Ministry of Education and Science of Ukraine

Sumy State University

DEPARTMENT OF ECONOMICS, ENTREPRENEURSHIP
AND BUSINESS ADMINISTRATION

MASTER THESIS

Topic: Economic mechanisms of green energy business development

Specialty 073 "Management"
Study program 8.073.00.09 "Business Administration"

Head of the Department: ________________/*Karintseva O.I.*/

Supervisors: ________________/*Sotnyk I.M.*/

________________/*Hens L.*/

Student: ________________/*Abou Khalil Johaina*/
Full name

Group: *BA.m-91AH/1i*
Code

Sumy 2020

SUMMARY

Master's thesis consists of 65 pages, 3 chapters, 6 tables, 12 figures, and a list of 108 references.

The *topic's relevance* is the need for formation and improvement of economic mechanisms for managing green energy business in developing countries to find the best solutions for the state energy policies.

The *aim of the research* is the investigation of economic mechanisms for managing national green energy business development and substantiation of ways for their improvement on the example of Lebanon.

The *research tasks* are: to identify the prerequisites and the world latest trends in the development of green energy business; to analyze the state support schemes used by governments to manage renewable energy development; to assess the renewables' potential of Lebanon and the state of its use as well as to identify economic and organizational incentives applied to encourage green energy business in the country; to analyze economic results of the green energy sector development in Lebanon and to reveal the problems of its administration; to develop recommendations on improving economic support of green energy business in the country, in particular, based on the economic substantiation of implementing distributed solar photovoltaic projects.

The *object of the research* is the green energy business. The *subject of the research* is economic mechanisms that aim at ensuring green energy business development in a national and local scale. The *research methods* are statistical, factor, structural and investment analysis, analytical approach, levelized cost of electricity (LCOE).

The *scientific novelty of the research* is scientifically substantiated improved economic mechanisms of green energy business development in Lebanon based on the analysis of successful world experience in the renewable energy sector and economic efficiency of distributed solar photovoltaic projects. The *practical significance of the research* is the developed recommendations for implementing proposed economic measures to encourage the green energy business in Lebanon.

The first chapter examines the prerequisites and the world's latest trends in green energy business advancement as well as the national economic support schemes used to manage renewable energy development.

The second chapter covers issues on evaluating the Lebanese renewable energy potential and the state of its use, identifying current economic and organizational incentives for national green energy business advancement, and analyzing the economic results of their implementation.

In *the third chapter*, for improving the management of green energy business in Lebanon, the economic substantiation of implementing distributed solar photovoltaic projects is conducted as well as recommendations on improving economic and organizational support of green energy business in the country are offered with regard to the revealed problems of its administration.

Keywords: BUSINESS, ECONOMIC MECHANISMS, ENERGY POLICY, GREEN ENERGY, LEBANON, RENEWABLES, SUPPORT SCHEME.

CONTENTS

INTRODUCTION

The relevance of the research topic. The need for energy supply for all nations is basic and constantly growing in the modern world. It is affected by the development of scientific and technological progress and the implementation of its achievements in management practices accompanied by the increase in the amount of energy necessary for people's everyday life to meet the ever-increasing living standards. Therefore, there is an urgent need to replace traditional fossil fuels with renewable alternatives. Clean renewable energy (RE) is better for the planet and humanity than energy derived from fossil fuels. Its benefits in avoiding greenhouse gas (GHG) emissions, delivering cleaner air and bringing energy to marginalized communities are essential to a better future for all. Moreover, RE can ensure the growth of energy security for the nations and create new jobs.

There are plenty of research works concerning RE issues and the expansion of the green energy business. Developed countries have accumulated considerable experience in managing RE advancement through a variety of administrative, economic, financial and other mechanisms ([1–17]), while developing and emerging economies are less experienced in this sphere and face with significant difficulties in finding effective mechanisms to encourage green energy business progress ([10; 14–15; 17–34; 86–108]). Therefore, there is still a need to research the economic mechanisms of RE advancement in developing countries to find the best solutions for state energy policies.

The **aim of the research** is the investigation of economic mechanisms for managing national green energy business development and substantiation of ways for their improvement on the example of Lebanon.

The **research tasks** are as follows:

- to identify the prerequisites and the world latest trends in the development of green energy business;
- to analyze the state support schemes that are used by different governments to manage RE development, their advantages and drawbacks;

- to assess the RE potential of Lebanon and the state of its use as well as to identify current economic and organizational incentives, which are applied to encourage green energy business in the country;
- to analyze the economic results of the green energy sector development in Lebanon and to reveal the problems of its administration;
- to develop recommendations on improving economic and organizational support of green energy business in the country, particularly based on the economic substantiation of implementing distributed solar photovoltaic (PV) projects.

The **object of the research** is the green energy business. The **subject of the research** is economic mechanisms that aim at ensuring green energy business development in a national and local scale.

The **research methods** are statistical, factor, structural and investment analysis, analytical approach, levelized cost of electricity (LCOE).

The **scientific novelty of the research**: there have been scientifically substantiated the improved economic mechanisms of green energy business development in Lebanon based on the analysis of successful world experience in the RE sector and economic efficiency of distributed solar PV projects.

The **practical significance of the research** is the developed recommendations for the implementation of proposed economic measures to encourage the green energy business in Lebanon.

The **study's information** base is formed by the data from international reports and working papers, periodicals, monographs, manuals on green energy business issues, laws and regulations of state authorities of Lebanon and other countries, and enterprises' surveys.

Master's thesis consists of 65 pages, 3 chapters, 6 tables, 12 figures and a list of 85 references.

The first chapter examines the prerequisites and the world's latest trends in the development of green energy business as well as the national economic support schemes that are used to manage RE development.

The second chapter covers issues on evaluating the Lebanese RE potential and the state of its use, identifying current economic and organizational incentives for national green energy business advancement and analyzing economic results of their implementation.

In *the third chapter*, for improving the management of green energy business in Lebanon, the economic substantiation of implementing distributed solar PV projects is conducted as well as recommendations on improving economic and organizational support of green energy business in the country are offered with regard to the revealed problems of its administration.

CHAPTER 1 GREEN ENERGY BUSINESS DEVELOPMENT IN THE WORLD

1.1 Prerequisites for the development of green energy business

The unequal territorial distribution of non-renewable fossil fuels, which are the basis of the energy sector in most countries, highlighted the search for alternative energy resources that would be sufficient to meet national economies' needs. The resource scarcity in many countries leads to political and military conflicts in the struggle to get access to energy sources, slows down the economic growth of nations. In addition to social, economic and political negative impacts, increased consumption of fossil fuels results in environmental pollution increase, breaking the balance of ecosystems and causing the threat of global warming [15].

The 70s and 80s of the 20^{th}-century energy crises, caused by the lack of available fossil fuels, clearly demonstrated the world community's need to move towards RE sources. Today their potential is practically unlimited and can be exploited by every country. To implement national sustainable development strategies and ensure energy security, the world's leading developed countries, as well as many developing countries, have been actively deploying the RE sector for the last 40 years.

The advantages of implementing modern RE technologies and conducting green energy business include energy supply for the population living in remote and inaccessible areas, as well as access to electricity for the poorest people. For example, the Solar Home System program helps the rural population of Bangladesh, one of the world's poorest countries, to install solar systems and receive electricity [35]. Besides, the alternative energy sector is gradually becoming a powerful employer, creating new jobs, providing health safety, not causing problems related to waste utilization and emission of harmful substances, and it is not a terror attack target. Its development allows investing in the local economy and increasing the population's living standards [15]. The authors of [36] summarize the potential outcomes of green energy business development regarding the achievement of Sustainable Development Goals (Table 1.1).

Table 1.1 – Strategic outcomes of green energy business development [36]

Strategic outcome	Green energy business contribution
Greenhouse gas (GHG) emission reduction	Reduction in GHG emissions by shifting to RE production and energy efficiency
Creation of green jobs	Green jobs from the production of renewable technologies' components in partner countries
Increased access to green, affordable energy	Expansion of access to energy by all through additional RE production
Improved air quality	Reduction in particles per million through transfer from coal and fossil fuel to clean RE production and energy efficiency

Growth in clean energies is unstoppable, as reflected in statistics produced annually by the International Energy Agency (IEA): they represented nearly half of all new electricity generation capacity installed in 2014, when they constituted the second biggest electricity source worldwide, behind coal. According to the IEA, world electricity demand will have increased by 70% by 2040 – its share of final energy use rising from 18 to 24% during the same period – driven mainly by the emerging economies of India, China, Africa, the Middle East and South-East Asia [27; 28]. While the contemporary structure of world energy consumption is still characterized by a high share of fossil fuels, the RE sources contribution to global energy generation appears to be increasing. For example, as at the end of 2017, the world's RE percentage in the power mix was 25%, 10% in the provision of heat and 3.5% in the transport sector [39]. Some countries have already achieved essential progress in RE development. For example, the share of RE in electricity generation was 97.9% in Norway in 2017, Colombia had 86.8% and New Zealand recorded 39.7% [40]. In 2020, due to the COVID-19 pandemic, it was observed the increasing weight of renewables in the power mix that had a noticeable impact on CO_2 emissions reduction (-8.6%). However, this effect is probably temporary and caused by the low power demand. At best the world will return to the previous trajectory or at worst experience a slowdown, depending on whether players slow down their investments in the RE area [41].

Green energy business development is vital for combating climate change and limiting its most devastating effects, since RE expansion can provide decoupling between economic growth and natural resources use [42; 43]. 2019 was the second warmest year on record. The Earth's temperature has risen by an average 0.85 °C since the end of the 19th century, states National Geographic. Meanwhile, some 1.1 billion inhabitants (17% of the world population) do not have access to electricity. Equally, 2.7 billion people (38% of the population) use conventional biomass for cooking, heating and lighting in their homes – at serious risk to their health [44].

RE received important backing from the international community through the Paris Agreement signed at the World Climate Summit held in the French capital in December 2015. The agreement, which entered into force in 2016, establishes, for the first time in history, a binding global objective. Nearly 200 signatory countries pledged to reduce their emissions so that the average temperature of the planet at the end of the current century remains "well below" 2 °C, the limit above which climate change will have more catastrophic effects. The aim is to try to keep it to 1.5 °C [44].

The transition to an energy system based on RE technologies will have very positive economic consequences on the global economy and on development. According to the International Renewable Energy Agency (IRENA), doubling the RE share in electricity generation to 57 % worldwide by 2030 will be necessary for meeting the Paris Agreement targets. This requires raising annual investments in RE from the current $330 billion to $750 billion, thereby boosting job creation and growth linked to the green economy [44].

Wind energy, solar, geothermal, bio-hydropower and environmental energy (heat pumps) are among the most demanded technologies in the world today [38; 45]. Their use depends on the climatic conditions (solar, wind energy), the availability of sufficient raw material (biomass energy), specific natural conditions (geothermal energy), water resources (hydropower, environmental energy), etc. At the same time, even under favorable natural conditions for RE development, such technologies are currently subsidized; they require governmental economic support. The reason is poor technology for RE generation that determines its high cost, and, consequently, long payback periods for projects, which deter wide and fast distribution of green power capacities [14; 15]. The authors of [13] indicates low energy density, its intermittence on the Earth's surface (in terms of hours, days of the year, geographic zones) as the most significant disadvantage of RE as well as high initial capital expenditures, though usually compensated by low operating costs, however, considerably influence alternative energy generation costs. Nevertheless, RE industry is actively developing in the modern world. The application of the latest R&D achievements in the sector allows constant decreasing the cost of green energy generation and therefore encourages green energy business to grow.

1.2 The world latest trends in green energy business growth

RE can enable economic development in developing countries, many of which are geographically well-placed to be able to exploit the energy potential (such as those in low latitudes with high sunlight), as well as support decent life standards in developed states. RE helps address increasing concerns about future energy prices and energy security, against a background of a rapid global increase in demand for energy, driven primarily by rising living standards in developing and emerging countries. There are economic opportunities in RE. Several RE technologies are already competitive at market prices. Decentralized electricity generation potentially mobilizes small-scale private investment. Investment in RE also offers considerable scope for generating employment opportunities, a key public policy concern in many countries. There is substantial employment potential associated with project development, construction and installation for all RE technologies [46].

Governments and companies around the world have committed to adding some 826 GW of new non-hydro RE capacity in the decade to 2030, at a likely cost of around $1 trillion. Those commitments fall far short of what would be needed to limit world temperature increases to less than 2°C. They also look modest compared to the $2.7 trillion invested during the 2010–2019 decade, as recorded by [4]. The COVID-19 crisis has slowed down deal-making in renewables in recent months, along with that in other sectors, and this will affect investment levels in 2020. However, governments now have the chance to tailor their economic recovery programs to accelerate the phase-out of polluting processes and the adoption of cost-competitive sustainable technologies.

In 2019, the amount of new RE capacity added (excluding large hydro) was the highest ever, at 184 GW, 20 GW more than in 2018. This included 118 GW of new solar systems, and 61 GW of wind turbines. Falling costs meant that this record commissioning of green gigawatts could happen in a year when dollar investment in RE capacity stayed almost flat. Consistent with earlier years were the growth of offshore wind, and the spread of large project financings to new markets (in 2019, the United Arab Emirates and Taiwan saw particularly large deals). A final trend was the dominant share of renewables in the net new capacity added to the world power generation mix [4].

It is likely that 2020, with the coronavirus health crisis and resulting economic recession, will mark at least a temporary break in some of those trends. However, green energy costs look likely to continue to fall, and governments and private sector entities will still face the climate change emergency when economies start to unfreeze [4; 47].

Figure 1.1 shows that the world invested $282.2 billion in RE capacity in 2019, some $2 billion (1%) more than in the previous year. The total for last year was made up of $230.1 billion of financings for utility-scale RE projects of more than 1MW, down 5% on the 2018 total; and $52.1 billion of spending on small-scale solar systems of less than 1MW – up 37%. Global investment in RE capacity has been relatively consistent since 2014, fluctuating in a $50 billion range between $265 billion and $315 billion. But beneath the headline figures, much has been changing on the unit costs of new additions, on the geographical split of investment, and on the mix between different technologies [4].

In 2019, wind attracted a record $138.2 billion, up 6% on 2018, while solar got $131.1 billion, down 3% and its lowest since 2013. The reasons for these were the further rise in activity in offshore wind, both off the coasts of Europe and in the sea off mainland China and Taiwan; and the downward trend in costs per MW for solar PV. Biomass and waste-to-energy maintains a consistent third place among RE sectors, with investment in 2019 up 9% at $9.7 billion. There were strong pockets of activity in 2019, notably in waste incineration plants in the U.K. and China. The remaining sectors all languished in terms of dollars committed in 2019. Small hydro-electric projects of less than 50 MW saw investment slip 3% to $1.7 billion, while geothermal had a 56% decline to $1 billion on a paucity of large new project financings. Biofuels took $500 million in new investment, down 43% and the lowest for three years, while marine (tidal and wave) energy saw no significant new financings at all [4].

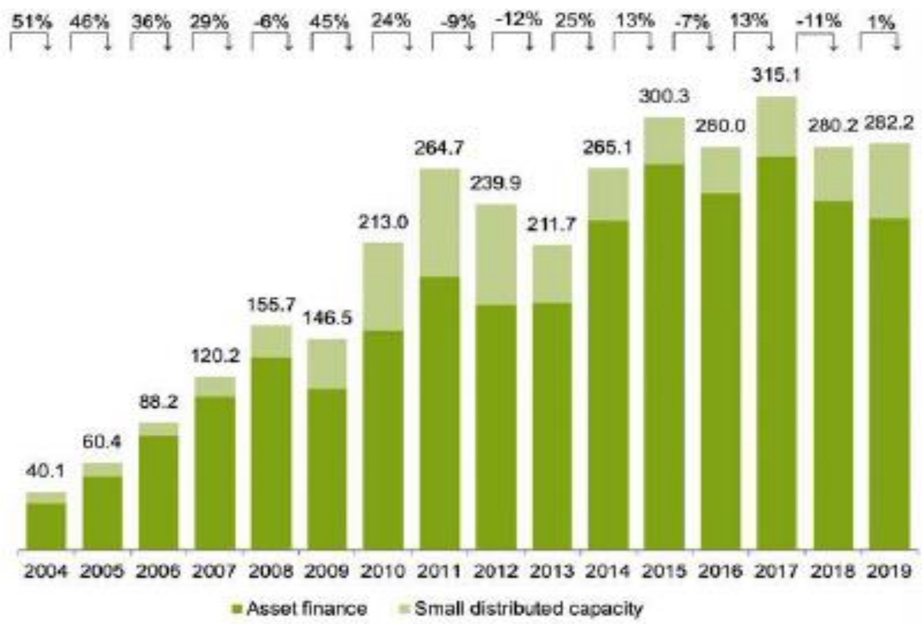

Figure 1.1 – Global RE capacity investment 2004-2019, $ billion [4]

In 2019, the leading regions for investment were once again China, the U.S., Europe and Asia-Pacific excluding China and India. However, their relative contribution shifted, with China slipping back, and the U.S. overtaking Europe. The Other Americas (excluding the U.S. and Brazil) region was a strong feature, investment there rising 28% to $12.6 billion, while Brazil enjoyed a 74% rebound to $6.5 billion. One of the trends in recent years has been the widening geographical spread of investment in renewables. In 2018, this was manifest in the highest number ever of economies investing $1 billion or more. In 2019, the signal on this was a record number investing more than $2 billion, at 21 – up from 20 in 2018 and 16 in 2017 [4].

The relative balance of investment has shifted between the three major markets during the 2004-2019 period. Europe started off as the dominant investor in renewables, and it remained the largest until it was overtaken by China in 2013 – as the solar booms in Germany and Italy cooled off dramatically and China raised its ambitions in both PVs and wind. China has been the dominant location for investment ever since, but its lead over the other two major markets peaked in 2017 – when it installed an unprecedented 53GW of solar, half of the world's total that year – and has since been shrinking. The U.S. lost its second place to China in 2009, won it back in 2011 as the Obama administration's 'green stimulus' took effect, but then slipped back into third place until 2019, when it overtook Europe for the first time. Developed economies tended to be the early adopters of RE technologies such as wind, solar and biomass – although this was not the case with biofuels, where Brazil was one of the main centers of activity. Increasingly during the 2010s, however, and particularly once costs fell toward parity with fossil fuel alternatives, developing economies picked up the baton. They have usually been looking to build additional generating capacity to meet rising electricity demand, while for many developed countries it has been more about replacing existing coal, gas or nuclear generation [4].

The developing economies accounted for the majority of global investment in renewables capacity for the first time in 2015 and have maintained that since. In 2019, they represented $152.2 billion out of the world total of $282.2 billion, a 54% share. This was the same proportion as in 2018, but down from 2017's share of 62% (Figure 1.2).

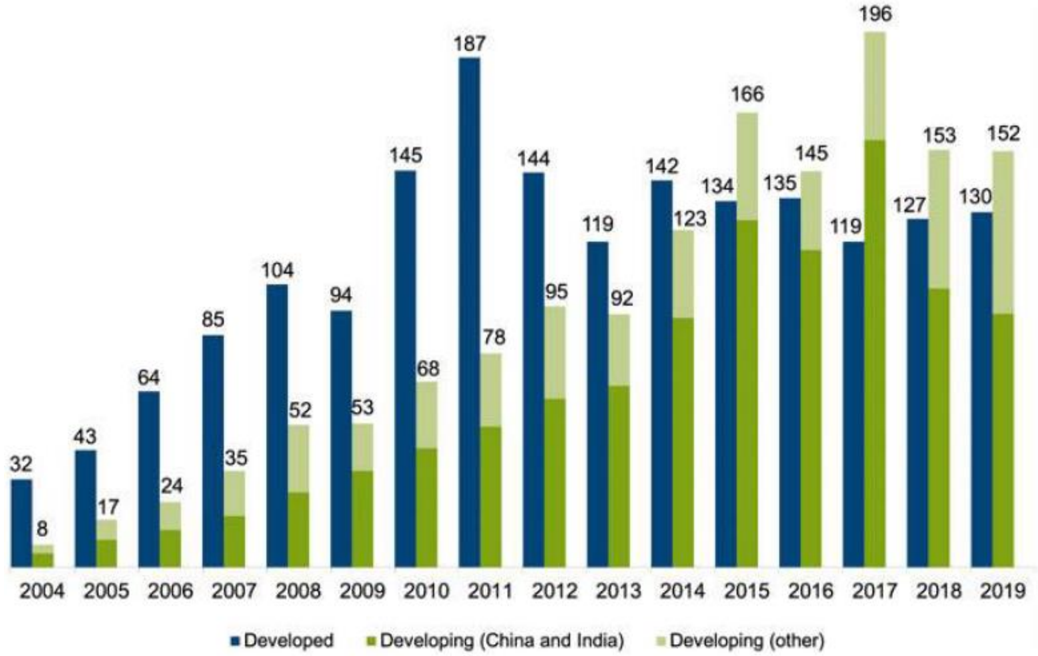

Figure 1.2 – Investment in RE capacity: developed vs. developing countries, 2004-2019, $ billion [4]

The lifetime cost of generating electricity from wind and solar continued to decline in 2019. The global benchmark LCOE, from onshore wind was $47 per MWh in the second half of last year, according to BloombergNEF analysis [48]. This was down 10% on the same period in 2018, and 49% lower than in the second half of 2009. For offshore wind, the global benchmark LCOE in the second half of 2019 was $78 per MWh, down 32% on a year earlier, and 51% on the second half of 2009 [4].

The biggest reductions in LCOE have come in solar PV. Their benchmark levelized cost stood at an average of $51 per MWh in the second half of 2019, down 15% on the year and a remarkable 83% lower than their figure of $304 in second half 2009, when solar generation was still an immature technology and heavily reliant on subsidy. The latest reductions in LCOE have meant that an estimated two-thirds of the world's population now live in countries where either solar or wind, or both, is the cheapest option for new electricity capacity [48]. This leads on to the important point that LCOE estimates vary widely depending on the country's resources and local regulatory, labor and finance cost characteristics, and this is true for both renewable and conventional generation sources. The big reductions in LCOE for wind and solar have come about as a result of a combination of lower capital costs, for instance as turbines have got bigger and more powerful and there have been further economies of scale in the manufacturing of solar panels; and improvements in the performance of equipment. The latter has seen the efficiency of PV monocrystalline modules increase from 17.5% in 2010 to 21.1% in 2019. Wind turbine capacity factors (the amount of electricity produced per megawatt of power capacity) have also increased steadily – thanks to better siting, higher towers and improved operations and maintenance practices [4].

The cost reductions respectively for a German small PV system of less than 10kW were down from $6.25 per Watt in early 2007, to $4.04 per Watt in early 2010, to an average of $1.59 per Watt during 2018, and $1.47 per Watt in 2019. In the U.S., the typical cost reduction has been from $7 per Watt in 2010 to $2.96 per Watt in 2019. Installation and balance-of-plant costs have fallen during the decade, but the most dramatic reduction has been in the modules themselves, with the Chinese multi-module price tumbling from $1.85 per Watt, to just 23 cents per Watt [4].

Investment dollars went overwhelmingly to renewables, rather than to fossil fuel and nuclear technologies. Figure 1.1 shows that renewables excluding large hydro attracted $282.2 billion of investment in 2019. If biofuels are also excluded, then the adjusted total would be $281.7 billion. Against that, new coal-fired generators are estimated to have taken $37 billion of investment, and new gas-fired plants $47 billion. Some $15 billion of investment is estimated to have gone into new nuclear reactors [4].

Renewables excluding large hydro were responsible for 13.4% of world electricity in 2019. Global emissions from the power sector are estimated to have been 13.5 Gt in 2019, as a result of electricity generation from coal, gas and oil-fired plants. If the 13.4% of electricity had come from the same mix as the remaining 86.6%, then emissions would have been 2.1 Gt more than they actually were [3].

Figure 1.3 shows that nearly $2.7 trillion was invested globally in RE excluding large hydro over the 2010-2019 period. This was more than three times, and possibly four times, the equivalent amount invested in 2000-2009. Solar was comfortably the largest recipient of finance for new projects in the decade just finished, attracting nearly $1.4 trillion, while wind took nearly $1.1 trillion. Biomass and waste-to-energy received

$123 billion, small hydro $45 billion, biofuels $28 billion, geothermal $20 billion and marine less than $400 million [4].

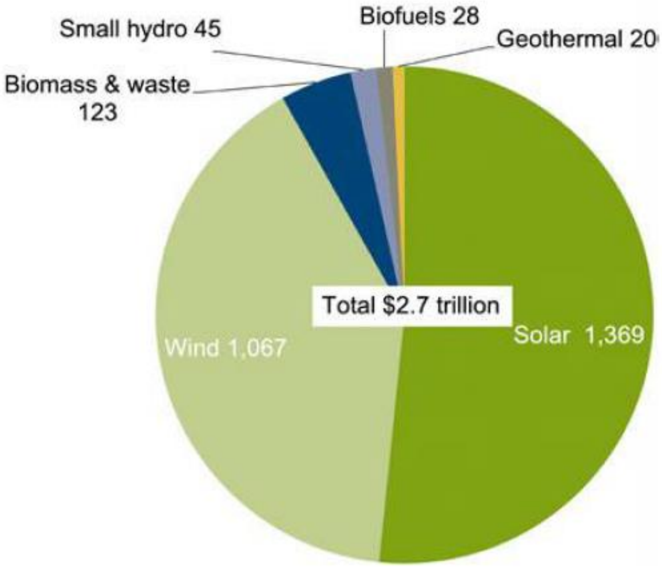

Figure 1.3 – Investment in RE capacity over the decade, 2010-2019, $ billion [4]

One of the ways to overcome RE disadvantages, intermittent character of alternative energy generation due to the high dependence on changes in natural conditions (day hours, weather, etc.), is to create the systems for the accumulation and storage of electricity from RE generators. Until recently, such systems were quite costly, but in recent years the situation has changed for the better: in the years 2010-2017, the average cost of energy storage systems (ESS) with lithium-ion batteries decreased 4.78 times – from $1.000 (2010) to $209 (2017) per kW, allowing potential consumers more access to alternative energy. In addition, RE sources contributed to increased energy supply reliability [15].

An important social aspect for RE development is its gradual transformation into a considerable employer. Thus, employment in RE worldwide was estimated at 11.5 million in 2019, up from 11 million in 2018. Women hold 32% of these jobs [1]. Employment trends in RE sector are shaped by its distribution around the world: despite the fact that alternative energy is developing in many countries, the main employers in the sector are a handful of countries, with China, Brazil, the United States, India, Germany and Japan in the lead. China alone accounted for 43% of all RE jobs in 2018.

Its share was particularly high in solar heating and cooling (83%) and in the solar PV sector (66%), and less so in wind power (44%) [2; 15].

In 2019, the PV industry was the largest employer with 33% of the total RE workforce. In 2019, 87% of global PV employment was concentrated in the ten countries that lead in worldwide advancement and in the production of equipment. Driven by output growth of 2% for ethanol and 13% for biodiesel in 2019, biofuels jobs worldwide expanded to 2.5 million. Production expanded robustly in Brazil, Colombia, Malaysia, the Philippines and Thailand, all of which have labor-intensive supply chains, whereas output in the United States and the European Union fell. Employment in wind power supports 1.2 million jobs, 21% of which are held by women. Onshore projects continue to predominate, but the number of countries with offshore farms now stands at 18, up from 10 a decade ago. Supply chains are expanding. Hydropower has the largest installed capacity of all renewables, but its growth is slowing. The sector employs close to 2 million people directly, many in operations and maintenance [1].

The onset of the COVID-19 crisis upended economic trends and dynamics around the world, including in the energy sector. To date, RE as a whole has fared better than fossil fuels. Nonetheless, renewables have been affected by temporary disruptions in the supply of equipment, components or raw materials, and more recently by demand-side impacts. Although the pace of new renewables installations has been slower in 2020 than predicted in pre-COVID forecasts, construction of many large-scale utility projects is proceeding, though with some delays. Jobs appear less affected in the operation of utility-scale wind and solar plants than in solar rooftop installation and off-grid solutions, where social distancing requirements and constrained household budgets have a significant impact [1].

Overall, the world green energy business demonstrated essential growth during the last years with great potential to further increasing. However, it still depends on the economic support of the states.

1.3 State support schemes for the green energy expansion

The RE industry is a significant part of the mitigation mission that humankind has set for the viability of the planet. The technology has to compete with the chubby oil market for the global community to shift from the current maelstrom to the renewable world. Governments around the globe are enacting policies to support RE expansion in the world. Some of these policies have been successful and some have failed. Most of such policies come from the Northern countries, where the industry originated. Some of the developed states have tried more than 10 different policies, and after a long process of trial and error, they have found the best practices. Such valuable experiences could help developing countries to set the appropriate policies according to their local conditions [17].

The most highly used incentives for RE expansion in private and business sectors of the national economies are [8; 9–13, 19]:

• direct incentives – financial incentives for RE producers, implemented through the use of specific economic mechanisms (preferential tariffs, preferential premiums, green certificates, tender schemes, investment grants, tax and customs privileges, subsidies, bonuses, etc.);

• indirect incentives – encourage the use of RE sources directly by reducing the attractiveness of fossil energy resources through the introduction of environmental taxes, CO_2 tax, etc.;

• voluntary programs that foresee consumers' will to pay high energy prices for RE through environmental care in order to maintain long-lasting stability. Such programs include donation programs and charity projects.

The general characteristics of the most common state support schemes for green energy business development are presented in Table 1.2, as well as results of their implementation in developed countries since they were the first to introduce these policies. Among the mentioned instruments, the most popular policy tools are feed-in tariff, net-metering, tendering system, and RE portfolio standard. Let us consider them in detail.

1.3.1 Feed-in tariff

A feed-in tariff (FIT) is a price-driven policy instrument that is based on energy generation. It is used to encourage the expansion of RE generation by ensuring that those who produce electricity from RE sources have a guaranteed market for the electricity they generate, regardless of its size. The FIT mechanism provides a guarantee of payments per kilowatt-hour ($/kWh) for the full output of the system for a guaranteed period of time, usually 15 to 20 years [9]. The payment often differs according to the technology and size of the project [16]. FIT obliges the energy companies responsible for operating the national grid to purchase electricity from RE sources.

The purchase price is pre-determined to stimulate new investment in the RE sector [9]. FIT, according to its price-driven character, sets the price and lets the market work on capacity and generation. It may define some caps, but the cap does not force the investors to meet the target. FIT policy tries to play with price in order to stabilize the generation trend [17].

Table 1.2 – Economic mechanisms of state support for RE development [10]

Mechanism	*Short description and features*		*Common occurrence*	*Influence on the development of RES in selected countries*
Feed-in tariff	Fixed tariff (usually for small RES objects)	Price is fixed by the state above the average market price	France, Austria, Latvia, Lithuania, Bulgaria, Ireland, Luxembourg, Greece, Hungary, Slovakia, China, Russia	Within 13–15 years, Austria becomes one of the EU leaders in RES utilization (hydro and bioenergy) thanks to preferential tariffs
Feed-in premium	Preferential tariff depending on market electricity prices (usually for large RES facilities)			
Trading of renewable energy certificates	Assignment of quotas of RES consumption	Market participants undertake obligations for the production, transmission or distribution of renewable energy	Sweden, Poland, Romania, Russia	In Sweden, the acquisition of renewable energy certificates led to RES share in total generation exceeding 50%
Tenders and auctions	Competitive form of selection of projects for the supply of electricity under specified conditions	Aimed only at supporting large projects	Almost all EU countries, UK	Lower energy costs for end users
Solar obligations	Support for the production of heat energy using only solar energy	List of documents regulating the obligations as to the volume of heat production	Denmark, Greece, France, Germany, Ireland, etc.	Introduction of solar thermal energy into district heating systems. Wider use of geothermal plants
Technology-neutral obligations	Support for heating technologies			
Grants, preferential loans, tax incentives	One-time support to compensate investors for initial investment costs (on a competitive basis). Tax benefit for 1 kWh of energy produced by the RES facility, provided for up to 10 years (production tax credit)		Almost all EU countries, UK	Growing number of large renewable energy projects
Green subsidies	Aimed at supporting environmental activities within RES projects		Almost all countries	Improved environmental sustainability of RE
Development of cooperation between EU countries	Based on the "Covenant of Mayors for climate and energy" – the mechanisms of mutual assistance in achieving EU targets		All EU countries	Energy efficiency improvements, 40% reduction in emissions
Renewable Heat Premium Payment	Payments to households for the buying of appropriate equipment		UK	Used for the first time in the world to support RE heat
Renewable Heat Incentive	Households or enterprises that install small-scale heating systems receive a fixed amount determined by the thermal performance of the RES installation		UK	
Cooperation between EU and non-EU countries	Enabling legislative and financial policies, loans, subsidies and grants, tax incentives		All EU countries	Creation of agencies working on the principle of "one window" to assist in implementation of business startups in the field of RES
Green Patent Pilot Program	Acceptance of patent applications in the field of RES		USA	Acceleration of acceptance of applications for patents in the field of RES
Centers of Energy Innovations	Involving the best experts to team-based interdisciplinary projects for the development of clean energy technologies		USA	Growing expert engagement

FIT is the most common RE policy enacted by more than 63 countries, states, provinces and territories in the world. It has been argued that a well-designed worldwide FIT policy would have a revolutionary outcome in the energy sector through CO_2 reduction, market creation and development, job creation and energy security [16]. The main objectives of the FIT system are to:

- facilitate resource mobilization by providing investment security and market stability for investors in RE sources;
- reduce transaction and administrative costs by eliminating conventional bidding or negotiation processes;
- encourage private investors to operate power plants prudently and efficiently so as to maximize returns [18].

The FIT mechanism could be applied in a variety of ways to meet different applications in every country. The type of technologies and the payment structures that FIT would work with are the main two variants that differentiate among FIT models. "Fixed FIT" and "Premium FIT" are the most common FIT types in the world. The system of fixed FIT allows electricity generators to sell electricity out of RE at a fixed tariff for a determined period of time. Alternatively, the FIT can be paid in the form of an additional premium on top of the electricity market price. Premium FIT sets the cap and the floor over the normal electricity tariffs in the market [17].

According to many researchers and practicians, FIT is the best instrument to launch the processes of RE development in a country. However, with the growth of RE generation volumes, FIT can create an unbearable financial burden on a state budget. At a certain moment, it should be replaced by other policy tools such as RE portfolio standards, green auctions, etc.

1.3.2 The Renewable Portfolio Standard

The Renewable Portfolio Standard (RPS) is a flexible, quantity-driven policy that guarantees a minimum amount of RE be integrated into the portfolio of electricity resources serving a state or a country [8]. Due to the flexibility of RPS to set the different quotas over time, the RPS can put the electricity industry on a path toward increasing sustainability through increasing the minimum required share of electricity from RE sources. Because RPS is a market standard, it mandates power producers to generate a percentage of its electricity from RE sources. Then each power producer has a its own choice of how to fulfill this mandate using a combination of RE sources, including wind, solar, biomass, geothermal, or other renewables [16]. According to the RPS mechanism, government is eligible to impose a penalty in case the power producers could not meet the target in the given period. RPS sets a structure of "Renewable Credit" that could stimulate electricity production from RE sources. Renewable credit is a tradable certificate of proof that one kilowatt hour of electricity has been generated by an RE source [50]. RPS requires all electricity generators to demonstrate, through ownership of Credits, that they have supported an amount of RE generation equivalent to some percentage of their total annual kilowatt-hour sales. RPS relies almost entirely on the private market for its implementation [8]. Private market performance could result in competition, efficiency and innovation that will deliver RE at the lowest possible cost [17].

The USA is the main application of RPS in the world, with the highest number of states that have applied RPS policy. In Europe, Sweden, Poland and England are the three aside from the other EU members that are dealing with RPS mechanisms to support RE sources [17]. Generally, the application of RPS as a policy instrument ensures both generation and consumption of a certain amount of green energy. It, therefore, stimulates business and households' transition to sustainable development.

1.3.3 The Tendering System

The tendering system is a set of market/price-driven policies administered by the government, in which RE developers bid for Power Purchase Agreements (PPA). Such bidding usually takes place through a formal competitive tendering process [16]. The tender involves a series of competitions, where potential investors or generators compete among each other based on the bid price per kilowatt-hour. Successful competitors would be offered long-term PPAs for a guaranteed price. The government usually obliges the other consumers or distributors to buy a certain amount of electricity from the winner [16]. The competition process leads to the selection of the most cost-effective options [17].

Obviously, the generation cost of RE would be higher than the conventional sources and the difference between the market price and bid price is met by the government. Then the authority passes excess costs of power purchase from RE installations through a tax on all subscribers. The tendering policy is a variation of FIT laws and RPSs, the key difference being that the price and the eligible projects are selected through a competitive bidding process [7]. In Europe, France and Ireland are the two countries that have applied the tendering system to support RE. This mechanism also used to promote wind power in China [6; 17].

The tendering system is somewhat effective in supporting the RE development in a country that has already launched the RE sector with FIT and has a robust technical base for implementing large-scale green energy projects. However, this policy instrument's use may create difficulties for the developing economies that have technical problems of connection to the grid and its capacity, lack of state financing, unfavorable investment environment, etc.

1.3.4 Net Metering

Net metering is generally a consumer-based RE incentive that approaches the small electricity producers from RE sources. This system allows subscribers to install small RE system at their home or office and sell their surplus generation into the grid. The policy obliges the utility to buy this excess electricity from the producer at wholesale market price. Depending on the policy definition, the utility could pay per kilowatt-hour of generation to feed the grid or offset it from the electricity bill.

The most mature type of net metering policy sets the value of electricity to the price of every kilowatt-hour of generation from RE sources. In such a case the electricity that is fed to the grid during peak time gets a higher price than the generation at midnight. This policy helps PV industry to be more efficient because PV delivers its highest amount at the peak time of the grid. Such type of net metering requires a specialized, reversible, smart electric meter that is programmed to determine electricity usage any time during the day. According to the size of the prospective projects and the amount of payments, net metering could just be a part of a comprehensive RE policy and not the main body, otherwise it is not enough to advance market penetration [16]. Governments with Value Added Tax (VAT) are often reluctant to introduce the net metering principle because of complications in paying and refunding the VAT that is payable on electricity. Net metering is being implemented in Korea, Mexico and Thailand where the main takers tend to be businesses [5]. The US has the most expanded net metering market in the world; more than 80% of the states have enacted net metering. Some states set a limit for the size of RE generators up to 100 KW, while Nebraska, for instance, has no limitation over the production size. In the developing world, Slovenia, Nicaragua, three of India's states and Israel have enacted the net metering policy [17].

As mentioned, net metering cannot be the main instrument to encourage the RE development of a country. In addition, its implementation requires the creation of a specific technical base that ensures no problems with accounting for the electricity generated and consumed in different hours.

Overall, many support schemes can be applied by states to develop RE sector in a national economy. However, at first, every government should set clear goals in the RE sphere regarding the RE potential of a country, improve its investment climate, solve all technical issues concerning grid connections and justify the most effective instruments for RE facilities expansion at the present state of RE development. Let us consider the case of Lebanon and its RE government policy in order to identify key problems in green energy business advancement in this country and offer the possible ways to overcome them.

CHAPTER 2 MANAGEMENT OF GREEN ENERGY BUSINESS DEVELOPMENT IN LEBANON

2.1 The potential of the country's renewable energy sources and the state of its use

Like any other country in the world, electricity is essential for Lebanon. The country is suffering greatly from the shortage in its electricity production, which is partially compensated for by the use of polluting private diesel generators. Power cuts and the application of private generators are hindering the energy progress of Lebanon and lowering the quality of life of people living in the country. Taking into account the pollution resulting from conventional sources of energy, the alternative (renewable) energy sources are proving to be the best option to obtain clean energy [24]. Since the option of RE has worked for many countries worldwide especially in Europe, researchers in this area [17] don't see why RE is not a good option for Lebanon [21].

The country, due to its geographical conditions, is in an excellent position to exploit this trend as it has almost all sources of RE available inside its borders, although some are not currently feasible. Lebanon is divided into four major geographical zones:

1. Coastal zone: (altitude 0 to 500 m) exhibiting a Mediterranean maritime climate characterized by hot humid summers and mild winters.

2. Mid-mountainous zone: (altitude 500 to 900 m) a region characterized by mild summers and cool to cold winters.

3. High mountainous zone: (altitude over 900 m) a region characterized by cool summers and cold snowy winters.

4. Inland zone: (variable altitude) a valley plane exhibiting continental tendencies characterized by a marked diurnal temperature drop [17; 39] (Figure 2.1).

Thus, due to favorable climate conditions, in Lebanon many of the alternative sources of energy (solar, wind, hydro, geothermal, wave, etc.) can be explored and used. Studies by Country Entrepreneurship for Distributed Renewables Opportunities (CEDRO) show good potential for solar and wind energy with reasonable technical requirements to have such forms of energy. As for hydroelectricity, which has great potential in Lebanon (mountains and frequent rainfalls), it is not being given the right attention by the national government. Lebanon has very few hydro projects (Litani, Al-Bared, and Safa) providing approximately 220 MW out of 3000 MW needed as an average load capacity. Unfortunately, the remaining needed power is generated thermally by burning oil.

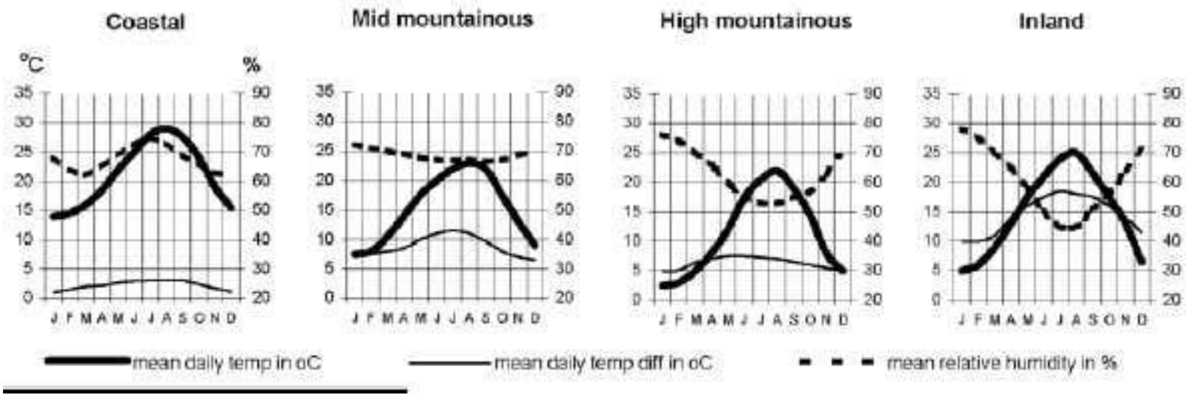

Figure 2.1 – The general climatic characteristics of Lebanon geographical zones [51]

The potential of wave and tidal energy is not well studied in Lebanon but having more than 220 Km coastline should trigger research works in this direction to explore the potential of this type of energy. At the end of the day, this is how the government can meet the RE 12% commitment through collecting every tiny piece of RE available in Lebanon. As for the geothermal energy, this type is usually exploited in seismically active regions (Greece, Italy), which makes Lebanon not the right place to explore such type of energy. Another energy source could be the nuclear energy. However, the infrastructure involved in nuclear energy is too expensive and the waste resulting from such form of energy is very dangerous and not easily disposed of. In addition, nuclear energy is creating conflicts between countries worldwide for being used for military purposes (nuclear weapons of Iran and Israel) [21].

Thus, there are various types of renewable sources of energy and each has been proven to be successful in a certain domain and in a certain place. Although different alternative sources could be used, the two types that most experts agree on their special applicability to Lebanon are solar and wind energy. This is due to Lebanon's geographical attributes which give this country a very good global solar radiation and wind speed compared to other countries in Europe.

Recently, solar water heaters (SWHs) have been used widely in Lebanon. However, the abundant solar energy (Table 2.1) has insufficiently been used to generate electricity [52]. Moderate Mediterranean weather with an average of 300 sunny days a year presents an ideal climate for using the thermal energy of the sun in Lebanon. Nevertheless, 75 % of Lebanese households are dependent on electricity for their domestic water heating and this places an unsustainable burden on the Lebanese electricity sector [53].

Table 2.1 – Solar data for Lebanon [51]

Month	Coastal Insulation, $kWh/m^2/day$	Interior Insulation, $kWh/m^2/day$	Coastal sunshine hours (Hrs)	Interior sunshine hours (Hrs)	Day length, (Hrs)
January	2.4	2.4	4.6	4.5	10
February	3.2	3.4	5.6	5.5	10.8
March	4.1	4.4	6.4	6.4	11.8
April	5.5	5.9	7.7	8.5	12.9
May	6.6	7.2	10.1	10.5	13.8
June	7.3	8.5	11.5	13.1	14.2
July	7.0	8.4	11.4	13.2	14
August	6.3	7.7	10.6	12.4	13.2
September	5.3	6.5	10.4	11.2	12.1
October	4	4.7	8.1	9	11
November	2.9	3.3	6.4	6.7	10.2
December	2.3	2.4	5	4.8	9.8

Many academic research works have studied the possibility of using PV and thermal solar energy in Lebanon, but those studies were never brought into real implementations except for few PV projects done by CEDRO. The solar street light system recently inaugurated for Chekka tunnel in North Lebanon is considered the largest functional PV installation completed in Lebanon so far, an example to followed by other municipalities in Lebanon to see more of the Lebanese tunnels lit by solar power instead of the polluting oil-based energy currently in use and when available [21]. Lebanon has a long way to go before achieving a status where it can be identified as RE producer, a status that many countries around the world have already achieved.

Wind also has the potential to produce energy in some regions. Few attempts have been made to install wind turbines before having the wind atlas for Lebanon, in addition to some PV street lighting systems without assessing the potential of solar radiation in places where the systems were installed. Most of those systems failed to deliver the expected power [17]. However, according to some studies, the North and the South of Lebanon have the highest wind velocity average in the country. The study done by Electricity Utility of Alay recorded a minimum of 7m/s wind velocity average (at 40 meter above the ground level) in Akkar. In the South of Lebanon, where people are suffering from 12-13 hour blackouts per day, the region has the highest wind velocity in the country with enough to run wind turbines up to 5 MW capacity (per unit of wind turbine) (Table 2.2) [17].

Table 2.2 – Wind data for Lebanon (ground level) [51]

Assessment Site	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Avg/ Year
Beirut-Airport	4.6	4.9	5.2	4.4	3.9	4.3	4.6	4.0	3.5	3.2	3.2	4.2	4.17
Ceders	2.9	3.1	3.4	3.0	3.3	2.9	2.7	2.4	2.1	2.8	2.3	2.8	2.81
Rayak	3.4	3.8	4.3	3.9	3.5	3.7	3.7	3.4	3.2	3.1	3.2	3.2	3.53
Ksara	3.2	3.8	4.2	3.9	4.5	4.8	4.2	3.4	2.6	2.4	2.9	3.68	3.63
Khalde	3.35	2.97	3.26	2.72	2.42	2.85	3.45	2.86	2.08	2.07	2.06	3.04	2.76
Marjayoun	4.24	4.16	4.88	4.24	4.59	5.19	5.78	5.4	4.6	4.07	3.84	3.93	4.58
Qlaiat	5.33	5.51	5.41	4.19	3.74	3.75	4.16	3.57	3.47	3.89	4.41	5.56	4.42
Tripoli-Mina	4.23	4.38	5.12	4.35	3.76	4.68	4.72	3.72	2.65	2.51	3.01	3.74	3.91
Dahr-El-Baidar	4.67	4.87	5.63	5.06	3.98	4.59	5.05	4.48	3.33	3.1	2.96	4.44	4.35

Villages like Majaeiyyoun, Khiyam, Maroun Al-Ras are all in the wind corridor that passes through the Southern part of the country. According to The National Wind Atlas of Lebanon, the potential 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 [54]. However, Lebanon has not significantly used its wind potential yet.

2.2 Economic and organizational support for the development of green energy business in the country

Energy and electricity demand have weighed heavily on the Lebanese economy in recent years. Imported fuel oil alone accounts for nearly a quarter of the national budget deficit. Population growth has pushed energy use up steadily, with the demand for power increasingly exceeding existing generation capacity. While private producers have helped to close the gap, such arrangements are costly for both consumers and the national utility, Electriciti du Liban (EDL). RE technologies, in contrast, promise stable, clean, fully domestic power and heat systems. Amid the coronavirus (COVID-19) outbreak in early 2020, renewables and energy efficiency have become a key part of the country's recovery plans [55].

Lebanon currently relies on gasoline, fuel oil and gas oil, which are 100% imported. Energy security concerns, combined the need to support economic growth, have driven an energy diversification strategy. This strategy was outlined in two updates to a key electricity reform paper: the first in 2010, which further led to the National Energy Efficiency Action Plan (NEEAP) in 2011 and the National Renewable Energy Action Plan (NREAP) for 2016–2020 [56]; and the second producing the NEEAP for 2016-2020 [57]. These action plans build on the high availability of RE sources and the potential for the deployment of RE and energy efficiency measures to satisfy 12% of primary energy consumption for both electricity generation and heating purposes by 2020.

Lebanon's commitment to scaling-up the use of RE technologies is fortified by ongoing updates to its RE targets. A new target aiming to meet 30% of total primary energy consumption (electricity and heating demand) from renewables by 2030 was introduced in 2018 and formed the basis of a first update to the electricity reform paper in March 2019. To date, total installed RE power capacity amounts to 350 megawatts (MW), including 286 MW from hydropower sources, 7 MW from landfill and 56.37 MW from solar power. Therefore, additional measures are required to scale-up renewables to the level of 30% by 2030 [55].

Overall, over the past twenty years, Lebanon has initiated several laws and policies to promote the advancement of RE. The evolution of these efforts is shown in Figure 2.2. In April 2019, the newly formed government adopted an updated plan that is largely based on the 2010 Electricity Policy Paper. On the RE side, the government plan committed to installing around 1 GW of wind and solar electricity as follows:

• Wind: 220 MW by 2020 and 400 MW by 2023;

• Solar PV: 180 MW by 2020 and 300 MW (with 210 MW of storage capacity) by 2022;

• Distributed Solar PV: 45 MW by 2019 [58].

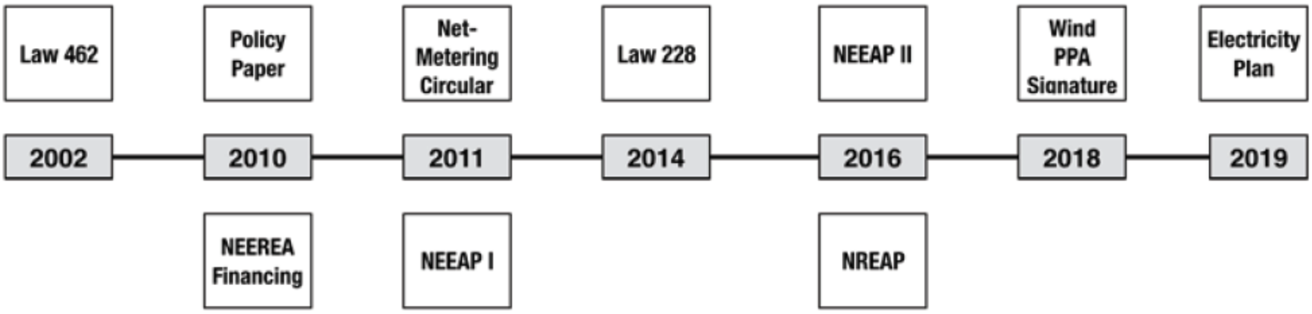

Figure 2.2 – Major RE laws and government policies [58]

In parallel, the Lebanese Parliament extended Law 288 until April 2021 and amended Law 462 to provide a legal cover for projects to be tendered on Build, Operate & Transfer (BOT) contract types. Prior to forming the government, Lebanese prime-minister Hariri announced that 30% of Lebanon's energy mix will be covered by renewables by 2030, without specifying how this goal will be reached. However, Ministry of Energy and Water (MOEW) is already working on a plan to achieve this target with the support of IRENA. In 2002, Law 462 was ratified and provided the legal framework for privatization, liberalization and unbundling of the electricity sector. It built on Law 228 of 2000, which provided the governance structure for privatization operations, specifying its conditions and scope of implementation. Law 462 split the power sector into three components: production, transmission and distribution. While the transmission component was restricted to EDL, private production and distribution were allowed under the PPP terms of Law 228 [58].

Law 462 also called for the establishment of a National Electricity Regulatory Authority (NERA), which is primarily mandated with licensing new power generation projects. Establishing NERA has been shelved for now with Law 288, the extension of which has given the MOEW and the Ministry of Finance (MOF) the ability to license independent power production (IPP) for a two-year period until 2021. According to Law 462, self-generation of below 1.5 MW, be it from RE or other sources, is permitted. For IPPs with a generation capacity higher than 1.5 MW, the current arrangement is for their projects to be proposed by the MOEW (minister) and voted on by the COM (Council of Ministers). Consequently, the deployment of distributed energy generation such as rooftop solar PV systems, which are used for self-consumption, is legal as far as Law 462 is concerned [58].

In 2010, COM adopted the Electricity Policy Paper, which was then ratified by Parliament through Law 181/2011. The Policy Paper clearly stated the commitment to "launching, supporting, and reinforcing all public, private and individual initiatives to adopt the utilization of renewable energies to reach 12% of electric and thermal supply." This was soon followed by completing the Wind Atlas of Lebanon in 2011 and launching the IPP wind farm project, as well as studying the feasibility of establishing solar PV farms in the country. The Policy Paper also focused on the development of hydropower energy. On the energy efficiency side, the 2010 Policy Paper committed to "the preparation and spreading of the culture for proper electricity use; adoption of national programs focused on demand side management as the basis for: effective energy use; peak shaving; load shifting; and demand growth control to save a minimum of 5% of the total demand." This was reflected in launching initiatives related to the adoption of SWHs, Compact Fluorescent Lamps (CFL), and green financing mechanisms through the National Energy Efficiency and Renewable Energy Action (NEEREA). The currently implemented policy instruments are explained in Table 2.3 [58].

Table 2.3 – Modern policy instruments for RE development in Lebanon (created by the author based on [45–49; 55])

Instrument	Characteristics
1	2
NEEREA (National Energy Efficiency and Renewable Energy Action) Mechanism	NEEREA is a green financing initiative that was launched by the Central Bank of Lebanon (BDL) in November 2010, in collaboration with MOEW, MOF, UNDP, and the European Union. The mechanism stipulates that BDL provides subsidized "green" loans to individuals, commercial and industrial firms to support projects that target either improving energy efficiency or RE generation (for self-consumption). The loans are given through Lebanese commercial banks and supported by BDL with a low interest rate (currently standing at 2.75%), a loan ceiling of $10 million per project and a maximum term of 14 years – including a grace period of between six months and four years. Currently, NEEREA covers the following activities: 1) interior and exterior efficient lighting systems; 2) efficient ventilation and heating systems; building envelope applications; 3) solar, wind, hydro, geothermal and biomass applications. In 2017, the total investments in distributed solar PV reached $18.23 million, three quarter of which ($13.19 million) are financed through the NEEREA mechanism. In terms of capacity, 64% of total installed capacity up to 2017 is NEEREA financed. In fact, interviewed solar companies have all emphasized the impact of the increase in NEEREA's interest rates on slowing down the growth rates of the solar energy market in Lebanon. NEEREA was designed to kick off the deployment of distributed renewables, especially solar PV systems; however, it is not a financially sustainable tool in the long-term. Furthermore, the sustainability of the NEEREA mechanism is under pressure given the escalating fiscal crisis in Lebanon. BDL and the involved commercial banks were not able to continue offering green loan subsidization as of March 2018 due to quota depletion, similar to what happened with housing loans. After rounds of reviews and discussions, the green energy loans were re-initiated at the end of 2018/beginning of 2019 but with higher interest rates reaching around 2.75% instead of the 0% and 1% given in the earlier phase.
Net-Metering	The potential benefits of net-metering go beyond the consumer level to directly benefit EDL, as its losses proportionally increase with the amount of power it generates. Given that the average EDL tariff is 9 cents/kWh and its cost of production is between 16 and 20 cents/kWh, every kWh generated on the distributed level by solar power or other sources saves EDL between 7 and 11 cents. Net-metering in Lebanon was launched by the MOEW and EDL in 2011. The mechanism stipulates that a bidirectional meter is installed on the end-user level, which measures the electricity flow from and to EDL's grid. The end-user is then billed based on the net energy consumption. At the end of each year, the remaining balance between both parties is zeroed, and the counter starts again. So far, most of the net-metering users belong to the commercial and industrial sectors. However, net metering in Lebanon suffers some serious technical challenges. From a procedural perspective, while there is a set of "expected" technical requirements to connect to EDL's grid on a net-metering arrangement, there is no enforcement or penalty mechanism, except that EDL's contract states that the owner of the distributed system must take care of all protection measures, such as the installation of disconnectors. Distributed solar can only be supplied to EDL's grid under a net-metering arrangement or if given a special concession by the government, but again, only to sell electricity to EDL's grid.

Continuation of Table 2.3

1	2
Lebanon Energy Efficiency and Renewable Energy Financing Facility (LEEREFF)	LEEREFF provides dedicated financing for local green energy projects, as well as free technical assistance by international team of engineers. Developed by the European Investment Bank (EIB), the French Development Agency (AFD) and BDL, the facility aims to support investments in energy efficiency, RE, and green building by private companies in Lebanon, both large and small. LEEREFF offers standard loans of 40,000 to 250,000 euros for small projects that will achieve at least a 20 percent energy savings and nonstandard investment loans of 250,000 to 15 million euros for a diverse range of larger projects.
Green Economy Financing Facility (GEFF)	With 4 billion euros in funding from the European Bank for Reconstruction and Development (EBRD), GEFF aims to reduce GHG emissions by financing green energy projects around the world. The facility operates through a network of more than 130 local financial institutions across 24 countries, providing credit lines to local institutions so they, in turn, can fund local beneficiaries. More than 120,000 clients have benefited from the program to date and, as a result, have avoided more than 7 million tons of carbon dioxide emissions. GEFF also provides advisory services aimed at helping financial institutions and their clients improve their market practices. In Lebanon, specifically, the facility will provide up to $190 million to local commercial banks to finance energy efficiency, RE, and resource efficiency projects.

Despite the challenges facing the energy sector in terms of grid infrastructure, this NEEREA national financing scheme, designed to incentivize the market, has achieved remarkable success. Having financed more than 938 projects as of March 2019 it also signals the commitment and interest of both the public and private sectors to the expansion of RE projects. In terms of large-scale projects, Lebanon signed its first PPA for electricity consumption from renewables in 2018, with a total capacity of 226 MW. However, the success of these schemes has been overshadowed by several factors including the current policy, legal and institutional framework governing large-scale projects, and a lack of awareness of support schemes provided at the small-scale level [55].

Recently, through funds from the Swedish International Development Cooperation Agency (SIDA), Economic and Social Commission for Western Asia (ESCWA) launched "Regional Initiative for Promoting Small-Scale Renewable Energy Applications in Rural Areas of the Arab Region". The main objective of the project is to improve the livelihood, satisfying energy needs, economic benefits, and social inclusion and gender equality of Arab rural communities, particularly marginalized groups. The project will work on integrating small-scaled RE technologies in rural areas, implementing a pilot project in North Lebanon within the agro-food sector demonstrating the impact that such technologies may have on the livelihoods of the rural communities [50; 51].

2.3 Economic results of the green energy sector development

The growth of RE for electricity generation in Lebanon is concentrated in the deployment of solar PVs, which accounts for almost all of the total non-hydro RE installed capacity. There are several economic and technical reasons for this dominance by solar PV technologies. First, solar PV systems are modular, and therefore, can be installed at variable capacities, depending on space availability and budget. Second, PV systems have witnessed dramatic cost reductions in recent years. Turnkey costs of solar PV projects in Lebanon have plummeted from around $7,000 per kWp in 2011 to around $800 in 2018, an 88% cost reduction in just eight years [62; 63]. Third, there is the country's climatic suitability. Lebanon benefits from around 300 sunny days in a year with 8 to 9 hours of sunshine during the day [46; 54]. Additionally, solar insolation levels are high across the country and range between 1,800 and 2,200 kWh/m^2, where specific yield ranges between 1,400 and 2,000 kWh/kWp. Installed capacity of solar PV grew from almost zero in 2011 to around 47 MWp in 2018. Subtracting the capacities of the Beirut River Solar Snake and the Zahrani Oil Installations projects, which account for 1.08 and 1.09 MWp, respectively, the remaining 44.8 MWp are all installed as decentralized systems. [58; 65].

In terms of electricity generation, solar PV projects generated around 53 GWh, which is equivalent to 0.25% of Lebanon's total demand and 0.4% of EDL's total production. Despite this being a very modest contribution, it does highlight the rapid growth of the solar PV market in the country. However, the triple digit growth in installed capacity that had been reported in the years prior to 2017 has slowed down recently (a 50% decrease year-on-year in 2017) due to the gradual increase of interest rates on the loans provided under the NEEREA mechanism, supported by BDL. In

2020, growth in solar PV projects is expected to stagnate as a result of the economic crisis. On the other hand, customs taxes were lifted on imported solar PV panels in March 2018, which could partly offset any growth slowdown [43; 46].

Up to 2017, a total of 1,417 solar PV projects had been implemented in Lebanon. Most of these projects, in numbers and capacity, are of relatively small size. Almost 90% of projects are of a capacity below 50 kWp and account for 27% of the total installed capacity [65]. The sectoral distribution of the installed capacity in 2017 is shown in Figure 2.3. About 30% of capacity, 12 MWp, is deployed by the industrial sector, followed by the commercial sector with 19% and the residential sector with 17%. It is not surprising that the industrial and commercial sectors are taking the lead in deploying solar PV systems. This is because of multiple factors: (1) both sectors often have more space available to install solar modules compared to residential buildings; (2) both sectors have access to capital and/or financing; and (3) they rely heavily on diesel generators for back-up power during EDL outages and installing solar PV could lower their total electricity bills substantially. [58].

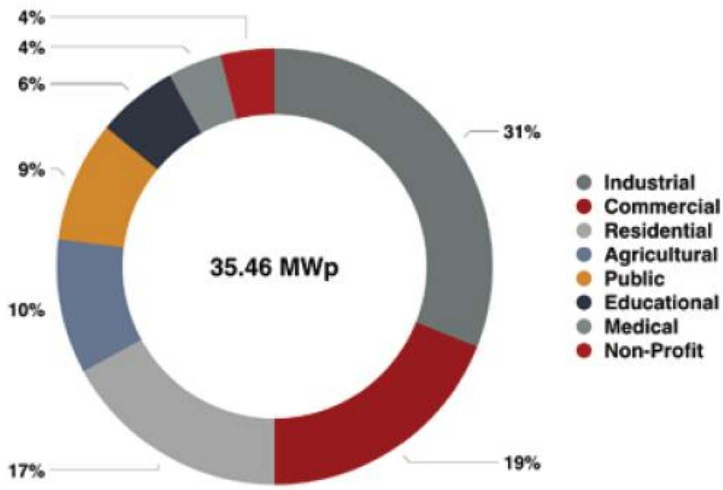

Figure 2.3 – Distribution of solar PV capacity by sector in Lebanon in 2017 [55; 58]

In terms of the split between different uses of the generated electricity, the majority of the distributed solar PV capacity (63%) is deployed in an "on-grid" or "grid-tied" mode, meaning that it is connected to and dependent on EDL's grid. Grid-tied systems offer the advantage of benefiting from the existing net-metering arrangement to lower electricity bills, as well as lowering installation costs. Currently, around 10% of projects deploy batteries, allowing them to function even if EDL's grid is not connected. This makes the installed solar system more flexible and captures more benefits from it. However, it also increases the costs due to the need to install added equipment and batteries. As the cost of storage continues to decrease and this mode of operation becomes more economically viable, its share is expected to increase.

According to the [65] data, in terms of geographical distribution, most projects (39%) are in Mount Lebanon governorate, followed by Beqaa (19%) and South Lebanon (14%). It is interesting to observe that those regions, with the exception of Beqaa, are not as optimal in terms of topography (large areas are south facing) and solar insolation compared to regions such as Baalbak-Hermel. This shows the untapped potential for further deployment of distributed solar PV projects in inland regions. The current installed capacity is concentrated in Mount Lebanon mainly due to the strong presence of the industrial sector, which as shown in Figure 2.3, constitutes around a third of the 2017 deployed capacity [58].

In 2018 CEDRO completed 'Village 24' Initiative the first community-led RE system in Lebanon [66]. Approximately 100 households in Kabrikha in Southern Lebanon signed up to the scheme entirely powered by 250kWp solar PV coupled with diesel generators. It is the first community to utilize the net-metering policy. The electricity expenses have dropped 30% and the village no longer experiences power cuts. The initiative allows a community-scale RE powerplant to plug into the separate local grid that is owned and operated by the municipality when the power is cut, and then allows the same RE power to plug into the utility network when national power is available [66]. It is expected that this model will lead to the implementation of other community-led RE systems (whether solar, wind or bioenergy) that provide energy security, environmental benefits, community cooperation and economies of scale [56; 67].

Overall, YY 2015-2018 demonstrated tremendous growth in solar PV capacities and electricity generation (Figure 2.4). In particular, the volumes of generated electricity increased 10.85 times during 2014-2018, while the share of solar PV electricity generation in total electricity mix was still tiny: 0.55% or 0.084 TWh in 2018. The number of solar PV annual new projects increased almost 2 times between 2014-2018; as of 2018, more than 90% of the projects were private. The specifics of Lebanon's new solar PV projects is that they are small-sized in their majority. Thus, in 2018, 85.9% of projects had a solar PV capacity of 0-49 kWp, while only 0.38% of projects had an energy capacity of 1000+ kWp.

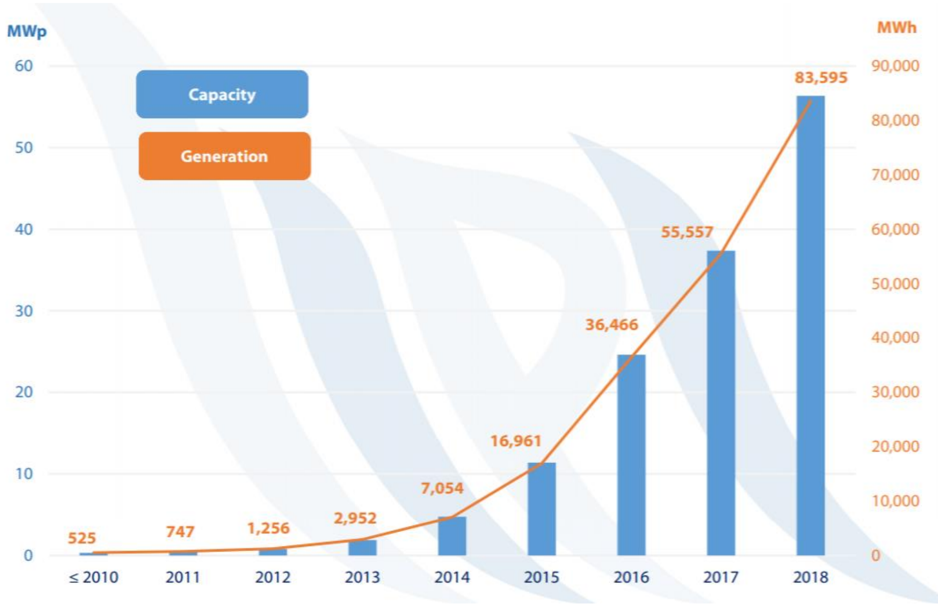

Figure 2.4 – Solar PV Capacity and Generation in Lebanon in 2010-2018 [68]

In 2019, RE in Lebanon continued to develop. For example, rooftop solar PV applications in the country exceeded 22 MW in 2019, according to the latest "2019 Decentralized Solar PV Status Report for Lebanon" (Figure 2.5).

The investments in RE sector of Lebanon also showed 5 times increase over 2014-2018: they went up from 20.42 to 105.39 mln $ in 2018. However, most new solar PV projects are still financed through NEEREA programs (54% or 57.27 mln $ in 2018). As for the sectors of implementation, the largest number of solar PV projects are introduced in industrial and commercial sectors (33% and 22% in 2018 respectively), while the residential sector accounted for only 16% of the projects in 2018. It shows that households are still unable to implement these projects due to the lack of finances and business risks, as well as technical and organizational problems referring to the grid connection and application of net-metering, etc. The most popular areas for constructing solar PV modules are Mount Lebanon and Beqaa (36% and 26% of total solar PV capacities in 2018 respectively), less popular regions are South Lebanon (13%) and Beirut (10%).

Figure 2.5 – Rooftop solar PV applications in Lebanon in 2019, MW [69]

The economic efficiency of installing PV systems can be substantiated by the Cost-Benefit Analysis. The economic feasibility of the solar PV projects in Lebanon is increasing over time due to the considerable decline in yearly average turnkey prices. For example, in 2011-2018, these prices fall 5.86 times and reduced 3 times during 2014-2018 (Figure 2.6). The most significant decline in turnkey price was reached for hybrid technologies, whereas the lowest reduction characterized the autonomous (off-grid) solar PV projects (Figure 2.7). Due to the use of solar energy, the total cumulative savings in Lebanon reached 45,412,230 $ for 2010-2018 with more than 4,5 mln $ contribution in 2018.

According to [70], the cost of generation of solar energy could reach as low as $6c per kWh in the upcoming bids. This could also contribute to considerable savings in oil expenditures. Given EDL's average production cost of about $17c per kWh, solar energy is a sustainable alternative for Lebanon with savings of up to $11c per kWh.

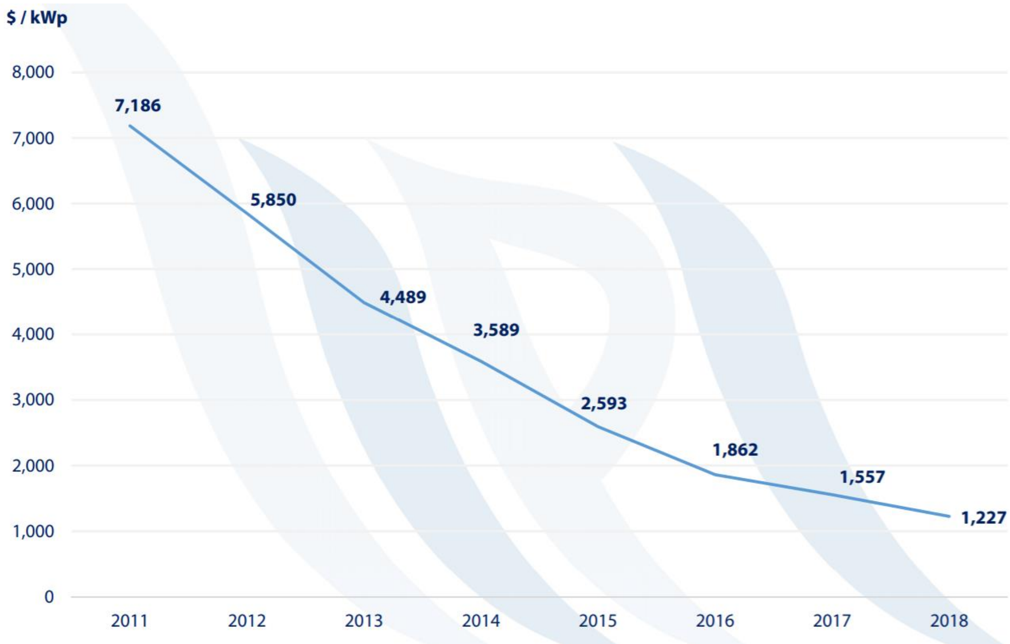

Figure 2.6 – Yearly average solar PV turnkey price in Lebanon in 2011-2018, $ / kWp [68]

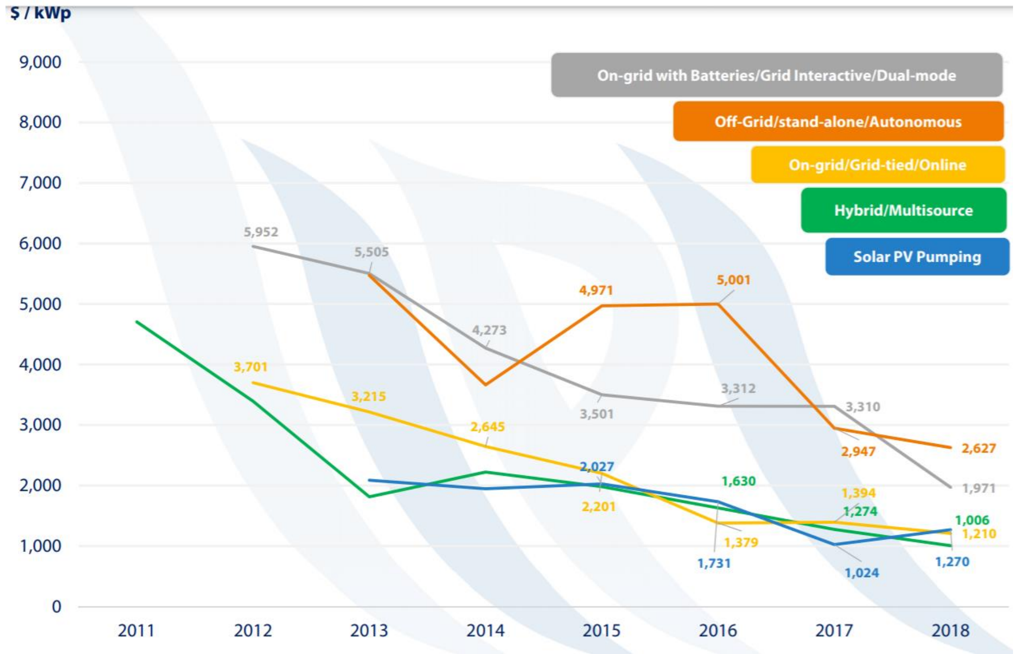

Figure 2.7 – Yearly average solar PV turnkey price by project type in Lebanon in 2011-2018, $ / kWp [68]

To conclude, RE in Lebanon has a great perspective to develop and may essentially decrease the country's dependence on imported fossil fuels. Despite the active extension of the solar and wind power sectors in Lebanon during the last years, there is still a need to improve the energy policy in the energy sector in order to make the green energy business more profitable for both industrial entities and households.

CHAPTER 3 IMPROVEMENT OF ECONOMIC MECHANISMS FOR MANAGING THE DEVELOPMENT OF GREEN ENERGY BUSINESS IN LEBANON

3.1 Problems of green energy business administration

As it was showed in Chapter 2, green energy projects in Lebanon are usually implemented in the private sector and with the help of NEEREA loans (Figure 3.1). Most projects deal with solar energy since it is more convenient to use this energy type. However, legal, technical, organizational, economic and other restraints impede the development and successful administration of RE facilities in the country, in particular deployment of solar PV stations.

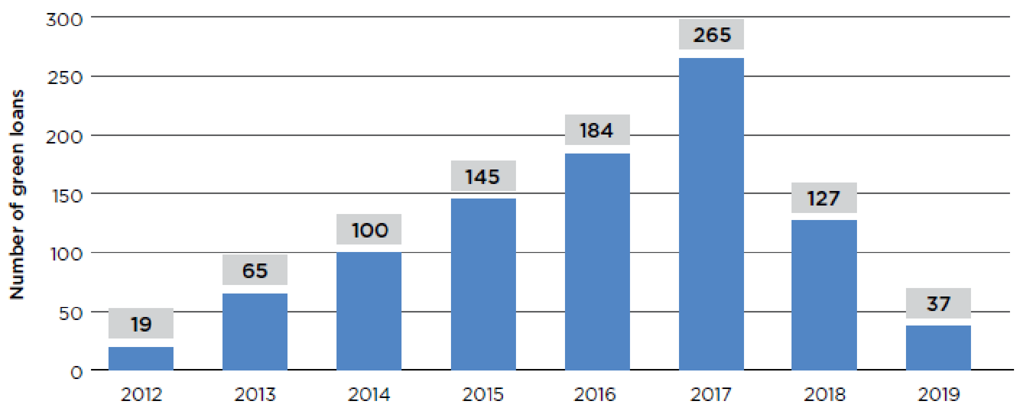

Figure 3.1 – Number of green loans funded by NEEREA [55]

Historically, Lebanon has been known for its entrepreneurial acumen [71]. Data from the [72] for 2018 shows that 21.6% of 18–64-year olds are established business owners, 24.08% are either a nascent entrepreneur or owner-manager of a new business, and 42.01% see good opportunities to start a business in the place they live. But entrepreneurs in Lebanon are constrained by high electricity costs and unstable supply as well as the hybrid-political order that can channel entrepreneurial talent into bribery and lobbying [23]. The reinforcement of family-owned business and entrepreneurs with connections to government [23] limits the potential for new RE entrepreneurs by limiting the diversity of ideas and knowledge [67].

Controversial legal framework in Lebanon hinders RE facilities deployment. Regulations are based on industrial traditions and codes, not up to date with sector developments. There are urgent legal and institutional problems which deal with privatization and liberalization of the Lebanese energy sector. EDL still remains a monopolist in energy generation, transmission and distribution in the country.

Low and not cost-reflective electricity tariffs are a barrier to expansion of RE because of the long amortization period. The heavily subsidized electricity does not permit any other sources of energy to enter the market competitively. EDL cannot increase the tariffs until infrastructure and the grid are reliable, but at the same time EDL does not have the finances to improve the systems reliability [22]. There is no dedicated department with EDL for incorporating RE into the national grid and no grid codes exist internationally that could be adopted [67].

Another constraint to a RE transition for Lebanon is the vested interest throughout the economy in oil imports and the entrenched nature and power of the private generator owners. The author of [73] estimates the private generator industry to be worth $1 billion. This gives the owners power and influence over lawmakers in an already fraught political sphere where key energy policy decision makers include the Lebanese Oil Installations Directorate and the Lebanese Petroleum Administration [74]. The entanglement of the generators in everyday life and within the distinct socio-political divides is a barrier to new systems of delivery and can inhibit mobilization against the current energy supply in Lebanon [75]. Energy policy should focus on RE needs to acknowledge this complexity and to engage with and enhance the capacities of both old and new players in the energy business [67].

One more issue that prevent a wide use of RE technologies is the discovery of domestic gas in Lebanon. It could reduce import dependence and CO_2 emissions. Commissioning of an investment program for construction of a number of gas-based power plants through the private sector, primarily in Salaata, Zahrani and Deir Ammar, are expected to be installed by 2021 [74]. The gas market is expected to initially be dominated by gas imports that will eventually partly be replaced by indigenous gas. However, it means that this new resource for Lebanon, but traditional fossil fuel, may delay the deployment of the cheaper and cleaner RE due to the higher investment cost in green energy technologies and new infrastructure needed. People are usually more conscious about the amount of initial payment for a product than its running cost over time. Comparing the investment needed for conventional sources of energy to RE for the generation of one kilowatt of electricity demonstrates a low initial cost for fossil fuel sources that RE. However, the RE cost can decline as delivery continues and technology improves. In 2006, the cost of a solar PV panel per watt was between $4 and $5 while in 2009, the same panel was available for just $2 per watt. Cost and pricing are the chief obstacles for a RE company. However, if the environmental impact of conventional energies could be measured and added to its price through some mechanism like a tax, then the competition between RE and conventional sources would crown RE as its winner [17].

An obstacle to high penetration of RE is land availability in Lebanon. Tfail, an inland region in the Bekaa Valley on the border with Syria, has been shown to include around 13 km^2 of elevated flat lands with high levels of solar irradiation. Given the location, solar PV projects could play a role in potential electricity swap deals and trading with the Syrian grid in the future [20]. This pre-feasibility research is important as it provides information for attracting investors and it has been reported that European Bank for Reconstruction and Development is seeking consultants for a feasibility study for the projects [76].

Lebanon also has a lack of awareness among the general population and its elites. They are not well informed about the ability of RE sources to support their country. They do not observe any RE projects yielding tangible, visible results in their country. However, the 1998 education reforms in Lebanon incorporated environmental studies, including climate change, into science, civic, and geography classes [77]. Still, those Lebanese outside of the classroom do not learn about these theories or information. The single RE resource which people observe in Lebanon is the SWHs, accounting for only 3% of water heater market. Today the growing popularity of the SWHs is the result of the awareness campaigns conducted by the Lebanese Center for Energy Conservation (LCEC). Having an effective public relations plan for RE resources in the country requires close collaboration between several organizations and ministries. This cooperation is fundamental to the creation of the electricity regulatory authority [17].

The RE market for electricity generation is a luxury rather than an alternative in Lebanon. One side of the problem is the high cost of RE systems while the more significant side is the absence of the country's technological capacity for RE. The lack of both skilled labor and serious competition among RE companies (to provide the best services at the lowest price) directly affects the potential for an RE market in Lebanon. The absence of skills and information may increase perceived uncertainties and interfere with policy decision-making [16; 67]. For instance, bank and insurance systems would hardly support any project that is not known by their experts. Misinformation or a lack of information hinders the expansion of RE and should be set as one of the main goals of the regulatory authority. The lack of visible installation sand familiarity with RE technologies can lead to the misperception that RE poses a greater technical risk than conventional energy sources [16; 17].

The above-mentioned organizational, social, technical, and legal barriers hinder the RE advancement in Lebanon, while many pilot projects have already proved the economic feasibility of investment in RE.

3.2 Economic substantiation of implementing distributed solar PV projects in Lebanon

According to the Global Solar Atlas [78], Lebanon has a great potential of solar PV energy. PV output 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 [22; 67]. It could be therefore expedient to investigate technologies that can substitute these generators with RE and create opportunities to develop new green energy business.

The potential benefits that can be achieved through scaling-up distributed solar PV systems in Lebanon include the following:

- lower generation and transmission investments for EDL;
- net costs savings, reduced exposure to fuel price volatility, improved energy security, short lead-time, lowering air pollution and noise for consumers;
- change in social attitude towards RE for the whole Lebanese society;
- new business opportunities for the private sector [58].

From the perspective of Lebanese consumers, installing distributed solar PV systems can bring serious cost savings. However, the magnitude of these savings is highly dependent on project parameters such as location, mounting structure required, capacity, etc. Figure 3.2 shows the current ranges of average per-kWh costs of electricity generated by EDL, as well as wind, solar and hydro energy facilities. Based on this information, we can conclude that RE sources provide a lower average cost of electricity in Lebanon than the traditional ones. Thus, it is expedient to replace fossil fuel used in diesel generators with clean RE, in particular distributed solar PV systems. Currently, EDL tariffs are 2.8 times higher than the average costs of generating electricity from solar energy.

The cost range of distributed solar PV can be estimated using the Levelized Cost of Electricity (LCOE) methodology, which is based on discounted cashflows. The LCOE is the ratio of the total cost to the benefits (in this case the electricity produced) with all figures being discounted to the same baseline year (2019). In a way, the LCOE is the break-even price at which electricity must be sold to yield a zero Net Present Value (NPV), and can be calculated as:

$$LCOE = k + f + v, \qquad (3.1)$$

where *k*, *f* and *v* are the time-discounted, per kWh, capital, fixed and variable costs, respectively [58]. These three parameters can be expressed as follows:

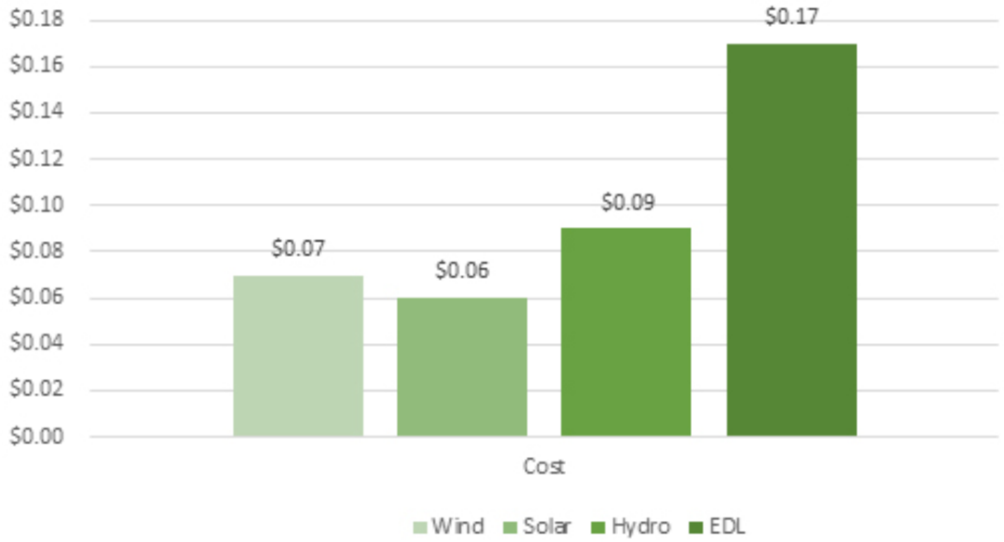

Figure 3.2 – Costs of electricity generation from clean energy sources compared to EDL, cents/kWh [70]

$$k = \frac{K}{\sum_i^T E_i \times \alpha_i}$$

$$f = \frac{\sum_i^T F_i \times \alpha_i}{\sum_i^T E_i \times \alpha_i}$$

$$v = \sum_i^T V_i \times E_i \times \alpha_i ,$$

where *i* denotes the year, *T* is the lifetime of the project, *K* is the overnight capital cost, E_i is the annual electricity produced, *F* is the annual fixed costs, *V* is the annual variable cost. All these parameters are discounted by α_i, the discounting factor expressed as:

$$\alpha_i = \frac{1}{1+r} ,$$

where *r* is the discount rate [58].

For the base case, a discount rate of 8% is assumed. This number is obtained from interviews with financiers and bankers based on their demand for a weighted average cost of capital (WACC) given Lebanon's credit risk rates and fiscal challenges. Also, it should be noted that this is a real discount rate, and inflation is implicitly taken into account. Other (subsidized) scenarios (like NEEREA funding) used lower interest rates.

Generally speaking, the cost of electricity produced depends not just on the number of years in which they are delivering power but also the precise distribution of annual capital expenditures. However, for the case of studying distributed energy systems with relatively small-capital requirements, all capital costs are assumed to be spent overnight [58].

Another factor that strongly affects the relative economics of the different energy systems examined is the capacity factor, which is the ratio of the energy produced in a given year to the amount that could have been produced if the system were to operate at full power all the time. Based on interviews with solar PV companies in Lebanon, the availability factor is somewhere between 16-17%, leading to a specific yield of around 1400 kWh/kWp. For capital costs, the numbers used were based on latest 2019 numbers obtained from interviews with solar PV companies working in the Lebanese market. The current range of costs offered to customers for an on-grid, 500 kWp, project is between $800 to $1000 per kWh [58]. As for projects with storage, the average cost for projects across Lebanon has been obtained from [79]. The ratios of fixed O&M costs were also obtained through the combination of interviews with solar companies and the literature. For on-grid systems, solar companies estimate that the fixed annual costs are at 2% of a project's capital costs. As for systems with storage, the ratio is understandably higher due to the presence of extra equipment and a value of 3.6% has been chosen based on Lazard's latest annual review of levelized cost of storage [80]. Finally, the economic lifetime of the solar system is 25 years. This methodology is implemented in MS Excel [58].

Based on the assumed values of solar PV projects in Lebanon, which have been extracted from interviews with leading solar PV companies in the country, the range of cost of installed solar PV modules fluctuates between $800 to $1,200 per kWp at two distinct discount rates 8% (unsubsidized) and 2.25% (subsidized), leading to a levelized cost, discounted over the 25 year project lifetime, of between 5 and 9.6 cents/kWh that is lower than the average EDL's electricity tariff.

Let us consider the cost structure of distributed solar PV projects. It depends on location, structural requirements, capacity, type of PV modules, whether storage is included or not. Table 3.1 lists the major cost components of a typical on-grid solar PV project: PV panels, inverters, mounting structure, electrical components and vendor services. PV modules and inverters comprise 53% and 21% of the total capital costs, respectively.

Table 3.1 – Cost components of a typical 500 kWp on-grid solar PV system [58; 63]

Component	Description	Quantity	Cost Breakdown
PV	405W Mono	1,204	212,500 (53%)
Panels Inverters	15, 20 and 50 KVA	11	82,800 (21%)
PV Mountings			54,700 (13.6%)
Electrical Components	Electrical Panels Protection Devices Monitoring and Data Logging System Energy Management System and Fuel Save DC Cables AC Cables Connectors Cable trays LCD Screen Other		32,500 (8.1%)
Professional Services	Protection Management Installation Works Project Design Drawings Logistics (Cranes, Transportation…) Testing and Commissioning 10 years Full Support		17,500 (4.3%)
Total Investment ($)			400,000
Total Power (kWp)			488
Capital cost ($/kWp)			820

Based on data shown in Chapter 2, almost 90% of the solar PV projects in Lebanon are of a capacity below 50 kWp. It is expected that as the project size decreases its capacity cost (per-kWp) will increase, as some of the cost components shown in Table 3.1, such as electrical components and professional services, would not necessarily decrease proportionally. Interviewed companies working in the Lebanese market have specified an economics of scale multiplier on project costs between 1.3 to

1.4, which means an increase in capital costs between 30 to 40% when shifting from projects of size of 500 kWp to ones below 50 kWp [58].

Based on the LCOE methodology, we can estimate the costs of different distributed energy systems and their breakdown into capital, O&M and other costs. Table 3.2 shows the calculations on LCOE of on-grid solar PV system with 500 kWp capacity. Based on current market prices and conditions, on-grid solar PV systems appear to have LCOE of 8 cents/kWh, which is significantly lower than EDL's per-kWh cost. The cost structure of solar systems is capital intensive where capital costs for PV comprise around 80%. Clearly, this cost differential analysis is based on today's cost assumptions. Further cost reductions in prices of PV modules will shift the costs down.

Table 3.2 – Calculation of LCOE for on-grid solar PV system [58]

Parameter	On-grid Solar PV
Project Capacity (kWp)	500
Unit Capital Cost ($/kW)	$1,000
Upfront Capital ($)	$500,000
O&M cost ratio	2.00%
Fixed O&M ($/kW-y)	$20.00
Variable O&M ($/kWh)	0
Economic life	25
Capacity Factor	16.0%
Specific Yield (kWh/year/kWp)	1401.6
Discount Rate	8.00%
Annual Energy Production (kWh)	700800
Total levelized cost (cent/kWh)	8.00

According to data obtained from the interviewed solar companies, solar yield in the inland Beqaa region is 10% higher than that obtained in projects based in Beirut. This increases the specific yield assumed from 1,400 to 1,540 kWh/Year/kWp. Factoring in such a substantial increase lowers the levelized cost of solar further to 7.3 cents/kWh, respectively [58].

The financial feasibility of on-grid solar PV is conducted through NPV [81]. One major parameter in the NPV analysis is the assumed discount rate. Two values of discount rate have been used: an 8% rate that reflects the weighted average cost of capital (WACC) based on input by Lebanese bankers and financiers, reflecting an unsubsidized investment costs; and a 2.25% discount rate for projects supported by the NEEREA financing mechanism that is initiated by BDL [82]. Under the NEEREA scenario, the capital is assumed to be paid through a NEEREA loan that would be repaid over a period of 10 years.

With a discount rate of 8%, the payback period, which is equal to the time required for the produced electricity to create cash inflows (savings) for the initial project investment to break-even, is around eight years under the effective tariff of 17 cents/kWh. Given that solar projects are capital intensive, reducing the payback period is of high importance to create higher incentives for adopting such solutions. With a NEEREA 2.25% discount rate and the same effective tariff, the payback period can be reduced to 4.4 years. Indeed, the value of the assumed effective tariff in the financial simulation significantly affects the financial feasibility and profitability. As the effective tariff increases, installing on-grid solar PV systems make more economic sense.

3.3 Recommendations on improving economic and organizational support of green energy business in the country

As shown in § 3.2, the implementation of RE technologies in Lebanon, particularly solar PV modules, is highly profitable and cheaper compared to the diesel generators used today by domestic consumers. Since the country has to import large amounts of fossil fuels, the current energy situation in Lebanon is not only a heavy burden macroeconomically but also on new and old resident’s quality of life and future prosperity. Enabling policies are needed to ensure effective innovation, supply, and consumption of renewable technologies. Policies must continuously adapt to the changing market conditions to ensure greater cost-competitiveness. The Government of Lebanon should adopt and enforce more aggressive targets for RE to contribute to the country's sustainable development and energy security. The current RE targets outlined in the NREAP are unambitious and do not reflect the successes and growth of the RE sector potential [22]. Lowering taxes on RE products and adopting a grid code for the Lebanese context would allow the industry to flourish.

The institutional challenges of EDL must be addressed by adjusting tariffs to reflect actual costs and by encouraging new expertise into EDL through regular employment processes. The use of another agency attached to MOEW could work as a buffer customer for RE projects [83]. Institutional and legal reforms need to be implemented to encourage private sector investment in RE infrastructure. Until this urgent action is implemented, the decentralized distribution of RE offers a pathway that does not only hinge on government performance.

A hybrid model of local ownership could help redefine energy citizenship and encourage people to engage with issues of energy access and payment. Community ownership is already a common ownership model in Lebanon, with buildings collectively buying generators to share, indicating there is traction for change and opportunities for decentralized approaches [84]. There needs to be policy recognition and research into the entanglement of energy provision shaping people's lives as well as creating energy cooperatives [49]. The Issam Fares Institute proposes that the best strategy to address private generator owners would be to involve them in the process of transitioning the economy to RE [85]. A transition would include diversification of energy supply, energy demand management and energy trade, particularly intra-regionally. When looking for pathways to transformation it is essential that we break down the consumer versus producer binary or the state versus community dichotomy, coming up with new solutions to the energy crisis premised on citizen control over their own lives and the resources of their communities. Energy policy should reflect this. Decentralization of RE systems changes the dynamic of how we think about energy and may help to change the way we use it. New forms of localism are taking hold around the world that are an opportunity for RE transitions. Local authorities need to be able to play an active role in controlling, spreading and efficiently using RE resources within their communities but this requires policy support from above [67]. In addition, it is expedient to promote the direct and decentralized use of micro-scale RE applications for providing energy services and encourage applications that can use RE in a direct manner without going through the grid, for example, water heating, food drying involved in some agricultural processes, and street lighting [84].

RE sphere in Lebanon requires economic changes such as implementing stronger economic incentives for solar PV projects introduction. A guaranteed FIT for RE to the grid can be one of them. This entails the existence of a clear regulatory framework which is currently a work in progress but needs to be pushed more strongly in policy and public forums. The Government of Lebanon should pass the draft law which would allow smaller consumers or producers to sell electricity to the grid based on net metering, collective net metering and municipal net metering based on a peer-to-peer exchange power. If Lebanon does this, it needs to pre-empt Jordan's problems of grid capacity and potential surplus of fossil fuels power. EDL must have the right incentives if it is to be the off-taker [84].

Another economic intensive is attractive tariffs for electricity from RE. Current prices for many RE technologies are very competitive with conventional electricity but are still higher than in other countries in the region. Even though RE is currently one of the cheapest ways to produce energy, Lebanon's huge fiscal deficit is partly caused by large subsidies of conventional energy. The only way to reduce this subsidy is to find long term solutions rather than short term ones to redirect subsidies from fossil fuels to RE sphere. Also, it is critical to create financial incentives and schemes for promoting solar PV projects for medium and small-scale RE projects and programs which are based on a large dissemination of small RE systems, especially for low-income households. For these types of projects, a comprehensive implementation scheme is needed that would include financing as well as a dissemination process which has clear logistical support for the end users and the people that will benefit from the financial support. It can be done through the further expansion of NEEREA, GEFF, LEEREFF and other financial programs in Lebanon. The future of central bank subsidies under the current financial crisis should continue after the banking liquidity crisis is resolved [84]. Lebanon needs reforms in the current market framework to increase investments and project bankability. Increasing tariffs and reducing electricity subsidies may encourage public and private investments in RE projects and allow for the proliferation of renewables through small- and medium-scale deployment, thus substituting expensive and aged thermal generation.

In addition to implementing institutional, organizational, and economic changes, Government of Lebanon should overcome technical problems, in particular reinforce the grid and conduct grid impact assessments. Despite ample RE potential in Lebanon, the grid is subject to major technical and non-technical losses, amounting to 21% in 2018 [55]. Therefore, RE projects – particularly large-scale projects – face significant difficulties. Several studies conducted by regional and international organizations have identified inconsistencies in the frequency readings of the grid. IRENA's REmap analysis finds that the 30% target can be reached if the stability of the system is preserved [22; 55].

The updated policy paper for the electricity sector considers a compound annual growth rate (CAGR) of 3% coupled with a drop of 8% in total energy demand assumed in 2020 after the expected tariff increase. The significant improvements to the transmission and distribution network may help meet electricity sector demand through expansion in installed capacity of grid-integrated renewables [55]. Furthermore, increasing interconnection capacity by signing agreements to ease energy flow may facilitate higher levels of penetration of renewables and guarantee grid stability.

The current net metering scheme was applied following a decision of the Board of Directors of EDL. It allowed for consumers to reinject excess RE into the national electricity grid. However, the customers cannot reinject more than the equivalent of their total annual consumption, which limits the extent of application of RE to other sectors such as the commercial and industrial ones. The deployment of virtual net-metering may be considered, by allowing consumers to buy shares in RE projects and having the income deducted from their electricity bills.

When dealing with large-scale projects, instability in the grid becomes a problem, particularly on the technical side where it causes major issues for RE plants when attempting to synchronize with the national grid. The frequency variations are the key parameters to shed loads based on a pre-assigned priority grid where the dispatching center begins to shed loads from the lowest priority and up until the frequency stabilizes. The Lebanese transmission network shows weak zones where it is not sufficiently developed to handle power and frequency fluctuations from RE generation, especially in the southeast or heavily congested areas like Mount Lebanon. This situation constrains the connection of large-scale RE projects. Moreover, regional instability has deprived the Lebanese grid of interconnection to the regional network, thus forcing additional measures to maintain stability. The size of PV farms allows for the advantage of direct connection to the distribution sector without going through the transmission network, hence saving on transmission losses and acting as a back-up load replacing bulky generators. Therefore, the extension of the low-voltage network to include future medium-scale PV farms being evaluated currently within the scope of the 180 MW of PV farms may lead to a reduction in losses [55].

However, to cope with the national grid instability, it is necessary to conduct special studies such as:

- an assessment of the RE carrying capacity of the Lebanese transmission and distribution grid under different geographical zones of interest. Such a study would also present the current picture of the grid’s inertial strength and flexibility limits, and identify areas of reinforcement in terms of advancing grid code, ancillary service regime and grid expansion priorities;
- a long-term generation adequacy study, appropriately modelling committed RE resources. The analysis could be performed for 5 or 10 years ahead and would also inform policy making to better incentivize future energy sector investments.

The aforementioned assessment would help EDL in the realistic review of the ability of renewables to meet the country’s power demand. This would also augment the planning processes at EDL whereby, in addition to transmission and generation planning, EDL can specifically plan for the flexibility and stability aspects of the grid [55; 84].

The considered measures will help Lebanon increase its energy security, reduce the import of fossil fuels, develop green energy business, and acquire essential ecological and economic gains.

CONCLUSIONS

Based on the goals set at the beginning of the work and the tasks formulated, the following conclusions can be drawn.

Recently, RE issues have become of great importance for many countries, due to positive effects of green energy technologies on national economies in terms of better energy access, increasing energy security, eradicating energy poverty, declining CO_2 emissions, creating new jobs etc. The world's latest trends in the deployment of green energy business show tremendous growth in RE investment over the recent years, and even COVID-19 pandemic does not stop the motion in this direction. It is interesting that starting 2014, developing countries invest more in RE facilities than developed ones. It ruins the myth that the RE industry is a luxury that is affordable only for rich nations. Along with the increasing investment, the world RE market demonstrates a stable tendency to decline the cost of green energy technologies and energy storage facilities that help to cope with the irregularity of energy generation from RE sources. However, even though some RE technologies are already competitive in the energy market, the green energy business is still required state support. Therefore, many developed and developing countries use different economic mechanisms to encourage RE deployment. Among them are FIT, net-metering, tendering schemes, RPS, subsidies, green certificates, quotas, etc. Nevertheless, the application of a certain economic instrument requires the preliminary analysis concerning the stage of RE development in a country, RE potential and the degree of its use, the society's readiness to accept mentally and financially transition to green energy.

In this thesis, it has been considered the development of the green energy business in Lebanon, which has a huge RE potential yet implemented. The country has already started the process of introducing solar and wind energy technologies in the public and private sectors. However, there is a need to do more in the legal sphere and involve the powerful economic mechanisms that will boost green energy deployment in the state. Lebanon imports approximately 100% of fossil fuels to satisfy its energy need and pays a high price for them. The research has revealed that it will be cheaper to replace diesel generators, commonly used in Lebanon to cope with electricity blackouts, with clean energy from solar and wind. To support the green energy business development, the government of Lebanon has adopted national plans regarding RE and energy efficiency advancement, introduced net metering, as well as LEEREFF, GEFF, and NEEREA mechanisms to finance green energy projects. However, the results of this policy show insufficient progress in RE facilities expansion.

The key problems concerning the management of RE sector growth in Lebanon include legal (controversial legal framework), economic (subsidies for traditional energy facilities, low electricity tariffs, monopoly of robust diesel generator industry, high initial investments in RE facilities), political (discovery of domestic gas), social (population unawareness of RE technologies' benefits, lack of specialists in the RE sector), technical (high losses in the electricity grid, imperfection of RE technologies), etc. Despite all these barriers that significantly reduce the attractiveness of green energy business in Lebanon, it is showed that generating electricity from a distributed solar PV facility in the country provides much lower average costs (2.8 times) of generation electricity from solar energy in comparison with convenient technologies. The payback periods for solar PV projects calculated based on LCOE and a discount rate of 8% is around eight years under the effective tariff of 17 cents/kWh. With a NEEREA 2.25% discount rate and the same effective tariff, the payback period can be reduced to 4.4 years.

The conducted calculations have demonstrated that development of green energy business in Lebanon is profitable (particularly in the solar PV sector). It should be enhanced by improving state economic and organizational support. The key measures to stimulate the national RE expansion are lowering taxes on RE products and adopting a grid code, adjusting tariffs to reflect actual production costs of traditional energy and installing attractive tariffs for electricity from RE, providing institutional and legal reforms, introducing FIT for RE capacities, developing RE financial programs, solving technical issues concerning the national grid instability.

REFERENCES

[1] IRENA, "Renewable energy and jobs – annual review 2020," 2020. Accessed: Dec. 13, 2020. [Online]. Available: /publications/2020/Sep/Renewable-Energy-and-Jobs-Annual-Review-2020.

[2] IRENA, "Renewable energy and jobs – annual review 2019," 2019. Accessed: Dec. 13, 2020. [Online]. Available: /publications/2019/Jun/Renewable-Energy-and-Jobs-Annual-Review-2019.

[3] Bloomberg NEF, "New Energy Outlook 2019 - Findings," 2019. [Online]. Available: https://about.bnef.com/new-energy-outlook/.

[4] BNEF, "Global trends in renewable energy investment 2020," 2020. Accessed: Dec. 12, 2020. [Online]. Available: https://www.fs-unep-centre.org/wp-content/uploads/2020/06/GTR_2020.pdf.

[5] N. Wamukonya, "Legislative and policy instruments for promotion of renewable energy in the power sector," Cape Town, 2005. Accessed: Dec. 12, 2020. [Online]. Available: https://www.un.org/esa/sustdev/sdissues/energy/op/parliamentarian_ forum/njeri_paper.pdf.

[6] Z. Y. Zhao, J. Hu, and J. Zuo, "Performance of wind power industry development in China: A DiamondModel study," Renew. Energy, vol. 34, no. 12, pp. 2883–2891, 2009, doi: 10.1016/j.renene.2009.06.008.

[7] R. Wiser, M. Bolinger, L. Milford, K. Porter, and R. Clark, "Innovation, renewable energy, and state investment: Case studies of leading clean energy funds," Berkeley, CA, 2002. doi: 10.2172/807421.

[8] U.S. Energy Information Administration (EIA), "Renewable energy explained - portfolio standards," 2020. https://www.eia.gov/energyexplained/renewable-sources/portfolio-standards.php (accessed Dec. 12, 2020).

[9] K. Cory, T. Couture, and C. Kreycik, "Feed-in tariff policy: design, implementation, and RPS policy interactions," 2009. Accessed: Dec. 12, 2020. [Online]. Available: https://www.nrel.gov/docs/fy09osti/45549.pdf.

[10] G. S. Chebotareva, "Impact of state support mechanisms on the cost of renewable energy projects: The case of developing countries," WIT Trans. Ecol. Environ., vol. 217, pp. 881–891, 2018, doi: 10.2495/SDP180741.

[11] Z. Abdmouleh, R. A. M. Alammari, and A. Gastli, "Review of policies encouraging renewable energy integration & best practices," Renew. Sustain. Energy Rev., vol. 45, pp. 249–262, 2015, doi: 10.1016/j.rser.2015.01.035.

[12] K. Hogg and R. O'Regan, "Renewable energy support mechanisms: an overview." Accessed: Dec. 11, 2020. [Online]. Available: https://www.globelawandbusiness.com/storage/files/books/1259-58d4fdcbcd6d1.pdf.

[13] T. Kurbatova and H. Khlyap, "State and economic prospects of developing potential of non-renewable and renewable energy resources in Ukraine," Renew. Sustain. Energy Rev., vol. 52, pp. 217–226, 2015, doi: 10.1016/j.rser.2015.07.093.

[14] T. Kurbatova, I. Sotnyk, and H. Khlyap, "Economical mechanisms for renewable energy stimulation in Ukraine," Renew. Sustain. Energy Rev., vol. 31, pp. 486–491, 2014, doi: 10.1016/j.rser.2013.12.004.

[15] I. Sotnyk, M. Sotnyk, and I. Dehtyarova, "Renewable energy to overcome the disparities in energy development in Ukraine and worldwide," in Reducing inequalities towards sustainable development goals: multilevel approach, B. Medani, P. and H. Shvindina, Eds. Denmark: River Publishers, 2019, pp. 185–204.

[16] M. Mendonca, "Feed-in Tariffs Accelerating the Deployment of Renewable Energy," London, 2007.

[17] H. Beheshti, Exploring renewable energy policy in Lebanon: Feed-in tariff as a policy tool in the electricity sector. Beirut: American University of Beirut, 2010.

[18] Kenya Ministry of Energy, "Feed-in tariffs policy on wind, biomass and small-hydro resource generated electricity in Kenya," 2008. Accessed: Dec. 12, 2020. [Online]. Available: https://www.ctc-n.org/resources/feed-tariffs-policy-wind-biomass-and-small-hydro-resource-generated-electricity-kenya.

[19] L. A. Barroso and C. Batlle, "Review of support schemes for renewable energy

sources in South America," 2011. Accessed: Dec. 11, 2020. [Online]. Available: https://repositorio.comillas.edu/rest/bitstreams/16892/retrieve.

[20] M. Ayoub and I. Boustany, "Bankability of a large-scale solar power plant in Tfail-Lebanon," Policy Br., vol. 5, 2019, Accessed: Dec. 07, 2020. [Online]. Available: https://www.eyrolles.com/Entreprise/.

[21] M. H. Ayoub, I. Assi, A. M. Hammoud, and A. Assi, "Renewable energy in Lebanon. Status, problems and solutions," 2013 25th Int. Conf. Microelectron. ICM 2013, 2013, doi: 10.1109/ICM.2013.6734950.

[22] X. Vallvé, U. Lehr, K. Petrick, R. Sallent, R. Chaar, and F. Hoballah, "Prioritization and assessment of value chains within the renewable energy sector in Lebanon," 2019. www.cedro-undp.org (accessed Dec. 07, 2020).

[23] N. Stel and W. Naudé, "'Public–private entanglement': entrepreneurship in Lebanon's hybrid political order," J. Dev. Stud., vol. 52, no. 2, pp. 254–268, Feb. 2016, doi: 10.1080/00220388.2015.1081173.

[24] M. Al Shamisi, Renewable energy initiatives in the Gulf and the Middle East region. United Arab Emirates: United Arab Emirates University., 2011.

[25] I. Sotnyk, Y. Kovalenko, Y. Chortok, and Y. Kripak, "Prospects of investment in green energy projects in Ukrainian households," Econ. Reg., vol. 2, no. 73, pp. 12–21, 2019, doi: DOI 10.26906/eip.2019.2(73).1621.

[26] I. Sotnyk, T. Kurbatova, V. Dashkin, and Y. Kovalenko, "Green energy projects in households and its financial support in Ukraine," Int. J. Sustain. Energy, vol. 39, no. 3, pp. 218–239, 2020, doi: 10.1080/14786451.2019.1671389.

[27] L. Sineviciene, I. Sotnyk, and O. Kubatko, "Determinants of energy efficiency and energy consumption of Eastern Europe post-communist economies," Energy Environ., vol. 28, no. 8, pp. 870–884, 2017, doi: 10.1177/0958305X17734386.

[28] L. Sineviciene, O. V. Kubatko, I. M. Sotnyk, and A. Lakstutiene, "Economic and environmental performance of post-communist transition economies," in Eurasian Economic Perspectives. Eurasian Studies in Business and Economics, vol. 11/1, M. Bilgin, H. Danis, E. Demir, and U. Can, Eds. Springer, Cham, 2019, pp. 125–141.

[29] I. Sotnyk, I. Dehtyarova, and Y. Kovalenko, “Current threats to energy and resource efficient development of Ukrainian economy,” Actual Probl. Econ., vol. 11, pp. 137–145, 2015, Accessed: Dec. 15, 2020. [Online]. Available: www.worldenergy.org,.

[30] I. Sotnyk, “Energy efficient development of Ukraine as respond to modern challenges,” in International economic relations and sustainable development, O. Prokopenko and T. Kurbatova, Eds. Ruda Śląska: Drukarnia i Studio Graficzne Omnidium, 2017, p. 151–166.

[31] I. Sotnyk, M. Sotnyk, A. Olondar, N. Pidopryhora, and M. Maslii, “Managing the energy-efficient development of the university: restraints and ways to overcome them,” Mech. Econ. Regul., vol. 3, pp. 68–86, 2020, doi: https://doi.org/10.21272/mer.2020.89.06.

[32] R. Li, H. Jiang, I. Sotnyk, O. Kubatko, and I. Almashaqbeh Y. A., “The CO2 emissions drivers of post-communist economies in Eastern Europe and Central Asia,” Atmosphere (Basel)., vol. 11, no. 9, p. 1019, 2020, doi: 10.3390/atmos11091019.

[33] T. Kurbatova, R. Sidortsov, I. Sotnyk, O. Telizhenko, T. Skibina, and H. Roubík, “Gain without pain: an international case for a tradable green certificates system to foster renewable energy development in Ukraine,” Probl. Perspect. Manag., vol. 17, no. 3, pp. 464–476, 2019, doi: 10.21511/ppm.17(3).2019.37.

[34] I. Sotnyk, I. Shvets, L. Momotiuk, and Y. Chortok, “Management of renewable energy innovative development in Ukrainian households: problems of financial support,” Mark. Manag. Innov., vol. 4, pp. 150–160, 2018, doi: 10.21272/mmi.2018.4-14.

[35] “Bangladesh towards 100% renewable energy,” Dhaka Tribune, 2017. https://www.dhakatribune.com/tribune-supplements/tribune-climate/2017/08/12/bangladesh-towards-100-renewable-energy (accessed Dec. 10, 2020).

[36] Global Green Growth Institute, “Green Energy Development. GGGI Technical Guideline No.4,” 2017. Accessed: Dec. 10, 2020. [Online]. Available:

https://gggi.org/site/assets/uploads/2017/12/GGGI's-Technical-Guidelines-on-Green-Energy-Development_dereje-senshaw2017.pdf.

[37] IEA, "Data & Statistics," 2020. https://www.iea.org/data-and-statistics?country=WORLD&fuel=Energy supply&indicator=TPESbySource (accessed Dec. 11, 2020).

[38] "World Energy Outlook 2019," 2019. Accessed: Dec. 10, 2020. [Online]. Available: https://www.iea.org/reports/world-energy-outlook-2019/renewables#abstract.

[39] IEA, "World Energy Outlook 2018," Paris: OECD & International Energy Agency, 2018. https://www.iea.org/reports/world-energy-outlook-2018 (accessed Dec. 11, 2020).

[40] Enerdata, "2018 Global Energy Trends & Projections," 2018. Accessed: Dec. 11, 2020. [Online]. Available: https://www.enerdata.net/publications/reports-presentations/2018-world-energy-trends-projections.html.

[41] Enerdata, "Global Energy Trends 2020 - Update," 2020. https://www.enerdata.net/publications/reports-presentations/world-energy-trends.html (accessed Dec. 11, 2020).

[42] I. Sotnyk and L. Kulyk, "Decoupling analysis of economic growth and environmental impact in the regions of Ukraine," Econ. Ann. – XXI, vol. 7–8, no. 2, pp. 60–64, 2014, Accessed: Dec. 11, 2020. [Online]. Available: http://soskin.info/en/ea/2014/7-8/contents_42.html.

[43] I. Sotnyk, D. Hulak, O. Yakushev, O. Yakusheva, O. V. Prokopenko, and A. Yevdokymov, "Development of the US electric car market: Macroeconomic determinants and forecasts," Polityka Energ., vol. 23, no. 3, pp. 147–164, 2020, doi: 10.33223/EPJ/127921.

[44] ACCIONA, "Renewable energy," 2020. https://www.acciona.com/renewable-energy/ (accessed Dec. 11, 2020).

[45] L. E. Doman et al., "International Energy Outlook 2013," 2013. Accessed: Dec. 10, 2020. [Online]. Available: www.eia.gov.

[46] ILO, "Investment in renewable energy generates jobs. Supply of skilled workforce

needs to catch up," 2011. Accessed: Dec. 12, 2020. [Online]. Available: https://www.ilo.org/wcmsp5/groups/public/---ed_emp/---ifp_skills/documents/publication/wcms_168354.pdf.

[47] I. Sotnyk, O. Kubatko, and A. Olondar, "Estimation of the coronavirus crisis impact on the energy and economic security of the national economy," in Socio-Economic Challenges : Proceedings of the International scientific and practical conference (Sumy, November 3–4, 2020), 2020, pp. 42–49.

[48] "BloombergNEF: 2H 2019 LCOE Update," 2019. [Online]. Available: https://www.bnef.com/core/insights/21567.

[49] T. Kurbatova and Y. Hyrchenko, "Energy co-ops as a driver for bio-energy sector growth in Ukraine," 2018 IEEE 3rd Int. Conf. Intell. Energy Power Syst., 2018, doi: 10.1109/IEPS.2018.8559516.

[50] P. Mozumder and A. Marathe, "Gains from an integrated market for tradable renewable energy credits," Ecol. Econ., vol. 49, no. 3, pp. 259–272, 2004, doi: 10.1016/j.ecolecon.2004.01.016.

[51] S. Karaki and R. Chedid, Renewable energy country profile for Lebanon. Beirut: American University of Beirut, Faculty of Engineering, 2009.

[52] Green Line Association, "Status and potentials of renewable energy technologies in Lebanon and the region (Egypt, Jordan, Palestine, Syria)," 2007.

[53] World Bank, "Lebanon social impact analysis - electricity and water sectors," 2009.

[54] CEDRO, "The National Wind Atlas of Lebanon," 2011. Accessed: Dec. 06, 2020. [Online]. Available: http://www.undp.org.lb/communication/publications/downloads/National_Wind_Atlas_report.pdf.

[55] IRENA, "Renewable Energy Outlook: Lebanon," 2020. https://www.irena.org/publications/2020/Jun/Renewable-Energy-Outlook-Lebanon (accessed Nov. 29, 2020).

[56] RCREEE, "The National Energy Efficiency Action Plan (NEEAP) for Lebanon," 2011. Accessed: Dec. 05, 2020. [Online]. Available: https://www.rcreee.org/content/national-energy-efficiency-action-plan-neeap-

lebanon.

[57] LCEC, “The Second National Energy Efficiency Action Plan for the Republic of Lebanon,” 2016. Accessed: Dec. 05, 2020. [Online]. Available: http://climatechange.moe.gov.lb/viewfile.aspx?id=229.

[58] A. Ahmad, “Distributed power generation for Lebanon market. Assessment and policy pathways,” 2020. Accessed: Dec. 05, 2020. [Online]. Available: www.worldbank.org.

[59] GEFF, “GEFF Lebanon – Welcome to the Green Economy Financing Facility.” https://ebrdgeff.com/lebanon/ (accessed Dec. 06, 2020).

[60] Berytech, “Clean technology: a focus on water, waste and energy in Lebanon.” https://berytech.org/clean-technology-a-focus-on-water-waste-and-energy-in-lebanon/ (accessed Dec. 06, 2020).

[61] “SIDA Project.” https://www.unescwa.org/RICCAR-SIDA-project (accessed Dec. 06, 2020).

[62] J. Amine and S. Rizk, “Solar PV status report for Lebanon,” Dbayeh, 2018. Accessed: Dec. 06, 2020. [Online]. Available: https://www.iptgroup.com.lb/library/assets/2017 Solar PV Status Report for Lebanon-compressed-102227.pdf.

[63] ECOsys, “Renewable Energy & Solutions,” Accessed: Dec. 06, 2020. [Online]. Available: https://www.itgholding.com/affiliate/5/ecosys/.

[64] CEDRO, “Solar photovoltaic electricity for your house!,” 2013. Accessed: Dec. 06, 2020. [Online]. Available: http://www.cedro-undp.org/content/uploads/publication/141010120115339~PV-booklet-EN.pdf.

[65] DREG, “Small decentralized renewable rnergy power generation | UNDP in Lebanon,” 2019. https://www.lb.undp.org/content/lebanon/en/home/projects/SmallDecentralizedRenewableEnergyPowerGenerationDREG1.html (accessed Dec. 06, 2020).

[66] UNDP-CEDRO, “Sustainable energy for Lebanese villages and communities: the Village 24 Initiative,” 2018.

[67] H. L. Moore and H. Collins, “Decentralised renewable energy and prosperity for

Lebanon," Energy Policy, vol. 137, 2020. doi: 10.1016/j.enpol.2019.111102.

[68] W. Farhat, "The 2018 solar PV status report for Lebanon," Dbayeh, 2019. Accessed: Dec. 06, 2020. [Online]. Available: https://beirutenergyforum.com/files2019/The 2018 Solar PV Status Report for Lebanon.pdf.

[69] LCEC, "Rooftoop solar photovoltaic applications in Lebanon exceeded 22 MW in 2019," 2020. https://twitter.com/LCECtweets/status/1311990059332141057 (accessed Dec. 06, 2020).

[70] "Renewable energy in Lebanon: Can the country embrace its resources sustainably?," Heinrich-Böll-Stiftung. https://lb.boell.org/en/2019/03/01/renewable-energy-lebanon-can-country-embrace-its-resources-sustainably (accessed Nov. 29, 2020).

[71] Z. U. Ahmed and C. C. Julian, "International entrepreneurship in Lebanon," Glob. Bus. Rev., vol. 13, no. 1, pp. 25–38, Feb. 2012, doi: 10.1177/097215091101300102.

[72] "GEM Global Entrepreneurship Monitor," 2019. https://www.gemconsortium.org/data (accessed Dec. 07, 2020).

[73] S. Rose, "Lebanese government tries to rein in billion-dollar 'generator mafias' - The National," 2018, Accessed: Dec. 07, 2020. [Online]. Available: https://www.thenationalnews.com/world/mena/lebanese-government-tries-to-rein-in-billion-dollar-generator-mafias-1.789451.

[74] World Bank, "Lebanon Electricity Transmission Project P170769," 2019. Accessed: Dec. 07, 2020. [Online]. Available: http://documents1.worldbank.org/curated/en/235831562864951356/text/Concept-Project-Information-Document-PID-Lebanon-Electricity-Transmission-Project-P170769.txt.

[75] D. Abi Ghanem, "Energy, the city and everyday life: Living with power outages in post-war Lebanon," Energy Res. Soc. Sci., vol. 36, pp. 36–43, Feb. 2018, doi: 10.1016/j.erss.2017.11.012.

[76] E. Bellini, "Lebanon's Tufail region may host planned 500 MW solar plant," PV

magazine International, 2019. https://www.pv-magazine.com/2019/05/23/lebanons-tufail-region-may-host-planned-500-mw-solar-plant/?utm_source=dlvr.it&utm_medium=twitter (accessed Dec. 07, 2020).

[77] World Bank, “World Development Report 2010 : Development and Climate Change,” Washington, DC., 2010. [Online]. Available: https://openknowledge.worldbank.org/handle/10986/4387 License: CC BY 3.0 IGO.”.

[78] “Global Solar Atlas,” Energydata.info, 2020. https://globalsolaratlas.info/map?c=32.793431,33.427733,5 (accessed Dec. 09, 2020).

[79] UNDP-DREG, “The 2017 solar PV status report for Lebanon,” 2018. [Online]. Available: http://www.lb.undp.org/content/dam/lebanon/docs/Energy and Environment/2017 Solar PV Status Report for Lebanon.pdf.

[80] Lazard, “Lazard’s Levelized Cost of storage analysis – Version 4.0,” 2018. Accessed: Dec. 09, 2020. [Online]. Available: https://www.lazard.com/media/450774/lazards-levelized-cost-of-storage-version-40-vfinal.pdf.

[81] “Net Present Value (NPV),” 2018. https://www.investopedia.com/terms/n/npv.asp (accessed Dec. 09, 2020).

[82] LCEC, “National Energy Efficiency and Renewable Energy Action (NEEREA).” http://lcec.org.lb/en/NEEREA/AboutUs (accessed Dec. 09, 2020).

[83] UN ESCWA, “Economic and Social Commission for Western Asia United Nations Development Account project on promoting renewable energy investments for climate change mitigation and sustainable development. Case study on policy reforms to promote renewable energy in Leba,” ESCWA, May 2018. Accessed: Dec. 10, 2020. [Online]. Available: www.unescwa.org.

[84] Institute for Global Prosperity, “Transitions to renewable energy and sustainable prosperity in Lebanon: Why democratic infrastructure supports innovative energy projects,” 2019. Accessed: Dec. 10, 2020. [Online]. Available:

https://static1.squarespace.com/static/5d89ee82afad6b391d45c37d/t/5e4e7777223f3d2c8b470561/1582200700456/Renewable+Energy_Working+Paper.pdf.

[85] A. Dziadosz, "Can green energy beat Lebanon's 'generator mafias?,'" 2018. https://www.bloomberg.com/news/features/2018-02-26/can-green-energy-beat-lebanon-s-generator-mafias (accessed Dec. 10, 2020).

[86] Burlakova I., Kovalov B., Šauer P., Dvořák A. Transformation Mechanisms of Transition to the Model of "Green" Economy in Ukraine. Journal of Environmental Management and Tourism. 2017. Vol. 8, No. 5, Issue Number 5(21). P. 1029–1040. URL: https://journals.aserspublishing.eu/jemt/article/view/1605.

[87] Hrynevych, O. V., & Goncharenko, O. S. (2018). The study of the solidarization of the wage system. The experience of the European Union. Ciencia, Técnica y Mainstreaming Social, (2), 1–6.

[88] Hrynevych, O. V., & Goncharenko, O. S. (2018). El estudio de la solidarización del sistema salarial. La experiencia de la Unión Europea. Ciencia, Técnica y Mainstreaming Social, (2), 1–6.

[89] Hrynevych, O., & Goncharenko, O. (2017). GREEN SOLIDARITY ECONOMY. XII МЕЖДУНАРОДНАЯ НАУЧНО-ПРАКТИЧЕСКАЯ КОНФЕРЕНЦИЯ" НАУЧНЫЙ ДИСПУТ: ВОПРОСЫ ЭКОНОМИКИ И ФИНАНСОВ", 45–47.

[90] Kovalov B., Burlakova I., Voronenko V. Evaluation of Tourism Competitiveness of Ukraine's Regions. Journal of Environmental Management and Tourism. 2017. Vol. 8, Issue Number 2(18), P. 460-466.URL: https://journals.aserspublishing.eu/jemt/article/view/1204.

[91] Kovalov B. L., Fedyna S. M., Pavlyk A. V. Biosocial economy as a mechanism for the sustainable development implementation. Economic and social development of Ukraine in XXI century: national vision and globalization challenges: Collection of scientific articles. 2017. Dradt2Digital Publishing House. P. 140-142.

[92] Kubatko, O. V., Chortok, Y. V., Honcharenko, O. S., Nechyporenko, R. M., & Moskalenko, I. M. (2019). Studying Features of Vehicle Type Selection by Trade

and Logistics Enterprise.

[93] Leonid Melnyk, Hanna Sommer, Oleksandra Kubatko, Marcin Rabe and Svitlana Fedyna (2020). The economic and social drivers of renewable energy development in OECD countries. Problems and Perspectives in Management,18(4), 37-48. doi:10.21511/ppm.18(4).2020.04

[94] Makarenko, I. O., Vasylieva, T. A., Lieonov, S. V., Plastun, O. L., Smolennikov, D. O., Chortok, Y. V., … Yevdokymov, A. V. (2019). Corporate social and environmental responsibility of business and national economy competitiveness: in search of interaction.

[95] Matsenko, O. &Ovcharenko, D. (2013). The quality of energy resources controlling as a part of effective enterprise management. Economic Annals-XXI, 9–10(1), 75–78. [in Russian]URL: https://essuir.sumdu.edu.ua/handle/123456789/74620.

[96] Matsenko, O.& Gramma, O. (2017). Justification of integrated environmental and economic assessment of the impact actions in the field of oil and gas extraction. Environmental Economics, 8(4), 25–30.DOI: https://doi.org/10.21511/ee.08(4).2017.03. URL: http://essuir.sumdu.edu.ua/handle/123456789/74794

[97] Melnyk, L., Dehtyarova, I., Kubatko, O., Karintseva, O., & Derykolenko, A. (2019). Disruptive technologies for the transition of digital economies towards sustainability. Economic Annals-XXI, 179(9-10), 22-30. doi: https://doi.org/10.21003/ea.V179-02

[98] Melnyk L.G., Kubatko O. The impact of green-innovations on environmental quality and energy resource consumption. International economic relations and sustainable development : monograph / edited by Dr. of Economics, Prof. O. Prokopenko, Ph.D in Economics T. Kurbatova. – RudaŚląska :Drukarnia i Studio GraficzneOmnidium, 2017. – 272 p. ISBN 978-83-61429-11-1

[99] Melnyk, L., Derykolenko, O., Matsenko, O., Pasyevin, O.& Khymchenko, Y.(2019). Organizational and Economic Potential of Joint Engagement of Venture Capital and Business Process Reengineering in the Marketing Activities of

Industrial Enterprises. Mechanism of Economic Regulation, 2, 17–29. DOI: https://doi.org/10.21272/mer.2018.83.06.
URL:http://essuir.sumdu.edu.ua/handle/123456789/74898

[100] Melnyk, L., Derykolenko, O., Kubatko, O. & Matsenko, O. (2019, June). Business Models of Reproduction Cycles for Digital Economy. Proceedings of the 15th International Conference on ICT in Education, Research and Industrial Applications. Integration, Harmonization and Knowledge Transfer. Volume II. Kherson : CEUR-WS. URL: https://essuir.sumdu.edu.ua/handle/123456789/74617

[101] Melnyk, L., Matsenko, O., Dehtyarova, I. & Derykolenko, O. (2019). The formation of the digital society: social and humanitarian aspects. Digital economy and digital society. T. Nestorenko& M. Wierzbik-Strońska (Ed.). Katowice: Katowice School of Technology. [in Ukrainian].URL: http://essuir.sumdu.edu.ua/handle/123456789/74570

[102] Sabadash V. and Denysenko P. Economic and social dimensions of ecological conflicts: root causes, risks, prevention and mitigation measures. Int. J. of Environmental Technology and Management. 2018. Vol. 21, Nos. 5/6. P. 273–288. DOI: 10.1504/IJETM.2018.100579

[103] Sotnyk I.M. Energy efficiency of Ukrainian economy: problems and prospects of achievement with the help of ESCOs. Actual Problems of Economy. 2016. № 1. P. 192-199.

[104] Shkarupa O.V. Socio-economic transformations of standarts as a factor to enironmental modernization on the regional level // Економіка і регіон. Науковий вісник Полтавського національного технічного університету ім. Юрія Кондратюка. 2016. № 5. С. 25-30.

[105] Smolennikov D., Kovalyov B., Kubatko V. International dimension of national economic sustainable development. The Economics of the XXI Century: Current State and Development Prospects : monograph. London : Sciemcee Publishing, 2018. P. 329–344. URL: https://drive.google.com/open?id=17KWInGivlMfn-1ZtNvBaiscu1hF8qV4S

[106] Studying Features of Vehicle Type Selection by Trade and Logistics Enterprise

[Текст] / O.V. Kubatko, Yu.V. Chortok, O.S. Goncharenko [et al.] // Механізм регулювання економіки. - 2019. - №3. - С. 73-82. - Bibliogr.: DOI: 10.21272/mer.2019.85.07.

[107] Viktor V. Sabadash, Peter J. Stauvermann & Ruslana O. Peleshchenko. Competitiveness of Ukrainian Companies in Foreign Markets: New Challenges and Opportunities. Механізм регулювання економіки. 2017. № 1. С. 60–70.

[108] Voronenko V., Kovalov B., Horobchenko D., Hrycenko P. The effects of the management of natural energy resources in the European Union. Journal of Environmental Management and Tourism. 2017. Vol. 8, Issue Number 7(23), P. 1410-1419. URL: https://journals.aserspublishing.eu/jemt/article/view/1777.