, of which 10.77 US$ cent/kWh (63%) were dedicated to the purchase of fuel. The tariff is not cost-reflective and generates financial deficit for EDL. The deficit of state-run EDL was estimated at $2 billion per year[1]. The same report determined at 5% the amount representing uncollected bills, with collection rates that vary largely depending on the region.

EDL has failed to provide uninterrupted electricity across Lebanon, mainly because of its constant budgetary deficit. This situation resulted in the creation of informal private generators that sell the electricity to third parties on local level through a more polluting and costly power generation option. From a legal standpoint, the legality of these private generators is controversial, as EDL is supposed to hold a monopolistic role in power generation (decree 16878). The government has attempted to control the fees imposed by private generators through the ministries of Energy and Water and Economy and Trade by enforcing the installation of electricity meters and regulating the tariffs. During the past years, and despite the fact that these generators are not fully regulated, the government seems to have accepted them as the only remedy to the current interrupted power supply.

1.2.2. Challenges of the Electricity Sector

The Lebanese power sector has been described in numerous publicly available studies together with the problems identified. The following list provides an overview of the main challenges:

1. Policy and Institutional Framework. Lebanon has a weak policy and institutional framework in regards to the renewable energy sector.

2. Energy deficit. There is a gap between energy demand and generation capacity. This gap might have been aggravated lately with the influx of refugees from neighboring countries (for an assessment see UNDP 2016).

3. EDL's financial deficit. Large deficit due to several reasons, one of them being identified as the gap between electricity prices and real generation cost. Tariffs are not cost-reflective, thus generating financial deficit for EDL. This deficit feeds back to the Lebanese economy and thus to the situation on the labor markets.

[1] *https://www.pressreader.com/lebanon/the-daily-star-lebanon/20180220/281505046695439*

4. Aged infrastructure. Power generation, transmission and distribution infrastructure is aging, which results in high technical losses and low system reliability. Numerous power plants are considered to be old and inefficient or even uneconomical according to the Policy Paper for the Electricity Sector.

5. High dependence on imported sources. Very high dependence on foreign energy sources, thus leaving the country highly vulnerable to other countries.

6. High share of fossil fuels in the energy mix. The high contribution of fosil fuels in Lebanon's energy mix results in high fuel bills with fluctuating and unpredictable prices. Additionally, the dependence on a single source of supply weakens the system reliability.

7. Low supply reliability. Blackouts are common in Lebanon. They generate billionaire losses to the Lebanese economy and impact the consumer's daily life.

8. Private generators. The previous point has resulted in the creation of informal private generators using polluting and costly technologies.

1.2.3. Renewable energy targets

The government of Lebanon established energy projections for the years 2015, 2020, 2025 and 2030 based on the actual national energy demand for electricity and heating in Lebanon during the baseline year of 2010. The government also set national targets for renewable energy and energy efficiency in the National Renewable Energy Action Plan (NREAP) and the National Energy Efficiency Action Plan (NEEAP), respectively.

While hydropower used to represent a large portion of the power sources in Lebanon (approximately 70% in 1976), total electricity production from this technology currently accounts just for 2-4% of total electricity generation. From 2005, renewable energy and energy efficiency started attracting a growing interest. This resulted in the preparation of the National Energy Efficiency Action Plan (NEEAP) for the Republic of Lebanon 2011-2015 that later on was followed by the second NEEAP 2016-2020 and the first National Renewable Energy Action Plan (NREAP) for the Republic of Lebanon 2016-2020.

The NREAP 2016-2020 provides the national targets for renewable energy in the future (years 2020, 2025 and 2030). NREAP's main target is to implement renewable energy projects to produce approximately 767 kilotonnes of oil equivalent (ktoe) in 2020, equivalent to 12% of the projected total electricity and heating demand in Lebanon during that year. The 12% milestone was already established by the Lebanese Government in 2009 during the Conference of the Parties meeting in Copenhagen.

Table 2. NREAP objectives for each RE technology in terms of installed capacities.

	Unit	2010	2015	2020	2025	2030
Wind Energy (onshore)	MW	-	-	200	350	450
PV Farms (PV and CPV)	MW	-	-	150	200	300
Distributed PV	MW	-	-	100	125	150
Concentrated Solar Power (CSP)	MW	-	-	50	50	100
Solar Water Heaters (SWH)	m^2	211,988	413,988	1,053,988	1,345,185	1,716,835
Rehabilitation of existing hydro plants	MW	-	-	236	259	282
New hydro plants	MW	-	-	93	139,5	186
Micro-hydro	MW	-	-	2.5	3.8	5
Geothermal energy	MW	-	-	1.3	6.5	15
Bioenergy (electricity + heat)	GWh	-	-	771.5	974.3	1,177

(Source: NREAP 2016-2020)

According to the NREAP, wind energy for electricity production would represent a major milestone for 2020 with a projected share of 2.06% of the total Lebanese demand. Solar energy - including solar photovoltaic (PV), concentrated solar power (CSP), and solar water heaters (SWH) - would be another important milestone with around 4.20%. Hydro resources for electricity production would account for a percentage of around 3.24%. Finally, biomass would cover around 2.50%.

In order to financially support its renewable energy and energy efficiency national targets, the Central Bank of Lebanon (Banque du Liban, BDL), launched the National Energy Efficiency & Renewable Energy Action (NEEREA). NEEREA is considered to have been a successful financing mechanism to boost EE, RE and green buildings development in Lebanon. NEEREA provides a wide range of soft loans through commercial banks with long repayment periods, grace periods and low interest rates.

In September 2015 Lebanon presented its Intended Nationally Determined Contribution (INDC) under the United Nations Framework Convention on Climate Change (UNFCCC). Lebanese INDC established:

• Unconditional targets:
- GHG emission reduction of 15% compared to the Business As-Usual (BAU) scenario in 2030.
- 15% of the power and heat demand in 2030 generated by renewable energy sources.
- A 3% reduction in power demand through energy-efficiency measures in 2030 compared to the demand under the Business-As-Usual scenario.

• Conditional target
- GHG emission reduction of 30% compared to the BAU scenario in 2030.
- 20% of the power and heat demand in 2030 is generated by renewable energy sources.
- 0% reduction in power demand through energy-efficiency in 2030 compared to the demand under the BAU scenario.

• The INDC also includes a section on adaptation.

1.2.4. Energy Efficiency targets

The National Energy Efficiency Action Plan (NEEAP) for the Republic of Lebanon 2011-2015 established 14 initiatives that covered both renewable energy and energy efficiency. The following table summarizes the level of accomplishment of its objectives at the end of its period.

Table 3. Evaluation results for the NEEAP 2011-2015

Initiative	Description	Percentage of completion
1	Towards banning the import of incandescent lamps to Lebanon	45
2	Adoption of energy conservation law and institutionalization of LCEC as the national agency for Lebanon	40
3	Promotion of decentralized power generation by PV and wind applications in the residential and commercial sectors	30
4	Solar water heaters for buildings and institutions	53
5	Design and implementation of national strategy for efficient and economic public street lighting	60
6	Electricity generation from wind power	23
7	Electricity generation from solar energy	42
8	Hydro power for electricity generation	34
9	Geothermal, waste-to-energy, and other technologies	30
10	Building code for Lebanon	0
11	Financing mechanisms and incentives	80
12	Awareness and capacity building	69
13	Paving the way for energy audit and ESCO business	20
14	Promotion of energy-efficient equipment	8

(Source: NREAP 2016-2020)

The second NEEAP covers another five years, from 2016 to 2020. The NEEAP includes a list of energy efficiency initiatives divided into primary energy measures (power generation, transmission and distribution) and the end-use measures covering:
- Power sector measures
- Horizontal end-use measures
- End-use measures in the building sector
- End-use measures in industry, SMEs and Agriculture
- Measures in mobility and transport
- End-use measures in the public sector

The following table provides the list of measures contemplated in the NEEAP 2016-2020, including the expected savings and the funds required.

Table 4. Summary of measures in NEEAP 2016-2020

List of measures	Savings (kWh)	Funds Needed (M US$)
Power sector measures		
P 01: Upgrading OCGT to CCGT	686,136,822	474
P 02: Increase of the efficiency of EDL transformers		
P 03: Reduction of system reactive power		
P 04: Modification of the voltage level at the distribution system		
P 05: Installation of Automated Meter Reading (AMR)		
Horizontal End-Use Measures		
H 01 Minimum Energy Performance Standards (MEPS)	49,200,000	588
H 02 Financing mechanism		
H 03 Awareness campaigns and capacity building		
H 04 ESCOs' business development		
H 05 Adoption of the Energy Conservation Law		
End-use measures in the building sector		
B 01 Double wall ordinance	148,922,440	37
B 02 Testing facility for buildings components		
B 03 Building Code		
B 04 Use of efficient equipment		
B 05 Energy performance certificate for buildings		
B 06 Energy audits for public buildings		
B 07 Implementing measures in selected public buildings		
B 08 Pilot project		
B 09 Capacity building for refurbishment		
End-use measures in industry and agriculture		
I 01 Mandatory energy audits	610,251,000	121-216
I 02 Implementing energy efficiency measures in 20% of the Lebanese industries		
I 03 Installing 100 variable speed drives on irrigation pumps		
End-Use Measures in the Public Sector		
Pu 01 Creation of financing mechanism for the public sector	19,731,620	2
Pu 02 Green procurement for new and existing public buildings		
Pu 03 SEAPs for municipalities		
Pu 04 Management of public street lighting		

(Source: NEEAP 2016-2020)

1.3. Economic situation in Lebanon

Renewable energy deployment takes place against the background of the economic situation in Lebanon. While the Lebanese economy grew at strong rates between 2004 and 2010, the impact of the Syrian crisis (LCRP 2016) has, among other effects, slowed down growth to around 2% or below (Table 1). The Lebanese Statistical Office provides data from 2004 until 2015 on GDP and on the contribution of 27 economic sectors to the overall economy.

Table 5. GDP development

	2004	2009	2010	2011	2012	2013	2014	2015
Gross domestic product At current prices (billions of Lebanese pounds)	31,877	53,482	57,918	60,414	66,132	69,366	72,109	74,560
% real change (year to year)		10.1	8.0	0.9	2.8	2.6	2.0	0.8

(Source: CAS National Accounts 2004-2015)

The Lebanese economy is strongly service oriented. The main contributing sectors to GDP in the year 2015 (see Figure 3) are financial intermediation business activities (more than 25 %), administration (13%), wholesale and retail trade (10%) or construction (7%). Education contributes 7% (part of other services in Figure 3).

Total manufacturing contributes as much as the public sector and twice as much as the construction sector. Given the large education sector, the country has opportunities and advantages in science based technology development. Lebanon hosts 32 universities, which is a very large number for the size of the country.

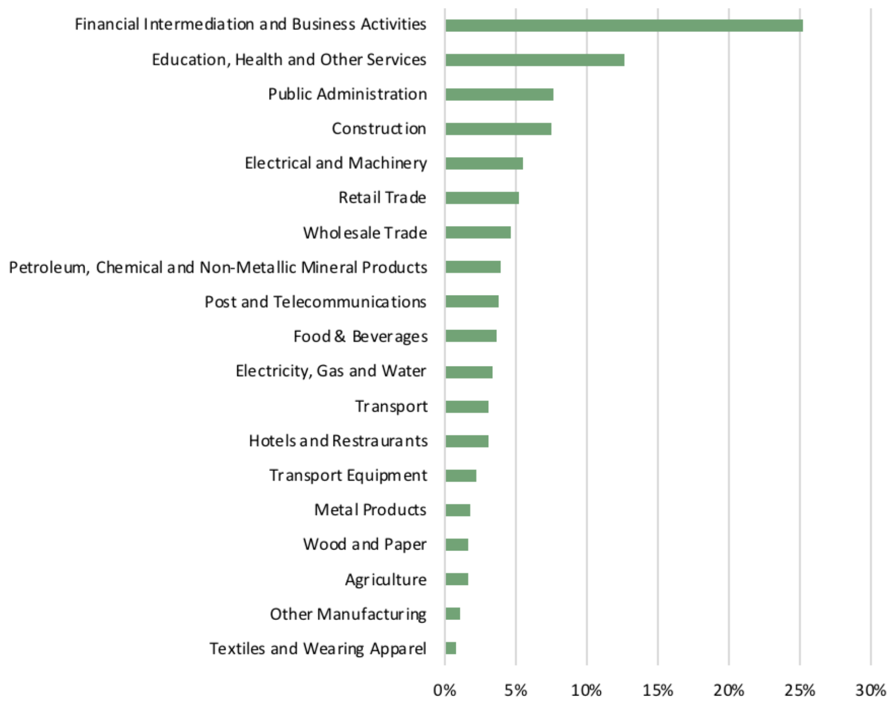

Figure 3. Main contributing sectors to the GDP.
(Source: CAS Lebanon, National Accounts)

In the manufacturing sector, food products and metal products and machinery are the largest sectors. Mineral manufacturing and chemicals, rubber, plastic industry also contributes 6-7% of total manufacturing output. The metal and machinery, as well as the mineral and the chemical industry provide relevant inputs for renewable energy technologies. These sectors will benefit from additional demand due to renewable energy deployment as will be shown in this report.

While GDP and its components are well documented in national and international statistics, data on population and the labor market are scarce. The latest population data published by the Central Administration of Statistics in Lebanon stem from 2007 and estimate the population at 3.7 million. The Lebanon Crisis Response Plan 2017-2020 estimates 5.9 million people living in Lebanon in 2017 including refugees, the World Fact Book has an estimate of 6.2 million Lebanese for 2017 and the German Export platform Germany trade and invest reports 4.6 million Lebanese, which matches the estimate of the crisis plan, taking the high number of refugees into consideration.

Data on the labor market and the work force are even scarcer. The International Labor Organization (ILO) together with Lebanon›s Central Administration for Statistics (CAS) currently carry out an EU funded project to "produce reliable, timely and representative statistical data on the current conditions of work in the country" (ILO 2017)[2]. The project is expected to end in 2019. The ILO states that Lebanon has a significant lack of reliable and timely data on the conditions of work and life in the country. The situation is increasingly stressful by the Syrian crisis on residents and refugees in Lebanon. Thus far, the data available at CAS are from 2009, which can be used as a reference for the structure of the labor market, but not for the absolute values of employment. The total size of the labor force in Lebanon is taken from the data at the World Fact Book[3]. According to this source, the labor force it is estimated at 2.16 million people.

The unemployment rate of Lebanon lies between 10% and 15% depending on age group, education, and gender (CAS 2012). Similar to Southern European and northern Mediterranean countries, unemployment is higher among the youth, which is often well qualified but has difficulties to find work.

Regarding the occupational structure, CAS writes in the Labor Market Report (SIF 2011): "Looking at occupation, our statistics show that 19% of jobs in Lebanon were craft related, and 14% were dedicated to senior officials and managers in both the public and private sector. Service, shop and market workers account for 13% of all workers."

On the issue of skills, CAS reports: "The percentage of working people with no or basic education reached 30% while the percentage of employed holding secondary or university degrees is 43%. Focusing on skilled working persons, we found that 43% of working women were holding university degree, while working men with university degree were 20%" (SIF 2011, p.8).

[2] *For further details see: http://www.ilo.org/beirut/projects/WCMS_340472/lang--en/index.htm*

[3] *https://www.cia.gov/library/publications/the-world-factbook/geos/le.html*

Regarding gender the data situation is as poor as labor market data. The participation of women differs across sectors. In agriculture, labor statistics show 21% women; in industry this share is around 14% and in the service sector this number rises to 38%. The share of women in the financial intermediation and insurance sector is also comparably high at 37%. In terms of occupation, women are found in higher qualification occupations. Almost as many women as men are found in absolute values in the category "Professionals", which means they hold over proportional shares. As the European Training Foundation points out in its 2015 report on the labor market and employment policy in Lebanon, "Female employees have a higher educational attainment level: 43% of employed women have a university degree" (ETF 2015). As CAS puts it: Although there were proportionately fewer employed women than men in Lebanon, almost 26% of working women were occupied in professional positions (such as doctors, teachers, engineers...) compared with only 8% of working men.

For the in-depth value chain analysis, some conclusions can be drawn and some assumptions deduced:

1. The Lebanese economy is strong in services. Therefore, the service components of all renewable energy technologies exhibit opportunities for domestic provision.

2. In terms of manufacturing, the metal industry and machinery can contribute to all renewable energy because despite it is small it is already existing.

For renewable energy, this translates to the following assumptions:

3. PV modules will be considered to be imported to one hundred percent. The reason behind this assumption is twofold. Firstly, PV module prices are sensitive to economics of scale, meaning that the larger a factory for the modules is the smaller cost of the module. Secondly, Lebanon currently has no semiconductor industry and no experience in this field. In consequence, Lebanon is not identified as a potential manufacturing country of PV modules.

4. The service sector for renewable energies has growth potential considering that the Lebanese economy is strong in services. Moreover, the research and science sector is also strong and is considered capable of contributing to services for renewable energies.

5. In the case of wind, it is assumed that wind turbines will be imported. This is due to the fact that the size of the projected wind farms is still small and would not justify the investments needed to set a local manufacturing industry. From the economic potential, blades could spin-off the existing chemicals and plastic fiber industry if the regional market is large enough. In any case, transportation and logistics will be an issue. Blades have a length of 50-100 m and the transport is challenging, in particular through mountainous regions.

6. In technologies which are currently mature in Lebanon, such as solar water heaters, the growth potential for further domestic is exhausted. Growth is expected to come from growing production and installation.

2. Value Chain Selection and Prioritization

2.1. Set of indicators

This chapter assesses a list of technologies that are considered relevant for the context of Lebanon. The selection of technologies is based on the conclusions from the desk review, the inputs gathered from interviews with relevant local stakeholders and finally the local perspective provided by UNDP team. Value chains are described based upon the literature and first round effects are identified. The analysis includes both technologies already installed in Lebanon and technologies which are expected to be relevant in the future.
A set of indicators have been prepared to justify the prioritization of value chains to be assessed. The key indicators for relevance that have been considered are:

A. Technical Potential.
A.1. Natural resource. Availability of resource to allow the deployment of the specific technology.
A.2. Relevance. The indicator measures the adequacy of the technology in the context of Lebanon considering the needs and challenges of the power sector in the country.

B. Economic potential
B.1. Short term potential. The indicator evaluates the existing industry and the existing services within the specific technology with regards to turnover and employment, as well as the growth potential in a short period of time.
B.2. Long term potential. The indicator assesses the capacities needed for the deployment of the specific technology in comparison with existing capacity. It also considers industrial integration and local content regulation (if any).
B.3. Value and employment the indicator reflects the potential value and employment creation in absolute terms.
B.4. Market development. The indicator measures how much support the market requires for its deployment, shows the installations planned and for the ex post evaluation, which were reached.

C. Institutional potential
C.1. Complexity of deployment. The indicator reflects the difficulty of deploying the specific technology taking into consideration how mature is such technology in Lebanon.
C.2. Alignment with government vision. This indicator reflects the extent to which the deployment of the technology aligns with the priorities of the government and its long term strategies.

Each technology has been assessed according to the list of indicators above. A traffic light has been included for each indicator in each technology to provide an illustrative qualitative evaluation.

Unfavorable Average Favorable

Indicators are not necessarily complementary. Short-term strategies may be at conflict with long-term development (cf. REValue 2014 or Lehr et al. 2012). Therefore, the following assessment provides the base for a joint agreement on future in-depth analysis.

The value chain description of first round effects will be following the logic of "Manufacturing > Installation > Operation" as depicted in Figure 16.

2.2. Solar Water Heaters (SWH)

2.2.1. Technical Potential of SWH in Lebanon

According to the Global Solar atlas, published by the World Bank and funded by ESMAP, Lebanon has a great potential for the deployment of SWH. Global Horizontal Irradiation (GHI)[4] levels ranges from 1,500 kWh/m² per year to more than 2,100 kWh/m². The resource varies within the country, being the eastern parts the ones with a higher solar potential.

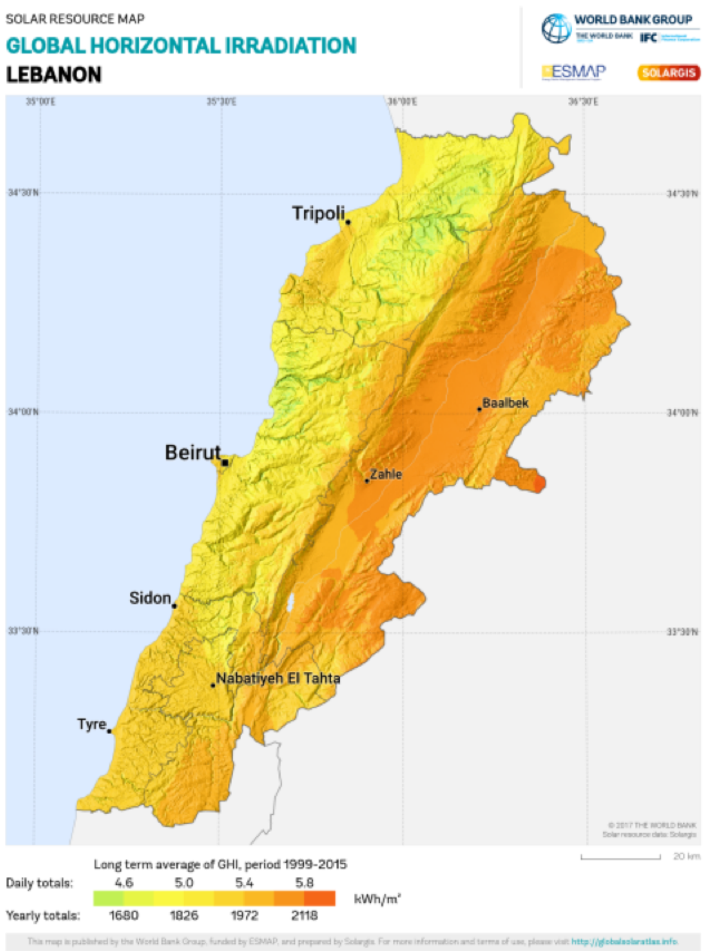

Figure 4. Global Horizontal Irradiation map of Lebanon (Source: World Bank, ESMAP)

[4] Global Horizontal Irradiation (Global Solar Atlas definition): Sum of direct and diffuse components of solar radiation [kWh/m²]. It is considered as a climate reference as it enables comparing individual sites or regions.

2.2.2. SWH Value chain and first round effects

The following information is largely based on Lebanon's First National Survey of the Solar Water Heaters Market (UNDP, 2014). While newer information is available, for instance the list of qualified solar water heater companies (MOEW/LCEC, 2017), or the Comprehensive List of Suppliers of Solar Photovoltaic Systems (MOEW/LCEC, 2017), the data in UNDP 2014 suffice for an illustration of the SWH value chain and will serve as the basis for later stage analyses.

In 2013, a total of 255.145 m^2 SWH were installed and associated water tanks amounted to a total capacity of more than 11 million liters. Roughly 130.000 systems were installed. The interview based market report finds that approximately 61.000 systems/components/tanks were produced in Lebanon, which is almost half of all systems. Local manufacturers in 2013 had a turnover of roughly $9 million. Things improved since then:

• In 2016, over 500,000 m2 of SWH collectors were installed (BEF 2016).
• Cumulative SWH installations since 2010 are estimated as follows. "Since October 2010 and until December 2016, companies have installed almost 315,000 m2, more than 21,000,000 liters and mobilized a capital exceeding $120,000,000" (BEF 2016).

Thus, SWH is used here as an example and as a benchmark, instead of as a sector with large needs for new support mechanisms.

A solar water heater system constitutes of the following main elements:
• Solar collector
• Water pump
• Heat exchanger
• Expansion tank
• Controls
• Valves (isolation, tempering)
• Mounting system
• Storage tank

The solar collector can be a flat plate collector, which consists of a dark absorber, typically under a transparent cover in a weatherproofed box. This is by far the dominant technology. In Europe, more than 90% are of this type (SWH Barometer). The alternative and more costly construction principle is the vacuum tube collector with parallel tubes filled with an absorber and under vacuum for insulation purposes.

Another distinction is between thermosiphon (passive) construction principle and pumped systems. In warm countries, it suffices to rely on physics and the thermosiphon principle according to which hot water is less dense and therefore naturally rises to the container.
The collectors themselves make the largest cost component in the system with 38%, followed by tanks (33%). Piping and control hold less than 10% each and the installation carries the remaining costs. A share of 55% of all Lebanese SWH companies produce tanks and 18% produce panels, which are the largest cost component. Pipes, frames and the heat exchange unit are produced by 9% of all manufacturers per component.

UNDP-CEDRO 2015 gives an overview of components and parts, which are single use SWH and dual use with conventional water heating systems. They conclude that single use has higher value. However, dual use gives the producers a fallback position if one of the two markets is slack and lets producers into the RES field who already have experience and a quality record of accomplishment.[5]

Data on the installation path (times series) will enable the calculation of the development of the value chain (and employment thereof). In the installation phase, a lot of domestic production and workforce is used. Stands are produced and the installation is locally provided. Pipes, resistors, and most likely cable, tools etc. is purchased from local manufacturers. On the other hand, solar water heaters do not require substantial operation and maintenance and therefore the contribution of this phase in terms of employment creation is rather low.

2.2.3. Outlook on second round effects for SWH

The analysis of second round effects helps to understand the value creation of RE throughout the whole economy. In the next step of the analysis, the economic structure of Lebanon will be analyzed in detail and the current and future potential and matches between strengths of the economy and needs of the various technologies will complement the picture.

The average cost structure of a SWH system is as follows:
- Collectors 38%
- Storage Tanks 33%
- Installation 13%
- Piping 9%
- Control 7%

If inputs to storage tanks are locally produced, the overall monetary impact is much larger, taking into consideration that one third of total costs goes to the tanks.

Table 6. Summary Table of first and second round effects for SWH.

PHASE	FIRST ROUND	SECOND ROUND	
		Inputs to the First Round	Locally sourced?
MANUFACTURING	Components: • Vacuum tubes • Pipes • Resistor • Tank • Collectors • Anodes • Batteries	Steel	Partly/Mostly
		Lead shields	Partly/Mostly
		Polyurethane/ foam	Mostly
		Powder paint	Mostly
		Porcelain powder	No
		Copper	Partly
		Aluminum	No
		Coating Powder	Partly
		Glass	No

[5] *Our definition of value added also contains the depth of production: simple assemblage has less to offer in terms of value compared to production with input materials also produced in Lebanon.*

PHASE	FIRST ROUND	SECOND ROUND	
		Inputs to the First Round	Locally sourced?
INSTALLATION	Construction sector, installers	Services: • System design • Testing of systems • Certification • Label (Solar keymark etc.)	Partly
		Materials: • Construction material	Mostly
		• Transport (cars, trucks) • Scaffolding	
Relation indirect / direct Employment:		Germany: 1.84 Tunisia: n/a Egypt: 0.3	
Employment factors – direct employment		Germany: Manufacturing 2.65 FTE/1000m² Tunisia: Manufacturing 4.67 FTE/1000 m²; Installation 11 FTE/1000 m². Egypt: Manufacturing: 5.2 FTE/1000 m²; Installation: 13.6 FTE/1000 m².	

More industrial integration as well as more testing facilities would contribute to root the SWH industry even deeper in the Lebanese economy.

2.2.4. Indicators and recommendations for SWH

Table 7. Table of indicators and recommendations for SWH

Ind. #	Indicator	Evaluation	
A	Technical Potential		
A.1	Natural Resource		Very high
A.2	Relevance		High, in particular for cooling/heating
B	Economic potential		
B.1	Short term potential		Tank manufacturing good; dual use no obstacle; collector production not high; installation good.
B.2	Long term potential		Collector production could be developed; regional hub difficult, because several neighboring countries have established SWH industries (e.g: Turkey).
B.3	Value and employment		Good turnover, large local content
B.4	Market development		Strong
C	Institutional potential		
C.1	Complexity of deployment		Good, already almost mature
C.2	Alignment with government vision		
RECOMMENDATION:		Keep this value-chain as benchmark in further analysis but do not dig into more detail.	

2.2.5. Experiences in other countries – employment SWH

Tunisia has been widely described and rather successful with the PROSOL scheme for the support of solar water heaters. This program has yielded 7 local manufacturers and assemblers plus 1,200 installers (micro companies) over the program period. The PROSOL program has achieved a turnover of about 100 million euro during the period 2010-2015. Approximately 68% of the market is served by local industry. After a decade of growth, the SWH market in Tunisia has reached maturity, at least in the residential sector. The perspectives beyond 2015 are around 80,000 m^2 per year, and aim at 1.3 million square meters of installed capacity by 2020 and about 2.7 million m^2 in 2030 (Lehr et al. 2016).

2.3. Solar Photovoltaic (PV)

2.3.1. Technical Potential of PV in Lebanon

According to the Global Solar atlas (World Bank, ESMAP), and similarly to the case of SWH, Lebanon has a great potential of solar PV energy. PV output[6] rates range from 1,300 kWh/kWp to 2,000kWh/kWp per year. Therefore, PV can find several applications in Lebanon. Firstly, on-grid solutions be it large MW installations or small private roof-top installations will add much needed capacity to the electricity system. Secondly, off-grid solutions can support remote users or individual purposes. Thirdly, solar pumping has been successfully tried and tested in agriculture for irrigation purposes in other countries (e.g. Egypt), so this might be an option for Lebanon. Last, but very relevant, PV can mitigate the use of back-up capacity in Lebanon.

One of the issues identified in the Lebanese power sector is the use of small diesel generators which offer uninterrupted electricity but are polluting. It could be therefore interesting to investigate technologies that can substitute these generators with renewable energy. One possibility is the combination of RE with batteries and a power management system. The key additional component would be the batteries. It has been therefore deemed interesting to investigate the value chain of such distributed and mini-grid applications. While batteries would probably have to be imported, the customization and combination could be potentially done by local Lebanese experts.

[6] *PV electricity output (Global Solar Atlas definition): Amount of energy, converted by a PV system into electricity [kWh/kWp] that is expected to be generated according to the geographical conditions of a site and a configuration of the PV system. Three configurations of a PV system are considered: (i) Small residential; (ii) Medium-size commercial; and (iii) Ground-mounted large scale.*

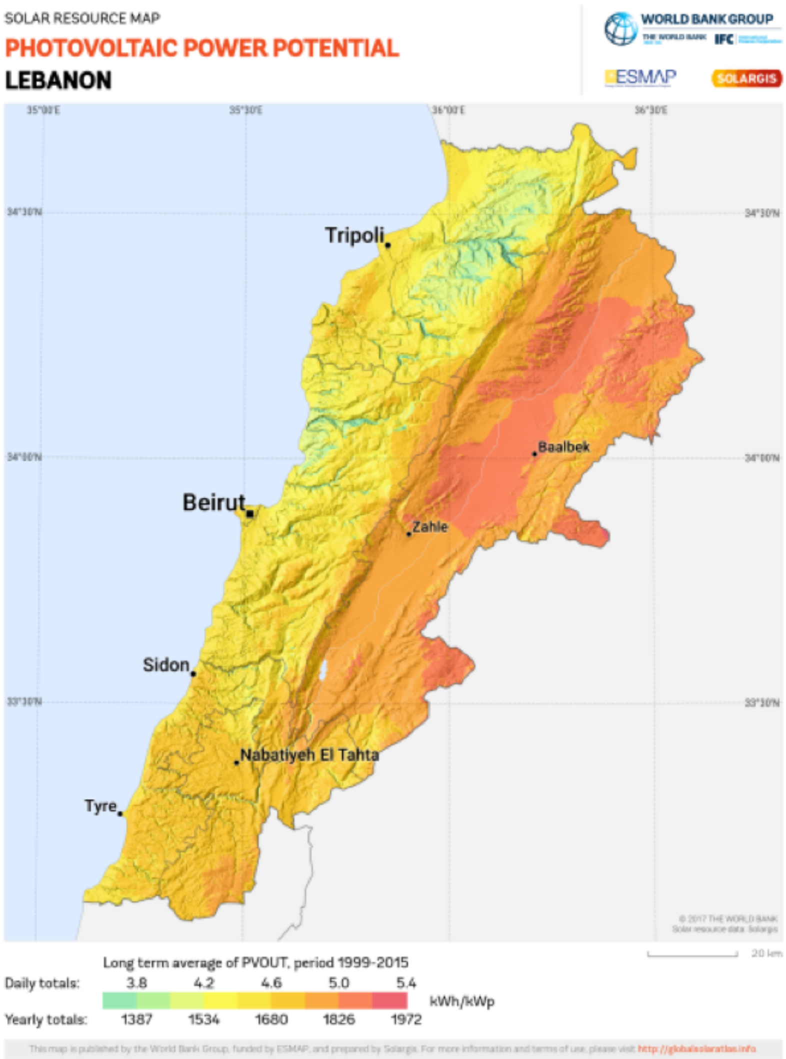

Figure 5. Photovoltaic Power Potential map of Lebanon.

2.3.2. PV Value chain and first round effects

Solar PV has started to develop promisingly in Lebanon. Installations rose from 1.94 MW in 2013 to 23 MW in 2016 (Solar PV Status Report for Lebanon 2016). Overall investment amounted to roughly $130 million between 2010 and 2016.

Given the electricity supply deficit in Lebanon, PV plus battery systems could be an environmentally friendly way of providing back up power supply, relieving the system of stress and mitigating power blackouts.

In any case, the PV manufacturing value chain is mainly the same for all systems. It is twofold, because the wafer, cell and module production often includes the raw material process from sand to silicon, whereas assembling the electrical system is part of a second process, followed by installation and operation.

Figure 6: Value chain of PV production
(Source: UNDP-CEDRO 2015)

The dominance of China or South-East Asia in silicon, cell and module production is overwhelming and it has withstood European attempts to protect their markets by tariffs and trade barriers. In comparison to China›s strong growth, silicon production in other major producing countries has remained at a relatively constant level in recent years. Other major producing countries include Russia, the United States and Norway. Wafer, cell and module production follow similar patterns. In production terms (PV Magazine 2017), experts forecasted China's production capacity to reach 60 GW in 2017 compared to 48 GW the year before. The large output capacities of Chinese firms give rise to tremendous economies of scale. Any small production cannot compete with this advantage. Producing the early stage of the value chain shown above domestically, one has to keep in mind that this increases prices for consumers, without providing neither jobs nor technological development, because the production is largely automated.

As part of a second process, assembling the PV system requires mounting it to an aluminum frame and wiring the electrical system, activities that can potentially be done locally.

A list of the electrical components for a PV system includes (UNDP-CEDRO 2015):
- Adhesives
- Batteries
- Cables
- Charge controllers
- Combiner boxes
- Connectors
- Disconnects
- Enclosures
- Grounding hardware
- Inverters
- Lightning and surge protection
- Monitoring devices
- Other essential system and associated components
- Over-current protection
- Stainless fastening hardware

All of these elements can potentially be produced in Lebanon.

The combination with battery storage systems increases the components needed and enlarges the value chain. The basic requirements of a PV/ battery system are as follows. PV systems can be combined with any common rechargeable battery on the market. However, a charge controller is required since voltage and current coming from the PV modules vary and can damage the system otherwise. Since PV/battery systems are stationary, aspects such as weight of the battery that matter for other applications like e-mobility, are not as relevant in the case of solar home systems. Most common batteries used nowadays are the valve regulated lead acid battery, followed by nickel-cadmium and lithium ion batteries.

2.3.3. Outlook on second round effects for PV

Most second round effects in PV stem from assembling and installation, since production mainly needs raw materials and machinery not produced in Lebanon.

The production of inverters requires various inputs and raw materials. Depending on the manufacturer and design of the inverter, the materials used differ considerably. Among others, copper, aluminum and potting compounds as well as plastics, silicon and electrolyte as essential valuable substances play a role (Lehr et al. 2016). Aluminum for the production of die-cast aluminum housings has the largest share. The components used are standard components (e.g., circuits, microcontrollers, and transistors). The same components are also used in production in the automotive industry, mechanical and plant engineering and information technology (PWC 2010). As has been pointed out above, dual use components have several advantages, when it comes to market development. Due to the initially small size of inverter manufacturers and their low demand for individual components compared to the other sectors, sporadic supply bottlenecks have occasionally occurred in the past, as the supplier industry was primarily responsible for the strong demand from large industries. Meanwhile the markets adjusted.

Table 8. Summary Table of first and second round effects for PV

PHASE	FIRST ROUND	SECOND ROUND	
		Inputs to the First Round	Locally sourced?
MANUFACTURING	Components: • Ingots • Cells • Modules	Sand	No
		Silicon	No
		Aluminum	Partly/Possible
		Plastics	Partly/Possible
		Cable, wiring, screws, nuts, bolts	Mostly
		Copper	Partly/Possible
INSTALLATION		Services: • System design • Testing of systems • Certification	Partly
		Materials: • Construction material • Transport (cars, trucks) • Scaffolding • Cable, wiring, screws, nuts, bolts	Mostly
O&M		• Cable, wiring, screws, nuts, bolts	Mostly
Relation Direct / Indirect Employment:		Germany: 2.16 Egypt: 0.8	
Employment factors – direct employment		Germany: Manufacturing 6.4 FTE/MW. Tunisia: Installation 4 FTE/MW. Egypt: Installation: 3.2-1.25 FTE/MW.	

2.3.4. Indicators and recommendations for PV

Table 9. Table of indicators and recommendations for PV

Ind. #	Indicator	Evaluation	
A	Technical Potential		
A.1	Natural Resource	(green)	Very high
A.2	Relevance	(green)	High, in particular in combination with storage.
B	Economic potential		
B.1	Short term potential	(red)	Few assemblers, enough installers for the few installations currently.
B.2	Long term potential	(yellow)	Cells and modules should be imported. Installation (roof, large, off-grid) should aim at %100 domestic, with a focus on regional local. Some components, BOS domestic. Services: Forecast, engineering, testing.
B.3	Value and employment	(green)	Local content in installation, value from trade, importation, system design.
B.4	Market development	(yellow)	Needs support
C	Institutional potential		
C.1	Complexity of deployment	(yellow)	Easy
C.2	Alignment with government vision	(green)	In complete alignment.
RECOMMENDATION:		Solar PV is selected for the in-depth analysis	

2.3.5. Experiences in other countries – employment PV

Two scenarios for solar PV were analyzed for Egypt. The benchmark scenario foresees capacities installed by 2020 of 1.5 GW, large and small. The sensitivity has a focus on small installations, rooftop and off-grid. Whereas battery solutions are not included, PV based solar pumping add another 100 MW each year and amounts to 1.1 GW by 2020. The sensitivity thus analyses what happens if installations focus on small installations such as rooftop PV, solar pumps and solar water heaters. These installations are more labor intensive and more spatially distributed, therefore requiring more logistics in distribution and installation.

In a simulation where PV installation is gradually shifted towards small installations and solar water heaters, employment increases significantly. Up to 12.000 additional jobs are created in Egypt under this scenario. The difference between this and the benchmark scenario decreases towards the end of the observation period due to increased productivity. Figure 7 shows the difference between employment from renewable energy in Egypt the benchmark scenario and the scenario with more distributed generation. The lines show absolute employment (left hand axis) and the bars show the difference between the scenarios (right hand axis). The additional investment necessary is much smaller than in the ambitious scenario, but the employment effect is significant.

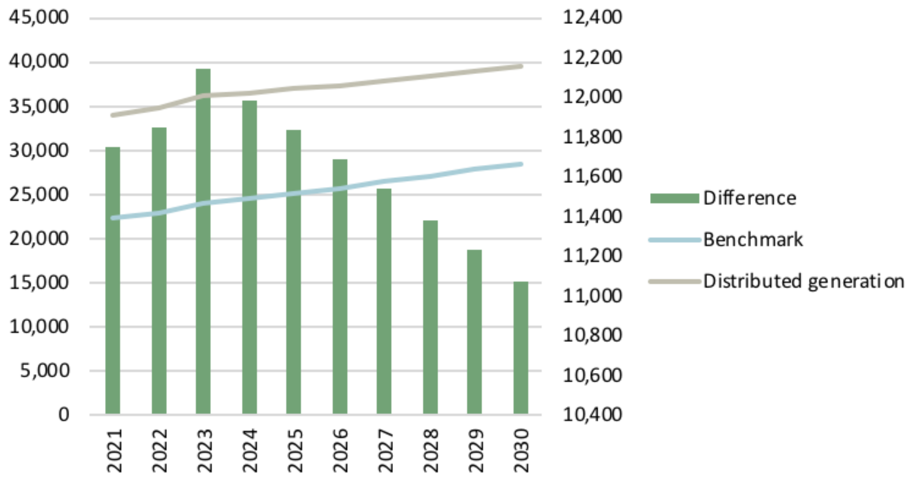

Figure 7. Employment from RE and EE, comparison of Benchmark and focus on small installations in Egypt. (Source: GIZ/RCREEE 2018)

Although the model does not include skill levels, one could argue that distributed generation and installation contributes to a more wide spread distribution of the required skills. This will be a challenge to the realization of such a scenario with a focus on distributed generation, because the training efforts have to be more regionally disperse to guarantee the quality of works in installation in all regions.

2.4. Wind energy

2.4.1. Technical Potential of Wind Energy in Lebanon

The physical potential for wind energy in Lebanon is significant. As part of the UNDP-CEDRO Project, UNDP prepared the National Wind Atlas for Lebanon (UNDP-CEDRO 2016). The document summarizes "the potential of installed onshore wind power capacity for Lebanon has been calculated as 6.1 GW based on the wind speed at 80 m above ground level, a number of high level assumptions and constraint data supplied by the Client. [...] If the downward wind speed perturbation is applied and the maximum practical terrain slope for turbine construction is reduced to 8°, the figure quoted above is reduced to 1.5 GW". Either way these are impressive figures, which can tempt manufacturers to produce some parts in Lebanon and service providers to consider Lebanon as a regional hub.

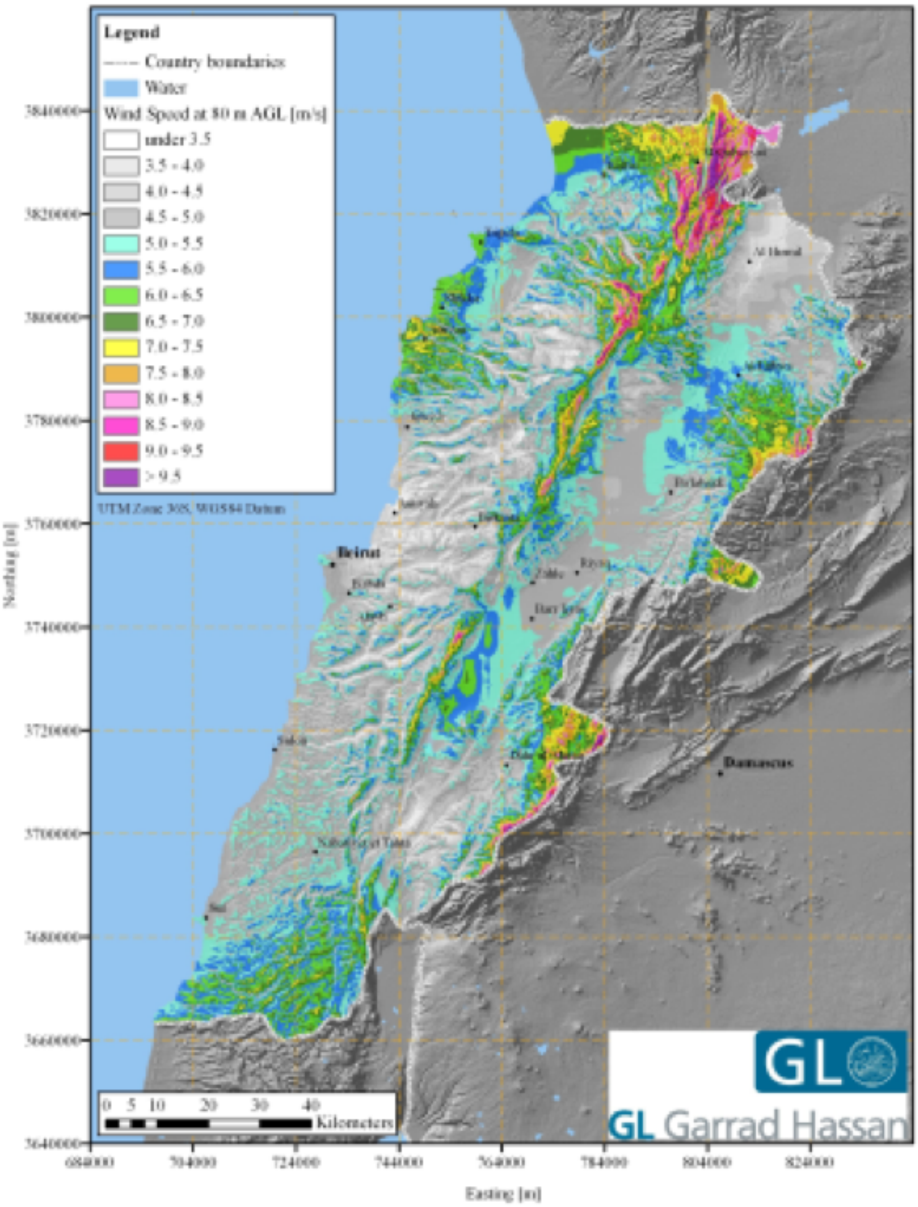

Figure 8. Wind map at 80m above sea level
(Source: National Wind Atlas for Lebanon)

2.4.2. Wind energy value chain and first round effects

Wind energy does not contribute to the Lebanese energy system largely as of yet. In August 2017, however, the project start of a wind farm in Akkar made the headlines. Three private companies in Akkar are currently negotiating Power Purchase Agreements to build wind farms in this northern region of Lebanon and generate 200MW in total. These companies are Hawa Akkar, Lebanon Wind Power, and Sustainable Akkar.

These pilot projects have several interesting aspects. In terms of value creation, wind turbines are of high interest. They belong to the more complex RE systems with many steps of value generation and a divers set of components.

The wind energy system comprises of the following components:
• Blades
• Tower
• Nacelle, gearbox, electronics
• Generator

The Nacelle itself contains many different components (UNDP-CEDRO 2015):
• main drive gear and generator gear
• generator shaft
• brake wheel and brakes
• generator
• transformer
• sensors and controls

The first component built domestically is typically the tower, as experiences from South Africa, South America, Egypt, Tunisia and other countries show. However, this is only economic if a sufficient pipeline of projects exists and therefore is not expected to be reached with the first round of PPAs.

Secondly, electronics, sensors and controls can spin off existing local industries or they are dual use (i.e. not exclusively used for RE). South Africa established local blade production and launched a Wind Energy Converter Company (Isivunguvungu), South Africa's first wind turbine rotor blade manufacturing plant in 2011. As a reference of South Africa's market size, today there are 19 wind energy developments, with more than 600 wind turbines totalling 1,471MW. Several turbines were built, but the company went out of business a couple of years later. Blade production, in particular, is a very relevant component for value creation and employment, because it is multi-faceted and labor intensive.

According to Adrian et al. (2014), wind turbine producers increasingly tend to modular production. While European producers still tend to high vertical integration, Asian production seems to be more modular. Few producers specialized on certain components deliver to the large turbine producers. This could open niches for developing countries and emerging economies.

The installation phase of the wind energy value chain is dominated by construction. Site preparation takes place at the beginning of the wind farm. Roads need to be built, the ground leveled and the bases for the towers laid. All these activities require civil engineering, planning, and construction workers, as well as trucks, building material and other machinery. This part is mainly kept local in all countries analyzed.

The actual erection of the tower and the installation of the nacelle with the blades require cranes, lifters and other heavy machinery but often this part is done by the same manufacturer of the turbine. Employment factors for the installation phase in Table 10 for Egypt are very low in the installation phase. The reason is that the installation is expected to be done mainly by teams of foreign workers, directly employed by the wind turbine manufacturer.

The same holds true for operation and maintenance, which are often part of the contract with the producers.

2.4.3. Outlook on second round effects for Wind

The production structure of wind energy is known from international data. A variety of materials and components is needed, starting from metal products, cables, insulation, connectors, to copper, transformers, cement and wood, trucks, gravel, asphalt or cranes.

Inputs from the service sectors include planning and design of the wind farm as well as environmental audits, wind speed forecasts and legal advice. Further services are in the banking sector (financing and loans), tax accountants, training, and education or media coverage.

Given the geographical nature of the country, transport logistics and security will create additional challenges and give jobs to people with the respective qualifications. Ports need to be altered, roads modified and secured, the construction site itself needs to be guarded during installation and over the life time of the wind farm...

Table 10. Table of first and second round effects for Wind.

PHASE	FIRST ROUND	SECOND ROUND	
		Inputs to the First Round	Locally sourced?
MANUFACTURING	Components: • Blade • Tower • Nacelle • Brakes • Gearbox	Wood, plastics, carbon fibers, resin	Could be, though currently there is no local wind energy market
		Cement, concrete, construction	
		Transformers, copper, cable	
		Trucks, gravel asphalt, civil engineering machinery	
		Steel, other metal products	
		Small iron products	
INSTALLATION		Services: • wind prognosis • wind farm design • Certification	
		Materials: •Construction material •Transport (trucks, cranes) • Scaffolding • Cable, wiring, screws, nuts, bolts	
Relation Direct / Indirect Employment:		Germany: Manufacturing 1.47; O&M 1.38 Tunisia: N/A Egypt: Installation 6,34	
Employment factors – direct employment		Germany: Manufacturing 9 FTE/MW; O&M 0,22FTE/MW Tunisia: Installation: 3,7 FTE/MW, O&M: 0,4 FTE/MW Egypt: Installation 0,7 FTE/MW, O&M: 0,28 FTE/MW	

2.4.4. Indicators and recommendations for Wind

Table 11. Table of indicators and recommendations for Wind

Ind. #	Indicator	Evaluation	Comments
A	Technical Potential		
A.1	Natural Resource	Yellow	Large (6 – 1.5 GW), but this does not consider sensitive areas.
A.2	Relevance	Yellow	Puts additional need for balancing and grid extension.
B	Economic potential		
B.1	Short term potential	Red	No industry. Competitive data analysis capacities, service sector, electronics
B.2	Long term potential	Green	Tower production easily established. Service sector, wind prognosis, market balances, environmental tests feasible Blade production should be checked.
B.3	Value and employment	Yellow	Attracts FDI. Local content regulation potentially necessary.
B.4	Market development	Yellow	No plan currently.
C	Institutional potential		
C.1	Complexity of deployment	Yellow	International experience high, Akkar could be the ice breaker, currently not enough incentives.
C.2	Alignment with government vision	Green	
RECOMMENDATION:		Wind is selected for the in-depth analysis	

2.4.5. Experiences in other countries – employment Wind

The use of wind energy in Egypt started 8 years ago. As in the cases of SWH and PV elaborated above, employment from wind power was analyzed in detail in different scenarios, the current plan of investments yielding a benchmark. In case of wind technology it is particularly interesting to note the effects not from a variation of investment paths or the amount of MW installed, but rather from a hypothetical increase of local production and the share of locally produced intermediate input factors.

With first installations being made in 2010, the capacity of wind power in Egypt amounts to 670 MW as of 2017, accounting for roughly 500 jobs (including direct and indirect) at that point. According to plan, the installation of wind power will jump to 820 MW in 2018 and steadily increase further up to 1,066 MW in 2030. By then 3,700 jobs are expected to be directly related to wind energy systems, most of them in operation & maintenance. Another 1,200 jobs would be created along the value chain in that respective year.

As already noted, the capacity of wind power installed each year is the same in a scenario with more local integration, as is the investment made in each year. While direct employment from construction and operation & maintenance is equal to the benchmark, between 1,400 and 1,600 jobs are directly linked to the manufacturing of up to 400 MW of wind power systems in a given year.

The manufacturing industry of course needs various intermediate input factors from different sectors of the economy, many of which can be produced in Egypt. This would lead to another 1,500 jobs along the value chain. Additional to that, there more locally produced goods and services used in the construction and operation & maintenance of the systems compared to the benchmark, resulting in a total of about 7,500 indirect jobs in 2030. This brings the total number of employment as a consequence of the installation, construction and operation & maintenance up to about 14,000 by 2030, the end of the considered time period.

2.5. Bioenergy

2.5.1. Technical Potential of Bioenergy in Lebanon

The UNDP-CEDRO Project prepared in 2012 The National Bioenergy Strategy for Lebanon. According to this report, Lebanon has a notable availability of bioenergy resources derived from forests and agricultural residues that could annually contribute up to 7,000 GWh of primary energy supply. Approximately one third of the country’s land is arable, with the most fertile areas being located along the coastal strip and in the Beqaa Valley. The diversity of the Republic›s topography and climate enables cultivation of a wide variety of vegetables, fruits, agro-industrial crops and cereals.

The strategy included a detailed assessment of relevant biomass resources, grouping them into 6 categories according to their source of origin in:

a) Forestry
b) Wood and paper industries
c) Agriculture
d) Energy Crops
e) Food processing industry
f) Municipal solid waste and non-hazardous industrial waste

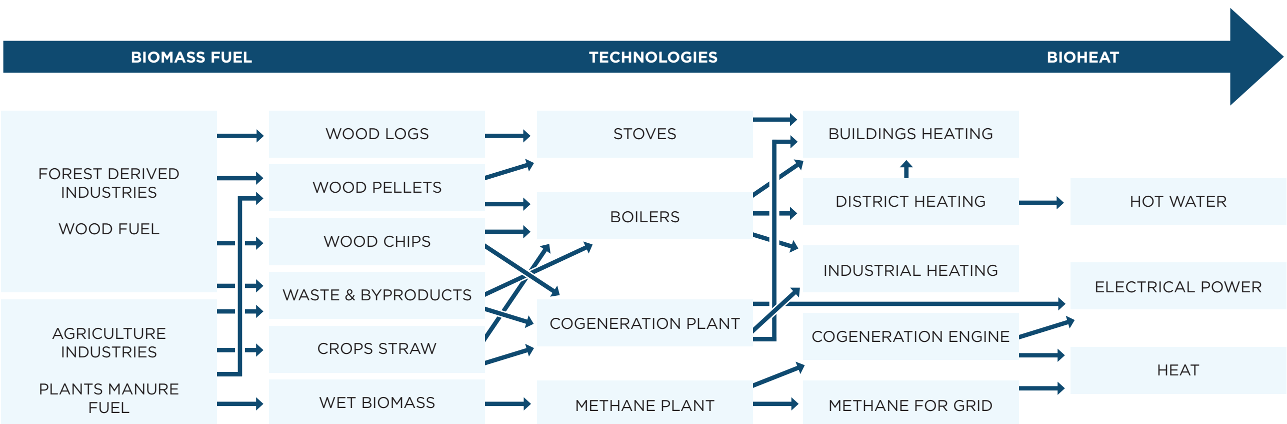

Figure 9. Variety of biomass to heat and power generation pathways
(Source: Renewable energy and industry promoting industry and job creation for Lebanon, UNDP-CEDRO 2015).

An overall evaluation of all biomass resources was performed as part of the National Bioenergy Strategy for Lebanon. The evaluation considered 4 factors: Energy Potential, Sustainability, Accessibility, and Legal Framework. As a result of the evaluation, the bioenergy streams were ranked. The resulting ranking of the ten most promising bioenergy streams was:

1. Residues from forestry fallings
2. Residues from fruit and olive trees
3. Residues from cereals
4. Energy crops on currently unused land
5. Olive cake by-products
6. Waste wood
7. Municipal sewage sludge
8. Animal fat and slaughterhouse residues
9. Yellow grease
10. Landfill gas recovery (specifically Naameh landfill)

The strategy also assessed the technology options for conversion of biomass streams into power, heat or liquid biofuels and matched the selected technologies with the resource assessment in order to determine the best potential combinations of resource-technologies in Lebanon. The report concluded that the most relevant technologies for Lebanon are the ones involving liquid fuels production and direct combustion of biomass for the production of power and heat.

2.5.2. Bioenergy Value chain and first round effects

The value chain of bioenergy links the raw material after its collection with the final energy uses. This chain is a multiple options combination of feedstock, processing technologies (possibly with several steps) and marketable end products such as other bioenergy carriers, liquid and gaseous biofuels, power and heat. Additionally, co-products that have value for other applications (e.g. glycerin from biodiesel production) can be produced in many of the bioenergy value chains.

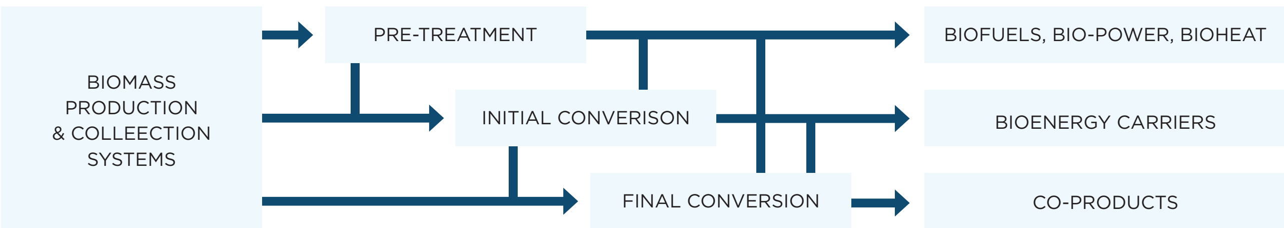

Figure 10. General Scheme of the bioenergy value chain (Source: The National Bioenergy Strategy for Lebanon)

In terms of job creation, two main areas arise:

A. Biomass harvesting, treatment and conversion to a fuel: Biofuel production quantity and type are driven by market demand, which is based on the type of application. For instance, in small-scale domestic applications of biomass boilers, the fuel usually takes the form of wood pellets, wood chips, and wood logs, which are biomass conversion processes that can be industrialized and developed in Lebanon (first 5 stages of the value chain presented in figure 11). Moreover, the activities comprised in this area can foster job opportunities development both for skilled and non-skilled workers, which is an aspect of great interest in a context of high unemployment rates or migrant (or refugee) workers.

B. Heat or Power generation from biofuels: Skilled individuals are needed to manufacture, maintain and operate stoves, boilers, cogeneration engines and turbine systems machinery, both for the residential and the industrial markets. For instance, a biomass boiler manufacturing facility may employ dozens of individuals, including engineers, human resource professionals, laborers, and maintenance workers. Smaller biomass projects have a smaller economic impact per unit sold, although they have the potential to sell more units of this manufactured product and may affect the economy in the consideration of scale. Large scale projects, like Steam turbine power plants or Cogeneration plants will also require skilled labor for the management, operation and maintenance duties of the facility.

Figure 11. Example of bioenergy value chain: forest wood to power and heat supply chain.

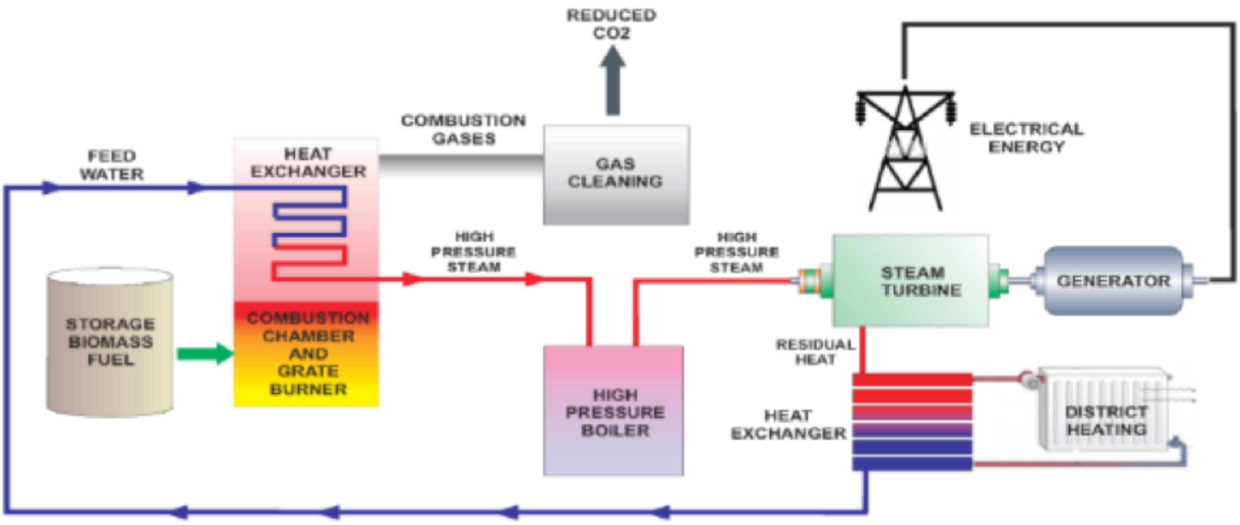

Figure 12. Block diagram of a biomass to CHP (combined heat and power) plant, corresponding to the value chain example presented in figure 11.
(Source: Renewable energy and industry promoting industry and job creation for Lebanon, UNDP-CEDRO 2015)

2.5.3. Outlook on second round effects for Bioenergy

According to the value chain analysis described in the 2015 project UNDP-CEDRO report “Renewable energy and industry promoting industry and job creation for Lebanon”, small modular biomass systems typically consist of a fuel conversion unit (e.g. combustion chamber in a stove or in a boiler, gasifier reactor) coupled to a power and/or heat generator unit (engine or turbine coupled to an alternator, heat exchangers).

The large scale deployment of small modular biomass systems can be a stepping stone in the mid and long term development of a biomass industry to cover all ranges of expected power applications, including small systems for distributed applications and/or individual power needs, CHP systems for industrial applications, and gasification for utility-scale power generation. As an example, figure 13 shows the internal components of a typical biomass boiler.

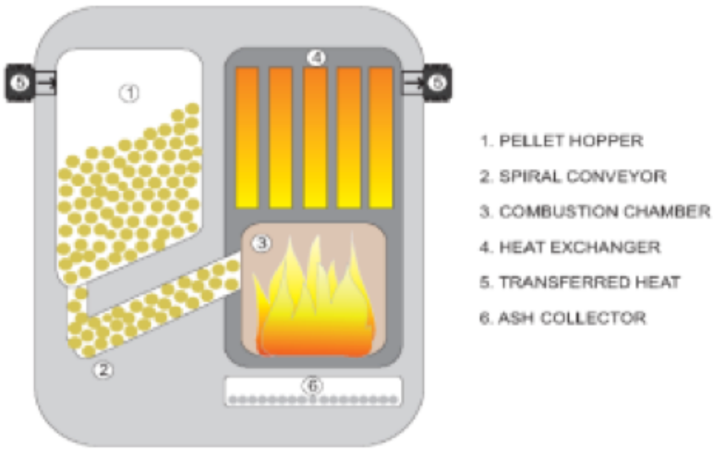

Figure 13. Example of bioenergy value chain: forest wood to power supply chain.

Table 12. Summary Table of first and second round effects for bioenergy.

PHASE	FIRST ROUND	SECOND ROUND	
		Inputs to the First Round	Locally sourced?
HARVESTING	Equipment, Components: • Chainsaws • Harvester vehicles (several types and sizes) • Puling cables • Transport vehicles	Materials: • Steel • Plastics • Tires	Mostly
TREATMENT and CONVERSION FACILITIES	Drying: • Conveyors • Heat exchangers • Sieves • Blowers Chipping: • Cutters/Blades • Conveyors • Sieves Briquetting/ Pelletizing: • Crushers • Conveyors • Extruders • Cutters/Blade	Services: • System and Facilities design, engineering • Construction supervision • Testing • Commissioning	Partly
		Materials: • Construction material, civil engineering machinery • Steel, Cooper • Transport (cars, trucks) • Scaffolding • Cable, wiring, screws, nuts, bolts	Mostly
HEAT/POWER PLANT FACILITIES CONSTRUCTION, O&M	Equipment, Components: • Boilers / Reactors • Heat Exchangers • Cleaning units • Engines • Turbines • Transformers • Piping • Cabling • Protections, Control	Services: Facilities design, engineering Construction supervision Testing Commissioning	Partly
		Materials: • Construction material, civil engineering machinery • Steel, Cooper • Transport (cars, trucks) • Scaffolding • Cable, wiring, screws, nuts, bolts	Mostly

Relation Direct / Indirect Employment:	Catalonia: 1.5 Harvesting, 1.6 Treatment/ Conversion Slovenia: 0.53 Harvesting + Treatment/ Conversion Croatia: 1.4 Harvesting + Treatment/ Conversion
Relation Direct / Induced Employment	Catalonia: 1.8 Harvesting, 1.8 Treatment/ Conversion Slovenia: 0.42 Croatia:0.95
Employment factors – direct employment (in FTE per 1000tonnes/year of biomass mobilized)	Catalonia: 0.41 Harvesting, 0.18 Treatment/ Conversion Slovenia: 0.32 Harvesting + Treatment/ Conversion Croatia: 0.60 Harvesting + Treatment/ Conversion

Data on Catalonia, Slovenia and Croatia is taken for the SecureChain project (HORIZON2020), BIO4ECO (Interreg Europe) and compared as well with N. Krajnc, J. Domac, "How to model different socio-economic and environmental aspects of biomass utilisation: Case study in selected regions in Slovenia and Croatia", Energy Policy, Volume 35, Issue 12, 2007.

2.5.4. Indicators and recommendations for Bioenergy

Table 13. Table of indicators and recommendations for Bioenergy

Ind. #	Indicator	Evaluation	Comments
A	Technical Potential		
A.1	Natural Resource		Good, diverse, and scattered among different regions in the country
A.2	Relevance		High, in particular for domestic heating applications in rural areas
B	Economic potential		
B.1	Short term potential		Moderate, first briquetting projects have initiated consumption at residential level. Industrial market is yet to be deployed
B.2	Long term potential		Industrial heat (steam generation) can be achieved with biomass boilers. Residential markets in areas close to biomass harvesting zones (forests, agro processing industries) can experience a fast growing demand of biomass. District heating and cooling networks based on biomass have also good potential in towns.
B.3	Value and employment		Local content in harvesting, treatment and conversion of biomass, as well as construction, installation and O&M of power and/or heat plants.
B.4	Market development		Needs support
C	Institutional potential		
C.1	Complexity of deployment		Easy, first demonstration projects led by project UNDP-CEDRO
C.2	Alignment with government vision		See National Bioenergy Strategy
RECOMMENDATION:		Wind is selected for the in-depth analysis	

2.6. Energy efficiency in Buildings

2.6.1. Technical Potential of Energy Efficiency

Energy efficiency (EE) is the often forgotten but very relevant sector for any energy transition. Increasing efficiency helps to get costs down, RE shares up and GHG emission down. The relevance stretches across all energy consuming sectors, be it industry, transport or households. However, experience shows (OECD 2012, Lehr et al. 2016, and Lehr et al. 2017), that in terms of economic value creation and employment, the residential sector carries the most weight. Energy efficiency in industry is improved by replacing inefficient appliances, valves, motors, drives, pipes, lights etc. with the replacement circle. But the employment impact is usually low, because no different operation and maintenance is needed and no additional production of these components is spurred. Moreover, the industrial sector is very heterogeneous and fragmented.

The experiences in Lehr et al. 2017 illustrate this vividly. All data collected on EE in the industry in Egypt stem from 150 Energy Efficiency projects applied in around 146 entities of different sectors by themselves, service provider, international program, or national program so the collected data represent available samples by no means comprehensive of all projects. Data exists on Motors System Optimization (MSO), Lighting System Optimization (LSO), Steam System Optimization (SSO), and Power Quality Optimization (PQO). 146 reports and samples from the following sectors were collected including industrial, tourism and commercial (large and SMEs). For efficient lighting, data were available for different phases, such as planning, manufacturing and installation. Investment on EE is in industry small in Egypt. It amounts to $ 100 million per year. Energy efficiency technologies, however, do not have operation and maintenance costs. All investment considered is in new systems and devices. Approximately 400 people work in energy efficiency in industry in the year 2015 in Egypt. Energy efficient lighting, however, led to domestic production and 475 direct and 640 indirect jobs in 2015.

The analysis of other countries in MENA point at the residential sector is being more promising in terms of value creation insulation. Insulation materials and efficient windows for buildings can be domestically produced and the construction sector is well developed and labor intensive. An interesting point in the analysis can be the enforcement of existing building codes, quality control and capacity building for higher building quality.

The recommendation for Lebanon would therefore be to pursue energy efficiency in the building sector specifically when looking at employment creation opportunities.

2.6.2. Efficient buildings – value chains

Efficient buildings can either be newly built, following efficiency codes and standards, or they can be a result of retrofitting existing buildings. For the value chain assessment, it is important to clearly define the additionality of efficiency, in particular for new buildings. “Honest” reporting of employment and value from efficiency should only contain additional expenditures, materials and employment, not the construction activity of building a new house as such.

Efficient buildings do not need any extra operation or maintenance compared to a conventional building, thus the focus to create jobs shall be on the value chain phase of studying the energy efficiency measures, the manufacturing of related materials and devices, and the construction/installation phase.

The components of an efficient building can be summarized as follows:
• Passive solutions:
- Walls: insulation (stone wool, wood wool, Styrofoam, other), building material (wood, stone, bricks, concrete, other), paint.
- Windows: multiple glazing, reflective glazing
- Roofs: insulation (see above), roof tiles, other roof material

• Active systems:
- Heating, Ventilation and Air Conditioning
- Lighting
- Others

The installation phase consists of the planning phase, the actual construction and erection of the building and the final auditing phase if a certain standard is to be met. In the planning phase, the following actors are involved:
• Banks, credit institutes
• Tax accountants
• Lawyers
• Municipal entities (Building authority, building permit)
• Architects and urban planners
• Engineers
• Builder/investor (private sector or public)
• Auditors

The construction phase then comprises the construction works, scaffolding, transport of workers and materials, cranes etc.

Value added from energy efficiency is that part of the costs/investment, which is due to a higher efficiency standard. E.g. if a triple pane window costs 60% more than a single pane window, the additional 60% is attributable to energy efficiency. If the installation of a certain type (or any) insulation requires special scaffolding, skills and people, then the additional investment is attributable to energy efficiency.

The delimitation is easier with retrofits when they are only targeted at energy efficiency. Often, retrofits also modernize other aspects of the building and one has to be careful of double counting.

In terms of indirect effects, value creation will be high, because the construction sector is well integrated into most economies. However, it has to be analyzed in detail, which of the efficiency relevant materials and components are actually produced in Lebanon.

2.6.3. Outlook on second round effects for Energy Efficient buildings

Table 14. Summary Table of first and second round effects for batteries.

PHASE	FIRST ROUND	SECOND ROUND	
		Inputs to the First Round	Locally sourced?
MANUFACTURING	Windows, insulation material,	Styrofoam	partly
		Plastic	partly
		Wood	partly
		Metal, steel	mostly
		Pipes	mostly
		Glass	partly
INSTALLATION	Scaffolding, construction	Metal	mostly
		Construction material	yes
		Wood	
O&M	NA		

2.6.4. Indicators and recommendations for Energy Efficiency

Table 15. Table of indicators and recommendations for energy efficiency

Ind. #	Indicator	Evaluation	Comments
A	Technical Potential		
A.1	Natural Resource		Large
A.2	Relevance		High
B	Economic potential		
B.1	Short term potential		Good. Construction sector is large, skills may be needed, auditing and controls need trained staff
B.2	Long term potential		Good
B.3	Value and employment		Large
B.4	Market development		Good
C	Institutional potential		
C.1	Complexity of deployment		Medium
C.2	Alignment with government vision		Good
RECOMMENDATION:		Energy Efficiency in buildings is a relevant value chain in terms of employment creation but has not been selected to be part of the in-depth analysis	

2.6.5. Experiences in other countries – employment from efficient buildings in Tunisia

The case of Tunisia is presented to show an example of the impacts of the energy efficiency sector. A total of 50 million Euros were spent on thermal insulation of buildings between 2012 and 2016 and the impact of the intervention was analyzed.

Because thermal insulation can be provided to a large share from domestic products, the study found that overall additional employment from the investment of 50 million Euro in thermal insulation during the construction and building phase of 5 years as 394 people. It thus exhibits the highest employment per money spent. Thermal insulation also is very rewarding in terms of energy saved per Euro spent and will repay itself over rather short time spans through energy savings for cooling the building. Operation and maintenance is not necessary with energy efficiency measures.

2.7. Other Value Chains

This chapter describes those value chains that while they are present in the Lebanese NREAP 2016-2020 they are not considered relevant for this value chain assessment for different reasons.

2.7.1. Concentrated Solar Power (CSP)

CSP has been a much discussed technology at the turn of the century in particular for the MENA region. Industry research projects such as Desertec spurred hope for electricity generation in the southern Mediterranean and electricity consumption in Europe. The enthusiasm has cooled down during the last years, but in several countries in the Sun Belt CSP projects have been carried out. Examples are the Ouarzazate CSP plant, whose first phase went online in February 2016. Abu Dhabi in the Arab Emirates plans an extension of the Mohammed bin Rashid Al Maktoum Solar Parks with a 700 MW CSP facility.

A detailed analysis of the potential of value creation from CSP can be found in (Worldbank 2011). The figure shows which components of a CSP plant contribute to each cost share. The largest share goes to the equipment of the solar field, followed by labor costs and project development, financing, management, etc. However, CSP is not expected to play a relevant role in the mid-term in Lebanon, and therefore it has not been prioritized for the in-depth value chain analysis.

2.7.2. Hydro power

Hydropower turbines are products that require high technological knowledge and capability to manufacture. Some countries produce turbines and other hydropower equipment and install new hydropower plants whereas some other countries, such as Germany, only produce for export. Construction and installation has a much higher share of local content than manufacturing. While international/ multinational firms carry out project planning and supervision to some extent, the bulk of employment lies in the actual construction works, which leads to domestic employment.

Total employment from installation and construction in the top ten countries and the rest of the world is shown in Table 16. Since the relevant physical quantity for the calculation of employment creation from construction and installation is the capacity added, China dominates the international picture.

Table 16: Total employment from installation and construction in hydropower, globally.

	2012	2013	2014	2015
Brazil	33,120	32,217	31,734	22,056
Canada	5,205	6,049	8,796	4,899
China	450,320	483,629	426,989	316,060
India	56,383	62,099	81,585	67,700
Iran	27,379	42,210	42,337	36,339
Peru	3,583	9,020	9,699	9,699
Russia	14,216	14,008	10,917	7,581
Turkey	17,355	15,169	13,009	10,708
Ukraine	6,936	14,928	18,218	15,165
Vietnam	95,200	52,793	45,201	33,586
Rest of Countries	57,139	63,618	55,590	41,060
TOTAL	**766,835**	**795,738**	**744,074**	**564,852**

(Source: Lehr and Walter 2017).

Total employment from operation and maintenance is between 619,000 in 2012 and 672,000 in 2015. Bucking the trend in the other sectors, employment in O&M is rather increasing than decreasing due to the higher amount of installed capacity in some reporting countries. An exception is the year 2014 in which some labor intensities drop perceptible (e.g. in Russia, China, USA, Brazil or India). This effect superimposes the effect of higher installed capacities and causes partly a decline in employment.

In Lebanon, the NREAP foresees the Lebanese hydro potential and the plan to develop 139 MW by 2025. However, CSP is not expected to play a relevant role in the mid-term in Lebanon, and therefore it has not been prioritized for the in-depth value chain analysis.

2.7.3. Geothermal energy

Geothermal energy is heat energy stored in the earth crust. If there are sufficiently high temperatures in accessible depths (up to a few thousand meters), it can be can be used for power generation. Shallow geothermal energy (from a few meters up to about 100m depth) can be used for heating or cooling purposes using ground source heat pumps (GSHP).

The National Geothermal Resource Assessment Report (2014)[7] investigated the resource potential in Lebanon for power generation. As can be seen the next figure, the recoverable heat in depth up to 4500m – which is already quite deep for geothermal power generation plants – is only available in the far north of Lebanon.

[7] *MEW / CEDRO (2014) National Geothermal Resource Assessment Report, http://www.lb.undp.org/content/dam/lebanon/docs/Energy%20and%20Environment/Publications/National%20Geothermal%20Resource%20Assessment%20Report.pdf*

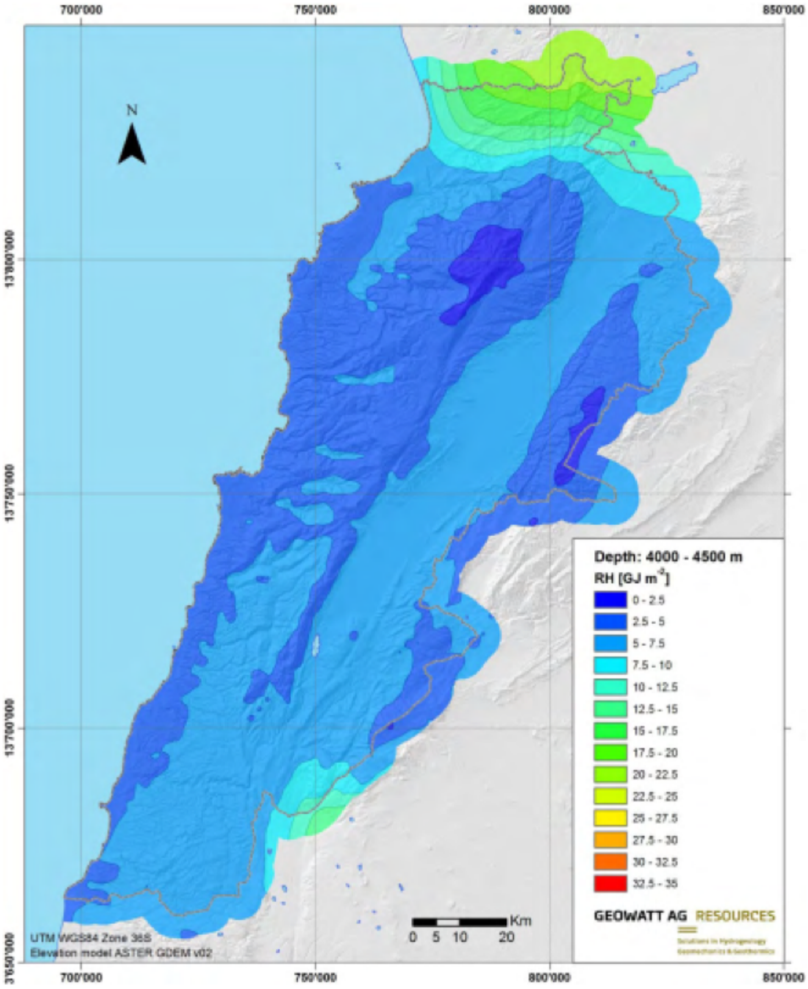

Figure 14. Recoverable heat for the depth interval 4,000-4,500 m

Even though the theoretical potential using hydrothermal technologies is about 12,000 GWh_{el}, it would require 2,000 power plants with 1.3 MW each to harvest this potential. In an optimistic scenario, however, only 5 power plants are assumed to be realistic, producing 30 GWh_{el} equaling some 0.2% of the Lebanese total energy demand, see Figure 15.

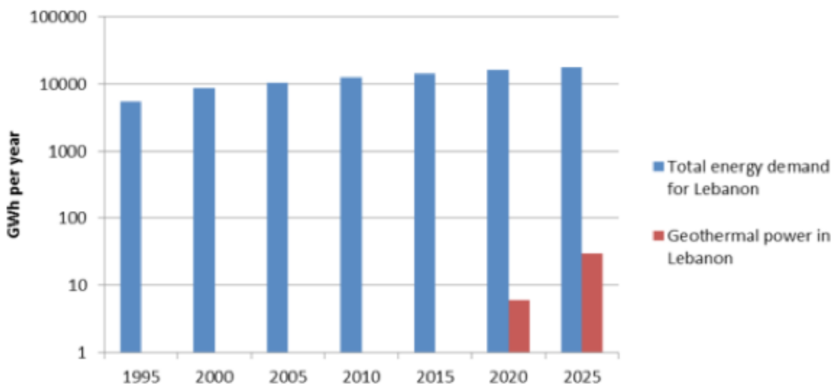

Figure 15. Comparison between the energy demand and the energy that could be produced by means of geothermal technologies by 2025. Note: See logarithmic scale (Source: MEW / UNDP-CEDRO 2014)

The report recommends improving the geological and structural information through further explorations in the Akkar region in the north.

For the purpose of the present project this means that for the next years even under optimistic assumptions there will not be a major deployment of geothermal power plants in Lebanon and consequently only a few jobs in this sector would be created, e.g. for planning and drilling; the equipment for geothermal power plants (heat exchanger, turbines, etc.) and further know-how would most likely have to be imported.

The resource potential for ground source heat pumps (GSHP) to produce heat or cooling for buildings or districts may be higher as it can be deployed basically anywhere where it is possible to drill without negatively affecting aquifers. However, the potentially has not been calculated yet for Lebanon.

In Europe a capacity of more than 20 GWth were deployed by 2015 through more than 1.7 million installations in Europe, mainly in Sweden, Germany, France, and Switzerland[8]. However, the installation growth rate in the shallow geothermal sector is declining due to costs of often drilling and unfavorable regulations; moreover, air source heat pumps are getting more and more efficient and are less costly. It is therefore not likely that this sector will develop quickly in the next years in Lebanon. Nevertheless, according to the Lebanese NREAP there are at least two important GSHP projects underway, the 1 MWth GSHP project at the Medrar Medical Center (for heating, cooling and hot water provision) and the Four Seasons Hotel in Beirut (for cooling). The shallow geothermal market is the largest market by far.

2.8. Value Chains Prioritized

Along this chapter, a total of eight value chains have been preliminary assessed in terms of direct and indirect effects to employment creation and considering a set of pre-established indicators that measured their technical, economic and institutional potentials. As a result of this assessment, a total of three value chains have been selected for further value chain analysis. The in-depth value chain assessment is presented in the following chapter of this report.

[8] *EGEC 2016 Market Report, https://www.egec.org/wp-content/uploads/2017/05/EGEC-Geothermal-Market-Report_KF_final_web.pdf*

The selection has been done considering the potential in terms of job creation, the potential of contributing to solutions for the challenges from the Lebanese energy system, and the feasibility in terms of realization potential. The three value chains selected for in-depth assessment are:

• **Solar Photovoltaic (PV).** Solar PV is already an established sector in Lebanon with a decent number of competitive private companies. However, the sector still has a large growth potential. This assumption is underpinned by the government's plans to upscale the installed capacity of this technology. Government's intentions are confirmed by the recent processes to sign Power Purchase Agreements (PPA) for the installation of large solar farms. Additionally, it is considered that solar PV can contribute towards the decentralization of power supply. The market trends show an increasing interest in the installation of this kind of facilities. Though value creation in the manufacturing of modules and cells seems to be better placed in Asia, all other aspects along the value chain look promising. For all these reasons, solar PV has been prioritized and selected for deeper assessment in this study, as a value chain with good opportunities for job creation in the future.

• **Wind Energy.** The wind energy sector is new in Lebanon. There are no previous experiences of wind farms in Lebanon. However, the government is currently in the final negotiation stages to sign PPAs with private developers for the installation of the first 200 Megawatt (MW) wind farm in the northern and mountainous district of Akkar. This process has been followed by an additional bidding process currently under evaluation to install additional capacity between 200 and 400 MW. In this context, wind energy has been selected for deeper assessment as it is deemed necessary to prepare the local workforce for these future developments.

• **Bioenergy.** Bioenergy has neither been developed extensively in the past in Lebanon nor has a privileged treatment in the government's long term plans. Nevertheless, bioenergy offers very good potential synergies with other sectors such as forestry, water treatment or waste management. That is why it was decided to select bionenergy for further assessment and specifically to narrow the focus to biomass (briquettes) and biogas.

Solar water heaters industries are the highest developed RE industry in Lebanon, as in several southern Mediterranean countries. The potential is large, the savings are immediate and the technology pays off rather quickly. However, this value chain has been discarded from the in-depth value chain analysis, because the sector is considered to be mature enough to not require large efforts in its promotion. However, it has been used as a benchmark for the other value chains, be it to illustrate certain effects or simply as an example.

The other value chains assessed, namely energy efficiency, Solar CSP, Hydropower, and Geothermal energy are considered to be very relevant for Lebanon, but have not been considered for this first in-depth analysis for different reasons.

3. Methodology

How much value do RE technologies create? Where is this value creation allocated in the economy?

The methodology of the assessment of employment from renewable energy has been developed over the past years and the consensus about the methods of choice is rather high. Renewable energy not only differs in terms of environmental impacts from conventional energy, also the economic impacts follow different economic channels. While conventional energy generation, especially from fossil fuels involves large mining activities, the fuel from wind, solar and hydro energy sources requires "harvesting instead of mining". The fuel as such does not require any economic activity in most of the cases. Labor on the other hand is necessary to build, operate and maintain the renewable energy system. Since the labor statistics as well as the further statistics on the energy sectors are developed from energy generation perspective which is dominated by conventional fuels, the economic impacts from renewable energy expansion often require additional calculation, ideally based on primary statistics and surveys.

However, surveys are time consuming and costly. Therefore, the scientific community developed methods to deduct and transfer information from existing studies to new estimates. International agencies such as IRENA or the ILO as well as NGOs such as Greenpeace contributed to the comprehensive picture of jobs estimates in relation to green energy, energy efficiency and green jobs in total. For the policy maker, past successes are as relevant and interesting as forecasts of future developments. Any estimation method suggested needs to work for both time horizons, the past and the future. By and large, the data situation for renewable energy installations, potential and employment is rather good.

The literature on employment in renewables often distinguishes direct and indirect employment. The underlying economic concept is that any product, such as PV cells, is produced by people working directly in a cell factory and at the same time causes production in those economic sectors, which produce the necessary materials for the cell factory. Therefore, total additional employment from an additional solar PV module comprises jobs in the cell factories (direct jobs) and jobs in the silicon industry, in the metal shaping industry, in the cable industry etc. (indirect jobs).

The relation between direct and indirect jobs depends on the development level of the respective industry. If the industry is domestically integrated, i.e. most intermediate goods are also domestically produced, typically as many indirect jobs are caused by production as direct jobs are accounted for. If most inputs are imported, the relative factor is much smaller.

For the different phases of the value chain, the following definitions of direct and indirect jobs hold:

• **Manufacturing:** direct jobs are found in the production of electricity or heat generating system itself be it turbines, PV modules, solar water heaters, efficient pumps or improved windows. Indirect jobs are connected to all intermediate goods used in the production of the above.

• **Construction and installation:** Direct jobs are in the construction works, such as digging, building of a dam (hydro), masonry, concrete works, piping, buildings for the operation, buildings for storage etc., and indirect jobs are in the manufacturing of building materials or building machinery. Jobs in planning and design of the wind farm, the solar field or the efficient building can be considered direct or indirect. The modeling tool used in this project considers them as direct jobs in installation.

• **Operation and maintenance:** Direct jobs are in controlling the performance, bookkeeping, accounting, cleaning, repairs, replacements, greasing, etc. and indirect jobs are in the production of replacement parts, greasing material, computers etc.

3.1. Measuring direct jobs

Employment factors are used to measure the number of jobs created per unit of produced product or service. They are often applied to estimate employment in the energy sector. The measure is usually job per capacity installed expressed in physical units, such as megawatt for electricity generating technologies (MW) or heat producing technologies (MWth), or square meter of solar water heater panel surface. For renewable energy fuels they may be expressed in jobs per million liters of production or in jobs per petajoule (i.e., by unit of energy content). The data for calculating employment factors can in principle be derived from a number of sources. These might include data from a broad industry survey; from specific enterprises or projects; from feasibility studies and technical literature specifications (Breitschopf, Nathani and Resch, 2011).

Surveys and inventories can provide a simple and effective way of assessing how many jobs related to RE and EE activities exist in specific sectors, regions or countries. A survey is usually carried out in the form of a questionnaire sent out to relevant companies, government departments or analysts, whilst an inventory commonly draws on a national or regional database to provide employment statistics. Some of these studies are comprehensive and relevant, whilst others only offer a snapshot, or 'scale-up' a more limited review so that it can provide an estimate of RE&EE jobs for a whole country or region. Inventories and surveys, if repeated consistently over a prolonged period, can also provide a useful measure of the extent of the new employment triggered by RE&EE policies.

Figure 16. Value chain phases[9]
(Source: Own graph)

[9] *In principle, the value chain comprises decommissioning and recycling, too. However, most systems will not enter this phase within the timeline of this analysis. Moreover, no data are available for this phase as of yet.*

Employment factors differ along the value chain: construction and installation is usually more labor intensive than manufacturing or operation and maintenance (O&M). Each phase has its own basic employment factor in terms of Jobs/Physical Unit. Each phase has a different relevant reference amount. In construction and installation new capacities over the building time of a new installation are relevant, in manufacturing, the amount of turbines and generators produced in a country drives employment and for the operation and maintenance phase, total capacity installed is the important input.

Countries differ in their economic structure, their capabilities as well as the speed and size of the economic development. Therefore, several authors suggested adjustment with regional factors for productivity, economic development and different stages of the value chain. Rutovitz and Harris (2015) suggested one of the most comprehensive approaches. Regional adjustment is based on relative productivity measured by GDP/employment; individual factors hold for installation, manufacturing and O&M and shares of local manufacturing are set.

Lehr, Walter and Nieters (2017), suggest a method of regionalization for the calculation of global employment from large hydro power plants. They take country specific adjustment with labor intensities for construction, manufacturing, machinery and electronics into account. Further, the authors take the building time of the power plants into consideration and adjust it for own production versus imports and exports. International trade data are used for the latter adjustment.

The main equations to calculate RE employment from this approach are the following:

$$jobs_{country,phase,year} = EF_{country,phase,year} * relevant\ MW_{country,phase,year} \tag{1}$$

with

$$EF_{country,phase,year} = \frac{\left(\frac{jobs}{output}\right)_{country,phase,year}}{\left(\frac{jobs}{output}\right)_{US,phase,year}} * EF_{US,phase,year} \tag{2}$$

“Phase” in equation 1 and equation 2 denotes the phase of the value chain, i.e. phase in {manufacturing, installation, O&M}.

Any country can serve as the benchmark country – preferably one with several and recent values obtained in a transparent method. The employment factors for large hydro for United States, which serve as a starting point for the analysis in Lehr, Walter and Nieters (2017), are 6 jobs/MW for installation, 1.5 jobs/MW for manufacturing and 0.3 jobs/MW for O&M in the year 2012. EFs are higher before and lower after 2012, both due to productivity growth. By assumption, productivity grows by the same amount as in the respective economic sector. Any country can serve as reference as long as the following conditions are met:

- Literature value obtained with thorough methodology for each value chain phase;
- Data available on each economic sector of interest for all years of interest to base the calibration upon.

"Country" in the equations above denotes the country where the large hydro power plant or pumped storage is located. "Sector" denotes the sector used for calibration. To transfer employment factors from one country to another, relative labor intensities from international statistics in selected sectors (see equation 2) are used. For instance, wind turbine installation in OECD leads to 3.2 jobs/MW while in Egypt it leads to 0.7 jobs/MW. For the installation phase, the authors apply relative labor intensities from the construction sector. The manufacturing phase reflects relative labor intensities in the machinery sector and O&M for most countries reflects relative labor intensities in the aggregated manufacturing sector (for more details on O&M see below).

Table 17. OECD employment factors

	Construction time	Construction/ Installation	Manufacturing	Operations & Maintenance
	Years	*Jobs/MW*	*Jobs/MW*	*Jobs/MW*
Biomass	2	14.0	2.9	1.5
Hydro-large	2	7.4	3.5	0.2
Hydro-small	2	15.8	10.9	4.9
Wind onshore	2	3.2	4.7	0.3
Wind offshore	4	8.0	15.6	0.2
Solar Photovoltaic	1	13.0	6.7	0.7
Geothermal	2	6.8	3.9	0.4
Solar thermal	2	8.0	4.0	0.6
Ocean	2	10.2	10.2	0.6
Geothermal - heat		6.9 jobs/ MW (construction and manufacturing)		

(Source: Rutovitz et al -2015)

The "relevant MW" denotes the physical base of the respective calculation in the different phases along the value chain. For O&M, the relevant base is the capacity installed; installation refers to an even distribution of all installations over an installation time of four years; manufacturing refers to domestic production of all turbines, generators and transformers including production for exports.

3.2. Measuring indirect effects

The estimate of indirect effects is based upon the renowned economic analysis tool of **Input-Output-Tables.** It covers indirect effects throughout the economy, such as deliveries of all economic sectors to installation, production and operation of RE. The ILO recommends the use of IO tables in its Green Jobs training program[10] which explicitly mentions renewable energy job assessments as one example for this approach. The feasibility of the approach hinges on the availability of the respective statistical data. For Lebanon, up-to-date Input-Output-Tables of good quality exist.

[10] *http://www.ilo.org/global/topics/green-jobs/lang--en/index.htm*

Economic sectors produce goods and services for other sectors and for final consumption and, at the same time, use other goods and services to be able to produce goods and services. The idea of grouping these kinds of input-output flows in a systematic and symmetric table goes back to Wassily Leontief who was awarded with the Nobel Prize in economics in 1973. Input-output tables provide information about the production and consumption of intermediate and final goods and disclose the cost structure of each economic sector. Input-output tables capture the circulation of products within an economy for a given period. They condense the complexity of economic action with all its effects, counter-effects, actions and re-actions. They also allow distinguishing between direct and indirect dependences of and between different sectors. Table 18 gives an example for an economy with the three sectors agriculture, manufacturing and services.

Table 18: Numerical example: IO table with 3 sectors

		Intermediate demand					
		Agriculture	Manufacturing	Services	Total	Final demand	Production
Intermediate Input	Agriculture	10	5	5	20	20	40
	Manufacturing	5	10	2	17	10	27
	Services	5	2	15	22	19	41
	Total	20	17	22	59	49	108
Value added		20	10	19			
Production		40	27	41			

(Source: Own graph)

The rows show the demand for goods in monetary units which are needed for the production process of another product, and as a final product for consumption. For instance, agriculture supplies agriculture goods to agriculture, in terms of seeds, fodder, or fertilizer. It further supplies agricultural products to the food industry or to the energy sector in terms of inputs to bio-energy, which both are included in manufacturing in the above example. Agricultural products are also directly used by private households or are produced for being exported. The sum of demand for intermediary inputs plus final demand equals final production, in the above example this is 40 units for the agriculture sector, 27 units for the manufacturing sector and 41 units for the service sector.

The columns represent the cost structures of production and services: each production sector needs a different combination of inputs to be able to produce. Again, taking agriculture as an example, the column denotes the inputs from different sectors such as energy, chemical industry (fertilizers), automotive (trucks and tractors), agriculture (seeds and manure) aggregated in Table 18 into manufacturing, which are necessary for agricultural production. Adding primary inputs such as cost of depreciation, labor compensation or taxes, results in total production by sectors. One important feature of this table is that the sums along the rows equal the sums along the columns. This feature has to be maintained no matter how the table is manipulated.

This framework serves as an information tool (who delivers what to whom?) and it can be employed for the analysis of output changes in all economic sectors in reaction to a demand change in a certain sector. Leontief developed an analytical set of equations, which relate total output to the sum of each sectors individual demand and final demand by consumers and government. If for instance the demand for agricultural goods doubles, agriculture has to buy more fertilizer, more machines etc. therefore, the additional demand for agricultural goods creates multiplier effects throughout the economy and throughout the labor market.

How can this framework be applied to the calculation of indirect jobs from renewable energy deployment? The manufacturing, installation, and operation of renewable energy technologies are cross-cutting economic activities, which involve several economic sectors and need inputs from several economic sectors. This led to the development of RE-technology specific input vectors, which are compatible in their classification with the European standard classification system NACE[11]. From these vectors, we know how additional installations of PV modules translate into additional demand in all economic sectors and into additional employment. The chain of effects is: PV installation needs cable, legal advice, planning and metal products. The production of cable, however, needs metal, plastic, legal advice and dyes. Therefore, from the installation of PV modules, we find additional employment for installers, for cable producers, for metal producers, for dye producers and for lawyers. The Input-output framework allows us to identify and calculate these effects for each phase of the value chain.

3.3. Adjustment of the relevant factors to Lebanon

The calculation of direct and indirect employment from renewable energy is based upon technology specific data and economic data. The technology specific data, such as employment factors, cost structures etc. are adjusted to the Lebanese economic capabilities and economic structure. They are described in more detail in the respective following chapters. The economic data, especially information on employment and the input output tables are taken from the EORA database[12]. The data are in the NACE economic sector classification, which is the European correspondence of the International Standard Industrial Classification of All Economic Activities. The sectors are aggregated, which makes the results sometimes puzzling. The following table gives an overview of the economic sectors reported and the goods and services provided by these sectors.

[11] *http://ec.europa.eu/eurostat/ramon/nomenclatures/index.cfm?TargetUrl=LST_CLS_DLD&StrNom=NACE_REV2&StrLanguageCode=EN&StrLayoutCode=HIERARCHIC*

[12] *Lenzen, M., Kanemoto, K., Moran, D., Geschke, A. Mapping the Structure of the World Economy (2012). Env. Sci. Tech. 46(15) pp 8374-8381. DOI:10.1021/es300171x*

Lenzen, M., Moran, D., Kanemoto, K., Geschke, A. (2013) Building Eora: A Global Multi-regional Input-Output Database at High Country and Sector Reso lution, Economic Systems Research, 25:1, 20-49, DOI:10.1080/09535314.2013.769 938

Table 19. Overview of the sector classification of the most relevant economic sectors for renewable energy impact analysis

SECTOR	DESCRIPTION
Financial Intermediation and Business Activities	• Financial service activities, except insurance and pension funding - E.g. monetary intermediation, activities of holding companies, trusts and funds, ... • Insurance, reinsurance and pension funding, except compulsory social security • Activities auxiliary to financial services and insurance activities • Real estate activities • Legal and accounting activities • Activities of head offices; management consultancy activities • Architectural and engineering activities; technical testing and analysis • Scientific research and development • Advertising and market research • Other professional, scientific and technical activities - E.g. photography, translating, ... • Rental and leasing activities • Services to buildings and landscape activities • Office administrative, office support and other business support activities
Construction	• Construction of buildings • Civil engineering - E.g. roads and highways, bridges and tunnels, utility projects, ... • Specialised construction activities - E.g. demolition and site preparation, electrical and other construction installation activities, ...
Wholesale Trade	• Wholesale trade, except of motor vehicles and motorcycles - E.g. wholesale of fuels, ores, metals and industrial chemicals, timber and building materials, machinery and industrial equipment, information and communication equipment ...)
Metal Products	• Manufacture of basic metals - E.g. iron, steel, aluminium, copper, lead, zinc, ... • Manufacture of fabricated metal products, except machinery and equipment - E.g. containers, steam generators, locks and hinges, tools, ...
Transport	• Transporting and storage - E.g. freight rail transport, ...
Transport Equipment	• Manufacture of motor vehicles, trailers and semi-trailers • Manufacture of other transport equipment - E.g. building of ships and boars, railway locomotives, ...
Retail Trade	• Retail trade, except of motor vehicles and motorcycles - E.g. retail sale of information and communication equipment, automotive fuel, ...
Maintenance and Repair	• Repair and installation of machinery and equipment - E.g. Repair of electronic and optical equipment, ...
Petroleum, Chemical and Non-Metallic Mineral Products	• Manufacture of coke and refined petroleum products • Manufacture of chemicals and chemical products • Manufacture of basic pharmaceutical products and pharmaceutical preparations • Manufacture of rubber and plastic products • Manufacture of other non-metallic mineral products - E.g. glass, clay building materials, porcelain/ceramic, cement, ...
Education, Health and other Services	• Education • Human health activities • Residential care activities • Social work activities without accommodation • Creative, arts and entertainment activities • Libraries, archives, museums and other cultural activities

4.
Value Chain Assessment

4.1. Introduction

The analysis of employment from renewable energy deployment in this section is organized as follows. Direct and indirect employment from the three RE technologies selected in Chapter 2 solar photovoltaic, wind energy and biogas for electricity generation is calculated using the method described in chapter 3. Earlier analyses (UNDP-CEDRO, 2015) did a jobs estimate for each of these technologies, too. The numbers there seem high in the light of today's knowledge about the development of the sector. Moreover, the data situation did not allow distinguishing between indirect jobs and direct jobs.

Therefore, each technology section describes the deployment and cost development over the last three to five years, i.e. globally and in Lebanon if possible with regard to the respective technology. Important aspects such as global installations, global cost development, and developments in the value chains, technology improvement and regional developments in RE are reflected.

The only technology which is already installed in Lebanon beyond pilot projects is PV. For this reason, the PV section includes an analysis of employment generated by the installations and the operation and maintenance of these installations until today.

Since wind energy and bioenergy are at a very early stage, there is no ex-post analysis possible. For the future development, we assume two scenarios for each technology. The next section describes these scenarios and compares them to Lebanon's strategy and plans.

Employment under these scenarios is calculated for each phase of the value chain, i.e. installation, manufacturing and O&M. The dismantling/decommissioning phase will approach at the end of the life cycle of a RE system, roughly after 20 years. This exceeds the horizon of the analysis, for which reason it is not considered in the following.

4.2. Scenarios

The future development of renewable energy in Lebanon seems to be at a gateway. If the original targets from the NREAP are fulfilled, Lebanon follows a conservative approach. Currently, signs point to the possibility of a more ambitious plan, be it from the PPA of 200MW wind energy in the north or from ambitious announcements regarding PV by the Ministry of Energy and Water (MOEW) and National Plans of the Government of Lebanon. The assessment has considered two scenarios, Optimistic and Conservative according to the following table.

Table 20. Installed capacities considered under each of the two scenarios.

	Cumulative Capacity (MW):			
	2018	2019	2020	2021
SCENARIO A: Optimistic				
SOLAR	73	283	738	1198
Large Solar	*0*	180	*450*	*720*
Large Solar with Storage	*0*	*0*	*150*	*300*
Distributed Solar	*73*	*103*	*138*	*178*
WIND	0	0	200	500
BIO	0	3	6	9
Total	73	286	944	1707
SCENARIO B: Conservative				
SOLAR	61	80	280	599
Large Solar	*0*	*0*	*180*	*180*
Large Solar with Storage	*0*	*0*	*0*	*300*
Distributed Solar	*61*	*80*	*100*	*119*
WIND	0	0	200	200
BIO	0	3	6	9
Total	61	83	486	808

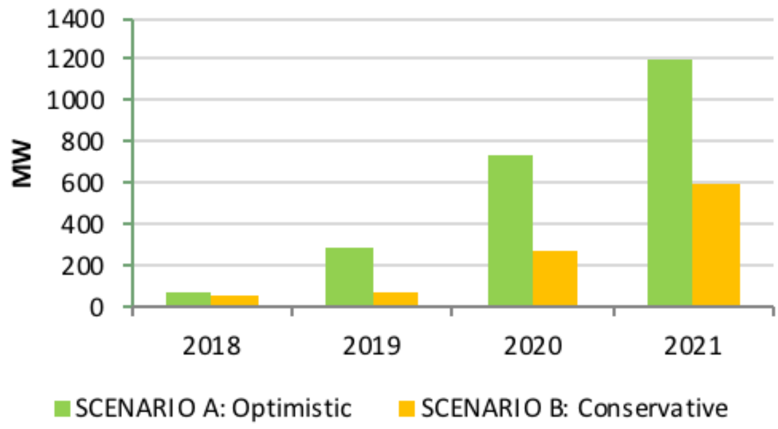

Figure 17. Cumulative installed capacity for solar PV according for each scenario.

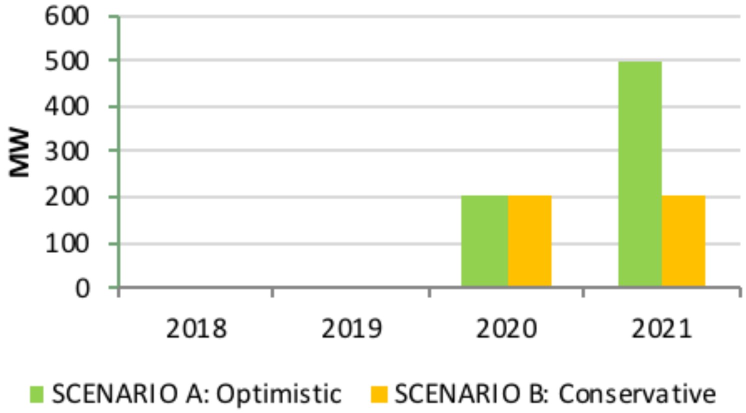

Figure 18. Cumulative installed capacity for solar wind according for each scenario.

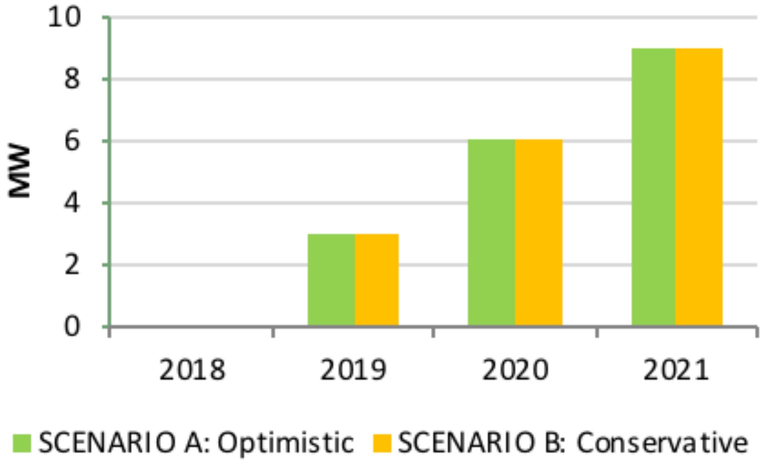

Figure 19. Cumulative installed capacity for solar bio according for each scenario.

Until 2021, more than 800 MW will be installed under the conservative scenario, from wind energy, PV and biogas. Under the optimistic scenario, this number more than doubles to 1,707 MW. The differences between the scenarios lie in size as well as in speed. The optimistic scenario shows installations at higher levels, and earlier.

4.3. Solar PV

4.3.1. Latest developments

4.3.1.1. PV cost development

The data used in UNDP-CEDRO 2015 rely to a large extend on ERC (2010), which is based upon the development until 2009. In particular in the PV sector, the development of prices, capacities installed, main installers and main manufacturers has seen large changes globally.

It is important to understand some of these changes to put the value creation in PV in Lebanon and employment opportunities along the value chain for Lebanese workers into the right perspective. The most relevant development in the solar sector over the last ten years is the drastic decrease in prices. While in 2008 the module prices per Watt peak (Wp) were around 4$/Wp, today we are looking at less than 0.4 $/Wp (pv-exchange.com) per module. System prices also fell, although the price decrease in Balance of System (BOS) elements such as mounting, frames etc. did not decrease as rapidly as the prices for modules and cells. Figure 20 shows the average price development of these two components. While module costs made up 71% of the more than 4,500€/kWp costs of a 2006 module, by 2013 they accounted for less than 50% of the (at this point in time) less than 1,500€/kWp costs of a PV system. In the present, prices for solar PV systems (without batteries) fell to between $700 and $1000 per kWp, all inclusive.

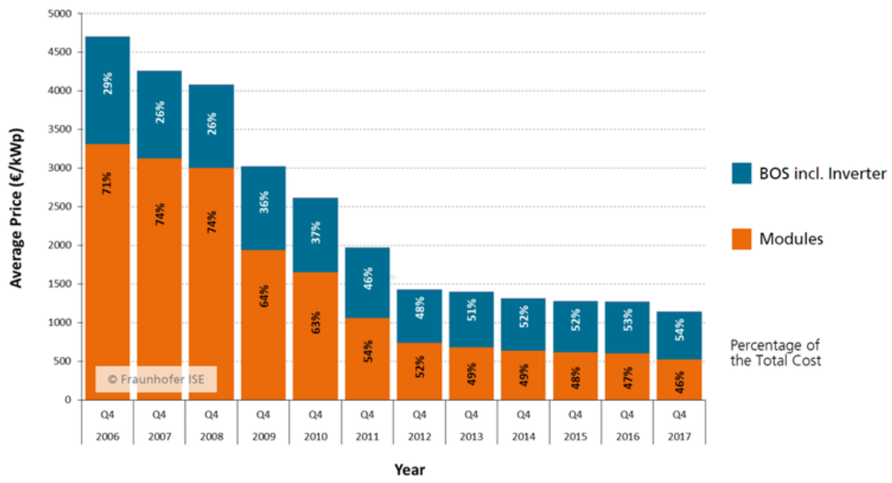

Figure 20. Price development – modules and system costs (Source: Fraunhofer ISE 2017)

This development goes largely back to the tremendous market development since2010 (Figure 21). Global capacity today is ten times as much as ten years ago. In the year 2016, the world installed more in one year, than global installations cumulated amounted to in 2011. The renewable energy network REN21 found that during 2016 at least 75 GW of solar PV capacity was added worldwide (equivalent to the installation of more than 31,000 solar panels every hour).

The market development had started in Europe and today has shifted to Asia and America in the recent years. China installed for the first year in a row the bulk of global new installations with almost 35 GW. The US saw new installations of 14.7 GW followed by Japan with 7.9 GW. In the EU, new installations continued their downward trend from 8.6 GW in 2015 to 6.9 GW in 2016. In Germany, one of the leading installers in the first decade of the century, installations stagnate around 1.5 GW, even below the targeted corridor.

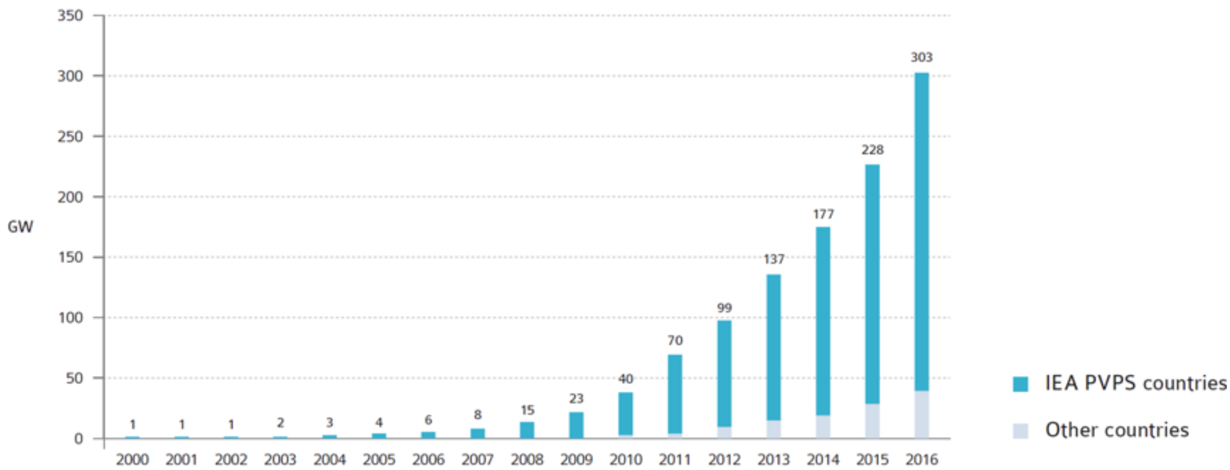

Figure 21. Evolution of global cumulative capacity installations (GW) (Source: IEA PVPS)

In the Middle East (IEA PVPS 2017) several projects are granted to super competitive tenders in Jordan or the UAE, which might point at the MENA region on the verge of becoming a new focal point for PV development. Jordan installed more than 150 MW Algeria installed 268 MW in 2015 and 54 MW in 2016.

The radiation potential in this region is very high. For this reason, winning bids in tenders in the United Arab Emirates (Dubai and Abu Dhabi) and Jordan offered extremely low price levels below 0,03 USD/KWh. Dubai plans to install 1GW in the coming years. Jordan at one time announced 200 MW, then that it aimed for at least 1 GW of PV in 2030 (IEA-PVPS 2017). Saudi Arabia launched a tender in 2017 and announced a 200GW installation over the next years. These activities spill over to Lebanon and affect prices, learning rates and employment opportunities.

4.3.1.2. Employment factor development

Large installations give rise to large production facilities and economies of scale. Today, the largest producers are found in Asia and the PV producing industry has matured into large scale industrial production. While in 2010 cell production and module production firms had an annual output of 200-300 MW, today's companies are producing 1.8-2 GW per year. The production capacity of the Chinese module production is 79 GW per year, which covers global additional installations. Direct employment in manufacturing mostly matters in China, although several countries entertain small scale manufacturing. This development changed the input structure of PV in the input-output framework: while manufacturing is largely automated, employment is small in the PV manufacturing sector. Employment opportunities shift more and more towards installation of distributed and utility scale solar fields.

Table 21. Overview of Employment Factors for PV, Full-Time-Employment (FTE)[13] per MW installed

	Construction / Installation	Manufacturing	Operations & Maintenance
2010	29.0	9.3	0.4
2012	13.0	6.7	0.7
2015	11.0	6.9	0.3

(Source: J. Rutovitz with different co-authors -2010, 2012, 2015)

Data provided in Table 21 reflect the results of industry surveys conducted in different years. Depending on the type of installation (distrributed or utility scale), the productivity of the country which installed most PV systems in the respective year, as well as other regional factors, the values change. The employment factor for operation and maintenance increased in 2012, because more utility scale systems were installed and O&M went through a learning curve, which led to the lower factor in 2015. Manufacturing is dominated by large scale mass production, but recent development in the fields of Passivated Emitter Rear Cells (PERC) or Copper Indium Gallium Selenide solar cells (CIGS) have led to manufacturing in smaller production units with a slightly higher employment factor.

[13] *FTE: full time employment equivalent is the amount of work one person does if working on the respective task for one year with 100% of her or his activity.*

In the analysis of employment from installation in Lebanon, we use the employment factors from Table 21 for the installation phase and the O&M phase. For the future simulation, we allow for productivity increases.

4.3.1.3. Batteries

From the wide range of energy storage technologies, typically Lithium-Ion batteries, Sodium, Zinc, Flow batteries or Lead-Acid batteries are combined with PV modules in solar home system applications. All of them have a similar life expectancy that ranges from 5 to 15 years (Lazard 2015) and mostly differ in performance, ability to operate in partly charged states, ease of manufacturing, and price. The underlying principle, however, is the same. PV-battery systems can potentially replace diesel generators as a back-up systems, and will further help to defer grid investments once larger amounts of RE are fed into the grid.

The battery production value chain comprises several steps. Currently, most battery production is located in Asia while countries strong in the automotive sector discuss increasing battery production for the transition to e-mobility. For Lebanese applications, batteries will most likely be imported, but the controls, the adaptation to Lebanese needs and the design of PV battery systems is partly domestic value creation.

4.3.2. Data and model assumptions

The modeling approach is described in the methodology section. It consists of determining direct employment from multiplication of employment factors with capacities installed and maintained, and indirect employment from crosscutting demand for intermediate goods necessary for the installation and operation of PV systems in all economic sectors. The modeling approach requires data on:

1. capacities installed
2. employment factors
3. installation costs and investment
4. cost structures
5. economic Input-Output data
6. economic sector output and employment

The results are given for the three value chain phases “Manufacturing”, “Installations” and “Operation and Maintenance (O&M)” individually in 4.3.3. Results.

The data base for capacities (1) installed is taken from the data and reports provided by MOEW/LCEC, as well as the Solar PV Status Report for Lebanon.

In terms of installations, the current status is at 22.5 MW and the 100 MW target for 2020 will be over accomplished according to all national experts.

Table 22. PV annual additional installation in MW

	2012	2013	2014	2015	2016	2017
PV off-grid (MW)	0.01	0.17	0.41	1.66	1.93	1.44
PV on-grid (MW)	0.06	0.68	1.63	6.63	7.71	5.78

(Source: Own compilation from MOEW/LCEC 2017)

Employment factors (2) are taken from the literature such as Table 21 above. Total investment (3) in 2016 amounted to $23.84 million, compared to $16.23 million in 2015. Nearly 60% of investment fell under the NEEREA loan program.

Installation cost per kWp was $2,709 in 2015 and fell to $1,875 in 2016. However, the installations reported for 2016 must have been bought at 2015 prices, otherwise reported investment does not match. Therefore, the analysis sets prices for 2015 and 2016 at the $2,709 level and the Lebanese price decrease becomes relevant in the market in the year 2017.

The installation of PV modules triggers demand across different sectors, and this gives rise to indirect effects. The structure and size of these demands are given by the cost structure. Since PV is a new technology, cost structures are the same around the world. The cost structure shown in Figure 22 is the result of a large industry survey (Lehr et al. 2015). The structure shows the shares of the production of wires or mounting frames, lawyers, importers, trade etc. participate for the installation phase. Figure 22 shows the structure of this triggered demands in the installation phase.

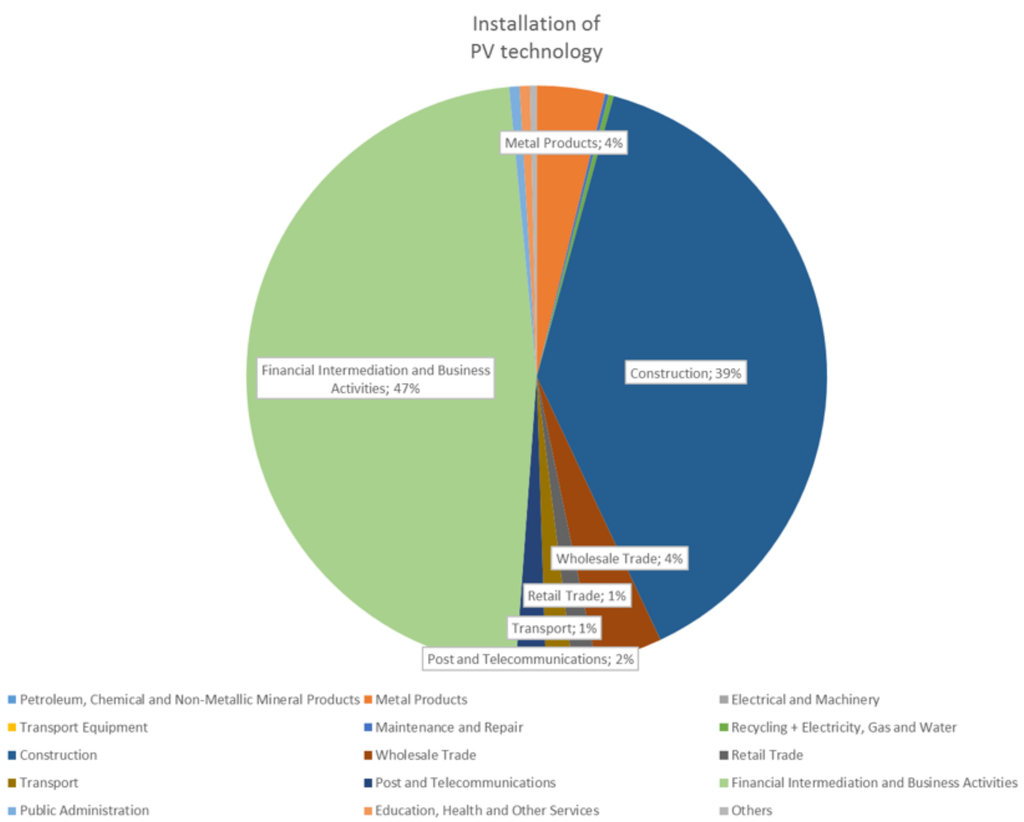

Figure 22. Cost structure for PV installation phase
(Source: Lehr et al. 2015)

The installation costs are dominated by financing, admission, legal services, consultation and planning (colored in green in the cart above, and accounting for 47% of the total) and construction (dark blue, 39%) activities. The next sectors by relevance are trade and metal products, each with 4%. While inputs from the first three sectors are 100% domestic, in the case of the metal products it can be assumed that imports take place to different degrees.

The manufacturing phase is currently not relevant in Lebanon and there are no plans to change this. All cells and modules are imported and will be imported in the future. **Operation and Maintenance** costs are very small for PV installations. They are considered to be significant only for utility scale installations. Operation and maintenance has a different structure, since the construction sector is not important in this phase. The replacement of parts, sales of electricity if possible, management of loads, etc. become more relevant in this phase. For large installations, radiation prognosis, storage management if applicable and repairs are the dominant beneficiaries in this phase.

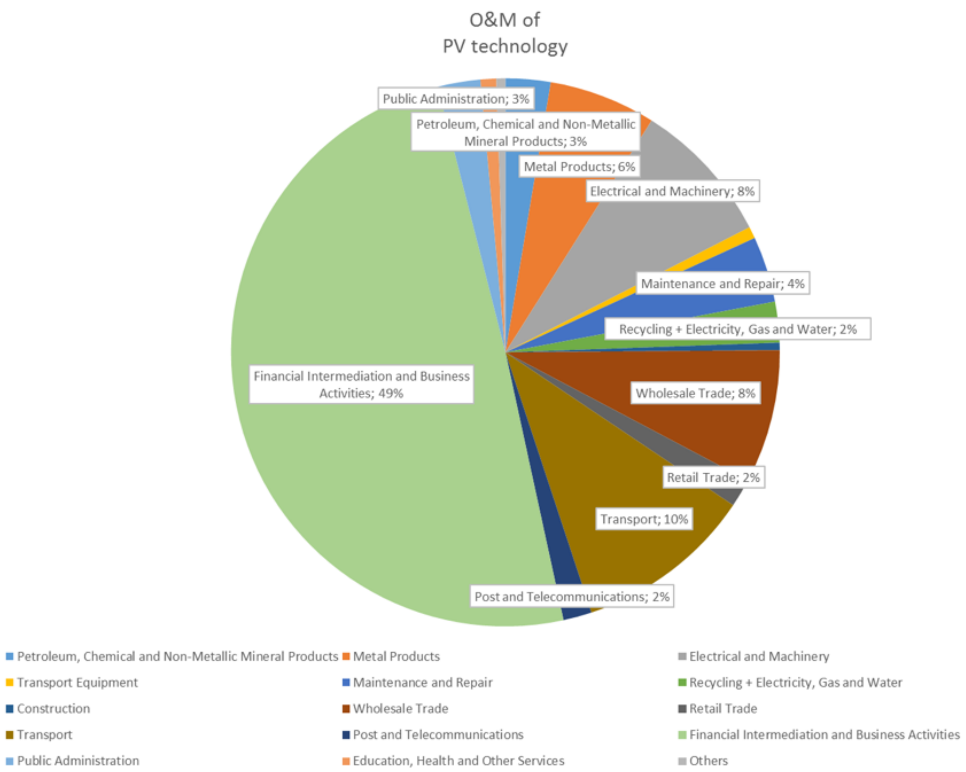

Figure 23. Cost structure for PV O&M phase
(Source: Lehr et al. 2015)

The Solar PV Status Report (2016) identifies 55 companies and at least 600 new jobs related to PV. The Lebanese companies cover importers, assemblers, designers, planners and installers of PV systems among others. From the interviews conducted during this project, the average salaries in direct jobs are known. Non-qualified staff can earn around $800, installers around $1,000 per month, while experienced engineers and technicians (more than 5 years) can earn from $2,000 to $3,000.

No data is available on the employment effects of battery installation. Assuming that the batteries will be imported, it has been considered appropriate to increase the employment factor for PV by 50% to account for the effects of battery storage.

The Input-Output Table (5) for Lebanon is taken from the large World MRIO database provided by EORA[14]. Output by economic sector (6) and contribution of the economic sectors to GDP are published by CAS and have been described in Section 1.3. The data on employment are scarce, as described in the same section.

4.3.3. Results

4.3.3.1. Current Employment

Considering an employment factor of 11 FTE/MW (Table 21) and the installation path given in the scenario description, we find direct jobs increasing to 360 jobs in 2017. The installation of small distributed units is almost twice as labor intensive (20.4 FTE/MW). The calculation assumes 20% of total installations to be of this category. Figure 24 gives an overview of the results for direct employment.

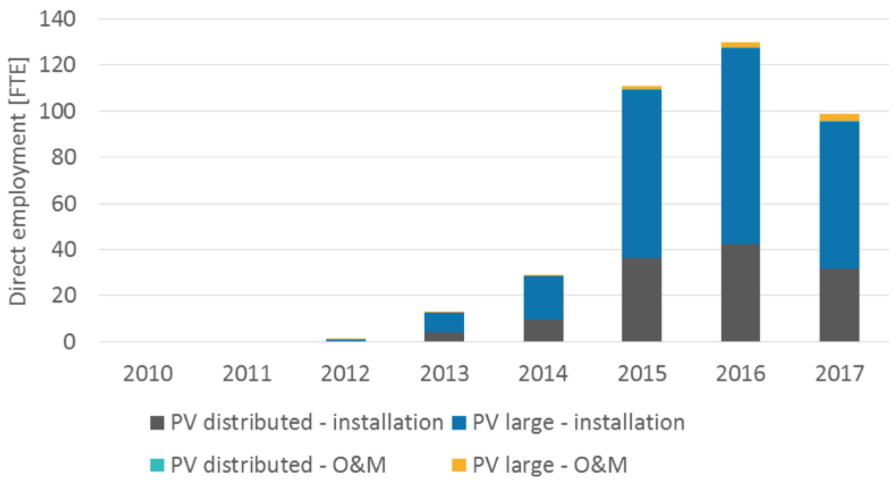

Figure 24. Direct employment PV 2010 - 2017
(Source: Own calculations)

This is, however, only the proverbial tip of the iceberg, because indirect jobs contribute the largest share of total employment. They are calculated with the approach described in the methodology chapter, i.e. from a combination of PV specific input structures and economy wide Input-Output tables. The demand for wiring, legal services etc. creates jobs in the respective economic sectors. Depending on the assumptions taken to estimate how much of this demand is covered by domestic employment, we find that indirect employment reaches 740 people in 2017. Total employment from PV therefore peaks under the most optimistic assumption at an estimated 1359 people in 2017. The assumption here is that Lebanon produces 60 % of the necessary input goods domestically. The identification of the value chains has shown that this is feasible.

[14] *Lenzen, M., Kanemoto, K., Moran, D., Geschke, A. Mapping the Structure of the World Economy (2012). Env. Sci. Tech. 46(15) pp 8374-8381. DOI:10.1021/es300171x*

Lenzen, M., Moran, D., Kanemoto, K., Geschke, A. (2013) Building Era: A Global Multi-regional Input-Output Database at High Country and Sector Reso lution, Economic Systems Research, 25:1, 20-49, DOI:10.1080/09535314.2013.769 938

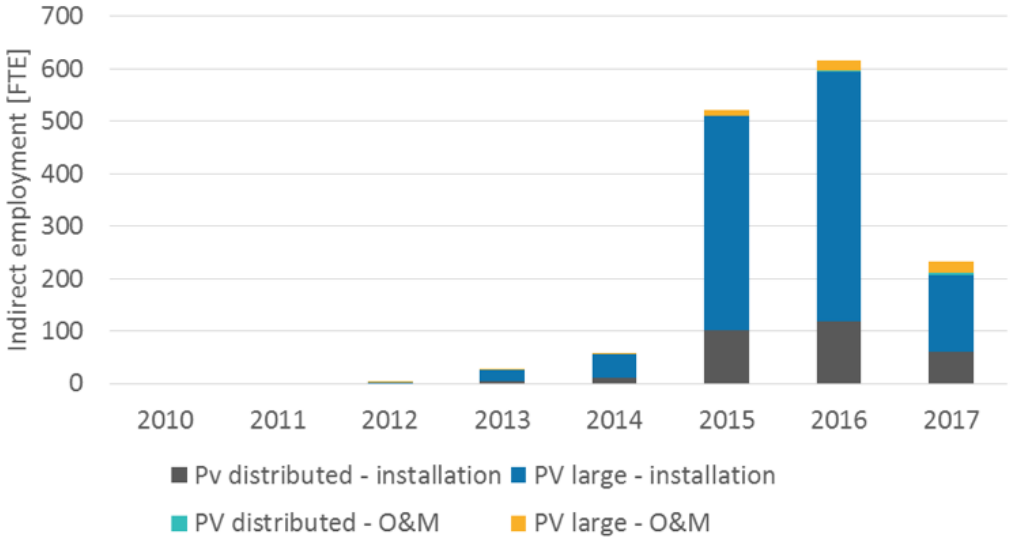

Figure 25. Indirect employment from PV 2011 – 2017 (Source: Own results)

4.3.3.2. Future employment

As outlined in section 4.2, for future development we consider an optimistic scenario and a conservative scenario. Firstly, we will provide the same graphs as in the ex-post analysis above for each scenario and then compare the scenarios. The results for the conservative scenario are shown next.

In **the conservative scenario,** total solar installations will amount to 309 MW by 2021. This leads to a total employment almost 11,700 jobs by 2021, with 2,820 direct jobs.

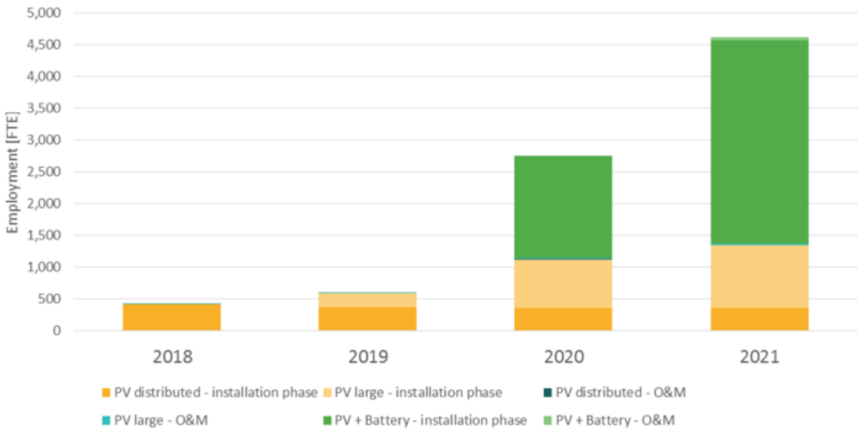

Figure 26. Direct employment from PV 2018 – 2021 under the conservative scenario (Source: Own results)

Employment is created through direct effects in installation and operation and maintenance (total 2820) and indirect effects along the value chain in the service sector, the construction sector, the metal industry, education on vocational and higher education level, whole sale and import as well as transport. The employment factors for the calculation of direct jobs are from international data (11 FTE/MW utility scale, 20.4 FTE/MW for distributed) and the Solar Industry Reports of Lebanon. In the short run of 4 years, we do not assume labor efficiency increases and the employment factors remain constant. Though the Solar Market Report does not report employment factors, we can deduct the magnitude from the fact that 600 jobs already exist in the respective companies.

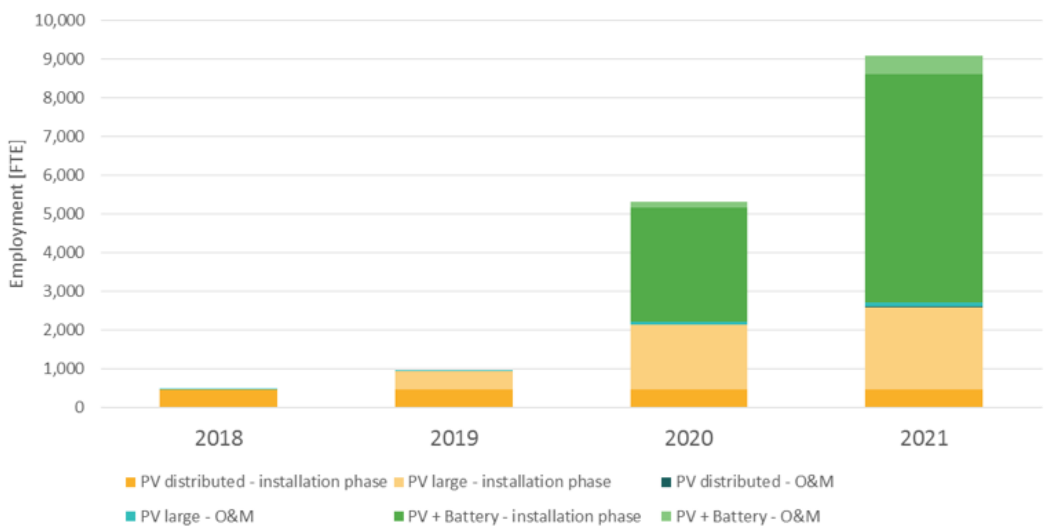

Figure 27. Indirect employment from PV under the conservative scenario 2018 – 2021 (Source: Own results)

Indirect employment amounts to more than 9,000 people by 2021 in the conservative scenario Figure 27. In particular battery combined large PV installations contribute to a lot of employment in the service sector, from planning and design to financial support, legal support, taxes etc. Training for the installation is required, as well as for operation and maintenance (for a more detailed set of suggestions, see 5. Strategic Action Plan). In the optimistic scenario, 18,894 jobs are created from PV installations by 2021. Next table gives an overview of the direct and indirect jobs in each scenario and each value chain phase.

Table 23. Employment from PV scenario overview

	2018	2019	2020	2021
SCENARIO A: Optimistic				
DIRECT EMPLOYMENT	**556**	**2.606**	**6.115**	**6.267**
Installation	*550*	*2.574*	*6.025*	*6.118*
Operation & Maintenance	*6*	*32*	*90*	*149*
INDIRECT EMPLOYMENT	**641**	**5,114**	**12,202**	**12,627**
Installation	*609*	*4,987*	*11,707*	*11,763*
Operation & Maintenance	*32*	*127*	*496*	*864*
TOTAL EMPLOYMENT	**1,197**	**7,720**	**18,317**	**18,894**
SCENARIO B: Conservative				
DIRECT EMPLOYMENT	**423**	**606**	**2759**	**4,619**
Installation	*418*	*596*	*2725*	*4,545*
Operation & Maintenance	*5*	*10*	*34*	*73*
INDIRECT EMPLOYMENT	**493**	**971**	**5,313**	**9,073**
Installation	*463*	*926*	*5,077*	*8,485*
Operation & Maintenance	*30*	*45*	*236*	*588*
TOTAL EMPLOYMENT	**917**	**1,577**	**8,072**	**13,692**
DIFFERENCE				
TOTAL EMPLOYMENT DIFFERENCE	**280**	**6,143**	**10,246**	**5,202**

(Source: Own calculation)

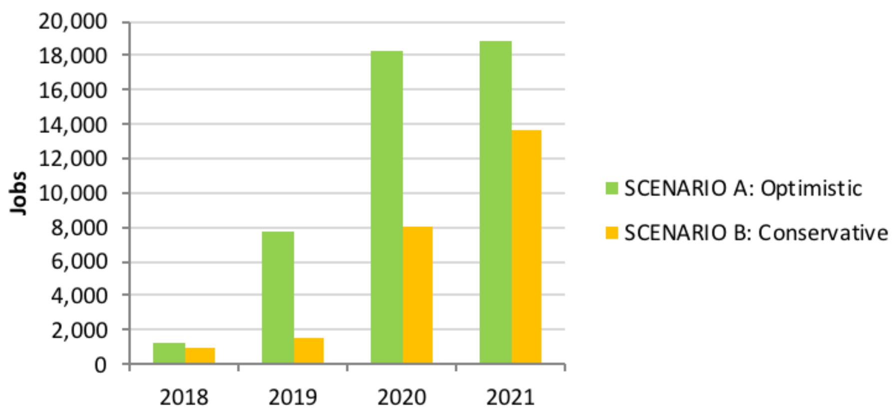

Figure 28. Employment from PV sector overview.
(Source: Own calculation)

Table 23 shows how indirect effects are much larger than direct employment. This is the added insight from the full value chain analysis. Over time, more integration will take place and more and more value can be created domestically, especially if the proper incentives and the right support are provided.

If we compare the two scenarios, we find that battery storage gives a large impact to employment under each scenario. Small installations and large installations are much larger in the optimistic scenario, hence the larger impact on jobs. The investment in the optimistic scenario starts earlier and takes off faster.

The sector structure of the indirect effects is taken as mainly constant over the coming four years. However, as more installations are carried out, training activities pick up in terms of relevance and more jobs are created in the vocational training sector. The structure of indirect employment obtained as a result from the structural model and IO analysis is shown for the conservative scenario and the year 2021 in Figure 29. The bars do not necessarily add up to the full sum of 9,073 due to rounding effects. Note that these are modeling results, meaning that number below 10 should be read as "numbers below 10", and not be taken as an exact prediction. However, the structure of economic sectors benefitting from PV deployment reflects the characteristics of the Lebanese economy and the results obtained show the typical effects from PV deployment elsewhere.

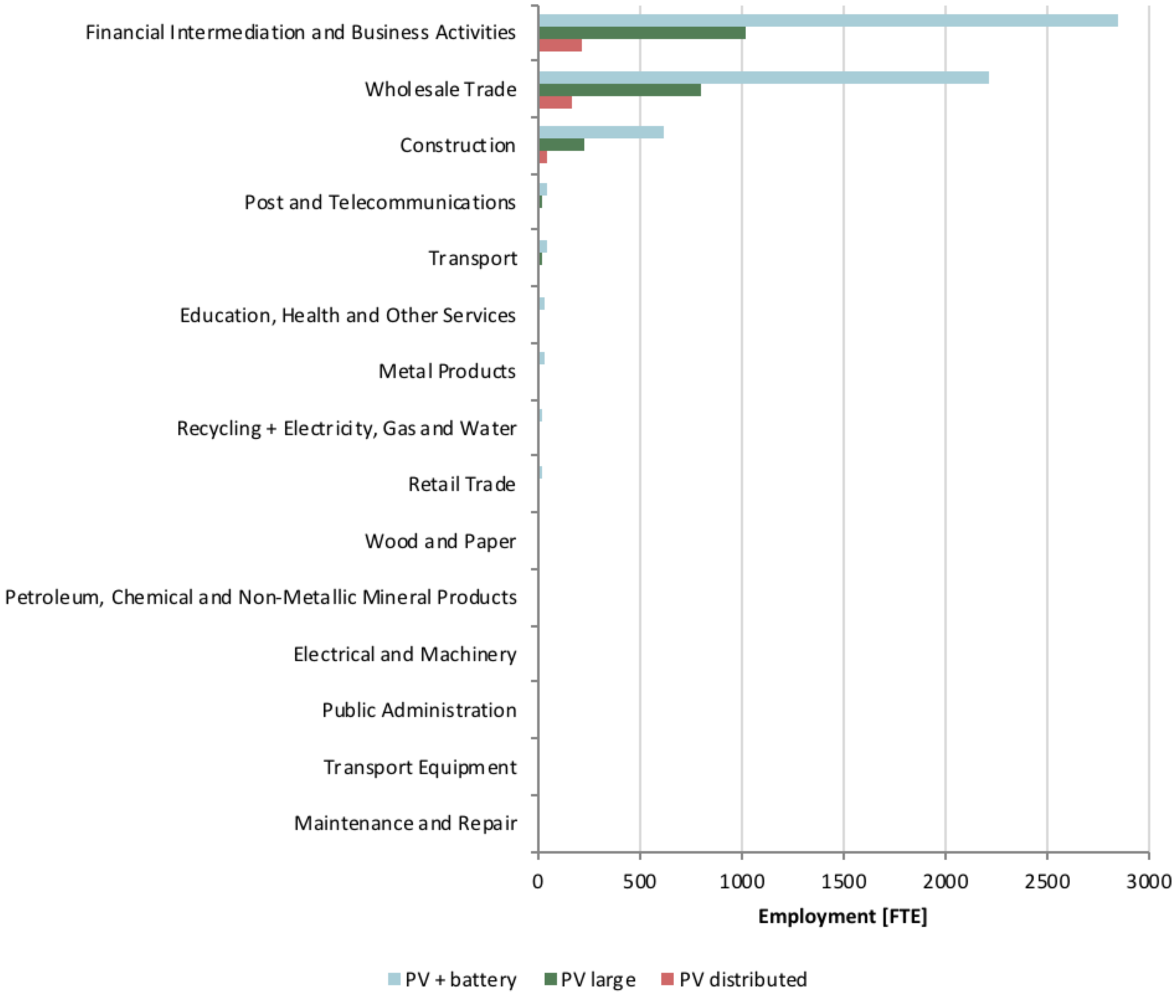

Figure 29. PV sector indirect employment from installation for the most relevant sectors in 2021 (Source: Own calculation)

According to the model run for the PV sector, as per 2021, 3,187 people work in whole sale trade and imports, 4,088 work in planning, design, finance, banking, legal advice, and other business related to services. The model estimates 889 indirect jobs in construction who provide inputs to the direct construction works of large PV installation. Finally, 47 additional jobs are estimated in education, which could either relate to training or higher education.

As a reminder, we look at the relevant sector called financial intermediation and business activities again. In the PV sector, all activities relating to services can be found in this sector. Starting with financial services from banks, insurance, services which give and collect information on the economic status of someone who wants to have a loan. Further, everything connected to the real estate side of a new PV farm is in this sector: lawyers, real estate companies etc.

The PV installation requires contracts and approvals. Typically, contracts and approvals are drafted with the support from lawyers.

Shifting towards engineering, the sector contains activities from technical testing and analysis. This can be environmental auditing, radiation measurement, design of the PV farm, adjustment to the site specific radiation and land specificities, but also includes research and development.

Last but not least, advertising, campaigns, photos etc. belong to the activities of this sector. Any report, newspaper issue, online publication on a new PV farm needs to be written, designed, illustrated with graphs etc. An each of the respective offices asks goods and services from others, be it building maintenance, cleaning or guard services.

Regarding gender, most jobs currently available in the PV sector have been in sectors which typically present lower female participation rates. However, the planning, design, finance, banking, legal advice, and other business activities take place in sectors in Lebanon with a female participation rate of more than 30%. Therefore we estimate female current employment from PV sector at around 3000 women.

If we add direct and indirect jobs, it is estimated that the construction sector including installers currently hosts 5434 jobs from PV deployment under the conservative scenario. The skill gap in this sector is especially wide for certain qualifications. The UNDP report "Mind the gap (UNDP 2015) states: "The problem posed by inadequate training is more serious for professionals such as engineers and surveyors. Among this group of employees difficulties were noted on several fronts: waste management (67 percent), awareness of environmental impact (62 percent), use of scientific methods (58 percent), knowledge of green building practices (57 percent) communication skills (55 percent), and applied mathematics (55 percent). More than half the construction companies in Lebanon struggle to find professionals who have these aptitudes." Additional demand for qualified workers will widen the qualification gap, if no immediate action is taken (see chapter on Action Plan).

SENSITIVITY ANALYSIS:
PV installations vary in size. The optimistic has a focus on larger installations. When shifting towards roof-top, off-grid or other distributed solutions, the labor intensity is higher and the total effect on employment also grows. However, the work in operation and maintenance decreases, because some parts thereof are done by the household who owns the panel (e.g: cleaning).

In order to understand better the effects of distributed installations, a sensitivity analysis in run maintaining unaltered the rest of the factors ("ceteris paribus" in economics). Typical applications of these kind of distributed plants are household or industry installations.

The sensitivities "Optimistic with share of 25% distributed" and "Optimistic with 50% distributed" maintain the same total installed capacity as the optimistic Scenario, but consider higher shares of distributed installations.

The main difference in the results is observed in the labor-intensity of installation and operation and maintenance. O&M is less relevant for small roof top installations.

Indirect effects again spread over several economic sectors, with financial and services, construction and trade on top. In terms of challenges, the results show that skill building should aim for these sectors in particular.

Total employment increases with increasing shares of distributed installations. Also, the distribution between direct and indirect employment differs. While direct employment from installation is higher for the smaller units, indirect employment in terms of planning and other services is lower in relative terms (per MW). The value chains of the two types of PV system differ in this respect.

The sensitivities are simulated for 2020 and 2021. The following table gives an overview of the capacities installed in each sensitivity and gives the optimistic scenario for comparison.

Table 24. Sensitivity analysis scenarios.

		2020	2021
Scenario optimistic			
PV distributed	MW	35	40
PV large scale	MW	270	270
Battery large unit PV cap	MW	150	150
Share of distributed PV	%	8%	9%
Scenario optimistic small scale 25%			
PV distributed	MW	114	115
PV large scale	MW	220	230
Battery large unit PV cap	MW	121	115
Share of distributed PV	%	25%	25%
Scenario optimistic small scale 40%			
PV distributed	MW	222,0	230,0
PV large scale	MW	110,0	115,0
Battery large unit PV cap	MW	122,0	115,0
Share of distributed PV	%	50%	50%

(Source: Own calculation)

The optimistic scenario has 8% small PV in 2020 and 9% in 2021. The scenarios with larger shares of small installations lead to structural changes and changes in the level of employment, though both changes are not very large.

The following chart gives an overview of both types of changes.

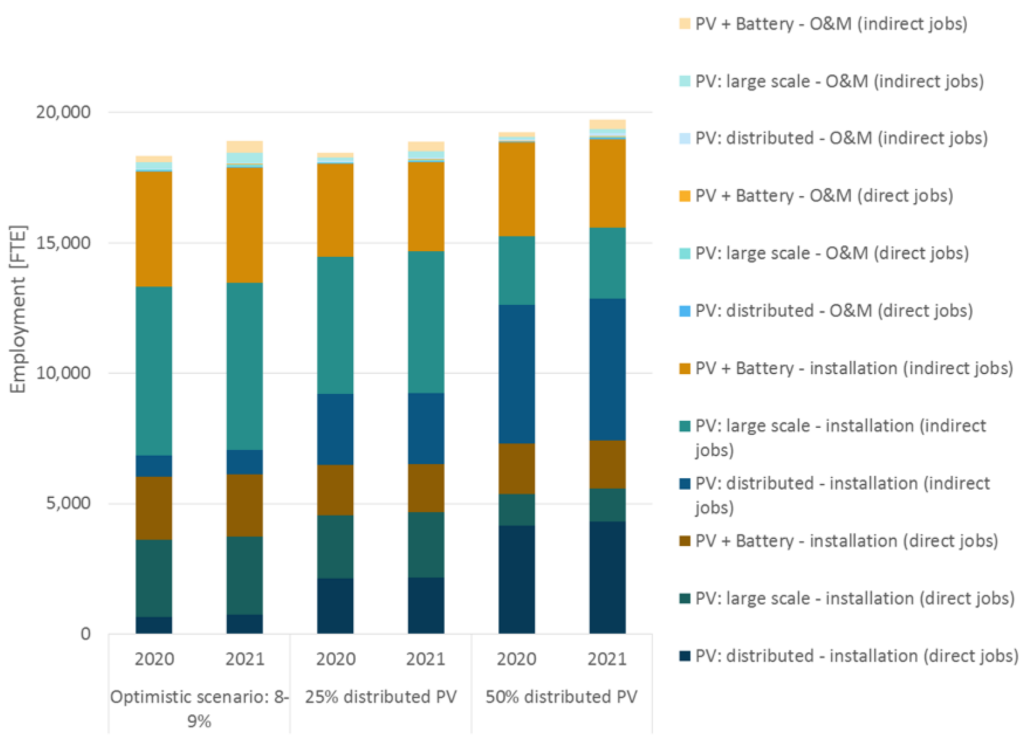

Figure 30. Employment by type of PV technology and direct and indirect jobs for the optimistic scenario and two sensitivities (FTE)

The differences in the structure of employment are more remarkable than the differences in actual total amount. If the benefits of distributed renewable energy are sought, the installation numbers have to be high. Distributed installation is more labor intensive per MW in terms of actual installation works, but has less indirect effects. The construction works for a large PV farm contribute largely to this difference. Planning and design could be more standardized in the distributed case. Operation and maintenance is obsolete for distributed units. Figure 30 shows how a mere 25% of total installation does not improve the balance, while increasing the distributed share to 25% does.

In terms of regional distribution, distributed PV is attractive, and it spreads employment opportunities regionally in a wider area than large solar. As a final note, it is highlighted that no matter what any country in the region pursues in terms of PV installation, it will be dwarfed by the Saudi Arabian plans for a 200 GW solar farm[15]. Whether these ambitious plans will improve the availability of experts on PV installation in the region remains to be seen.

[15] *https://www.bloomberg.com/news/articles/2018-03-28/saudi-arabia-softbank-ink-deal-on-200-billion-solar-project*

4.4. Wind energy

4.4.1. Latest developments

Wind energy has experienced a very significant growth globally with a total installed capacity of 539.6 GW in 2017 (GWEC 2018). Annual capacity additions peaked at 63.6 GW in 2015 and levelled to above 50GW in the two following years (54.6 GW in 2016 and 52.7 GW in 2017). China is currently the leading country in terms of both new installations and total capacity installed, followed by the US and Germany. Almost three quarters of all installations (72%) can be found in the top five nations China, US, Germany, India and Spain. In the Middle East, no new installations were added in the year 2017 according to GWEC 2018. Egypt and Morocco are leading countries in the MENA region in terms of capacity installed with less than 1 GW each, as of 2018.

The wind atlas for Lebanon states large physical potential based upon the following assumptions:
• Wind speeds superior than 6.5 m/s at 80 m above ground level
• Installation densities of 8 MW/km^2

Based on these assumptions, the onshore wind power potential of Lebanon is considered to be around 6.1 GW.

Initiative 6 of the NEEAP aims at promoting electricity generation from wind power and targets building the first wind farm in Lebanon and launching IPP with the private sector in the coming years (UNDP 2013). After the recent bidding processes for the installation of 200 MW in Akkar and North regions, the longer-term goal is to continue the development of wind energy to reach a capacity of 400 to 500 MW. The 200 MW target is modeled in the simulations below considering that this capacity will be completed by 2021.

4.4.2. Data and model assumptions

Given that wind energy does not contribute currently to any significant extent to electricity generation (as of spring 2018) in Lebanon, most data are taken from international sources and adjusted with regional factors and national economic indicators.

Prices for wind turbines and wind farms fell over time even though not as drastically as PV modules. The IEA Wind Energy Organization gives the average investment costs (€/kW) for wind energy in 2010 in the range of 1571€ (Sweden) to 2133€ (United States). For 2016, the IEA data show the range of 1151€ (Sweden) to 1513€ (Germany). This results in price decreases of around 20%, far lower than the three-digit cost decreases in the PV industry. However, also in the wind industry prices fell as a result of growing markets and economies of scale in manufacturing.

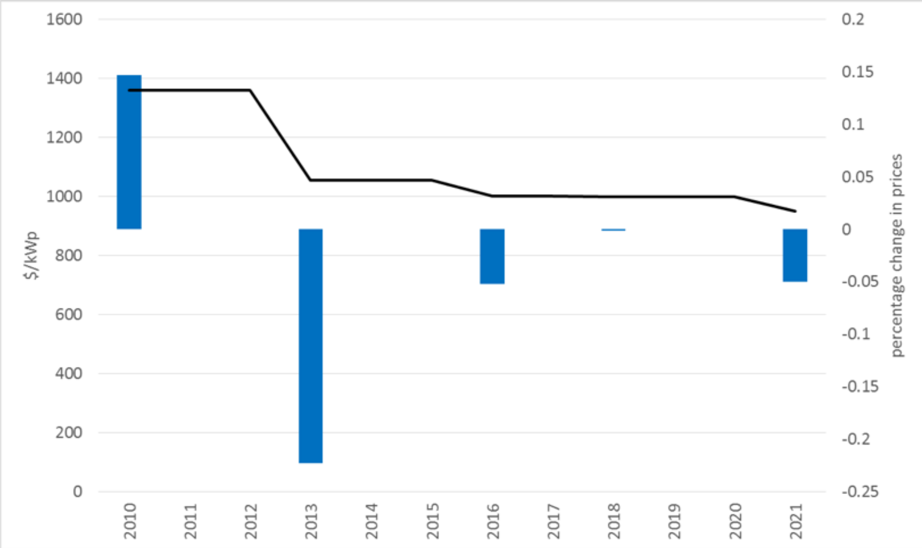

Figure 31. Price development of wind energy (historical and forecasted)
(Source: Lehr et al. 2018)

For Lebanon, wind turbines will be purchased on international markets, as well as most parts necessary for installation. Therefore, the use of international data gives a valid estimate. However, costs for installation can be higher than international averages due to learning curve effects. In order to consider this local effect the international employment factor of 3.2 jobs/MW has been increased by 25% (4 jobs/MW).

As a caveat, it is pointed out that in other MENA countries, the local employment factors are lower instead of higher than international standards. This is due to the effect that in countries with little experience in wind energy, international contractors might tend to rely entirely on foreign products and work with international staff rather than using local sources. In future rounds of auctioning, the share of local production could be fixed in advance. That way, the numbers in the simulation below could actually be attained.

The cost structure of the wind farms, apart from the turbine itself, is given in figure 7. Financial intermediation, services in planning and design are the main cost component accounting for almost 50% of the costs during installation, and these services are all creating local value, because they are provided domestically.

Construction is the second largest cost component with 23%. In this respect, wind energy differs from solar, because the construction works at wind energy sites are much more complex compared to solar. The construction of a wind farm comprises multiple activities and phases.

Firstly, appropriate infrastructure has to be built and the site needs to be prepared. Project sites need roads which are wide enough to allow the transport of heavy equipment, blades and other large parts of the wind turbine. Each turbine needs a foundation and the surface around the foundation has to be built. The erection of the tower is usually done onsite, either from prefabricated steel elements or from concrete. This is where the 7% metal products come into play.

The nacelle and the blades are assembled either on the ground or on the tower. Special cranes are needed to lift nacelle and blades to their high destinations. The cranes are part of the sector transport equipment in the cost chart below.

Although the construction sector in Lebanon is well established and equipped, the sector does not have any experience and might not have the right equipment for some of these works. If cranes are rented or imported together with the turbines by the manufacturer of the turbine, for sure the respective personnel will be imported too. In such case, the construction sector might not necessarily benefit from the full impact of additional demand from wind energy. Given the strain on the construction sector from the Syrian crisis (Mind the gap 2016), this calls for additional qualification and training efforts in this sector.

Additional training needed is reflected in the impact to the education sector, and it can be academic training as well as vocational. The planning, design, wind speed forecasts and environmental auditing is comprised in the financial and service sector, as well as the actual financial transactions, registrations, administrative activities and registrations etc. This is expected to be provided domestically to a large extent. That is why it has been assumed that for the first year, up to 80% of these services will be sourced locally.

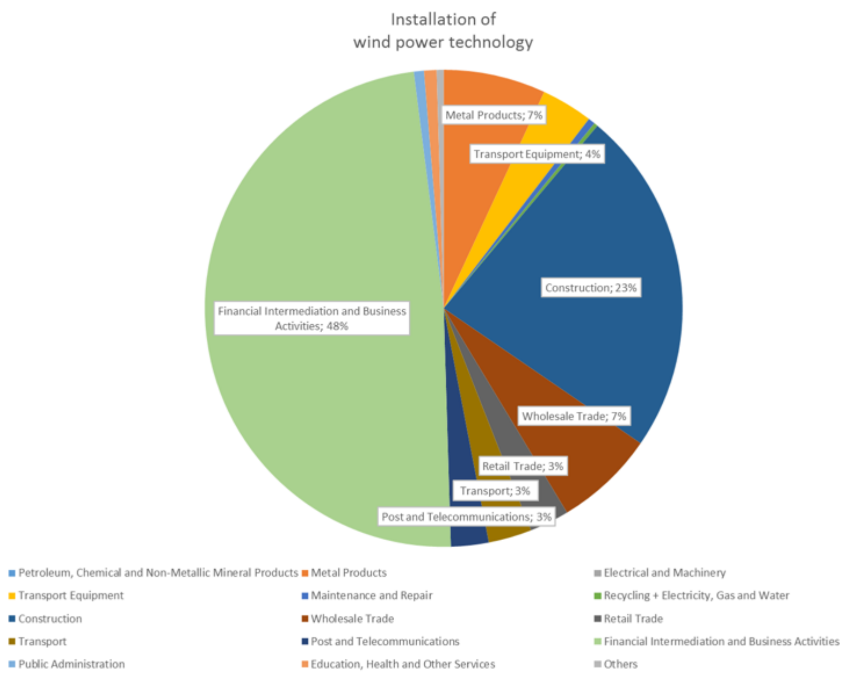

Figure 32. Cost structure wind energy - installation
(Source: Lehr et al. 2018)

The turbines are manufactured by large international companies. If Lebanon develops a long-term strategy and ambitious targets, the manufacturers might opt to produce some components in Lebanon in the future. Moreover, if Lebanon is positioned as a regional hub for certain parts, this would be an attractive opportunity for manufacturers. In this regard, blades are the most labor intensive part in a wind farm and at the same time the most difficult part to transport.

Figure 33. Global blade manufacturing
(Source: Wind power monthly 2018[16])

Blade production primarily takes place in Europe (Germany, Denmark, Spain, Italy), the US, Brazil and China and India. The closest blade production to Lebanon and to the Middle East is in Turkey (near Izmir), where Enercon has recently built a production site. Depending on the plans in the region, there might be room for additional sites.

The transportation of all parts of a wind farm is challenging. The nacelle is usually pre-assembled and transported by ship and truck. The main problem is its weight, which increases with the capacity. While a typical nacelle (without rotor) of a 600 kW wind turbine weighs 20 tons, that of a 1.5 MW turbine weighs 50 tons and that of a 2.0 MW turbine weighs 70 tons (www.wind-energie.de).

Most common towers are tubular steel towers. They are transported piecewise divided into segments of 20 to 30 meters in length. With a length of 22 meters, maneuvering becomes difficult. The passages under bridges are usually 4.0 to 4.2 meters high, which corresponds to the diameter of the lower tower parts of a 2 MW wind turbine. For larger wind turbines, the transport of tower segments gets increasingly difficult because bridges are often too low. In that such cases, concrete tower segments might be preferred.

[16] *https://www.windpowermonthly.com/article/1083654/global-guide-rotor-blade-manufacturers*

The transportation of the blades is the typically the most complicated because of their length. The blades of a 1.5 MW turbine are 30 to 35 meters long while for a 3 MW turbine length can reach up to 45 meters. Another problem of blade transport is the maximum blade width, which can be larger than four meters for very large wind turbines. The maximum blade width of a 4.5 MW wind turbine is 5.8 meters.

The complex challenges of blade transport makes manufacturing close to an evolving market more attractive. Either way, transport of wind turbine parts is an important part of the value chain.

4.4.3 Results

Since no wind power is currently available in Lebanon, all employment from wind energy happens in the future. The scenario assumes an installation of 50 MW each year starting 2018 amounting to 200 MW in 2020 in the conservative case. In the optimistic case another 300 MW will be erected by 2021, therefore the installation per year increases by 100 MW starting in 2019.

Because the wind industry is at its beginning in Lebanon, the employment factors are assumed higher than in countries with an established wind sector, but the domestic part is considered lower. Though it is true that nascent industries typically are not as efficient as established branches, the reduction reflects the fact that the works necessary will be partly carried out by the manufacturers of the wind turbine with expert staff brought into Lebanon. This situation reflects similar experiences from other countries, such as Tunisia or Egypt.

The same assumption holds true for intermediate inputs and indirect effects. Financial and administrative services will be domestic, whole sale trade, and other services, too. But in the initial years of building the wind farm, the domestic metal industry will not immediately supply the towers, or parts thereof. In the long-run, however, this could be one specialization of the respective industry.

Table 25. Employment from Wind scenario overview

	2018	2019	2020	2021
SCENARIO A: Optimistic				
DIRECT EMPLOYMENT	**0**	**0**	**777**	**1.222**
Installation	*0*	*0*	*720*	*1.080*
Operation & Maintenance	*0*	*0*	*57*	*142*
INDIRECT EMPLOYMENT	**0**	**0**	**902**	**1.531**
Installation	*0*	*0*	*657*	*936*
Operation & Maintenance	*0*	*0*	*245*	*595*
TOTAL EMPLOYMENT	**0**	**0**	**1.679**	**2.753**
SCENARIO B: Conservative				
DIRECT EMPLOYMENT	**0**	**0**	**777**	**57**
Installation	*0*	*0*	*657*	*0*
Operation & Maintenance	*0*	*0*	*57*	*57*
INDIRECT EMPLOYMENT	**0**	**0**	**902**	**245**
Installation	*0*	*0*	*657*	*0*
Operation & Maintenance	*0*	*0*	*245*	*245*
TOTAL EMPLOYMENT	**0**	**0**	**1679**	**302**
DIFFERENCE				
TOTAL EMPLOYMENT DIFFERENCE	**0**	**0**	**0**	**2.451**

(Source: Own calculation)

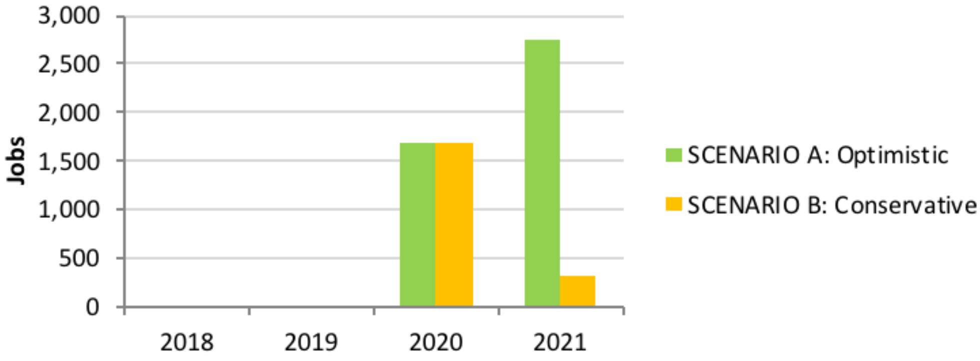

Figure 34. Employment from Wind scenario overview
(Source: Own calculation)

By 2021, it is expected that there will be more than 635 new jobs created from the installation and the operation of 200 MW of wind power under the conservative scenario. Operation and Maintenance is catching up in relevance. Note that employment in O&M is permanent over the lifetime of a wind farm. The direct jobs are mainly in construction and electrical wiring, indirect jobs go across all elements of the service sector, whole sale and transport. Figure 35 gives an overview.

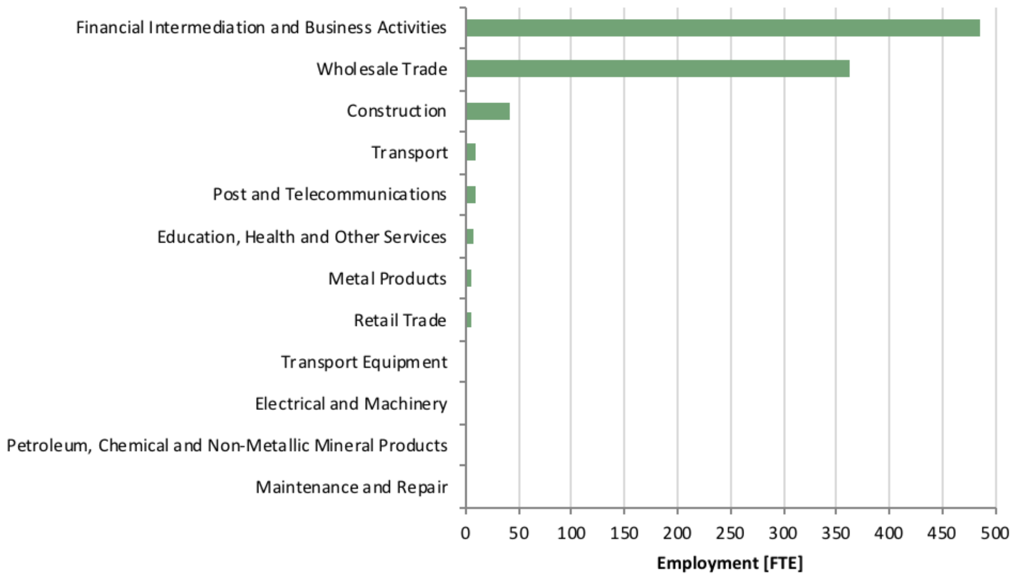

Figure 35. Distribution of indirect jobs created by wind energy sector in the installation phase for the optimistic scenario in 2021.
(Source: Own calculation)

The distribution of indirect employment here for the optimistic scenario (Figure 35) is concentrated on services trade and construction as explained above. We chose the optimistic scenario, because a one-shot installation of 200 MW will provide jobs, but not be enough to demand for action in terms of growing expertise and training. Transport and transport equipment are two sectors which will benefit from wind energy even in the early stages. The manufacturing of electrical components will need to specialize on the respective components before a significant impact can be observed. The development of joint ventures to offer the products needed by the manufacturers of the respective component could support industrial development in this respect.

Under the optimistic scenario, we find more new jobs, 1,222 direct jobs and 1,531 indirect jobs in the year 2021. This could be the beginning of a positive development for wind in Lebanon. In particular the impact on the service sector matters, given the economic structure of Lebanon. The demand for training and provision of information will span from banks, accountants, universities to consultancies. In particular special wind energy related services, such as wind speed forecasts, site selection, environmental audits have market opportunities, because the can be offered for the whole region. See chapter 5 on Action plan for further detail.

In terms of gender, female participation is still low in wind energy sector globally. The renewable energy agency IRENA conducted a survey of 90 renewable energy companies worldwide and found that women represent an average 35% of the workforce (IRENA, 2016). The finding was consistent with national level surveys from the United States, Germany and Spain (Solar Foundation, 2017; IRENA, 2013). They show that the share of women in the renewable energy industries is larger than in the traditional energy sector, but lower than that of the broader economy. Wind energy has the lowest share of female participation among all RE sectors. However, the indirect employment impacts in Lebanon have an effect primarily to sectors such as services, which have higher female participation rates than, for instance, manufacturing. The barriers for females on the access to the job market consist of inflexible work hours, too few opportunities for child care and unequal pay. All these barriers are considered to exist as well in the other renewable energy industries, according to IRENA 2016.

4.5. Biogas and Biomass

4.5.1. Introduction

The bioenergy strategy in Lebanon (UNDP-CEDRO Bioenergy Strategy 2012) seems to pursue different and potentially conflicting targets. While several stakeholders are supporting bioenergy, in particular solid biomass briquetting and biogas production from municipal waste, the Waste to Energy Plan under decision 55 suggests a focus on large waste incineration in Beirut, Tyr, Tripoli and Baalbek (UNDP-CEDRO Bioenergy Strategy 2012).

Nevertheless, interviews with stakeholders with which the authors agree, suggest that briquetting and biogas from municipal waste are two technologies which are worth a more detailed analysis. In this study, briquetting will be treated in a simplified way to show the impacts of the briquetting process as such. Upstream activities such as the manufacturing of the briquetting machine do not occur domestically. The collection of wood, the sales of the briquettes and other upstream and downstream activities depend largely on the respective regulatory framework. The collection of residuals should be encouraged, while informal wood collection should be discouraged or prohibited.

4.5.1.1. Briquettes

For the biomass wood briquettes processing plants, recent data from a pilot project in Lebanon used in the following (Sfeir 2016).

The value chain of briquetting comprises five core steps (Figure 36) plus the packing and delivery.

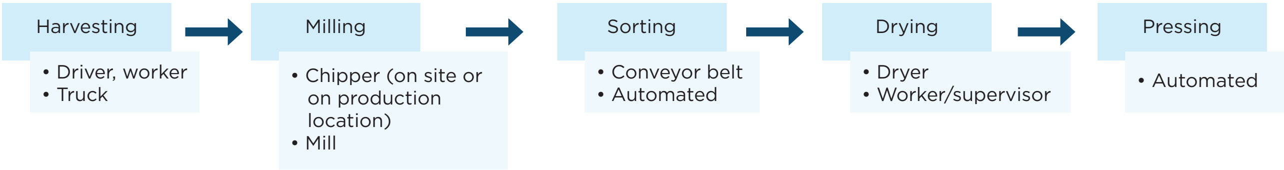

Figure 36. Value chain of briquetting indicating the associated equipment needed for each step.

According to the pilot project, the one-time investment costs are estimated at $210.000. During operation and maintenance, 7-8 jobs per plant are reported from the pilot project in (Sfeir 2016). The same report estimates that up to 40 processing plants could be installed in Lebanon. With these 40 plants, the report estimates that 280 additional jobs would be created from O&M only.

Looking at the equipment needed, 40 projects would require an investment of $8.4 million. The machinery can either be imported or developed in Lebanon. An input of $1 million to the machinery industry in Lebanon yields 60 additional jobs. Selling the briquettes can yield more work, but depending on the delivery method to customers this could be one or two people. Harvesting is not explicitly considered in this exercise, because of the environmental difficulties with it.

Biomass from forests comes with some challenges, which should not discourage the promotion of this technology. The wood collected has to be monitored to ensure sustainable collection methods and quantities and the availability of wood for briquetting frequently has to be checked and approved.

The briquettes could potentially replace part of the demand of subsidized diesel fuel for thermal purposes, while at the same time decrease the fumes and burn CO_2-neutral.

4.5.1.2. Biogas from waste

Using biogas from municipal waste for electricity generation can be one option to cope with part of the municipal waste in the future, in particular in medium to small municipalities. The Lebanese Bioenergy Strategy describes biogas production as a mature technology. In the section on biogas conversion for the production of power (and heat), several sources for biogas production from anaerobic digestion are described: sewage sludge, slaughterhouse waste or municipal waste feature dominantly, but also animal manure could be fed into the biogas digestion process. The bioenergy strategy suggests four different scenarios to contribute to the Lebanese electricity generation policy and the 12% target for renewable energy therein. However, the biogas contributions are not very elaborate. For this reason, the value chain assessment will be based on a modest biogas scenario for Tunisia and the experiences with a biogas pilot project in Lebanon (Arcenciel 2017).

The value chain of biogas from municipal waste in depicted in Figure 37. While the digester and the Combined Heat & Power (CHP) turbine are assumed to be imported, sorting and collecting, operation of the digester, provision of bins, trucks etc. as well as operation and maintenance of the CHP plant are activities with domestic value creation and domestic jobs.

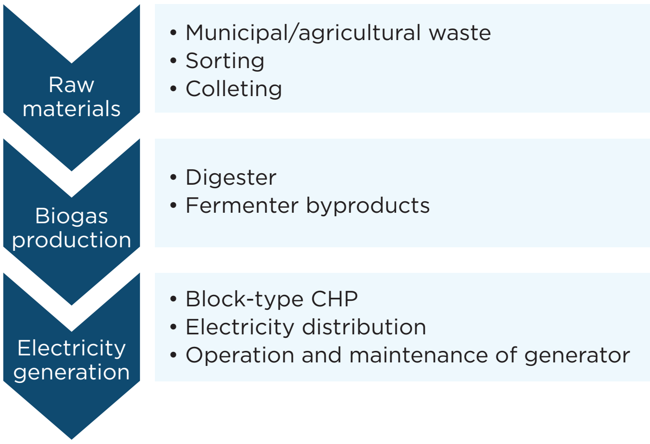

Figure 37. Value chain of Biogas from Municipal waste

4.5.2. Data and model assumptions

Currently, Lebanon does not have a target for biogas or an installation path. The Council of Ministers approved the Policy Summary on Integrated Solid Waste Management (January 11, 2018), which leaves room for Biogas, but does not make explicit reference to it. To show value creation from biogas in Lebanon, data from earlier studies is used. In particular in Tunisia, biogas is a small, but significant part of the renewable energy expansion strategy (Lehr et al. 2012 and Lehr et al. 2016). The annual capacity installation target for that country is 3MW per year. This amounts to more than 80 facilities similar to the small pilot planned by the Lebanese company Arcenciel which intended to use residue from a cow farm and a dairy production plant in Taanayel, Bekaa. The same capacity targets have been considered for the assessment.

The costs are estimated considering this Lebanese planned pilot and European projects, as well as costs assumed in Tunisia. Averaging costs leads to 5000 $/kW, or $15 million investment per year in the case of Tunisia.

From case studies published by the European Biogas Association an employment factor (direct employment) for operation and maintenance is estimated at 1 job per MW. This compares well to the international data described by Rutovitz et al. 2015. The employment factor in installation is considered to be 14 FTE/MW.

4.5.3. Results

The scenario considered starts with 3MW of biogas installations in the year 2018 and continue with annual installations of 3MW until 2021, the current simulation horizon in the analysis. By 2021, 12 MW will then be installed and will be operated and maintained. Table 23 gives an overview of direct and indirect employment from the installation and O&M of biogas systems.

Table 26: Employment from biogas installation and O&M

	2018	2019	2020	2021
DIRECT EMPLOYMENT	0	47	51	56
INDIRECT EMPLOYMENT	0	234	252	273
TOTAL EMPLOYMENT	**0**	**280**	**303**	**328**

(Source: Own calculation)

By 2021, it is estimated that up to 328 people could potentially find a job in the new biogas sector. Direct jobs in installation and O&M would amount to 56 jobs, while indirect jobs would be five times higher. This, again, is an effect of the fact that the manufacturing of the system and its components is not domestic, while the services, the collection of the feed, the control of the digester, the operation of the digester etc., are domestic activities. Employment from installation has a large share of construction works, as well as designing and planning of the facilities. Operation jobs start from collection and sorting to transport, monitoring of the substrate mix, monitoring of the digester and operation of electricity generation. Most jobs in operation and maintenance require higher education and careful training, in particular the monitoring of the substrate and the digester.

Indirect effects from operation and maintenance are found in the service sector, trade transport and agriculture. Transport refers to the collection of the bio-waste, service sector comprises the biological controls as well as the physical filling, sorting, cleaning of the feed material. Trade features in all activities, be it for spare parts, for chemicals to mix with the feed, and eventually of the necessary framework is set up, for selling power to the grid. Agriculture provides some of the feed in our example so there is an impact on the agriculture sector.

Indirect effects in the installation phase feature a high input from services, be it financial, legal, administrative or from the design, the planning and the calculation of the plant. The construction sector also shows job effects in the installation phase. Education and training is necessary as well as jobs in agriculture to create the necessary infrastructure for waste collection.

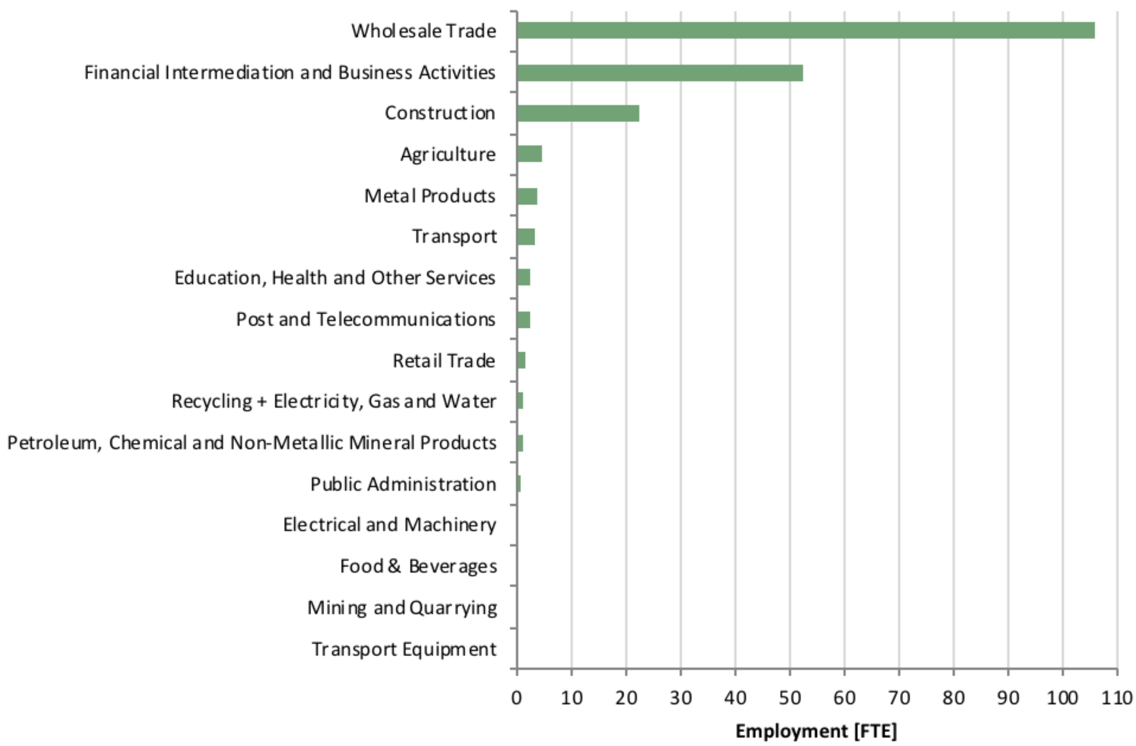

Figure 38. Indirect employment from biogas installation.
(Source: Own results)

A 3 MW biogas installation is not a very large facility, though ten times as large as the prototype facility suggested by Arcenciel (Arcenciel 2017). Case studies from the European Biogas Association report examples of much larger systems from Ljubljana, Uppsala Milano, and Miscolc. For comparison, these case studies are reviewed in brief below.

4.5.4. European experiences

4.5.4.1. Ljubljana

Ljubljana has a very advanced system of bi- waste collection. Downtown Ljubljana has a grid of underground containers, where residents have access to with a key card. This card counts the amount of waste disposed of per household. Bio-waste may disposed of for free for up to 4 times per month, all other waste must be paid for.

The KOTO biogas plant is operated by KOTO Company, which originally had specialized in the treatment of slaughterhouse waste and infectious animal material. Recently, the company took biogas into their portfolio. It is operating 3 digesters of 500 m^3 size. The biogas is used in a CHP unit to generate electricity and heat. It sells 10% of the electricity to the grid and the remainder is for its own consumption. 148 people work in the KOTO biogas plant. The plant has the anaerobic digester and since 2014, an algae tank, where the residues are treated and algae biomass is produced.

4.5.4.2. Uppsala

The Uppsala biogas plant has a very large capacity of two digesters with 2,400 m^3 each. It produces biogas, which then is stored and used for heating purposes either directly in homes, in a heat plant or distributed through a bio methane station for cars. 9 employees operate it, the process is highly automated. The biogas farm is run by the local water authority which has eight recycling centers that receive all types of waste. Bio-waste is collected in a separate collection.

4.5.4.3. Milan

The Montello anaerobic digestion plant has a history going back to the 1990s and has developed into a very large scale (45,200m^3 digester) plant with a 13 MW plant generating electricity. 98 people work at the Montello plant. The plant includes initial pre-treatment of waste, followed by anaerobic digestion and composting of the digestate, which is treated to become a fertilizer afterwards.

The collection of organic waste from households started in 2014 and works through giving out biodegradable plastic bags to households, which can be thrown into separate bins. However, sorting has to take place at the biogas plant, too, to make sure that there are no unwanted components in the substrate.

4.5.4.4. Miskolc

Miskolc in Hungary employs a biogas plant since 2015 as an add-on to a sewage treatment plant, which was operating inefficiently and dissatisfactory before. The feedstock comes from bio-waste, sludge and other outputs from the waste water process. The electricity generated contributes to the plant's electricity needs between 80% and 92%. The plant has 8 employees working for the operation and maintenance of the biogas part only.

This brief overview shows the wide spread of biogas applications, output and employment. All success stories have established elaborate waste collection schemes, which help to ensure the quality of the feed for the biogas plant. Therefore one of the lessons from these success stories is to mainstream biogas into the bioenergy strategy as well as into the municipal waste strategies.

4.6. Summary and conclusions

More than 20,000 jobs could result from the deployment of renewable energy systems by 2021 under the optimistic scenario (Figure 39). The bulk of this number is found in the PV sector, from distributed as well as from large PV installation, with or without batteries. Most jobs are in the installation phase, which means they are temporary. When the installation is completed, employment from this installation is also completed. A succession of installations can turn these temporary jobs into a permanent career.

The calculation of the employment effect results in full-time equivalents. This means that the number of persons actually working for renewables can be even larger. In particular, when looking at the sectors in which indirect employment takes place, this concept becomes clear. A banker will not cover loans from renewables 100% of his time. He will be working on several other projects, too. This is also true for the lawyer, the real estate agent, the tax accountant, the harbor worker and the construction worker. Nevertheless, it is important, that these profession are trained in the special characteristics of a PV loan, a contract to buy power from biogas, or the transport requirements of wind turbine blades. The following section Strategic Action Plan will elaborate on this point.

Figure 39 shows for the year 2021, the last year in the scenarios, the 21,976 jobs under the optimistic scenario and compares them to the 14,323 jobs under the conservative scenario. Wind energy will give work to 2,753 people under the optimistic scenario, roughly half of them in direct jobs. They are employed in installation and already in operation and maintenance of the by then existing 200 MW of wind power. If the installation will be smaller, expertise will be small and the relation between direct and indirect jobs is favoring indirect jobs in administration, law, real estate, etc..

For PV, the learning curve is not as steep, because there are already experts and companies for PV in Lebanon. Therefore, the relation between direct and indirect jobs does not develop as rapidly as with wind energy. Biogas stays the same under both scenarios.

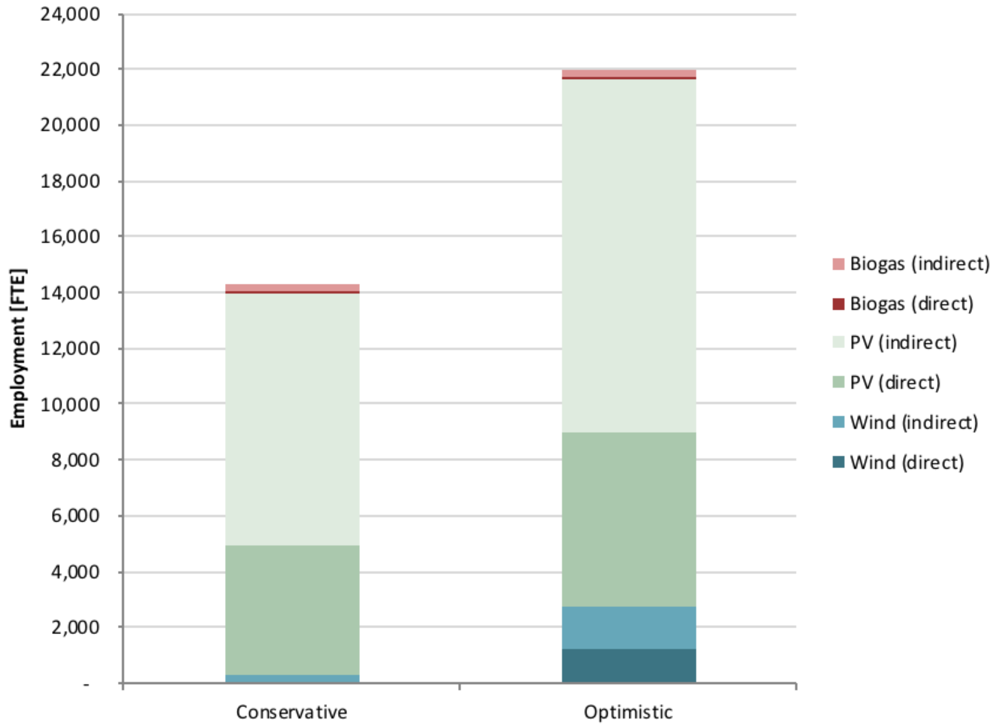

Figure 39. Employment from PV, wind and biogas, by value chain phase for 2021 under the conservative and the optimistic scenario (Source: Own graph)

Wind energy creates jobs in installation and operation and maintenance. Again, the largest number of jobs is in the service sector and in construction. For the transport of wind energy, infrastructure is needed, be it at the port or along the roads. Roads have to be widened, the area around the roads has to be cleared, and these activities are part of the construction works. However, they need planning, and supervision, which also is part of the service sector.

The services are relevant for operation and maintenance of a wind farm. Jobs in operation and maintenance are permanent over the life time of the RE system.

The largest share of permanent jobs can be found in technologies which need fuel. Therefore, the biogas deployment can lead to high shares of permanent jobs. However, since the waste management strategies in Lebanon are not fine-tuned between incineration, waste to biogas and other uses, we have not modeled explicitly employment from waste collection.

From the interviews and the economic data, one can conclude, that the Lebanese industry can become more involved in the growth of renewables and jobs. Currently, industry sees itself on the demand side for renewables, the supply side with the new possibilities of production of parts and components for renewables is still too little developed.

5.
Strategic Action Plan

5.1. Introduction

5.1.1. Objectives and structure of the action plan

The objectives of this section are to:
• Develop a detailed three-year support plan for the assessed RE value chains in Lebanon.
• Provide technical specifications for necessary activities defined through the value chain assessments and action plans.

The strategic action plan aims to support both the deployment of RE as well as the creation of jobs in Lebanon. The plan is divided into actions that are applicable to all RE value chains and subsequently the specific actions for the solar, wind and bioenergy sector. The actions are clustered according to the categories for industrial RE strategies established in IEA-RETD 2014 RE-Value-Policies.

Actions that are potentially of specific interest for UNDP are described in more detail.

5.1.2 Overall strategy

Based on the findings of the interviews and the sector analysis, and due to the peculiarities of the three technologies and their value chains, it is suggested that each technology requires a specific approach regarding their implementation strategy as depicted in Figure 40:
• Solar – decentralized approach with central support due to the expected uptake of distributed generation.
• Wind – centralized approach as projects are large and only expected in the northern part of Lebanon where wind resource is high.
• Bioenergy – centralized approach with local project support because of the complexity of the technology, which requires special knowledge but also potential support in-situ where plants are to be built.

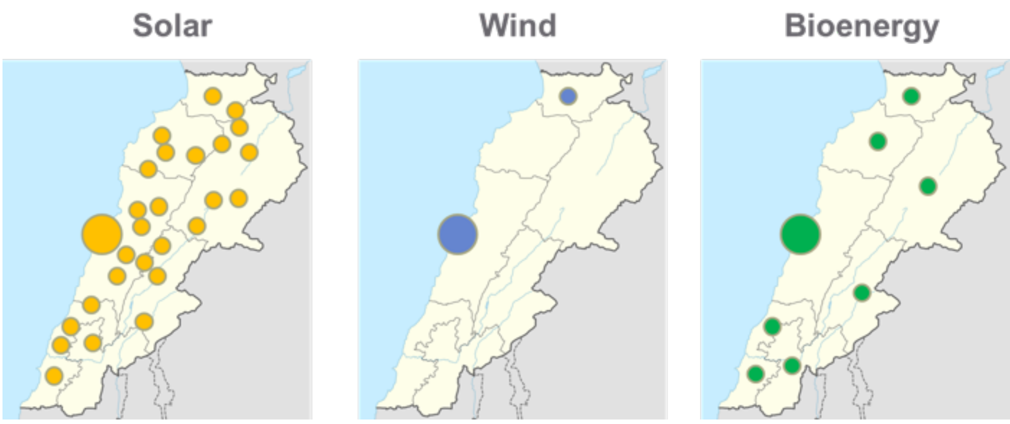

Figure 40. Strategic approach of the three value chains (overview)

Since all technologies require a strong knowledge centre where expertise is available to support the respective technology in Lebanon, it is suggested to combine these individual knowledge hubs in one RE knowledge hub located in Beirut to establish a strong voice for RE in Lebanon, see Figure 41.

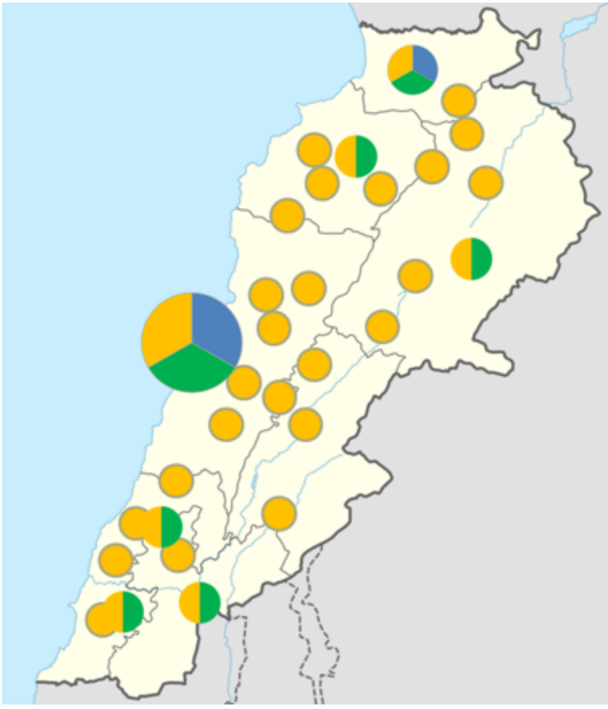

Figure 41. Overall strategy – one central RE hub, additional distributed knowledge centers

Similarly, some of the distributed centers in other cities may combine several technologies within the same offices or premises to share resources. The following actions are aligned with this overall strategic approach: Most of them can be centrally managed and – especially for PV and bioenergy – subsequently extended to other Lebanese cities, municipalities or regions.

5.2. Proposed actions applicable to all RE value chains

5.2.1. Renewable Energy Strategy

5.2.1.1. Update the NREAP taking into account the recent developments

A Renewable Energy Strategy aims to achieve a sustainable energy sector with low emissions and long-term low and stable costs. Job creation is not the primary goal but rather a positive side-effect. The Lebanese Renewable Energy Strategy is described in the NREAP published in 2016. It establishes RE deployment target for the different RE technologies for the years 2020, 2025 and 2030. However, after not even two years from its publication, the targets for RE as described in the NREAP seem to have become obsolete due to the recent positive developments. For instance, the NREAP 2030 targets for wind will already be reached in 2020 if the 200 MW project in Akkar, for which a PPA has been signed, is installed as planned. In addition, another Call for EoI for 200-400 MW has been recently launched.

This means that the current targets are not only unambitious, but they also do not seem to be realistic anymore as they underrepresent the actual developments. While it is in general positive to over-achieve RE targets, it represents a planning risk for the sector: Companies will not be able to plan their capacity needs for the years to come and will therefore be cautious to hire additional staff or invest in specific equipment. Hence, the full domestic employment potential in the RE sector – for both direct and indirect jobs – will not be used.

As discussed in section 4.2, two scenarios for the short term until 2021 were proposed. In order to better understand the potential trajectories which RE deployment may take, it is suggested to introduce two long term scenarios which lead to 2030. The assumptions taken are as follows:

• Both long-term scenarios start off in 2020 with the numbers used in the short-term scenarios (optimistic scenario: 738 MW for solar, 200 MW for wind; conservative scenario: 280 MW for solar, 200 MW for wind).

• From 2021 onwards, the optimistic scenario applies the annual capacity additions planned in 2020/21, i.e. 270 MW for solar PV and 200 MW for wind. If the planned MWs until 2020/21 are actually installed, then at least from the industrial capacity perspective it would be possible to keep similar deployment rates in the following years. However, those values are quite ambitious given the slow development in the past and considering that electricity system upgrades, improved grid operation, etc. will be required and currently do not seem to be tackled in a comprehensive way. Therefore for this scenario to happen, various supporting measures from the government and energy sector will be required (a number of those are described in this action plan).

• The second long-term scenario assumes a conservative RE uptake by just using 50% of the capacity additions of the optimistic scenario. While it is also possible that the deployment will be even lower, it may require an active suppression of new RE installations or a lack of progress in the general framework conditions (procedures, grid upgrades, institutional capacity, etc.).

The following graph depicts the two scenarios until 2030.

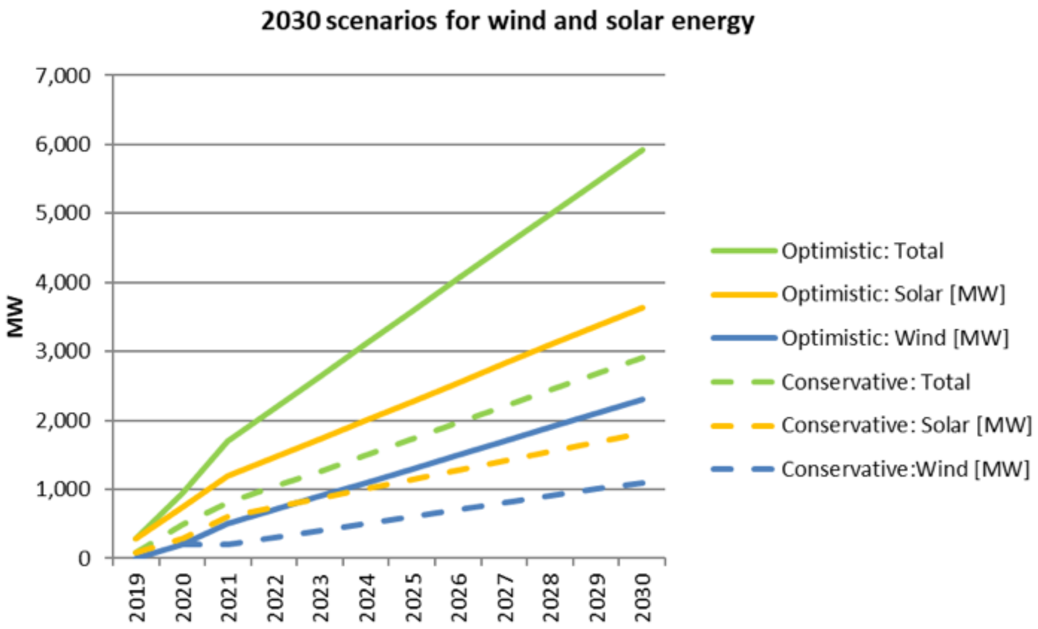

Figure 42. 2030 RE deployment scenarios

The optimistic long-term scenario leads to an installed capacity of about 6 GW in 2030, and the conservative scenario to some 3 GW. Both values are far beyond the current NREAP targets for 2030 (1000 MW for wind and solar energy). As can be seen, even the optimistic scenario uses a lower rate of annual capacity additions than what is actually planned until 2021 (see kink of the curves in 2021)[18].

The NREAP may also take other developments in the energy sector into account. For instance, Lebanon recently signed contracts for the extraction of gas with 3 consortia from Italy, Russia and France. Investments in (currently non-existing) gas infrastructure may divert urgently required financial and human resources away from the RE sector. Apart from that, new fossil fuel infrastructure will lead to sunk costs if the commitments made at the Paris Agreement are taken seriously.

Timeline	Priority	costs/ efforts	Responsible
2018-19	high	low	government

5.2.1.2. Regularly enhance RE support policies to counter RE investment risks

Transparent and consistent RE policies are the crucial basis for any industrial development in the RE sector. If there is no market for RE technologies in Lebanon, it will not be possible to create jobs. According to the interviews, current support policies may be in general sufficient for some technologies – at least for PV a market seems to emerge given the high prices for electricity from private generators due to costs for diesel. However, the overall framework conditions with clear connection and electricity injection rules, predictable pipeline for wind projects, fast application processes, etc. requires further improvements.

[18] *It is interesting to note that the approximate capacity of wind and solar required to produce the 15,000 GWh of electricity demand in 2009 is in the area of 8 GW (assuming 60% wind and 40% solar). This does not take into account the need for storage.*

Therefore a frequent review of RE policies and measures and their further enhancement is recommended to ensure the viability of RE projects.

Timeline	Priority	costs/ efforts	Responsible
annually, starting 2018	medium-high	Low-medium	Government, input from RE sector

5.2.1.3. Tackle energy sector reform, establish regulatory authority

According to interviewees the issues of the energy sector are to a large extent institutional/ political and not technical. Therefore an institutional reform of the energy sector is required to establish the conditions for large-scale RE deployment and thus the entrance of many new players into the power market.

For instance, even though Law 462 law specified already in 2002 that a National Electricity Regulatory Authority (NERA) should be created, it is not yet in place[19]. Such an institution is needed – among others – for planning purposes, to regulate the private (RE and non-RE) power plants needed to fill the generation gap, and to oversee the Power Purchase Agreements (PPAs). Currently the Council of Ministers is tasked to issue PPAs.

Moreover, it is recommended to review the currently subsidized EDL electricity tariffs in order to create a level playing field for renewable applications and for inciting energy efficiency measures.

Timeline	Priority	costs/ efforts	Responsible
2019-20	medium-high	medium	government

5.2.2. Industrial strategy

5.2.2.1. Introduction

An industrial strategy targets specific firms and segments of the value chain based on a long-term vision for specific sectors, in the present case for the RE sector. In contrast to the Renewable Energy Strategy, its focus is primarily on job creation and industrial competitiveness. It is important to define the industrial strategy in a consistent way with the renewable energy strategy[20].

Ideally industrial policy is about **organizing stakeholder processes in a way that market failures and important problems of society are addressed and resolved.** The search for concrete technological solutions and investment opportunities should be largely left to market actors (IEA-RETD 2014)[21].

[19] *UNDP 2017 DREI report*

[20] *For instance promoting industries that are mainly working in the oil & gas sector would not be consistent with the goal to increase the share of renewables.*

[21] *Notwithstanding, certain countries pursue top-down industrial policies that follow (geo-)political strategies to support their national industries to gain market power.*

In Lebanon it is mainly the Ministry of Economy and Trade who is in charge of industrial policies [22]. This strategy, however, does not discuss specific sectors, instead it encompasses all SMEs. In contrast, a UNHCR/GIZ study from 2016 specifically mentions the RE sector as a promising sector for employment creation[23]. According to the Association of Lebanese Industrialists (ALI) the view of RE and EE as a chance for the Lebanese industry from the supply side is not yet established.

Lebanon does not have a proper national strategy on Sustainable Development or a "Green Economy Strategy". However, in 2015 a National Action Plan on Sustainable Production and Consumption (SCP) was published which focuses on the industrial sector (published with the support of the SwitchMed program). The Med Green Economy Report (2016) notes that it is a "useful document with relevant goals".

The aim of an industrial strategy is to enhance value creation by turning RE deployment successes into socio-economic successes. The following will discuss policy instruments that can be combined and set up in a way that they generate first and second round effects in the different RE value chains. While RE deployment can potentially be achieved with imports, using national products and solutions not only creates domestic jobs but may also increase the population's support for RE installations – at least as long as prices and quality are competitive.

5.2.2.2. Define a Lebanese industrial RE strategy

An industrial RE strategy means that Lebanon intends that domestic[24] companies have a large share in the RE value chain allowing them to create domestic deployment. In addition, they may even export their products and services and thus create value beyond the domestic market. In general, it is possible to build up a RE industry sector without domestic market. For instance, in the first years of large scale PV deployment from about 2005 onwards, China had basically no domestic market but exported almost all PV cells and modules to Germany (which was the key market at that time due to the newly introduced FiT scheme) and Europe. Only later China began to deploy PV domestically.

However, this kind of export-oriented strategy is only possible if a government gives strong financial support to the respective companies and if there is a foreign market for products and services of a given country. Nowadays, with a much more developed global RE industry in place and global competition, it is very difficult if not impossible to become a major international player for RE products, especially for a relatively small country like Lebanon.

Therefore it is crucial to have a thriving domestic RE market which allows the development of a national RE industry – which means that a long-term, comprehensive RE strategy underpinned by stable RE policies is a basic prerequisite to build a successful domestic RE industry. Certain companies may then also be able to extend their offerings to the regional or international level.

The present document could be considered as a first version of an industrial RE strategy for Lebanon. The implementation of the proposed actions will require the support of the government and the RE sector.

[22] *http://www.economy.gov.lb/en/services/support-to-smes/resourses*

[23] *UNHCR/GIZ (2016), Employment and Labour Market Analysis (ELMA) https://data2.unhcr.org/en/documents/download/43215*

[24] *In general the terms "local", "domestic" and "national" are often used synonymously, meaning "in Lebanon". In certain cases "local jobs" refers to jobs within a municipality.*

Box: Best-practice principles for industrial development policies
The following list provides a list of best-practice principles which should be applied for industrial development policies (Source: IEA-RETD / Med Solar Plan):

1. Industrial policy should balance economic with social and environmental objectives;

2. A wide range of public and private stakeholders should be invited to contribute to the policy design from the very beginning.

3. A balanced and coherent policy entails cooperation among state agencies, which in turn requires that mandates, competences, and responsibilities are clearly defined;

4. Technological objectives should be defined in a way that they can be achieved without long-term subsidies. While targets may well go beyond what the current enterprise structure can deliver, they should reflect the country's "latent comparative advantages";

5. Industrial policies should build on private sector-led experimentation rather than top-down planning. Private investors should share some of the costs and risks – if they are not willing to do this, it is a clear signal that investors do not believe in commercial success;

6. Whenever pilot projects are supported, it is paramount to incorporate mechanisms, already from the start, to ensure scaling up and/or replication if the pilots are successful;

7. "Nudging" private companies and inviting them to collaborate is often more effective than "command and control", especially when the government's capacities to enforce are weak;

8. All policies should be subject to continuous follow-up and independent third-party evaluation. Follow-up and evaluation systems should not only measure in- or outputs but also outcomes and impacts (both expected and achieved). To do so, these need to be defined in precise and measurable terms;

9. Different policy functions – like target-setting, implementation, funding and evaluation – should be institutionally unbundled to create clear lines of accountability;

10. Service agencies should have strong incentives to act in a customer-oriented and business-like manner. Competitive tenders and results-based management are ways to ensure this.

11. Additional point: Quality. As experience from value chain assessments in Tunisia and Egypt show, it is crucial to focus all policy interventions on quality: High quality of products, processes and projects is key in order to gain customer confidence, attract (foreign and national) investors, develop markets and reach long-term deployment targets. The project team will thus put specific emphasis on quality aspects.

Timeline	Priority	costs/ efforts	Responsible
2018-19	high	low-medium	RE sector, supported by government

5.2.2.3. Establish a central RE knowledge hub

A relatively small country like Lebanon needs to combine its resources in order to be efficient and effective in promoting RE and the related industry. While for each value chain a specific strategic approach is suggested (see respective sections below), a common feature is that all need centralized support. As the RE sector as a whole is still in its infancy, it is therefore recommended to establish a RE knowledge hub for all RE technologies that combines the technology-specific central knowledge-hubs and thus establish a stronger voice for RE and the RE sector in Lebanon.

It must be highlighted that within the UNDP and particularly within the CEDRO Program, there is an incredible amount of knowledge, experience and data from which the knowledge hub can build upon.

Activities to be performed by the hub include:

• Coordinate the key measures of the RE and industrial strategy in cooperation with the relevant public and private stakeholders, including government, LCEC, Association of Lebanese Industrialists (ALI), Industrial Research Institute (IRI), CEDRO, RE companies, NGOs, energy cooperatives, finance institutions, potential foreign investors, etc.

• Support companies working in or for the RE sector, promoting the potential of RE-related SMEs and their importance for the Lebanese economy in general and the energy sector specifically.

• Develop strong formal and informal networks between SMEs and support them with administrative, fiscal, data, information and advisory services. This may be done in form of a Help Desk, maybe similar or combined with the Green Help Desk currently operated by ALI[25].

• Provide tools and/or financial support for information sharing and communication. Such mechanisms would aim to promote a mix of competition and cooperation between firms: Companies working in the same field do not necessarily collaborate for fear of sharing business ideas or intellectual property. It is therefore important to build up trust that allows for a mix of competition and cooperation between firms. They would be "nudged" to participate in the sector development by working on joint projects (like setting up standards, common training, marketing etc.) that are beneficial for all companies.

• Provide technology-specific support, training, information, etc. (see respective actions in the technology-specific sections below)

• Carry out some of the proposed actions in this report, e.g. activities to attract foreign investment, organizing trade shows and events,

This centre will need resources from government, industry and donors to fulfill the proposed tasks.

[25] *http://www.ali.org.lb/services/green-production-help-desk-ali-escwa-partnership*

Timeline	Priority	costs/ efforts	Responsible
2018-19	high	medium	RE sector, supported by government

5.2.2.4. Attract foreign direct investment

Foreign direct investment (FDI) can be a major source to provide finance and technology for a) concrete RE projects, and b) for companies active in the sector. Transnational corporations tend to be the key players in this field (IEA-RETD 2014)[26]. Attracting FDI does not necessarily mean to have special incentives for foreign investors in place because those can also potentially be interested in any national or local support schemes.

Lebanon is currently not particularly well positioned when it comes to ease-of-doing business. According to the World Bank indicator "Doing Business" which provides measures of business regulations for local firms in 190 economies, Lebanon ranks 133 out of 190 economies with an indicator value of 54.67 (out of 100), two points behind the regional average (see figure below)[27].

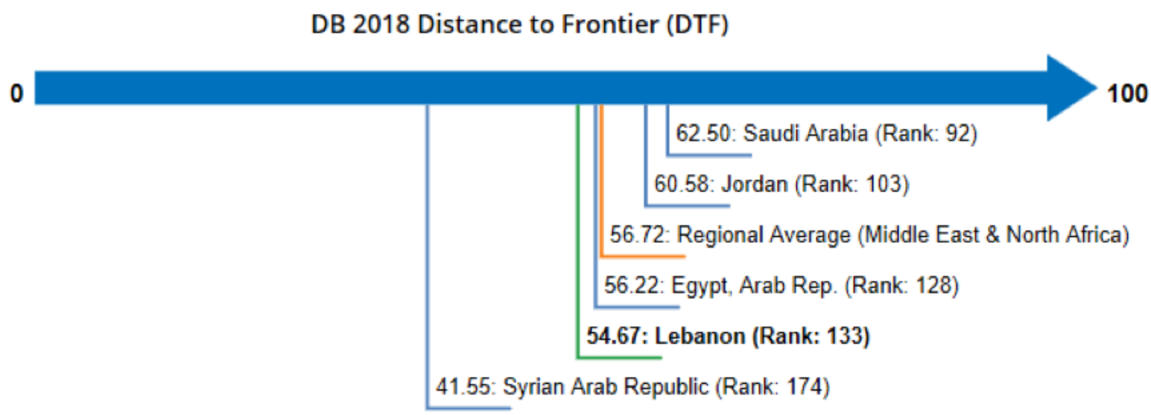

Figure 43. World Bank indicator "Doing Business" in Lebanon (2018)

Foreign (and actually also local) RE investments in Lebanon has to deal with a number of risks. The UNDP Derisking Renewable Energy Report[28] shows how a range of investment risks currently contribute to high financing costs. The cost of equity for wind energy and solar PV in Lebanon today is estimated in that report at 16%, and the cost of debt at 9%. The four main risks identified – power market risk (incl. price paid for RE), grid/ transmission risk (failure-free feed-in of the electricity produced), counterparty risk (creditworthiness), political risk (general intra- and international stability) – increase the cost of equity by more than 1% point each. Investing in de-risking instruments has been proven to be cost-effective.

[26] *However, as Marcias et al. (2011) argue, "the way in which FDI affects development remain obscure, hidden within a 'black box'".*

[27] *http://www.doingbusiness.org/data/exploreeconomies/lebanon*

[28] *UNDP (2017), Derisking Renewable Energy Investment (DREI)*

FDI can have both positive and negative effects, therefore it is important to target well the FDI that is most beneficial for the Lebanese economy and society in the long-term. FDI should not have priority over investments from national or local investors. The risk with FDI is that investors only look at return-on-investment and do not take the needs of the local population or the specific circumstances into account. In case foreign investors are not interested in local value-creation, local content requirements could be introduced, even though those may have also negative effects (see section 5.2.3.1).

It should be further investigated which foreign companies may be interested in investing or establishing offices in Lebanon. Companies could be approached to join fairs and conferences like the Beirut Energy Forum, conferences or other events where business opportunities in Lebanon in the RE sector are laid out.

This also requires having examples of successful business cases prepared that can be presented to potential investors.

Timeline	Priority	costs/ efforts	Responsible
2018-20	medium	medium	RE sector, supported by government

5.2.2.5. Promote local investment through prosumer projects

Prosumers (producers and consumers of energy) invest in local RE projects. They can do this individually or together with others for larger projects like wind or solar farms, e.g. through cooperatives or other forms of cooperation. As they are local citizens or commercial entities (like SMEs with available roof-space), the revenues of the projects are more likely to stay within the local community as when foreign investors finance RE projects. Prosumers also play a key role to increase acceptance of RE installations and to secure distributed generation.

Prosumer projects should therefore be promoted to lift the local potential of funding. The RE knowledge hub (or other organizations) could for instance:
• define and propose prosumer projects;
• invite interested individual or collective prosumers to submit project ideas;
• support in finding financing and/or funding;
• support in creating information (leaflets, newsletters, etc.) on best-practice examples;
• show business case calculations, or accompany the creation process of prosumer initiatives with technical, economic and legal advice. CEDRO has successfully implemented prosumer projects and could therefore be seen as a role model in this field.

Eventually prosumerism should be an integral part of the future energy system of Lebanon, therefore any activities that help increasing the number of locally supported projects will increase the number of local jobs.

Timeline	Priority	costs/ efforts	Responsible
2018-20	medium	low	RE sector, supported by government

5.2.3. Linking investment to employment creation and capacity building

5.2.3.1. Introduction - supplier development programs and Local Content Requirements (LCRs)

As mentioned above, it is important to ensure that FDI or any other types of investment lead to **local added value and job creation.** Foreign companies which are technology leaders in their field would find interest in investing in Lebanon if they find cheaper workforce, well-skilled and educated employees, or an interesting market. To build relationships between local and foreign companies helps to ensure that foreign companies are committed to long-term investments.

Supplier development programs: Supplier development programs aim at upgrading the capabilities of domestic SMEs so that they can provide components and services locally, allowing them to capture value from RE investments and foster closer linkages with foreign investors. Upgrading capabilities of local firms is necessary to ensure that value creation opportunities stay in the region, by increasing the feasibility of sourcing components and services locally.

Local Content Requirements (LCRs): LCRs determine to which extent projects must use locally manufactured products. Their aim is to increase local jobs, local economic development and “buy-in” to RE deployment from local stakeholders. LCRs are often combined, such as preferential tariffs, tax exemptions, low-interest loans, infrastructure support and land acquisition support (IEA-RETD 2014). Even though LCR have been on the rise since the financial crisis in 2008, the OECD notes that LCRs undermine long-term competitiveness and diversification, that import and exports decline and domestic production costs rise as a result of LCR (OECD 2016) . Also the World Trade Organization (WTO) considers LCRs inconsistent with rules governing free and fair international trade.

Lebanon has currently no LCRs in place . But according to LCEC, in the solar PV qualification criteria for PPA a local partner is indirectly required as previous experience of 30MW internationally and 100kW installed in Lebanon are eligibility criteria. Therefore they expect partnerships/joint ventures between large solar firms and Lebanese solar companies.

As Lebanon has not joined the WTO yet, it would not have to comply with WTO rules on LCRs which have forced various countries to withdraw them (e.g. Ontario eliminated LCRs in 2014 which had been introduced for RE projects to be eligible for the feed-in-tariff). However, Lebanon’s accession to the WTO is under negotiation, and therefore the pros and cons of LCRs should be well considered. In case the government considers LCRs policies for RE installations, they should apply best-practices, such as being limited in duration, having planned evaluation phases incorporated, being technology-neutral and consistent with other industry promotion policies.

5.2.3.2. Organize trade RE shows and events

The Lebanese government can help SMEs that provide RE products or services to become more visible on the national and international level, e.g. through support of trade shows, road shows, visits to other countries, support for marketing material, etc. These activities should also be supported by the Association of Lebanese Industrialists (ALI) and Chambers of Commerce. The Beirut Energy Forum could be further expanded in the sense that technology specific offerings are provided where e.g. PV developers and installers could meet (matchmaking of potential customers and suppliers)[31].

Timeline	Priority	costs/ efforts	Responsible
2018-20	medium	low-medium	RE sector, supported by government

5.2.3.3. Provide economic incentives to encourage local subcontracting

These incentives can support customers (such as tax relief, subsidies and advisory services) and suppliers (e.g. credit guarantees, soft credit lines, exception from duties). In order to avoid that supplier-customer relations rely only on incentives, it is important to ensure that potential customers have an interest in local suppliers and that the suppliers are competitive with regards to prices and quality.

Timeline	Priority	costs/ efforts	Responsible
2018-20	medium	medium	government

5.2.4. Improving cooperation between public research organizations and private sector

5.2.4.1. Introduction

To create a more favorable environment for innovation, entrepreneurship and technology development, the linkages between public research organizations (universities and research institutes) and the private sector should have a high priority for policy-makers. Research institutes such as the Industrial Research Institute (IRI) in Lebanon, the Fraunhofer Institutes in Germany, or the National Renewable Energy Laboratory (NREL) in the US can transfer and combine theoretical knowledge with commercial applications.

Companies benefit by improving products and processes and thus their competitiveness, having external innovative advisors, getting access to young professionals, educated by teachers with practical experience[32].

According to the interviews, research and the private sector are largely decoupled in Lebanon so that there is a real need to bring them closer together.

[31] *http://beirutenergyforum.com/ The list of exhibitors of the 2017 edition shows some 30 organizations of which less than a third were RE project developers or manufacturers.*
http://beirutenergyforum.com/files/309/List%20of%20exhibitors.pdf

[32] *Key features that have contributed to fostering public research organizations-enterprise linkages have been: funding mechanism that rely on several types of sources (i.e. industry and non-industry, government funding); a balance between application-oriented fundamental research and basic research; focus on practical applications to technical and organizational problems of firms; emphasis on entrepreneurship and spin-off creation; and intent to achieve a high reputation for quality research and problem-solving skills.*

5.2.4.2. Think about RE clusters – but rather at a later stage

Industrial or business clusters are geographic concentrations of interconnected companies and institutions in a particular field. They aim to increase competitiveness and productivity of different stakeholders, i.e. SMEs, financial institutions, industry associations, and chambers of commerce. Governments can initiate and – ideally only in the first phase – support clusters financially.

In 2014, the United Nations Industrial Development Organization (UNIDO) announced that together with the Ministry of Industry of Lebanon a new cluster development programme for the country's cultural and creative industry has been introduced. However, without having gone into more detail, it seems that this programme is rather focused on individual companies and less on a cluster definition used above[33].

The development of clusters does not necessarily mean that the companies or the concept will be successful. Due to the increasing globalization it is more and more possible for companies to collaborate remotely in virtual networks. Clusters can also lead to a waste of public money if the cluster requires continued financial support because the companies fail to establish viable businesses. Clusters also have to be able to respond to market dynamics. In fact, the finding of reports about RE clusters that were written just 3 to 5 years ago need to be re-checked because developments in the sector are fast and a change of policies highly affects the performance and viability of RE clusters.

For a comparably small country like Lebanon this means that it needs to be carefully considered if a cluster approach makes sense as long as the RE market is small and production as well as research & development is negligible. For the time being, the preferred strategy may be to organize the exchange between SMEs and research organizations through the RE knowledge hub and its partners.

Timeline	Priority	costs/ efforts	Responsible
beyond 2020	low	tbd	RE sector, supported by government

5.2.5. Enhancing know-how through education & training

5.2.5.1. Introduction

A large-scale and sustained deployment of RE is only possible if there is a skilled and educated workforce in place. A lack of skilled engineers and workers, sub-optimal RE policies due to un-informed policy makers leading to lost industrial and business opportunities, and issues with public acceptance represent barriers to RE deployment that can be avoided with a comprehensive strategy for education and training in place. In addition, ideally all citizens should be informed and/or educated to understand the benefits and specificities of RE ("mainstreaming of RE").

[33] *From 12 applications, two were selected (an Armenian jewelry store located and a producer of furniture) and supported financially to enhance their competitiveness. https://www.unido.org/news/unido-supports-cultural-and-creative-industry-clusters-lebanon,www.aicsbeirut.org/portal/en-US/economic-and-local-development/23/c/development-of-clusters-in-cultural-and-creative-industries/203/#sthash.YpfAy1Me.dpbs*

Despite its importance, it is worthwhile noting that education & training sector tends to be rather "reactive" when it comes to building up RE knowledge. In IEA-RETD 2010 this has been described as "chain of influence": It is governments' RE policies that are the crucial trigger because only if those are in place, companies start to engage in the RE sector. Once they see business opportunities they require skilled personnel; this will in turn trigger students and workers who see the job opportunities in the sector. In order to qualify for the jobs they will ask for RE specific education and training. It is basically only then that the education sector will define the required curricula and start to offer education and training – unless specific actions are taken that engage the sector in preparing these offerings early-on. This is where the following actions as well as the ones described in the respective technology chapters can accelerate the overall capacity building process.

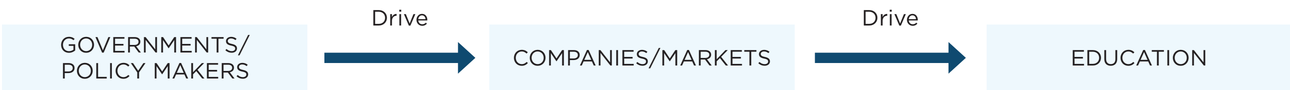

Figure 44: Chain of influence
(Source: IEA-RETD RE-EDUCATION 2010)

As a number of policies have been also already been implemented in Lebanon and the RE sector starts seeing the potential for future business, the education and training sector is also starting to get prepared. A number of initiatives and courses are listed in the annex.

5.2.5.2. Implement quality standards for RE education and training

With the objective of monitoring the development in RE related education, an annual data gathering and analyses project may be set up in order to gain transparency the offerings about RE related education at primary and secondary schools, in vocational training, at universities and in post-graduate courses.

Most important in the short to medium term is the definition, adoption, implementation and enforcement of quality standards and quality assurance mechanisms for RE (and EE) training. This will allow companies and individuals to identify what is on offer and who is the right contact for their needs. Furthermore, skill shortages in the labor market can be addressed quickest by training those who have already received a first academic or professional qualification or are already employed but need further qualifications. Trainings need to be technology-specific, see subsequent sections.

To that end it is proposed apply the approach recommended by the project RE-ACTIVATE ("Employment Promotion through Renewable Energy and Energy Efficiency in the Middle East and North Africa")[35]. Activities include:

• Set up working group of technical experts that identifies where installation quality is lacking and the reasons. Take stock of the key existing quality standards for RE/EE vocational and further training at the national level.

[35] *Project carried out by GIZ and the Regional Centre for Renewable Energy and Energy Efficiency (RCREEE); report see: RENAC, GIZ (2015)*

• The Working Group develops the Job Task Analyses for the various occupations, setting Occupational Standards.

• Compile and develop recognized Codes of Practice.

• Develop training programmes to address the needs of all target groups, providing a high proportion of practical, hands-on training.

• Identify and map the most important national actors in this field: Regulator, Occupational Standards Body, Training Development & Approval Body and Training (see definitions in the annex 7.1.1). As mentioned above, an overview of education and training programs in Lebanon has been compiled in a preliminary desk review, see annex 6.1.2.

• Describe their current and potential future roles and activities.

• Conduct trainings through training providers and Train-the-Trainer programmes (both technical and didactical).

• Introduce a mandatory certification scheme for companies operating in the RE/EE sectors, especially where installations are co-financed with public funds. It should cover all occupation levels involved (i.e. installers, technicians and engineers). Certification obligation should end once the market is mature. It does not need to be accredited to international standards immediately; but the quality management and quality assurance mechanisms should be in place to become potentially accredited at a later stage.

As for the three pilot countries of the project (Tunisia, Egypt, Morocco), Lebanon could share the results on the RCREEE's "Taqaway" website in order to improve the understanding of RE/EE training in the MENA region[36,37].

Furthermore, it needs to be assessed in more detail by technology which profiles are available to promote development of training programs that match market needs. The companies active in the sector need to be involved in this assessment.

Timeline	Priority	costs/ efforts	Responsible
2018-19	medium-high	Low-medium	government, RE sector, training providers

5.2.5.3. Plan RE Education and training

RE policies need to be "translated" into requirements for education in order to provide the market with enough personnel and the right skills. It may also encompass the investigation of the lack of skilled personnel in certain sectors (gap analysis). In this context it could be useful to examine what current professions have the right skills to transition into RE professions through capacity development and training. An important part of should be "train the trainer" programs on RETs.

[36] *RCREEE 2016, RE-ACTIVATE – RE/EE Training Sector Mapping for Morocco, Tunisia, Egypt https://drive.google.com/file/d/0Bw3iuAFOs3kXQzEtY3Y2RjdWQUk/view;www.taqaway.net*

[37] *Until recently IRENA offered the so-called "IRENA Renewable Energy Learning Partnership (IRELP)" which provided a platform to post RE training and education offerings by country and globally. It seems that the website www.irelp.org is not active anymore.*

It should be considered that training programs target vulnerable people by potentially providing them free of charge.

Apart from the sector itself, education and training also needs to be planned in the following areas, therefore “educating” of the following audiences is required:

• **Primary and secondary schools:** In order to increase the general level of knowledge and awareness of RE and sustainability related topics in general, education in schools will play an important part. An effective approach on how to teach RE knowledge as well as the definition of teaching material by age group will be required. Apart from the specific curricula, an online platform could be created where educational RE material can be shared. Awareness raising of pupils and young students may be considered a mid to long-term action.

• **Universities:** It may take universities longer than 2-3 years (the timeframe of this action plan) to set up new university curricula. However, universities should be informed that there is an increase of students to be expected that see job opportunities in the RE sector so that existing curricula can be enhanced in a way that includes RE topics.

• **Vocational training providers:** Currently there are different initiatives running in parallel (e.g. UNDP vocational trainings for PV and SWH, GIZ, etc.) but not coordinated. The coordination role could be potentially taken over by MOEW/LCEC, involving relevant sector stakeholders and the Ministry of Education. Curricula could be developed for vocational centers and universities through the Ministry of Education so that it is applied in general.

Apart from these training providers, there are two crucial institutions that may require specific trainings as they are crucial for the further deployment of RE. Planning or organizing trainings for their employees should be carried out:

• **Public administration:** Public administration needs to understand that especially distributed energy generation like solar PV or bioenergy require certain support on the local and national level. Awareness raising and specific courses for administrative staff especially in the areas of building permits, urban planning should be developed.

• **EDL:** The opportunities for EDL in terms of RE deployment may not be fully known yet. LCEC proposed to create new teams within EDL dedicated exclusively to the integration of RE.

Timeline	Priority	costs/ efforts	Responsible
2018-20	medium	low	RE sector, supported by government

5.3. Specific Actions for PV

5.3.1. General strategy – decentralized approach with central support

Due to its modularity, solar PV can be deployed in a decentralized, small to medium scale roof-top applications or as large-scale, ground-mounted systems. Both the renewable as well as the industrial strategy should take this feature into account. This translates to the following actions:

5.3.1.1. Establish a central PV knowledge hub

In order to create a strong voice for the PV sector and build up the required technical and institutional capacity, a central PV knowledge hub (or PV centre) should be established. It would ideally be integrated into the RE knowledge hub. It would deal with all PV-related aspects that need to be handled on the national level in a centralized way to ensure consistency and to make Lebanon attractive for RE investments as a whole.

Proposed activities include (in combination and in addition to the general activities proposed for the RE knowledge hub, see 5.2.2.3):

• Set up and maintain a PV-specific website that addresses potential customers (residential and commercial prosumers), sector companies, and government administration.

• Maintain a list of certified suppliers, i.e. companies that have gone through PV-specific trainings, to be reviewed at least every two years.

• Provide information about PV in general and on a technical level.

• Provide up-to-date legislation and regulation.

• Run a help desk for prosumers and companies (the resources for this task needs to be well planned as it can be time-consuming).

• Be a voice of the PV sector (in conjunction with e.g. the PV sector association and other stakeholders) that should be regularly consulted when it comes to new regulation.

• Maintain a list of PV education and training facilities and courses.

• Potentially offer PV trainings (or in conjunction with training facilities).

• Support the local energy centers (see next action) in terms of PV specific knowledge, advocacy, etc.

• Provide advice and potentially office space as incubator for innovative start-ups in the PV sector.

• Promote and/or organize innovative pilot projects.

• Organize knowledge sharing activities like workshops, seminars and conferences among PV companies.

• Organize conference and events for the PV sector on national and international level.

• Participate in international events to promote the Lebanese PV sector and attract investments (e.g. World Future Sustainable Energy Forum, Intersolar, etc.).

• Promote innovative PV pilot projects, e.g. in combination with battery storage (see also 5.3.3.1) or building integrated PV.

• Carry out some of the actions proposed below.

Not all of these activities are required to be set up from the very beginning. When defining the work programme, a prioritization and matching with potential funding would have to be done.

Timeline	Priority	costs/ efforts	Responsible
2018-19	high	medium	PV sector, supported by government, donors

5.3.1.2. Establish local energy centers

In addition to the central hub, various local energy centers should be established that can support citizens and SMEs locally across Lebanon, i.e. in cities and villages, to make use of PV and become prosumers[38]. The local centers would thus help developing the distributed generation with PV, especially roof-top and building integrated systems, thus contributing to lifting the job creation potential for this kind of smaller installations where more jobs per MW can be created than for centralized plants (see value chain analysis above).

They would carry out several actions mentioned for the central hub like awareness raising, help desk services, investment promotion, education and training, identification of potential sites and buildings, etc. The local energy agencies may also take care of other energy related topics such as promotion and awareness rising on energy efficiency measures and savings.

The centers would need to be installed first in the cities or regions where most PV projects are taking place, and then subsequently rolled-out based on potential and actual demand.

The funding of these agencies will have to be defined (government, or international donors).

Timeline	Priority	costs/ efforts	Responsible
Starting 2018	medium-high	medium-high	PV sector, supported by government, donors

[38] *The local energy agencies may also take care of other energy related topics such as energy savings.*

The strategic approach is depicted in the following figure:

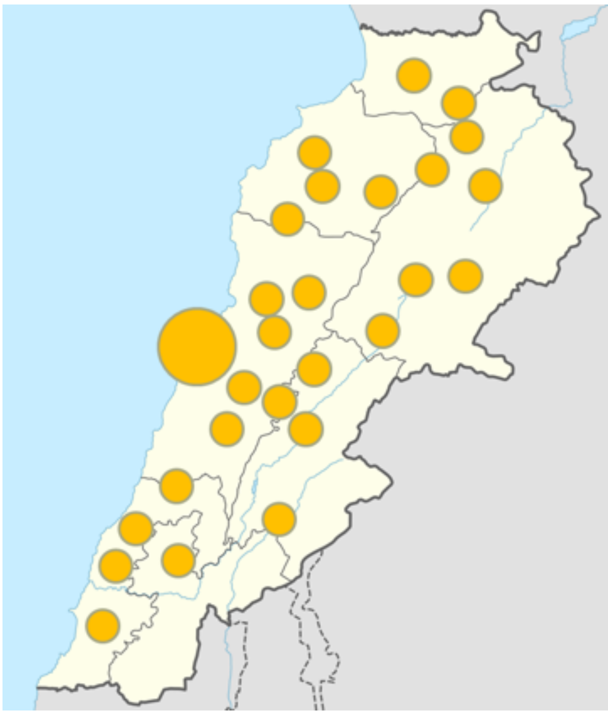

Figure 45. Conceptual depiction of the PV strategy

5.3.2. Strategic investment promotion

5.3.2.1. Introduction – PV value chain

As discussed in section 4, it is not likely that Lebanese companies will be able to compete with especially Chinese companies to produce silicon, PV cells or modules. According to the assessment, the key areas in the value chain are in the installation phase, including services (system design, testing of systems, certification) and materials (for construction, transport, scaffolding, cables, wires, etc.). The strategic focus would be on:

- Engineers (for system design, testing, certification).
- Installers (for installation, potentially system design).
- Suppliers for installation material.

While certain electrical system components for a PV system could be potentially produced in Lebanon (batteries, DC UV-resistant cable –currently not available locally-, mounting structure, AC accessories, charge controllers, inverters, protections, etc.), it is likely that more complex components like inverters or batteries are imported and only customization (where needed) is carried out in Lebanon.

For larger projects, additional evaluation points could be awarded in the tender design if components from national suppliers would be used.

According to LSES, local Lebanese SMEs have a strong capacity: There are more than 100 companies active in the field of solar PV of which several ones are reported to be capable to manage large solar projects. Many local companies compete in the market for smaller, distributed projects. According to the interviews, for companies it is difficult to find skilled engineers and technicians and when found to keep them with low salaries because of fierce competition among PV companies[39].

5.3.2.2. (Continue to) provide and promote an attractive and stable PV support scheme

Foreign and local investors get only interested if the risk for investment is reasonable compared to the expected return. This is a general need for all RE investments and is further discussed under section 5.2.1.

The business case for PV may not be sufficiently known yet, therefore it is suggested to promote the opportunities for investors.

Residential systems:
Residential customers typically do not own diesel generators for their own consumption, but instead rely on the power supplied by the informal power providers. In these cases, the actions could either be focused towards the private generators or the final customers. The former might not be interested in solar PV or hybrid solutions, as diesel generators utilize much less space, are easier to move and require less investment than solar PV.

By contrast, the final customers can indeed be interested in solar PV because as prosumers they have the potential opportunity to terminate the subscription of the private generators and thus avoid their high tariffs (they are usually flat fees based on contracted capacity, not on energy demand – they translate to costs of 0.16-0.35 US$/kWh depending on actual consumption levels). However, becoming independent from private generators is only possible if the PV system is equipped with a battery which increases investment costs[40]. The EDL power supply would be kept as the tariffs are low due to subsidization (range of 0.1 US$/kWh)[41] which means that PV generation during hours of supply from EDL can be used to charge the battery. During blackout periods the solar system would supply the loads, and during non-blackout periods the solar generator could follow the grid and inject any surplus of power to the grid through the net-metering scheme. According to experts, payback periods for residential users can be of 4-6 years depending on the price of their current subscription with private generators. Apparently virtual net metering is now also in place, allowing communities to apply for this scheme[42].

[39] *According to LSES, salary levels are for non-qualified workers about 800€/month, for installer and plumbers about 1000€ and for experienced engineers and technicians (>5 years) about 2000-3000€ max. The "brain-drain" may be exacerbated with more PV projects to be expected in other Arab countries like Saudi-Arabia that are potentially able to pay higher salaries.*

[40] *Private generators often offer flat rates so net metering would not make sense – apart from the fact that they would probably not accept the off-taking of excess power.*

[41] *A comprehensive (renewable) energy strategy would tackle the subsidization of power and redirect public funds towards investments into RE.*

[42] *EDL added a new dimension to net metering (see NREAP)*

In any case the residential application of distributed solar PV still requires further study as the experience is still limited. The technical solution requires innovation, the potential customers and their capacity to pay need to be characterized, and some barriers such as the regulatory framework for the use of rooftops need to be overcome (see also the action on hybrids 5.3.3.1).

Industrial / commercial systems and buildings with own generator: Lebanon has built a certain level of experience in distributed Solar PV plants in industrial buildings. Commercial PV projects currently prevail over residential ones as their self-consumption ratio is higher so that they do not need batteries. This kind of customer typically has its own diesel generators to secure the power supply during blackouts. Therefore, solar PV competes with the price of diesel and consequently becomes economically attractive by its own. In addition, the decrease of fossil fuels usage with its fluctuating and unpredictable prices offers a more stable price for the power supply, which is a very relevant factor in the more energy intensive industrial activities. These customers would aim to decrease their fuel demand (fuel-save system). According to interviews, they can reach a PV LCOE of 0.07 US$/kWh.

However, the net-metering scheme does not seem to be implemented for medium voltage (MV). It is therefore important to extend net metering to the MV level so that also larger commercial or industrial customers can benefit from it. Furthermore, commercial plants should be encouraged by ensuring a smooth functioning of the NEEREA mechanism.

It is likely that the net metering system will need to be adjusted in future as tariffs and costs for PV will change.

Large, ground-mounted systems: For these systems a process of public tendering is in place. It seems that there are sufficient proposals, showing that companies are eager to win these projects. It is very important to make sure that in these public tenders the whole process is based in transparent rules and the results are made publicly available. This will further encourage participation in future processes.

Timeline	Priority	costs/ efforts	Responsible
on-going	high	low	government

5.3.2.3. Streamline/accelerate the NEEREA process

Both residential as well as commercial prosumers require bank loans to stem the investment. They should be supported in finding banks whose personnel are familiar with this kind of systems so that loans are issued smoothly.

NEEREA is the National Energy Efficiency and Renewable Energy Action, a national financing mechanism initiated by the Central Bank of Lebanon (BDL – Banque du Liban) launched in 2010 which provides subsidized loans for RE/EE projects[43]. In general this scheme is seen positively by debt investors as it reduces market risk[44].

However, even though the process is supposed to take only two months, feedback from interviews was that the process can be very lengthy (one interviewee reported more than 6 months, another one even experienced up to two years)[45]. A reason may be the increase of applications. The process is apparently also not sufficiently transparent as applicants do not receive information about the status of their application. An online system should be established that allows accessing the file and reviewing its status. The process and available resources should be reviewed to allow a fast processing of all applications.

Financial institutions will need to train their staff so that they know and understand PV installations, the risks and financial flows. Leaflets and other information may help supporting staff working directly with customers.

Timeline	Priority	costs/ efforts	Responsible
2018-19	high	low	government

5.3.2.4. Accelerate the introduction of grid connection standards and guidelines
To date, Lebanon does not have a national grid connection standard, which is needed to secure RE integration along with grid specification to avoid exceeding certain parameters that may lead to network damage. A grid connection code is expected to materialize by 2019 but it would help especially PV projects if it was available earlier. Examples of useful grid standards for small scale PV systems can be found e.g. in Dubai[46], Oman or Bahrain. Additionally, technical guidelines can be prepared and published to disseminate best practices.

Other actions include:
• **Extending net metering to Medium Voltage.** As mentioned above, it is serious limitation large commercial & industrial customers if they cannot benefit from the net metering scheme.

• **Conduct a grid impact study and train grid operators.** If the currently planned RE projects are connected to the national grid, the increase intermittent power sources may cause grid stability issues. Currently Lebanon may not have sufficient experience on how to deal with this. Therefore it is important to secure Resources for EDL (e.g. control room) and train staff.

Timeline	Priority	costs/ efforts	Responsible
2018-20	medium-high	medium	government, EDL

[43] *www.cedro-undp.org/content/uploads/event/160802025139842~NEEREA-EnergyManagementinIndustries-Examples-MJ.pdf*

[44] *UNDP 2017: Derisking Renewable Energy Investment (DREI) in Lebanon*

[45] *It should be noted though that there were contradicting views on the NEEREA process, for instances LSES was of the opinion that is working very well.*

[46] *See Shams Dubai https://www.dewa.gov.ae/en/customer/innovation/smart-initiatives/shamsdubai*

5.3.3. Improving cooperation between public research organizations and private sector

5.3.3.1. Promote R&D, pilots and companies working on hybrid systems

The specific situation of Lebanon with regular black-outs calls for a solution in social, economic and environmental terms. RE can help to solve at least parts of the issue through the application of hybrid systems. This would include PV systems with batteries with or without diesel back-up, with or without integration into the electric grid, power management that balances supply and demand, virtual power plants, micro-grids, etc. Energy storage is expected to play a critical role especially within the residential sector as hybrid solutions including batteries can help to narrow the demand-supply gap. Batteries can even become economically attractive if used to store the cheap (subsidized) energy from EDL during non-blackout periods and deliver it during blackouts, and thus the contracting of private generators becomes obsolete.

For the past 2-3 years the oil price was very low but as oil price increase hybrid solutions become more competitive. The battery market is still incipient, but it may develop now that oil prices increase. In general hybrids grid/diesel generator/PV are reported to work well so far, but still need the support of NEEREA anyway.

In the unique area of hybrid systems, Lebanon may even be well positioned to play a role on an international level. Lebanese companies that have gained experience with hybrid systems have already started exporting their services to Africa. Also in terms of R&D these systems present an interesting opportunity.

The following actions with regards to hybrid systems are proposed:

• Several interviewees, among them LSES, suggested that cooperation between universities and municipalities on research projects could be strengthened.

• For a mini-or micro-grid projects, more pilots (like the CEDRO project in Kabrikha based on virtual net-metering) are needed which could be easily extrapolated if successful.

• Apart from technical issues, it is also important to improve learning regarding organizational issues as projects will also have to deal with municipalities and EDL.

• Government and the private sector should establish ways on how to fund RE technology research in an efficient and effective way. Universities (faculties and students) should get involved in applied research through various channels (e.g., joint appointments, internships).

• The government could also promote companies that work on solutions for system integration by providing special incentives, e.g. tax exemptions, grants or low-interest loans. For instance, it could be interesting to support projects that help the current private generators to switch from diesel to PV-battery systems. This would also help to overcome the resistance of private generators to changes in the current set-up as they usually see RE as competing technology.

• Another idea could be to launch an inducement or recognition prize which awards organizations (suppliers or IPPs) that have made progress in this field. Prize award schemes are for instance launched by the European Commission but also on national level[47].

Timeline	Priority	costs/ efforts	Responsible
2019-21	medium	medium	PV sector, government, research institutes

5.3.3.2. Improve Building Code

In terms of energy efficiency and integration of PV in buildings, the building code needs to be improved. Currently most new buildings do not require any RE or EE measures. Given the current boom in real estate development, a new code should be introduced as soon as possible to avoid a building code with high energy demand in future.

It was reported that a new building code is under preparation. There is a committee composed by diverse stakeholders and LIBNOR. They are following European standards but apparently not the new one for net-zero buildings (Energy Performance of Buildings Directive, EPBD). Interviewees proposed that foreign support would be useful.

Tax regimes related to buildings need to be adjusted as well: In order to save taxes, building owners currently tend to declare a roof of a multi storey building not as roof but as potential floor of the next level. This discourages PV installations.

Promoting Building Integrated Solar PV (BIPV): Integration of PV into buildings (facades for instance) is a subsector that needs further development, especially in urban areas due to the limited roof availability (Beirut city growing vertically).

Timeline	Priority	costs/ efforts	Responsible
2018-20	high	medium	PV sector, government, research institutes

5.3.4. Enhancing know-how through education and training

5.3.4.1. Implement a quality assurance framework for PV

Interviewees reported that while there are more than hundred companies competing for PV projects, not all of them may deliver projects with desirable quality. Quality is especially important for distributed PV as the private customers have less expertise and possibilities than companies to ensure good quality. Cases where badly installed PV plants led to not only to underperformance but also to safety issues (like fires) need to be avoided as they can lead to negative perceptions.

[47] *For instance the EU Inducement Prizes http://ec.europa.eu/research/horizonprize/index.cfm?lg=en&pg=prizes, the EU SOFT Innovation Prize 2018 http://ec.europa.eu/research/participants/portal/desktop/en/opportunities/h2020/topics/prize-innovation-soft-2018.html , or the NESTA Prize in the UK https://www.nesta.org.uk/challenge-prize-centre*

Ideally a quality assurance framework for the PV sector would be introduced that encompasses the products as well as the project developers and installation companies. For products, there are Lebanese Quality Standards (LSES and DREG contributed to their preparation) but not always applied, so some products are imported without meeting the standards, (also for SWH). A Decree is pending to be ratified in order to make them mandatory. UNDP is working with Industrial Testing Institute to provide equipment. However, it should be avoided to complicate processes for installations in Lebanon as long as international product standards are adhered to. For large-scale PV systems, the bidding processes apparently already require products according to international standards.

According to the interviewees, quality standards should ideally be required when the goods are imported, or when finance is required at NEEREA or when requesting the net-metering.

Such an installer certification scheme could be set up similar to what has been implemented in Dubai[48] and soon also in Saudi Arabia. In order to be eligible to install PV systems, companies and individual installers have to pass a training course that certifies that they have the capacity to carry out installations according to certain quality criteria.

Others measures to improve quality should be taken such as:
• Establish lists of products that adhere to international quality standards (especially for PV modules and inverters), available online and regularly updated.
• Develop an education and training framework (see also annex 1), including:
- Develop technical standards / Codes of Practice.
- Develop training programmes based on Job Task Analyses (JTAs).
- Develop curricula, teaching materials, equipment lists, practical and theory exams.
- Define examination regulations.
- Define certification schemes.
- Develop assessment procedures for training providers.
- Etc.

• Potentially establish an organization that serves as certification body for RE companies. For instance, the Industrial Research Institute may be empowered as its current portfolio already includes certification activities[49].

The quality framework should be set up in a way that it does not results in long lead times, holding off PV projects. It should be made clear that it provides additional value-add and guarantees for customers.

Timeline	Priority	costs/ efforts	Responsible
2019-20	high	medium	PV sector, supported by government

[48] *https://www.dewa.gov.ae/en/customer/innovation/smart-initiatives/shams-consultant-and-constructors*

[49] *http://www.iri.org.lb/certification.html*

5.3.4.2. Provide technical and vocational training to installers (and others)

Provide technical and vocational training to installers: Especially AC/DC training is required according to interview partners. Those trainings need to be organized locally, i.e. there should be offerings in every larger city. Although those training offerings may become available through specialized service providers once demand for distributed PV systems goes up, it would help to pro-actively organize trainings within a network of certified training institutions.

DREG supported the implementation of a vocational PV training course as part to Electrical Engineering studies at Central School. DREG donated laboratory material for practical training and as part of the program they trained the trainers. The curricula was implemented last year during the academic year, so in June 2018 the first graduates will finish. DREG intends to use some of them for the commissioning of the currently ongoing DREG projects.

Produce PV training material: Training for PV systems and curricula is available in many countries. Useful material should be adapted to the Lebanese context and provided online. Training courses would then mainly focus on practical, hands-on activities.

Educate and train craftsmen working in the informal and specifically in the construction sector, who very often have no or very little formal qualifications, but who play an important role for the RE sector as well. As part of this, RE employers should be encouraged and supported to provide on-the-job-training and apprenticeships.

Educate architects and real estate developers / promoters: As the design of buildings establishes for decades to come the energy needs of their users, it is crucial to educate architects and real estate promotion companies early on. Since they usually do not have an incentive to build energy efficient way or to integrate renewables, building codes are indispensable. However, the more these professionals understand and know about RE/EE, the more they may get interested to apply them in order to increase customer satisfaction.

Timeline	Priority	costs/ efforts	Responsible
2018-20	medium-high	medium	PV sector, education sector

5.3.4.3. Organize awareness raising campaigns to promote PV prosumers

Local funding is of special interest for distributed, roof-top installations. Prosumers (producers and consumers of energy) will be the most common investor for roof-top installations. These campaigns can run on a national level, showing the advantages of net metering in terms of savings on the energy bill, highlighting also the positive effects on local employment. In addition, these campaigns could educate prosumers to take quality issues seriously, i.e. to look for certified inverters, modules, batteries and other components, and to avoid looking only at the lowest-price offer.

Such a campaign could have the following features:
a) Running for at least one year.
b) Using especially social media (Facebook, Twitter, etc.) but if possible also radio and TV spots.
c) Involving popular ambassadors.
d) Providing an easy to use website with technical and financial information, a business case calculation tool, contact lists of certified suppliers, etc.

In addition, the local solar agencies should organize meetings with local citizens and companies explaining PV and the process: Target group for the meetings would be individuals or companies that have roof or other space available (e.g. parking lots) to install PV systems. At these meetings it should also be discussed how the business case for net metering would look like for typical system sizes and how the installation can be financed.

Timeline	Priority	costs/ efforts	Responsible
2018-20	medium-high	low-medium	PV sector, supported by government

5.4. Specific Actions for Wind

5.4.1. General strategy – centralized approach

The deployment of wind energy starts with the 200 MW project in Akkar. Three Lebanese private companies participated in Lebanon's wind PPA (Hawa Akkar, Sustainable Akkar and Lebanon Wind Power). Future projects are also in the range of several hundred megawatts launched through tenders in selected locations, similar to large ground-mounted PV plants.

5.4.1.1. Establish a central wind knowledge hub

For the time being, these projects can only be carried out by a few specialized companies. Moreover, compared to solar energy, the wind resource is not as abundant in all parts of Lebanon but is mainly concentrated in the North around Akkar and some other areas. Therefore it is proposed to apply a centralized approach for the wind energy sector where the activities are bundled centrally (probably Beirut). An additional wind centre may be set up in Akkar at a later stage.

The strategic approach is conceptualized in the following graph:

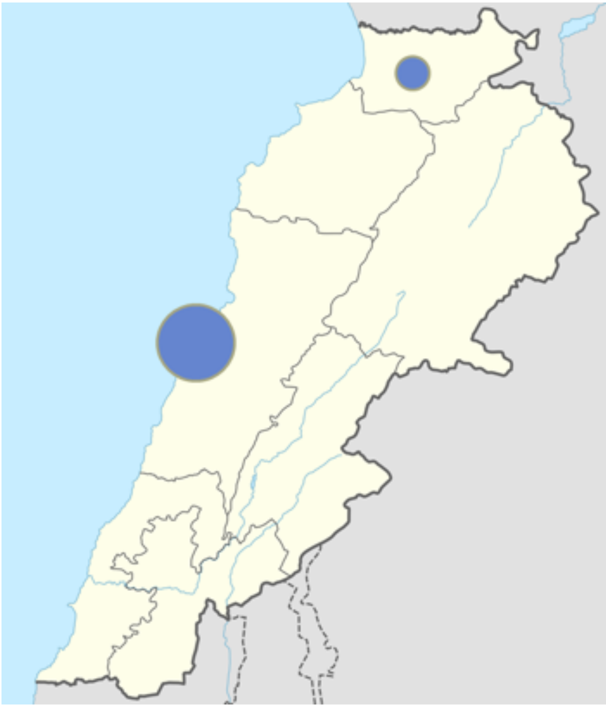

Figure 46. Conceptual depiction of the wind strategy

The central wind knowledge hub would have to carry out more focused activities than the knowledge hub for PV as the number of companies and customers is comparably small. Activities may include (in combination to the general activities proposed for the RE knowledge hub, see 5.2.2.3):

• Bring together project developers, civil engineering, logistics companies as well as service and potentially research organizations that have an interest in further developing the wind sector in Lebanon. Those stakeholders may discuss the establishment of a wind sector association.

• Advocate wind projects with the government and in communities with good wind resources.

• Make policy proposals to improve the regulatory framework and speed up consenting processes.

• Build the capacities required to grow the sector through organizing and/or offering education and training to carry out some of the actions proposed below.

Timeline	Priority	costs/ efforts	Responsible
2018-19	high	low-medium	wind sector, supported by government

5.4.2. Strategic investment promotion

5.4.2.1. Introduction – wind value chain

The wind sector may create between a few hundred and about 1,500 direct full time equivalents by 2021 (see section 4). As discussed, a number of activities of the industry's value chain can be carried out in Lebanon. It is possible to locally provide project planning and development, installation, and O&M services (which require more man power than for PV systems). Moreover, Lebanese companies could have a large share in towers, civil works, cabling, assembly as well as logistics. This means that Lebanon has the potential to develop know-how in most wind subsector value chain phases, except for the first phase ('Equipment manufacture and distribution').

In addition Lebanon may provide also services to other countries in the region (e.g. Jordan plans 600-1000 MW by 2020), especially engineering and installation know-how once this has been built up. In case Lebanon would plan to export larger components like towers or specialized cranes to other Arab countries, this may be challenging unless they can be shipped by sea (as the land-routes through Syria and Israel are currently restricted).

5.4.2.2. Define and show the pipeline of wind projects

As the wind sector requires more specialization and is less modular than PV (usually larger wind parks are built, there is no possibility to just build a few kW), it is even more important for companies to see the pipeline of expected projects / tenders. SMEs that are e.g. active in project development, logistics or component supplies will then be willing to make the necessary investments in equipment and personnel. Otherwise, if a stop-and-go policy is applied, wind projects would be only executed with foreign suppliers and the potential for local value-add will not be used. According to interviewees, it took several years to sign the PPAs for the first 200 MW that are to be operational by 2020. Another EoI about 200 to 400 MW was launched recently (with the deadline on 12 April 2018). If this capacity were implemented in the early 2020s, the 2030 NREAP target of 450 MW would already be overachieved, making it necessary to have the expected investment available several years earlier[50]. If the 2030 target is maintained it would mean that only 250 MW would be added between 2020 and 2030 – not enough for creating a local industry.

As said above, the potential for wind in Lebanon could be several GW, i.e. at least several hundreds if not thousands of wind turbines. If a realistic planning pipeline which intends to capture this potential in the long-term can be defined with the necessary framework, the wind sector will build up the necessary capacity and create domestic jobs.

Timeline	Priority	costs/ efforts	Responsible
2018-19	high	low	government

[50] *UNDP 2017 DREI report estimates that to reach the 450 MW 2030 target about USD 635 million in private sector investment are required.*

5.4.2.3. Promote small wind farms with citizen participation

To overcome land constraints it is suggested that Lebanon should also promote small-to-medium sized wind farms (e.g. 10-40 MW), or even single turbines, rather than large-scale wind farms. Ideally these wind farms would be at least partially financed by local citizens, prosumer groups or cooperatives, thus increasing acceptance for this technology. The government may consider specific incentives for smaller projects with citizen participation[51].

Compared to PV, wind projects are potentially more complex and may need longer lead times. However, if a e.g. a community in Northern Lebanon has a suitable site with good resource potential, it should be empowered to develop a wind project and harness the benefits. It should also be considered that Lebanon will need a mix of renewables as for a single technology is more difficult to provide stable supply.

Timeline	Priority	costs/ efforts	Responsible
2019-20	low	low	wind sector, supported by (local) government

5.4.3. Enhancing know-how through education and training

The following actions could also be combined under an overarching action **"Creating a wind hub for knowledge exchange, education and training".**

5.4.3.1. Develop trainings for service for wind companies

Set up a training center for engineers and project developers: Pooling the needs for training for engineers and project developers for Lebanon will simplify the work of the companies active in the sector. Project developers also must be trained to take precautionary measures to mitigate or avoid potential environmental and social consequences (e.g. noise, interference with bird migration) associated with wind systems. For instance, Lebanon lies on a major global bird migration route and wind systems can cause interference with this. It is crucial for developers to conduct detailed social and Environmental Impact Assessments to avoid negative environmental impacts.

The training center could be financed by the companies active in the wind sector with support of government funding. That way, foreign experts giving lectures or trainings would also have a single point of contact. Establishing a pool of experts will also help to potentially share resources and reduce the risk of unemployment in case projects are lost or wind deployment is slower than expected.

Educate and train O&M personnel: Interviewees noted that Lebanon lacks the expertise needed to operate and maintain wind projects. Therefore Lebanese developers will need to request foreign support to repair components. For the first 200 MW, about 140 persons as O&M staff will be required. Providing trainings, potentially in-house abroad, will help to be prepared once the turbines are installed.

[51] *Once the first projects have been implemented, and in case they have been successful, the general wind strategy may become more de-centralized.*

The training could be organized by the RE/wind knowledge hub in cooperation with the project developers, OEMs and training providers specialized in wind service. These trainings may also include a train-the-trainer concept – i.e. not only service technicians get trained but also trainers – which allow carrying out future training with Lebanese trainers.

Timeline	Priority	costs/ efforts	Responsible
2018-19	high	low	government

5.4.3.2. Develop trainings for suppliers

Train potential key suppliers of towers: Steel and concrete towers could be built in Lebanon. The companies that could potentially built these towers should be brought together to discuss with them the opportunities of the sector. Foreign experts of tower manufacturers could be invited to provide training or knowledge transfer.

Train key logistics companies: Companies that can provide cranes for the erection of wind towers and turbines as well as transportation of large components should be gathered to inform them about the opportunities. Cooperation or frame contracts with wind developers and foreign OEMs could be set up to give logistics companies a certain security to recover their investments in cranes or special vehicles.

Train financial intermediaries: According to the model, a large share of the domestic jobs relate to financial services. Training could encompass: Specificities of the wind business, risks and insurance, etc.

Timeline	Priority	costs/ efforts	Responsible
2019-20	medium	low-medium	wind sector, supported by government

5.4.4. Improving cooperation between public research organizations and private sector

5.4.4.1. Improve information on resources and site availability

Improve data accuracy of National Wind Atlas: According to the interviewees, Lebanon lacks sufficient, reliable data for wind system development. They noted that The National Wind Atlas of Lebanon only provides preliminary data that lacks completeness and accuracy, making it difficult to develop and track wind projects. To obtain missing data and precise site information, private companies complained that they often need to conduct their own simulations for preliminary assessments, which are time-consuming and inaccurate.

Wind measurements (LIDAR and/or wind masts) at various sites over extended periods of time could be carried out by Lebanese companies. They may require training and equipment might be purchased abroad.

Identify sites: Developers face difficulty in finding suitable locations to host wind systems as land is limited and locations must meet many several requirements to be suitable for wind systems: they must have good wind resources, be available, affordable, ideally close to the grid yet distant from households and large enough to fit wind turbines. In combination with the activities to improve the Wind Atlas, suitable sites should be identified to facilitate the development of new projects.

Timeline	Priority	costs/ efforts	Responsible
2019-20	medium-high	low-medium	wind sector, supported by government

5.5. Specific Actions for Bioenergy

5.5.1. General strategy – centralized approach with local project support

Compared to PV and wind, the bioenergy sector will be much smaller, and even more so the biogas sector. Biogas projects are also relatively small and need to be well linked to the local resource availability. But the knowledge in this sector is still limited and needs to be built up on a national level to reach a meaningful scale. The following action is proposed:

5.5.1.1. Establish a central bioenergy knowledge hub and give local project support

Due to the above reasons, a centralized approach with local project support should be established. Bioenergy will benefit from collaboration with universities or research institutes.

The strategic approach is shown in the figure below:

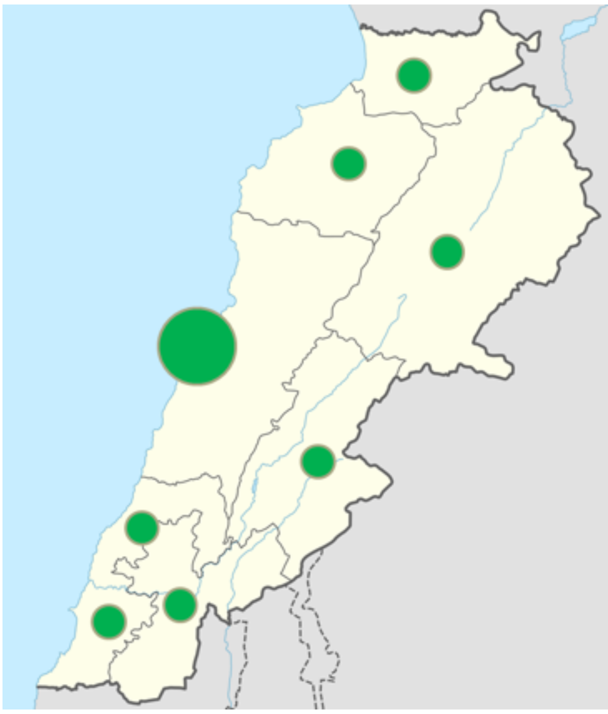

Figure 47. Conceptual depiction of the bioenergy strategy

Activities may include (in combination with the general activities proposed for the RE knowledge hub, see 5.2.2.3):

• Bring together bioenergy experts, companies and research organizations to develop the bioenergy sector in Lebanon.

• Advocate bioenergy projects with the government and in communities with good bioenergy resources.

• Make policy proposals to improve the regulatory framework and speed up consenting processes.

• Carry out some of the actions proposed below.

Timeline	Priority	costs/ efforts	Responsible
2018-19	high	low-medium	bioenergy sector, supported by government

5.5.2. Strategic investment promotion

5.5.2.1. Introduction – bioenergy value chain

As can be seen in the previous chapter, under the deployment assumptions taken **the expected number of direct jobs in the biomass sector is expected to be rather low** (a few dozen) and also the indirect jobs will be only a few hundred.

One of the issues is that there are no feed-in tariffs for biogas plants, so generation is basically limited to own demand (net-metering), making it difficult for biogas projects to be viable if the self-consumption capacity is just a few dozen kW . Biogas plants should therefore get special tariffs for grid-injection, or they should be allowed to sell directly to customers through a mini/micro/local grid[53].

Even if additional incentives are given, the biomass / biogas sectors will be always less dynamic than wind and solar given the resource potential and the complexity of the technology and related processes.

However, if especially the biogas sector is seen in context with a **proper waste management**, this sector as a whole can become of a strategic value due the expected synergies. The majority of municipal solid waste (MSW) in Lebanon is dumped in open landfills where it is often burned. As landfill capacity is limited and has reached its capacity limits, waste is often burned openly without any energy recovery, leading to high local pollution[54]. About 50-55% of MSW is organic and could thus be used for composting or production of biogas through anaerobic digestion[55].

[53] *This was said in an interview; however, it needs to be checked again if private generators could not also use biogas instead of diesel if they wanted to*

[54] *https://www.hrw.org/news/2017/11/10/lebanon-needs-long-term-waste-management-strategy*

[55] *AUB 2016, Guide to Municipal Solid Waste Management http://website.aub.edu.lb/units/natureconservation/gallery/Documents/guide_to_municipal_solid_waste_management.pdf*

There are currently two contradictory government strategies: On the one hand, there is decree for decentralized waste management at municipality level, which according to interviewees is not working due to lack of funds and unclear governance guidelines (lack of guided transition from current centralized system to decentralized at municipal level). On the other hand, the government has plans to install three to four large incineration plants. It is expected that the bidding process for the incineration plants will be launched in the coming months.

Given this situation, the following actions are proposed.

5.5.2.2. Define a bioenergy strategy

At the moment, the government does not have a comprehensive bioenergy strategy. This should be developed over the next years.

For biogas plants in particular, the business case can become attractive if revenue is secured through sale of electricity. A biogas plant needs a certain size to be viable, therefore a pure net metering scheme will only work in cases where the plant is connected to a larger facility with high energy needs. The incentives may be set in function of the plant size. LCEC mentioned that for this specific case, LCEC is open to offer a PPA with fixed price. They see this case different from the other RE, as in this case the Ministry of Environment is also involved. Establish a network of companies working in the biomass and biogas field. It is unlikely that there will be enough employment and start-up opportunities in the biomass/gas sector in the short term to be able to set up a whole cluster for this field. But a network of bioenergy companies will help to get the sector growing.

Timeline	Priority	costs/ efforts	Responsible
2018-19	medium- high	low-medium	bioenergy sector, supported by government

5.5.2.3. Define a holistic waste management strategy

A holistic waste management strategy would include regulation of how to deal with organic waste. Collection is key prerequisite, and any disposal in landfills should be avoided through waste management measures: reduction, reuse, recycling, biogas extraction and/or composting. Introducing high fees for waste disposal may generate revenues that could be used to finance the biogas incentive scheme. It should be analyzed to which extent organic waste is better composted or used for biogas production (currently 90% of compost used in Lebanon is imported).

Experience from other countries shows that local waste management is the most sustainable solution. Moreover, the separation and processing of waste generates local jobs.

Timeline	Priority	costs/ efforts	Responsible
2019-20	high	high	government, supported by bioenergy sector

5.5.3. Improving cooperation between public research organizations and private sector

5.5.3.1. Combine biogas plants for MSW with agricultural waste and/or sewage plants

In order to increase the capacity of biogas plants, it may be possible to combine different feedstocks. This may lead to lower investment costs per installed capacity. In any case it is important that the generated electricity can be sold. The situation in each municipality needs to be analyzed and an action plan designed. As there are no national policies or regulation in place, currently each municipality sets its own agenda in terms of waste management. LCEC for instance could offer a list of potential locations (close to the power grid) and then MOEW could choose the project locations according to their priorities. For the implement pilots and demonstration sites, funding needs to be provided.

Timeline	Priority	costs/ efforts	Responsible
2019 onwards	medium	medium	local governments, bioenergy sector

5.5.4. Enhancing know-how through education and training

5.5.4.1. Provide education and training for engineers and project developers

Biogas plants require solid understanding of the biological processes and the technological specificities. To acquire the necessary knowledge and learn from best-practices, engineers and system operators will need to be trained potentially in other countries where the technologies are applied. Otherwise it will be difficult to build up the experience within Lebanon. These trainings require funding. In order to be as efficient as possible, it is necessary to define the technological focus early on, so that companies know in which direction they need to go. The trainings will also provide inspiration to further improve and adjust bioenergy technologies to the Lebanese environment and to capture the potential resource streams.

Timeline	Priority	costs/ efforts	Responsible
2019-20	medium	medium	bioenergy sector, supported by government

5.6. Conclusions

5.6.1. Conclusions

The actions proposed in the strategic action plan aim to support the deployment of RE as well as the creation of jobs in Lebanon. It takes into consideration the experience from other jurisdictions that the establishment of a thriving RE industry can only be achieved with a strong domestic market.

A number of actions are valid for all RE technologies. These include actions that require determined government action like the update of the NREAP especially in terms targets and assumptions, the enhancement of RE support policies, the acceleration of the NEEREA process, and more in general an energy sector reform which includes the introduction of a regulatory body and the revision of subsidized EDL electricity tariffs.

Due to the peculiarities of the three technologies and their value chains, a number of technology-specific actions have been proposed which could be driven forward by the sector companies, even though governmental and external support is helpful and in certain cases also needed. Each technology requires a specific approach regarding their implementation strategy: As solar energy resource is available across the country, it needs a decentralized approach but with central support in order to allow the uptake of many distributed PV installations. The wind sector has most potential in the North of Lebanon and due to its complexity and mostly large scale projects, a centralized approach is recommended. The bioenergy sector will require a centralized approach to allow the build-up of the specific knowledge but it will also need local project support.

Among the 35 proposed actions, a number of key actions can be highlighted as they could be chosen by UNDP to provide specific support:

• Establishing a central RE knowledge hub that provides general RE but also technology-specific support and services

• Promoting R&D and companies working on hybrid systems

• Implementing a quality assurance framework for PV

• Providing education and training, especially for PV installers and wind service engineers

These key actions may be discussed in a dedicated session at the next BEF in September 2018. This could be on the NREAP, a workshop on how to improve the availability of roofs, an awareness building side event, or others.

5.6.2. Overview table of actions

The following table provides an overview of the actions described above.

ACTIONS	TIMELINE	PRIORITY	COSTS/ EFFORTS	RESPONSIBLE
Proposed actions applicable to all RE value chains				
Renewable Energy Strategy				
Update the NREAP taking into account the recent developments	2018-19	high	low	government
Regularly enhance RE support policies to counter RE investment risks	annually, starting 2018	medium-high	low-medium	government, input from RE sector
Tackle energy sector reform, establish regulatory authority	2019-20	medium-high	medium	government
Industrial strategy				
Introduction				
Define a strategy for the Lebanese RE industry	2018-19	high	low-medium	RE sector, supported by government
Establish a RE knowledge hub / RE help desk	2018-19	high	medium	RE sector, supported by government
Attract foreign direct investment	2018-20	medium	medium	RE sector, supported by government
Promote local investment through prosumer projects	2018-20	medium	low	RE sector, supported by government
Linking investment to employment creation and capacity building				
Introduction - supplier development programs and Local Content Requirements (LCRs)				
Organize trade RE shows and events	2018-20	medium	low-medium	RE sector, supported by government
Provide economic incentives to encourage local subcontracting	2018-20	medium	medium	government

ACTIONS	TIMELINE	PRIORITY	COSTS/ EFFORTS	RESPONSIBLE
Improving cooperation between public research organizations and private sector				
Introduction				
Think about RE clusters – but rather at a later stage	beyond 2020	low	tbd	government, RE sector
Enhancing know-how through education & training				
Introduction				
Implement quality standards for RE education and training	2018-19	medium-high	low-medium	government, RE sector, training providers
Plan RE Education and training	2018-20	medium	low	RE sector, supported by government
Specific Actions for PV				
General strategy – decentralized approach with central support				
Establish a central PV knowledge hub	2018-19	high	medium	PV sector, supported by government, donors
Establish local energy centers on PV (and EE)	Starting 2018	medium-high	medium-high	PV sector, supported by government, donors
Strategic investment promotion				
Introduction – PV value chain				
(Continue to) provide and promote an attractive and stable PV support scheme	on-going	high	low	government
Streamline the NEEREA process	2018-19	high	low	government
Accelerate the introduction of grid connection standards and guidelines	2018-20	medium-high	medium	government, EDL
Provide maps indicating useful roof-tops and available land	2019-20	medium-high	medium	PV sector, supported by government

ACTIONS	TIMELINE	PRIORITY	COSTS/ EFFORTS	RESPONSIBLE
Improving cooperation between public research organizations and private sector				
Promote R&D, pilots and companies working on hybrid systems	2019-21	medium	medium	PV sector, government, research institutes
Improve Building Code	2018-20	high	medium	PV sector, government, research institutes, building developers
Enhancing know-how through education and training				
Implement a quality assurance framework for PV	2019-20	high	medium	PV sector, supported by government
Provide technical and vocational training to installers (and others)	2018-20	medium-high	medium	PV sector, education sector
Organize awareness raising campaigns to promote RE prosumers	2018-20	medium-high	low-medium	PV sector, supported by government
Specific Actions for Wind				
General strategy – centralized approach				
Establish a central wind knowledge hub	2018-19	high	low-medium	wind sector, supported by government
Strategic investment promotion				
Introduction – wind value chain				
Define and show the pipeline of wind projects	2018-19	high	low	government
Promote small wind farms with citizen participation	2019-20	low	low	wind sector, supported by (local) government
Enhancing know-how through education and training				

ACTIONS	TIMELINE	PRIORITY	COSTS/ EFFORTS	RESPONSIBLE
Develop trainings for service for wind companies	2018-20	medium-high	low-medium	wind sector
Develop trainings for suppliers	2018-20	medium	low-medium	wind sector, supported by government
Improving cooperation between public research organizations and private sector				
Improve information on resources and site availability	2019-20	medium-high	low-medium	wind sector, supported by government
Specific Actions for Bioenergy				
General strategy – centralized approach with local project support				
Establish a central bioenergy knowledge hub and give local project support	2018-19	high	low-medium	bioenergy sector, supported by government
Strategic investment promotion				
Introduction – bioenergy value chain				
Define a bioenergy strategy and an incentive scheme for biogas plants	2018-19	medium-high	low-medium	bioenergy sector, supported by government
Define a holistic waste management strategy	2019-20	high	high	government, supported by bioenergy sector
Improving cooperation between public research organizations and private sector				
Combine biogas plants for of MSW with agricultural waste and/ or sewage plants	2019 onwards	medium	medium	local governments, bioenergy sector
Enhancing know-how through education and training				
Provide education and training for engineers and project developers	2019-20	medium	medium	bioenergy sector, supported by government

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7. Annexes

7.1. Annex I: Current education status assessment

7.1.1. Generic roles of stakeholders in education and training

The generic roles of the different stakeholders are described in the RENAC study "International Quality Standards and Quality Assurance Mechanisms for RE/EE Training Programmes"[56].

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(Overarching) Training Regulator	Occupational Standards Body
National Technical and Vocational Education and Training (TVET) Regulator, usually part of national government • Overall responsibility for TVET • Assure quality of Occupational Standards Body and Training Development & Approval Body	Working group of technical experts • Assess existing training installations • Develop technical standards / Codes of Practice • Define professional roles / Job Task Analyses (JTAs)
Training Development & Approval Body	**Training Providers**
• Working group of technical experts Role 1: Training Development • Develop training programmes based on Job Task Analyses (JTAs) • Develop curricula, teaching materials, equipment lists, practical and theory exams • Define entry requirements • Define examination regulations • Define certification schemes Role 2: Training Approval • Develop assessment procedures for training providers • Conduct train-the-instructor seminars • Support training providers in preparations for approval • Identify, assess and approv training providers • Continuous review and re-approval through external assessment	• Develop training programmes, incl. the necessary technical infrastructure • Put self-assessment and quality management systems in place • Commit to continuous review and improvement • Ensure quality of training staff

[56] *https://energypedia.info/index.php?title=File:RENAC_Int.Quality_Standards_and_Quality_Assurance_Mechanisms_for_RE-EE_Trainings-Benchmarks_and_Good_Practices.pdf&page=1*

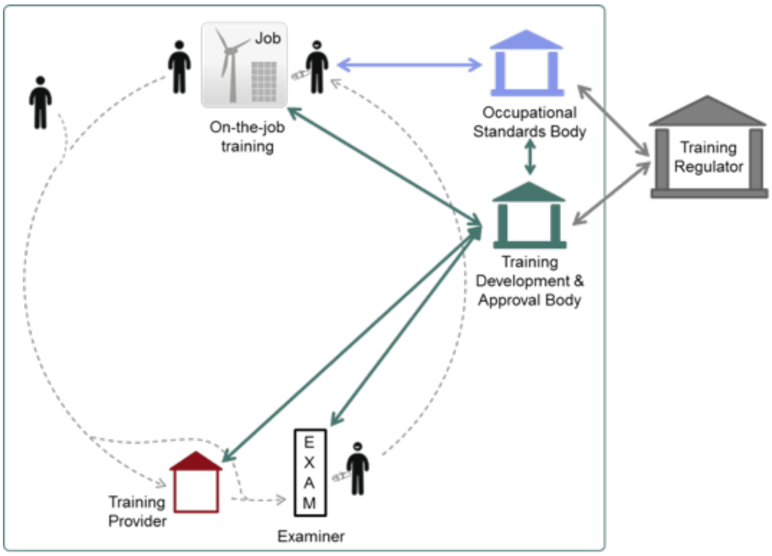

Figure 48. Involved stakeholders/parties in RE/EE training, based on the RENAC template. (Source: RRENAC 2015)

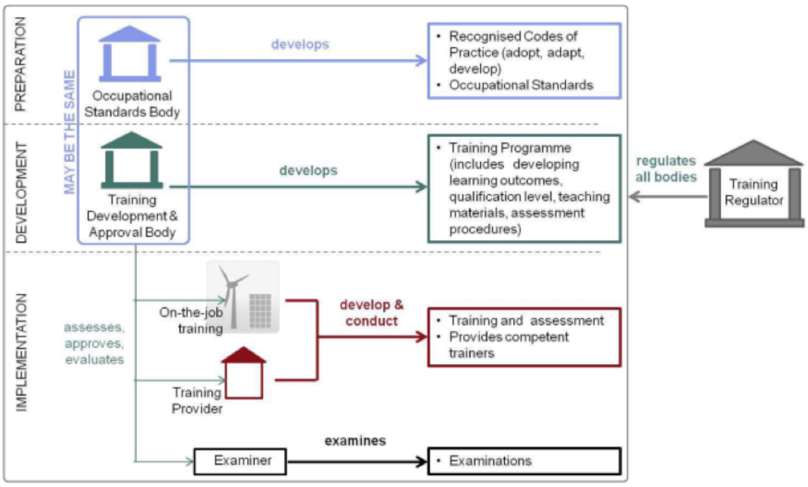

Figure 49. Roles, responsibilities and linkages of bodies and actors involved in training. (Source: RRENAC 2015)

7.1.2. Preliminary Desk Review: Overview of Education/Training Programs available in Lebanon

7.1.2.1. Solar PV Programs

VOCATIONAL TRAINING FOR PV INSTALLERS, UNDP & LCEC

• http://slideplayer.com/slide/5704606/

• Planned through the project "Small Decewntralized Renewable Energy Power Generation"

• Funded by GEC, Managed by UNDP, in collaboration with the Ministry of Energy and Water through the LCEC

• Objectives:
- Create a qualified workforce for installing and monitoring PV systems: Electrical norms, safety regulations, placement and connection of panels, principles of battery operation, etc…
- Overcome low technical know-how for PV installations in Lebanon
- Raise the quality of installations
- Diminish installation errors caused by poor experience/knowledge

FONDS D'AIDE AU SECTEUR PRIVÉ SOLAR PV TRAINING/EDUCATIONAL PLATFORM – IRI, LCEC, UNDP

• http://slideplayer.com/slide/5704606/; http://lcec.org.lb/Content/uploads/LCECOther/161214021429307~NREAP_DEC14.pdf

• Industrial Research Institute (IRI) and LCEC launched the Fonds d'Aide au Secteur Privé solar training platform

• Source of financing: FASEP – Formation Professionelle, a French financing mechanism.

• Partners: Ministry of Energy and Water, LCEC, IRI, UNDP, Private Sector Companies and organizations (France solar industry, Transenergie, …)

• Objectives:
- Create an educational and demonstrational platform for PV
- Offer a training platform for the technical workforce
- Create a link between the Lebanese and French Markets
- Training of the trainers was planned to begin in 2016

• This training platform (started in 2017) for PV installers in Lebanon covers different types of solar panels, inverters, and batteries and three main training courses (grid-tied systems, off-grid systems, and high voltage applications)

• The FASEP solar photovoltaic training platform is built at the premises of the IRI at the Lebanese University campus in Hadath. UNDP is the main partner of this project.

GREENPEACE SOLAR TECHNICIAN (GST) PROGRAMME

• https://www.greenpeacearabic.solutions/en-solartechnicians

• Aims to build qualified solar energy technicians in Lebanon and the capacity of the solar energy sector in Lebanon

• Targets: Electricians, Technicians, and Installers aged between 16-30 years old, Males & Females, across all of Lebanon.

• Pilots: Tyr, Zahle, & Beirut

• Consists of theoretical and practical trainings on solar PV and water heating systems; covers design, installation, operation, and maintenance of different solar systems. The online platform also allows people to request solar technicians, linking technicians with jobs.

MED-DESIRE TRAINING INITIATIVE

• http://slideplayer.com/slide/5704606/

• MED Desire Project: Pilot training on solar energy technology – curriculum for solar standards and rules

• MED-DESIRE Project was:
- Funded by ENPI-CBC MED Programme
- Includes 9 partners from 5 countries: Italy, Spain, Tunisa, Egypt, and Lebanon
- Budget: Euros 4.47 Million
- Includes several solar energy initiatives

LCEC AND UNDP DEVELOPED A NEW COURSE ON SOLAR PV APPLICATIONS ADOPTED BY THE MINISTRY OF EDUCATION AND HIGHER EDUCATION

•http://www.rcreee.org/news/lcec-and-undp-develop-new-course-solar-pv-applications-adopted-ministry-education-and-higher

• The Lebanese Ministry of Education and Higher Education issued a decision (decision number is 164/2017) to include a 60-hour technical course on “solar photovoltaic installations, maintenance and operation” in the curriculum of the third year technical baccalaureate (BT “electrotechnique”).

• Course contents were developed with the support of the UNDP through the DREG project and in collaboration with LCEC. The content is based on the outputs of the EU-funded project MED-DESIRE.

• With the support of two Lebanese companies, Solarnet and Ecosys, LCEC had previously installed a solar PV system at the Dekwaneh technical school as a pilot project to be used by professors and students.

• Roger's notes from UNDP mission meetings: UNDP DREG supported the implementation of a vocational training PV Course hands on as part to Electrical Engineering studies at Central School. DREG donated laboratory material for practical training. As part of the program they trained the trainers. The curricula was implemented last year during the academic year, so in June 2018 the first graduates will finish. DREG intends to use some of them for the commissioning of the currently ongoing DREG projects.

SHAAMS EU-FUNDED PROJECT, IN COLLABORATION WITH BERYTECH

• www.shaams.org, http://berytech.org/berytech-organizes-shaams-technology-capacity-building-training-on-pv-solar-panels/

• In the framework of SHAAMS EU-funded project, Berytech organized a technology and capacity building training for PV Solar Panels on September 16 & 17, 2015

• The training aimed at promoting RE in Lebanon by empowering RE experts with technical competencies to be able to work in the PV industry implementing a self-sustaining growth process. The training covered solar radiation basics, PV basics and technologies, PV system components, design and sizing of PV systems, testing and commissioning of PV systems.

7.1.2.2. Solar Water Heaters Programs:

LSES TRAINING PROGRAM ON SOLAR HEATERS INSTALLATION

• http://lses-lb.org/activitiesdetails.aspx?ID=98

• As part of an agreement with Mercy Corps (NGO), LSES carried out a ten-day training program, 5 days of which were in classes and 5 days were in site workshops

• The program was for starter level people interested in learning basic and advanced skills in solar water heating installation. The aim was to create capacity building program for persons in fairly rural areas.

• The training participation was for free.

VOCATIONAL TRAINING FOR SWH INSTALLERS

• http://slideplayer.com/slide/5704606/

• Main stakeholders: GSWH project, UNDP, GEF, Ministry of Energy and Water and LCEC, Ministry of Education, Directorate of vocational training and fine arts

• Objectives:
- Create a qualified workforce for installing and monitoring SWH systems: Placement of panels, shading principles, basic design knowledge, piping, wielding, etc...
- Raise the quality of installations
- Diminsh installation errors caused by poor experience/knowledge

7.1.2.3. Energy Efficiency Programs

CAPACITY BUILDING FOR REFURBISHMENT:

• http://climatechange.moe.gov.lb/viewfile.aspx?id=229

• The "Capacity Building for Refurbishment" measure aims to train and educate the ESCOs and the energy efficiency consultants the methodology for building renovation

• Target Group: Energy auditors, consultants, contractors

• Implementing bodies: Order of Engineers and Architects of Beirut, Order of Engineers and Architects of Tripoli, Ministry of Public Works and Transport / Higher Council for Urban Planning, LCEC. LCEC will be organizing the trainings and the workshops

• Start date: 2016; End date: 2020

• Next Steps After 2020: The next step would be to impose mandatory refurbishment of the Lebanese buildings older than 30 years.

• Funding: Estimated at 150,000 USD per year over 4 years.

7.1.2.4. SEEDS Courses

• http://seeds-intl.com/courses

• Lebanese-based company SEEDs (Sustainable Energy & Environmental Design Solutions) offers two courses:

• **Course #1. LEED Accredited Professional**
- The LEED Accredited Professional Building Design & Construction credential targets professionals who want to gain in-depth knowledge in registering and certifying a building under the LEED rating system, understand the intent for each LEED prerequisite and credit, calculate points for LEED credits, identify the responsible party for each prerequisite and credit, earn exemplary and innovative performance bonus credits and best implement local codes and building standards.
- Duration: 50 Hours
- Cost in Lebanon: 750 USD

• **Course #2. "LEED V4 Green Associate"**
- The LEED Green Associate credential, a prerequisite to earn the LEED AP credential, targets professionals who want to demonstrate green building expertise in non-technical fields of practice and gain a competitive edge in today's job market, even with no prior experience in green construction.
- Duration: 30 Hours
- Cost in Lebanon: 450 USD

7.1.2.5. General RE Programs

MED-ENEC

• http://climatechange.moe.gov.lb/viewfile.aspx?id=229

• MED-ENEC, or Energy Efficiency in the Construction Sector in the Mediterranean, is a regional project funded by the EU. MED-ENEC's objectives include building institutional capacities and offering technical training in southern and eastern Mediterranean countries.

• LCEC cooperates actively with the MED-ENEC project as the national focal point for Lebanon.

• The EU-funded MED-ENEC2 project supported a training entitled ''ESCOs for Management and Business Developers'' aimed to promote ESCO business in Lebanon.

IECD PROGRAM

• http://www.iecd.org/en/projets/training-young-libanese-for-careers-in-electrical-engineering/

• The "Seeds of Hope" program. In 2007, in partnership with Schneider Electric and a network of companies and schools, IECD introduced a modernized training course that includes practical training (internships and technical facilities), as well as the development of personal skills and know-how to ensure young graduates are equipped for entry into work.

• Three years later, in 2010, the Electrical Technical Baccalaureate was recognized by the State and the quality of its teaching was hailed by Lebanese companies and different technical education stakeholders.

SUSTAINABLE URBAN DEMONSTRATION PROJECTS (SUDEP-SOUTH PROJECT) – EU

• The Sustainable Urban Demonstration Projects (SUDEP-South project) funded by the European Union and implemented by the GIZ-International Services launched its first training program, hosted by the Rene Moawad Foundation (RMF), for beneficiary municipalities and their local partners on October 19, 2016. Four international experts carried out two separate training activities; one dedicated to procurement, monitoring, and evaluation and a second one focused in measurement, verification and energy management systems.

• The overall objective of the SUDEP Programme is to assist local authorities on responding to sustainable energy challenges.

• A Support Mechanism (SUDEP-South SM) has been established and operated to perform activities including assisting local authorities and reinforce their capacities and their partners in the implementation of their demonstration projects

THE ASSOCIATION OF ENERGY ENGINEERS (AEE)

• https://www.aeecenter.org/aee-lebanon-chapter-development-holds-2nd-cem-training-course

• As part of its continuous development, and after a successful first CEM training course held in July 2017, the AEE Lebanon Chapter In-Development organized its second CEM training course and exam in Beirut between the 8th and 12th of February, 2018

THE ENERGY UNIVERSITY BY SCHNEIDER ELECTRIC, IN COLLABORATION WITH LCEC

• http://slideplayer.com/slide/5704606/

• The Energy University is a FREE, online, educational resource offering courses on energy efficiency and data center topics

• 319 online courses in 12 languages; the platform is divided into several educational levels; directed to professionals in the RE and EE sectors and self-paced;

• Schneider is the owner of the platform

• LCEC collaborated with Schneider Electric in the development of three paths within Schneider Electric's Energy University Program for Energy Management Education:
- Path 1: Common Language
- Path 2: Energy Fundamentals
- Path 3: In Depth Energy

• On completion, a Schneider Certificate is distributed; for the LCEC path an independent certificate will be granted

• There are several international partners and universities

• First collaboration of its kind in the Middle East

• These paths will be required from Professionals in the Energy Field collaborating with LCEC. Completing one or more of these paths is recommended for working in the energy field in Lebanon and was said to soon be a required prerequisite for working with LCEC.

• The Energy University could be accessed through MyEnergyUniversity.com with the keycode 39401P for the LCEC referral.

ECOTRUCK BY LSES

• http://lses-lb.org

• The Ecotruck offers educational material and learning tools about RE systems and applications. It is equipped with renewable energy technologies including solar water heating, micro wind, photovoltaic, and biomass systems. It is also equipped with other educational and illustrative material used in educating school students in Lebanon. The truck will be available as well as paying on demand to visit to other NGO›s, Municipalities, summer schools, and science fairs.

• You can book the Ecotruck to visit your institution with a highly skilled team and well-presented educational material.

"TRAINING ON THE INTEGRATION OF RENEWABLE ENERGY INTO THE ELECTRICITY GRID" BY RENAC

• https://www.giz.de/en/downloads/giz2017-en-renac-03.pdf

• Project title: "Training on the Integration of renewable Energy into the electricity grid in Morocco, Tunisia, Algeria, Egypt, Lebanon, Jordan, and Libya (RE-GridSystem)"

• Area: Capacity building

• Country: Supraregional/MENA

• Duration: 12/2010 – 12/2014

• Implementing organization: Renewables Academy AG (RENAC)

• Summary: Renewables Academy AG (RENAC) conducted trainings on the integration of RE into the electricity grid in the MENA region. With the help of a "blended learning" approach, which combines online activities with classroom seminars, knowledge about the grid integration of electricity from fluctuating energy sources was imparted and REs were advocated for to support mitigation of greenhouse gases and climate change.

AUB OFFERINGS

• Universities are offering courses and diplomas on RE topics in Lebanon

• AUB offers the "Online Professional Joint Diploma in Green Technologies" (Pro-Green diploma), a program that caters to professionals looking to enhance their skills in green businesses and technologies.

• AUB also offers courses on RE topics

• AUB has a graduate program called Energy Studies that accommodates people coming from both technical and non-technical majors (e.g. social sciences). It incoporate technical, social, and environmental dimensions.

• AUB works with students to develop 'Final Year Projects' (FYPs) on RE-related topics (e.g. it worked with a team of students to develop and install AUB's first solar PV system on its campus).

• As part of the FYP, AUB sent students to receive RE training by SMA.

OTHER NOTES

• UNDP and LCEC also regularly conduct periodical/continuous training programs, seminars, and workshops (http://slideplayer.com/slide/5704606/; http://www.solarthermalworld.org/content/lebanon-solar-thermal-included-official-vocational-training)

• According to the LCEC, vocational training in Lebanon is normally divided into three parts.
- "Baccalaureate Technique (BT): At this level, graduates are considered to be skilled workers who can operate machinery, install HVAC systems and/or electrical wiring."
- "Technicien Superieur (TS): Students at this level will become increasingly aware of some design aspects of their previous studies and they are considered to be highly skilled workers, supervisors and/or foremen."
- "Licence Technique (LT): Students are exposed to in-depth information about designing systems and understanding how they work. They have also taken courses in general and technical studies. At this level, students are expected to fully understand technical drawings and calculations and be able to design smaller systems themselves."