DECENTRALISED RENEWABLE ENERGY:
A PATHWAY TO PROSPERITY FOR LEBANON?

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ABSTRACT

This chapter reviews the current state of play on energy and prosperity in Lebanon. The focus is on opportunities for decentralised renewable energy (RE) to not only address Lebanon's insufficient energy supply but to incite whole systems change in Lebanon to address the compounding challenges of mass displacement, changing climate and economic crises. In recent years Lebanon has made great progress in RE despite the ongoing regional turbulence but more could be done to utilise the country's abundance of renewable resources, growing population and entrepreneurial acumen. Using empirical findings from communities living and working in two neighbourhoods in Lebanon, Hamra and El Mina, we argue that energy policy from a prosperity perspective must be informed by the role public services play in people's self-defined aspirations of what it means to live a good life. With the policy support from above, locally managed and decentralised RE supply has potential to not only address the energy crisis and mitigate the impacts of climate change, but also setting Lebanon on a path to a sustainable and prosperous future.

CONTENTS

1. INTRODUCTION

For the most part there is agreement on the need to transition to sustainable economies but little agreement on what the transition and the corresponding policies could look like. By looking at energy policy beyond just the macroeconomic questions and contribution to infrastructure development, we look at the benefit of transformations of energy systems in terms of people's quality of life and the role public services play in building capacities and capabilities. This is important for countries that have sustained systemic shocks, such as war and mass displacement, and are also experiencing the threat of the climate emergency. When devising policies for transformation through complex challenges it is important to keep in mind the need for citizen-based focus on quality of life and balance the short-term emergencies with the long-term prospects of a human-induced changing climate (IPCC, 2021). This chapter looks at what is happening in Lebanon and why community-led renewable energy (RE) projects can address carbon emissions and future prosperity.

Traditionally, literature on Lebanon's energy policy has focused on classical economic analysis, but there is a shift in global understanding, away from traditional economic models which emphasise economic growth to prosperity (Jackson, 2011; Moore, 2015; Stiglitz, Sen & Fitoussi, 2010). Prosperity encapsulates what we value and how we can all flourish within the confines of our planet's resources. The strength and challenge of global prosperity is in its foundation; that there are diverse ways to flourish and no single model of development. We need to engage with diversity to create inclusive sustainable change, tying social value to economic value (Moore, 2015). In the context of Lebanon, a prosperity lens is crucial to create energy policy that can address the needs of a population that has dramatically increased due to mass-displacement (Yassin, 2018), and is facing the current and predicted impacts of climate change (Ministry of Environment, 2011; Ministry of Foreign Affairs of the Netherlands, 2018; ANND, 2017) while experiencing social, infrastructural and economic challenges due to Covid-19, the Beirut port explosion in August 2020, rising political unrest and financial crisis since 2019. These multiple intersecting crises have affected peoples' quality of life; diminishing job opportunities, and diminishing facilities of public services in education, health, clean water and energy.

To bring the energy policy landscape up to date in Lebanon we explore the current policy frameworks, the drivers that are shaping it and the RE projects that have already been implemented. Prosperity for Lebanon is dependent on a RE transition, inextricably linked to public services (Ahmad et al., 2020; Moore & Collins, 2019). This complex inter-dependency means that a reliable energy supply would improve the wellbeing, employability, safety, health and education for residents of Lebanon. Energy policy in Lebanon should focus on decentralisation, informed by Lebanon's citizens who are already engaging in RE alternatives to the energy crisis.

2. CHALLENGES FOR ENERGY POLICY IN LEBANON

The impact of climate change covers the entire economy of Lebanon and all aspects of the environment which is vulnerable to the rising sea levels and heat waves (Ministry of Foreign Affairs of the Netherlands, 2018). The Lebanese population has been subject to severe water shortages for decades, in July 2021 more than four million people were at risk of losing access to safe drinking water as the country's main power plants ran out of fuel (UNICEF, 2021). Water shortages and heat waves add additional strains to a struggling energy system. Projections for temperature rises of between 1°C to 3°C by 2040 are estimated to lead to an annual increase in electricity consumption for cooling between 9.04% and 28.55% (Ministry of Environment, 2011).

There is a mixed response in Lebanon, and around the world, to the changing landscape of energy investment and the IPCC (2018; 2021) deadlines on climate change. Lebanon is searching for oil and gas reserves but has set a target of 30% of renewable energies by 2030 after pledging to reach 12% of its primary energy sources by 2020, a target that was missed due to the consecutive political and financial crises in the country. The energy sector, including transport, is responsible for 79% of the country's total GHG emissions. Power generation is the main contributor to the energy sector's GHG emissions because 88% of imported fuel and 53% of diesel and gas are used for thermal power generation (Shehabi et al., 2021).

Electricité du Liban (EDL) holds the monopoly of energy supply in Lebanon. It is a vertically integrated national utility accountable to the Ministry of Energy and Water (MoEW) which is responsible for policy formulation for electricity, fuel and water sectors. Overall responsibility rests with the Council of Ministers (CoM) chaired by the Prime Minister and includes ministries that represent the major political parties in the country (World Bank, 2019). EDL is a highly politicised entity, with government appointment boards chosen through opaque processes based on sectarian quotas.

The electricity sector is a huge financial burden on Lebanon's public finances. In 2020 the Energy Minister said that losses from the electricity sector cost about USD1.6 billion in public funds each year, while other reports state up to USD2 billion – three per cent of the country's entire economy (Chehayeb, 2021). The government estimated that more than one fourth of Lebanon's debt – currently more than ninety billion dollars – results from EDL's deficit (Jones, 2021; McDowall, 2019). EDL's tariffs are based on 1994 fuel cost of USD23 per barrel of oil and only cover 37% of average operating cost in 2018. Despite these large subsidies, electricity supply is insufficient to meet demand. Inadequate energy infrastructure and supply has resulted in endemic power outages. The power gap is estimated at about 1GW equalling daily cuts of three hours in Beirut and up to 17 hours in the Bekaa Valley (World Bank, 2019). And this was prior to Covid-19 and the economic crash. In the year since the Beirut port explosion Lebanese currency fell fifteenfold in value. Hyperinflation meant staple food was out of reach for many, essential medicines were out of stock and there was even less fuel to supply the overburdened energy infrastructure. Over half of the Lebanese population is now living in poverty and extreme poverty has risen threefold since 2019 meaning many people cannot afford basic services (UN, 2021). Lebanese residents in 2021 witnessed an increase in severe electricity shortages and corresponding blackouts, extenuated by the reduction in foreign currency reserves necessary for

fuel imports, and the contract of Sonatrach, the largest heavy fuel supplier for EDL, which expired at the end of 2020. Power rationing increases dependency on expensive private diesel generators, but the latter's fuel is also dependent on imports and the availability of foreign currencies (Shehabi et al., 2021). Today, in the context of the overall deterioration mentioned above, public electricity cuts can last as long as 21 hours per day.

The unreliability of the energy services has become inherent in everyday life in Lebanon. Informal connections to private diesel generators have been normalised to maintain the necessary electricity to reach basic requirements for households and businesses (Abi Ghanem, 2018). The percentage of 'illegal' connections to the grid result in a financial burden on the national economy exceeding USD330 million per year (AEMS, 2017). In 2017, 66% of Lebanon's households relied on diesel generators to back-up power supply, with over 46% of households paying 8.4% of their income to secure electricity (UNDP-CEDRO, 2018a). Residents pay a double electricity bill; one for EDL and the other for back-up generation, almost twice that of EDL, which results in the highest electricity bills in the region (Fardoun et al., 2012). Neighbourhoods are allocated one private energy provider, with the backing of politicians, who do not face competition and can set their own fees (Mohsen, 2012). They are further legitimised through local tariffs aimed at them. New housing blocks are built with space for generators so new tenants have little choice but to accept this informal arrangement (Verdeil, 2016; Abi Ghanem, 2018). This contractual and physical entanglement of private generators in daily life reflects the adaptability of the population creating their own access to this intrinsic service.

Figure 1. Private generators in Hamra, Beirut and El Mina, Tripoli.

Source: Mohamad Mkayes, Hamra Citizen Scientist; and Sima El Sheikh, Researcher at RELIEF and Catalytic Action

Since the civil war Lebanon has relied heavily on energy imports. The dependence on oil imports not only contaminates the environment it also increases the vulnerability of the Lebanese economy to fluctuating oil prices (UN ESCWA, 2018). There is global consensus (UN Sustainable Development Goal 9; UNDP, 2019b) that energy is crucial not only as a basic requirement to live a good life, but across all economic activities, as drivers of new industries and innovation and for information and communication technologies.

Compounding this is the fact that twenty-five percent of people living in Lebanon are displaced people from the Syrian civil war, the highest percentage refugee population of any country in the world. This does not include the 449 957 registered Palestinian refugees[1] (UNRWA, 2014). While the inadequate energy supply predates the Syrian civil war significantly[2] the influx of people not only strains the system even more, but it also means that like the Lebanese, displaced people in Lebanon in both formal and informal settings are not obtaining the required electricity to get-by. New and existing models of RE delivery in Lebanon must recognise the challenge of climate change and people's energy needs across varied contexts, considering socio-economic conditions and self-defined aspirations for prosperity.

2.1 RE TECHNOLOGY AND POLICY IN LEBANON

The landscape of energy policy in Lebanon is complex, incorporating different actors and drivers. The rise of RE technology can be directly linked to certain policies and projects highlighting the crucial role of government and policy makers in supporting a RE transition.

The Lebanese Centre for Energy Conservation (LCEC) was initiated as a joint project between the MoEW and the UNDP in 2002. Their main objective was to create a national energy agency to push for energy efficiency and they are now the national energy agency for Lebanon affiliated to the MoEW but with a financially and administratively independent statute (LCEC, 2018). The first milestone for the development of RE in Lebanon came in 2010 when the MoEW committed to the Policy Paper for the Electricity Sector (PPES) to launch, support and reinforce public, private and individual initiatives to adopt RE, and to reach 12% of electric and thermal supply from RE by 2020, which they failed to reach. In 2018 the Government of Lebanon (GoL) further pledged a switch to natural gas and RE in their Capital Investment Plan (CIP; GoL, 2018) and extended the target to 30% of electricity and heat consumption through renewables by 2030 (IRENA, 2019) which would save USD250 million per year for the power sector through avoided fossil fuel imports (IRENA, 2020). Following on from the country's National Energy Efficiency Plan (NEEAP 2011-2016) Lebanon was one of the first countries to develop its own National Renewable Energy Action Plans (NREAP) 2016-2020. The NREAP 2016-2020 clarifies the individual targets for different RE technologies needed to reach the 12% target by 2020 (LCEC, 2016; Table 1.). Implementation of the NREAP 2016-2020 needed between USD1320 million and USD3166 million while the direct cumulative savings for the economy were estimated at USD319 million (UN ESCWA, 2018). The NREAP projects implemented by 2020 aimed to provide an extra 1890 hours of

[1] Most Palestinian refugees in Lebanon live across 12 camps where they have no right to work (UNRWA, 2014). They are left out of RE initiatives as it is government policy that no permanent infrastructure should be installed in informal settlements.

[2] The grid has yet to be restored since it was severely damaged during the Lebanese civil war (1975-1990) and some claim the electricity sector has always struggled to provide 24-hour electricity to Lebanon's inhabitants (Abu-Rish, 2015).

electricity with the first to benefit those people in Lebanon who are least able to afford the financial burden of the high electricity bills. Environmentally, full implementation of the NREAP would have reduced Lebanon's yearly carbon dioxide emissions by 11.25% (UN ESCWA, 2018). By 2020 total installed RE power capacity amounted to 350MW, including 286MW from hydropower, 7MW from landfill and 56.37MW from solar (IRENA, 2020). Additional measures are required to scale up RE to the level of 30% by 2030. The NREAP 2021-2025, with updated targets has not been developed (LCEC, 2021).

The National Energy Efficiency and Renewable Energy Action (NEEREA) is a national financing mechanism initiated in 2010 by Lebanese Central Bank (BDL) with support from the European Union and technical assistance from LCEC. It provides incentives for RE projects through interest free and long-term loans (LCEC, 2019a). The NEEREA supports the financing of new and existing energy efficient, RE and sustainable building projects. It allows private sector entities to apply for subsidised loans for environmentally friendly projects. By the end of 2017 690 loans had been approved through the NEEREA totalling USD405 million. However, financing for largescale RE projects are constrained as the NEEREA only finances RE projects for individual consumption, not for independent power production (IPP; UN ESCWA, 2018).

2.1.1 RE SOURCES IN LEBANON

RE contribution to total power production in Lebanon is estimated at between 4% and 6% mainly via hydropower. The only forms of energy produced within in Lebanon come from solar water heaters and hydroelectric plants (UN ESCWA, 2018). In 1976 approximately 70% of the total electricity production came from hydroelectricity (LCEC, 2016). The development of hydropower plants depends on the construction of dams, a controversial solution, as they threaten Lebanon's biodiversity (Kranz, 2019). The water network is so damaged that approximately 48% of the water gets lost before reaching the end user making constructing more dams without repairing the system wasteful (El Solh, 2016). Despite this, dams continue to be planned and built.

Wind power has reached grid parity as a viable and cost-competitive choice for electric power generation and was to contribute 2.06% to the 12% target. The National Wind Atlas of Lebanon estimated a wind potential of at least 1500 MW (UNDP, 2011 in Khoury et al., 2016). Technical expertise as well as large investments are needed to implement large-scale wind farms and require significant government support. Smaller-scale wind farms or single turbines would help overcome land constraints, engage citizens and increase acceptance of the technology (UNDP-CEDRO, 2019).

Biomass, with a focus on waste-energy, is a biological material derived from living things which can be used directly via combustion to produce heat, or indirectly after converting it to biofuel (El-Jamal, Ibrahim and Ghandour, 2014). Biomass is the fourth largest energy source in Lebanon and is important as it can produce different forms of energy and resources are common around the world (LCEC, 2016). It offers synergies with other sectors such as waste management, water treatment and forestry (UNDP-CEDRO, 2019). Lebanon has a relative abundance of bioenergy resource as one-third of the country's land is arable. Utilising local resources and biofuels is an important component of a RE transition for Lebanon that the government is failing to recognise.

The solar photovoltaic (PV) sector is now established with over 100 competitive companies in Lebanon with potential for further growth. Solar PV energy production is in abundant supply in Lebanon with around 300 days of sunshine per year, for eight to nine hours each day (Berjawi et al., 2017). Given that most electricity rationing in Lebanon occurs during the day solar energy offers a sustainable alternative to cuts and diesel generators. Solar PV plants can be

complemented with wind power given that when the sun is not shining the wind is blowing.

Solar water heaters (SWHs) are the most developed RE technology in Lebanon gaining momentum since the 2010 to achieve *"a solar water heater for every household,"* (Bassil, 2010). The NEEAP 2011-2015 laid out a financing scheme for the SWH market (LCEC, 2016). Private banks, initiated through BDL, offer five-year, interest free loans for residential SWHs (that do not exceed $5000) and the MoEW contributes $200 to cover capital costs. SWH projects that exceed $5000 can apply for the NEEREA loan. These loan schemes created momentum in the Lebanese SWH market which has more than doubled since 2010 (LCEC, 2019b). Thirty-eight percent of the SWH systems installed in Lebanon were partially or totally manufactured in Lebanon (UNDP-GEF, 2014) showing potential for further market development in other RE systems.

In 2011 EDL adopted a net-metering policy supporting the expansion of solar energy in Lebanon to households. It was expanded to communities in 2016. Net-metering allows for a two-directional flow of energy, from the grid to the customer and from the customer's RE facility to the grid using a bi-directional meter (Berjawi et al., 2017). EDL does not pay for the net production produced by consumers but credits the excess production to the next bill. More than 50 projects are connected to the net-metering network but due to the lack of meters at EDL net amounts must be calculated manually limiting the effectiveness of the policy (UN ESCWA, 2018).

From 2010 to 2017 solar PV capacity rose from around 0.35MWp to over 35MWp, averaging an annual equivalent growth of 100% (UNDP-DREG, 2018). Solar PV generation increased from 35,000MWh in 2016 to 53,000MWh in 2017 constituting 0.35% of the annual electricity generation by EDL (UNDP-DREG, 2018). The Beirut River Solar Snake (BRSS) came as part of the NEEAP 2016-2020 plan to install 200MW of solar farms by 2020. It is the first solar PV farm at a national level with a total planned output of 10MW. The private sector designed, built and transferred the RE generation plant with government support. The idea for the BRSS was to take advantage of the 'unused' space above the Beirut River to supply energy and to raise awareness of the potential of solar energy (LCEC, 2020). Only the first stage of the project has been completed adding an extra 1MW of electricity to the grid (Machnouk, El Housseini, Kateb & Stephan, 2019).

Solar PV alone could cover at least the daily power peak load, far outreaching the LCEC 2020 target, improving energy security, energy billing and reducing the impact of fossil fuels for electricity generation (Berjawi et al., 2017).

Steps have been taken to develop Lebanon's energy sector towards renewable sources. There is recognition within different sections of government (through the 30% target goal; NREAP 2016-2020; the NEEREA loan scheme; and the CIP), from the public (through the uptake of SWHs) and the private sector (through private bank loans for SWHs, the financing of wind farms in Akkar and the BRSS) that RE is the way forward. While there is some coordination between the big players of RE in Lebanon, it is apparent that a lack of legal framework is inhibiting the sector from flourishing and limiting it to small-scale projects. A sector reform policy paper is not enough, and extreme measures need to be taken to find different ways to provide electricity. A long-term solution to the energy crisis will need to come with wider economic and political restructuring, likely against the interests of the majority of Lebanon's ruling elite. We need to look beyond just recalibrating the Lebanese energy system in the form of institutional reforms which are slow to implement. Decentralised, local production of energy can provide the population with a high standard of reliable, affordable and renewable energy.

2.2 CONSTRAINTS AND OPPORTUNITIES FOR A RE TRANSITION IN LEBANON

On top of Covid-19, the financial crash and being without a government for nearly a year, the main barrier to full deployment of RE technologies is the lack of components and clarity within the existing and outdated institutional and legal frameworks. Regulations are based on industrial traditions and codes, not up to date with sector developments. Delays to implementation of legal framework to privatise, liberalise and unbundle the sector have meant that only one wind power programme signed a PPA, under a law that has since expired (UN ESCWA, 2018). This means that decrees that give EDL the monopoly in generation, transmission and distribution are still being applied. A legal regulator to set prices and liaise between government and private power producers has not been appointed. Currently, the CoMs is tasked with assigning PPAs. It is not clear which legal process the GoL will deploy, and this uncertainty is delaying major investments in utility-scale RE. A critical challenge for Lebanon will be managing governance and transparency in the energy sector (Ahmad, Mahmalat & Saghir, 2021).
Low and not cost-reflective electricity tariffs are a barrier to deployment of RE because of the long amortization period. 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 (UNDP-CEDRO, 2019). EDL will be the main customer for all large-scale RE projects, but their financial deficit and bankability problems increase the risk of investment. There is no dedicated department in EDL for incorporating RE into the national grid and no grid codes exist internationally that could be adopted (UN ESCWA, 2018).

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. Some estimate the private generator industry to be worth USD1 billion (Rose, 2018). 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 (World Bank, 2019). 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 mobilisation against the current energy supply in Lebanon (Abi Ghanem, 2018). Energy policy focussed 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.

The prospect of natural resource discovery has generated a great deal of investment interest and political debate (Fattouh & Mahadeva, 2016). Domestic gas could reduce import dependence and emissions. The gas market is expected to initially be dominated by gas imports that will eventually partly be replaced by indigenous gas. Gas streams will enter the Lebanese market at different geographic locations and on different contractual terms but there is no developed legal or physical infrastructure to manage market ownership and structure. The AUB Policy Institute (2018) suggest that the GoL needs to play a central role in regulating the gas market. There is potential for a hybrid-energy system here that allows for private sector investment in gas and RE technologies, but this needs to be connected to a broader agenda and policy for long-term prosperity in Lebanon.

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 (Ayoub & Boustany, 2019). An examination of the technical and economic feasibility of a 300 MW solar PV plant

in Tfail demonstrates robust technical and financial incentives with Levelized Cost of Electricity ranges between 4.2 to 5.3 cents/kWh of electricity produced. The average annual energy generation over the project's lifetime is around 600 GWh/year. Given the location, such a project could play a role in potential electricity swap deals and trading with the Syrian grid in the future (Ayoub & Boustany, 2019). 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 project (Bellini, 2019).

While energy supply in Lebanon is insufficient to meet the populations basic needs and the current RE contribution to total supply is minute, for a RE transition to be successful people must also be willing to modify their lifestyle through reducing and adapting power consumption[3] (Khoury et al., 2016). For a RE transition to be successful insights into energy options must be made available to consumers so they can make informed decisions for themselves and the environment. There is potential in the Lebanese public's adaptability to changing their energy supply (Abi Ghanem, 2018). The higher the amount people pay for informal generators the more willing they are to pay for RE options, so designing RE programmes that displace diesel generators have a better chance of success and can attract more funding (UNDP-CEDRO, 2015). However, findings from a 2020 Citizen's Assembly on the energy crisis, found resistance from government officials to including ordinary citizens in energy matters, and staunch desire to defend the technical boundaries between experts and citizens (Shehabi et al., 2021: 27). Although this may be reflective of attitudes of Lebanon's ruling class it signals that without any grand political restructuring community-led RE initiatives will struggle to make large inroads in transforming the energy sector in Lebanon.

Unemployment in Lebanon is subject to a wide-range of estimates with an absence of reliable data. Between 2018-2019 less than 50% of the working age population were participating in the labour force (ILO, 2019). Lebanon has identified agriculture, infrastructure and environment as sectors with potential for employability for displaced people, making investment and action in RE infrastructure an employment solution for people in Lebanon. Analysis of the RE technology value chain in Lebanon estimates that 20,000 jobs could result from the deployment of RE technologies, the bulk being in the solar PV sector (UNDP-CEDRO, 2019).

A study by IRENA and UN ESCWA (2018) found strengths for local manufacturing in Lebanon, where industries related to electronics, steel, aluminium and plastics are well developed and can play a role in stimulating the RE industry. Furthermore, university programmes associated with RE research mean that the technical know-how is available and there is good potential for local integration and manufacturing of RE technology in Lebanon (IRENA & UN ESCWA, 2018).

With the absence of reliable and continuous electricity decentralised RE systems are among the easiest to deploy, are cost-effective and sustainable. The costs of RE are less than that of diesel generators and less than the average costs EDL pays for energy distribution and generation (UNDP-CEDRO, 2015). While the economic, social, legal and political hurdles are constraining large-scale RE projects, the opportunities for a RE transition in Lebanon and future prosperity are in decentralised community-led projects.

[3] This is not just a Lebanese problem, changing mindsets in the age of consumption is a significant hurdle towards RE transitions worldwide (Loveday et al., 2008; Von Borgstede, Andersson & Johnsson, 2013; Shi, Wang & Wang, 2019)

2.2.1 A COMPARISON OF ENERGY INFRASTRUCTURE AND USE: HAMRA AND EL MINA

Between 2017-2021 neighbourhood profiling was undertaken in Hamra, Beirut (RELIEF Centre & UN-Habitat, 2020) and El Mina (Pietrostefani et al., 2021) as part of the Institute for Global Prosperity's RELIEF Centre project[4]. Energy infrastructure was investigated through a mixed-method approach of qualitative and quantitative data gathered using systematic questionnaires and geographic information system (GIS)-based mapping[5]. Details of the two projects are beyond the scope of the present chapter, but insights about the Lebanese context and opportunities for RE futures can be drawn comparing energy related findings from the two neighbourhoods. Citizen-led development of a Prosperity Index in Lebanon show that good quality housing and infrastructure as well as affordable and reliable utilities contribute to what Lebanese residents describe as the foundations of a prosperous life (Figure 2).

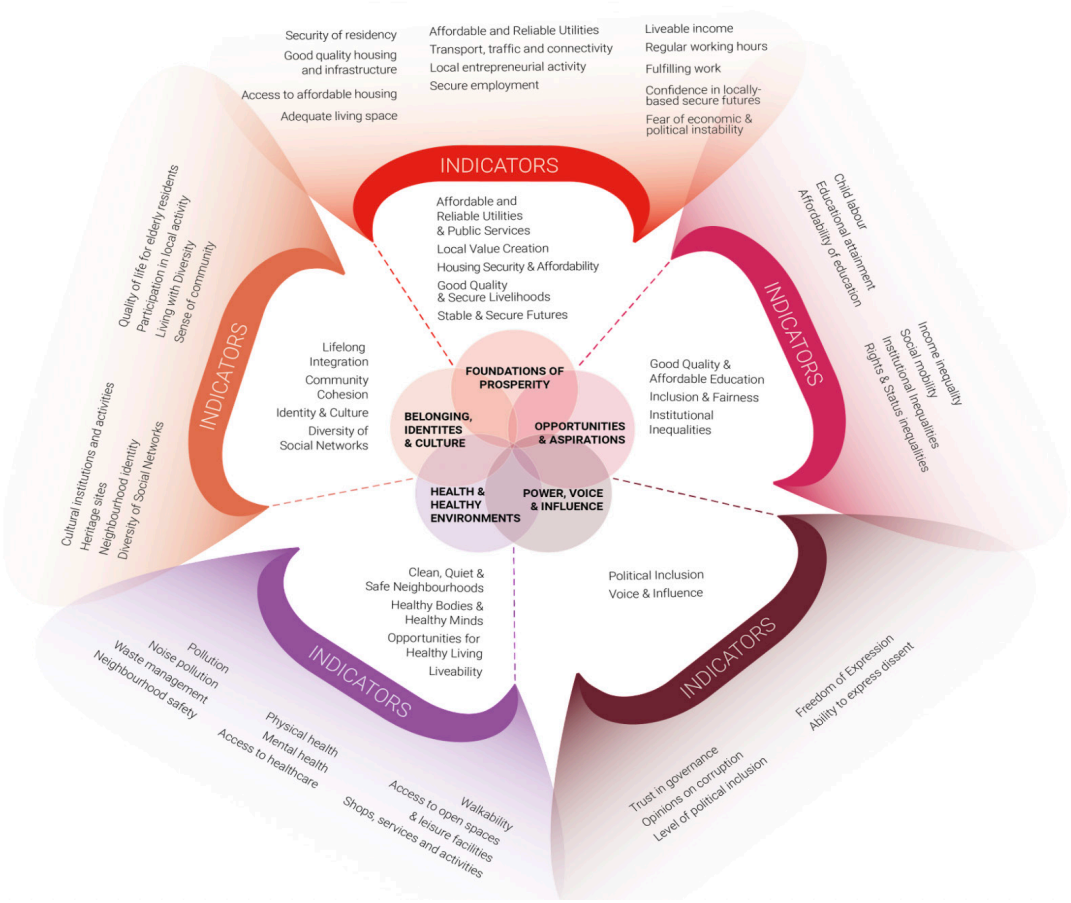

Figure 2. The Prosperity Index highlighting affordable and reliable utilities and public services, such as electricity, as a foundation of prosperity (Source: Moore and Mintchev, 2021).

[4] The RELIEF Centre aims to speed up transitions to sustainable, prosperous societies in the context of mass displacement, to improve the quality of people's lives. The project is about the prosperity of Lebanon in particular, but is also part of a larger agenda for developing sustainable ways to improve the quality of life of people throughout the world (see www.relief-centre.org).

[5] Based on visual inspection that is guided by structured questionnaires and conducted by Local Citizen Scientists (CSs), the building and infrastructure surveys involve assessments of building conditions and basic urban services (water and sanitation, solid waste management, electricity and mobility), and population identification by nationality by building for all sampled buildings. Questions within the field surveys were based on the UN-Habitat–UNICEF Neighbourhood Profile methodology but El Mina Neighbourhood questionnaires were heavily modified or refined by RELIEF – Catalytic Action staff in consultation with citizen scientists to reflect El Mina's buildings and infrastructure and to collect more accurate data.

What the findings from the two neighbourhood studies show are the context specific electricity landscapes contributing to resident's ability to get by, highlighting that locally specific knowledge is necessary to address the unique energy circumstance each place faces. For example, residents in El Mina pay less for energy (44.4% paid between LL1,500-30,000 per month for public electricity in 2020) than Hamra (42.4% paid between LL150,000-300,000 per month for public electricity in 2019) but rely more on generators - 59% of households surveyed in Hamra are connected to private generators (Figure 3) while this is 84% in El Mina (Figure 4). In terms of RE options, El Mina recorded more solar panels (63) than Hamra (30). Unsurprisingly, neighbourhoods with higher income levels in El Mina have installed more rooftop solar panels than neighbourhoods with lower income levels.

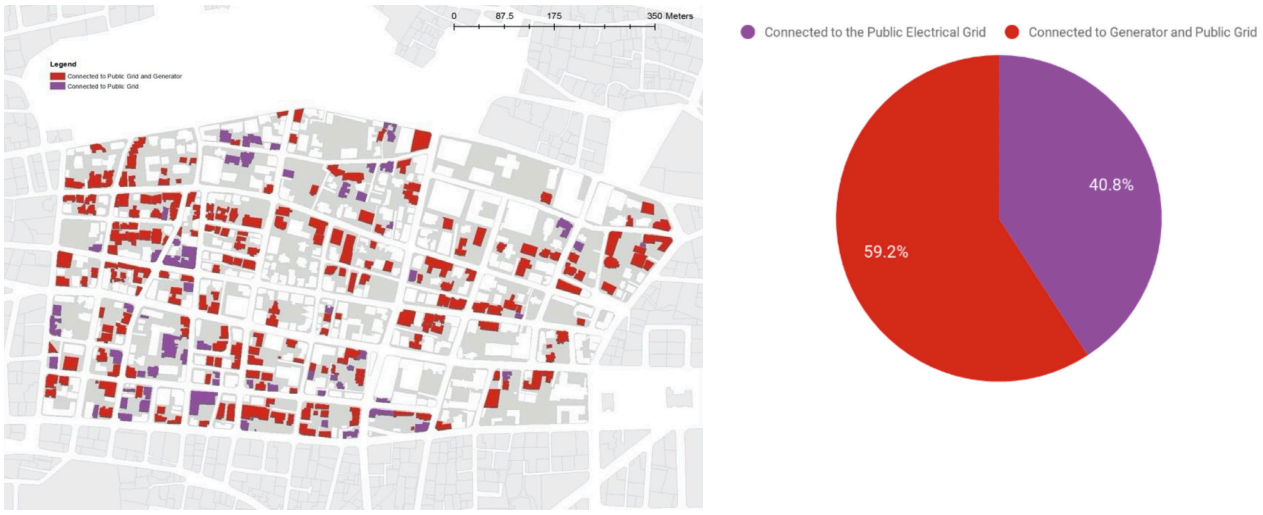

Figure 3. Household survey results from Hamra showing 59.2% of households are connected to private generators (Source: RELIEF Centre & UN-Habitat, 2020)

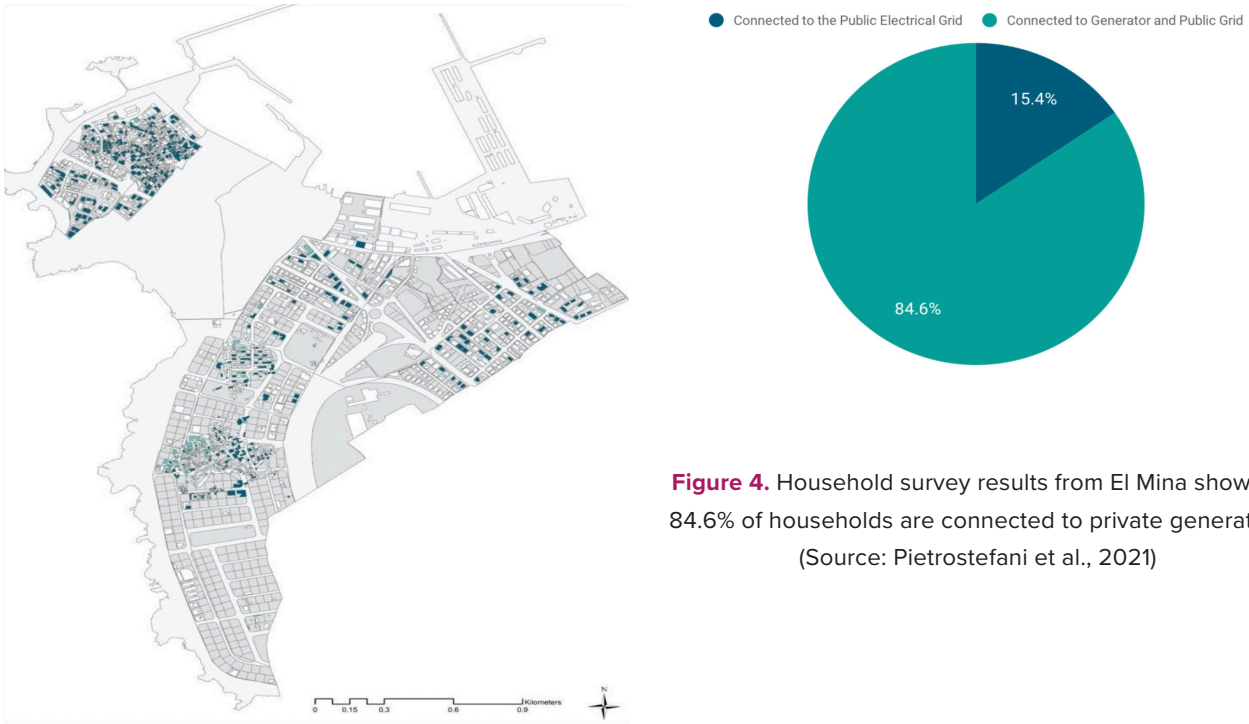

Figure 4. Household survey results from El Mina showing 84.6% of households are connected to private generators (Source: Pietrostefani et al., 2021)

Results showed the interconnection of basic services such as energy, housing and education levels as well as the role ethnicity places in accessing electricity. The older the buildings the worse the electricity supply – the electricity supply is dependent on condition of the buildings. In El Mina 40% of the buildings had major defects in need of repair that were connected to electricity, while this number was 10% in Hamra. The majority of the buildings with major or critical defects of connection date back between 1976 and 2000 in El Mina, and to years prior to the civil war in Hamra. Similarly, buildings with highly precarious and/or potentially life-threatening structural and/or architectural elements, amounting to 57.6% in El Mina and 66.7% in Hamra, need major or emergency intervention for their electric connection. Connectivity to generator increases with income and education level of head of household in both Hamra and Mina (Figure 5 and 6). Lebanese households were nearly twice as likely to be connected to a private generator than Syrian households in Hamra, this increased to three times more likely in El Mina. However, Lebanese households in El Mina pay much more (more than LL150,000) than Syrian households in El Mina (LL 1,500-50,000) and Lebanese households in Hamra (LL 1,500 to LL37,500) (Figure 7).

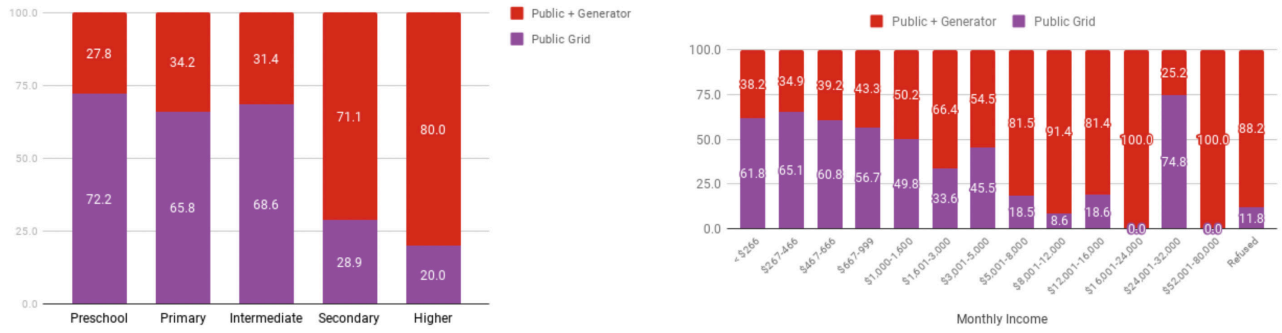

Figure 5. Household survey results from Hamra showing residents' connection to electricity vs. education and income of head of household (Source: RELIEF Centre & UN-Habitat, 2020).

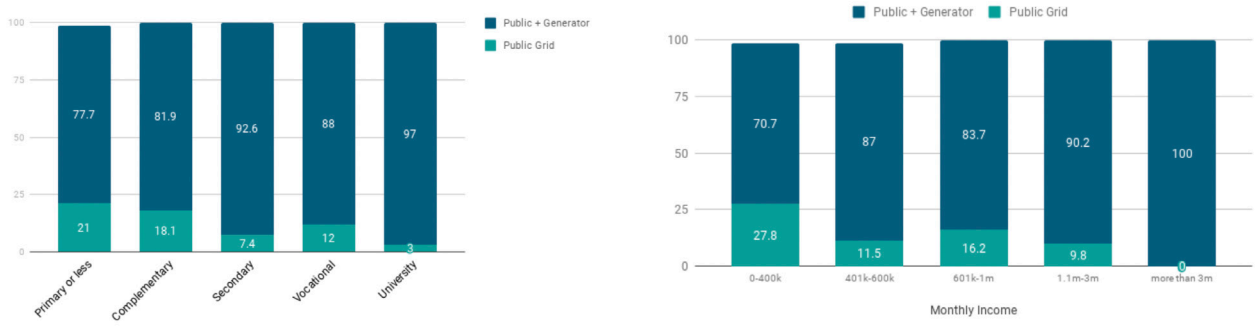

Figure 6. Household survey results from El Mina showing residents' connection to electricity vs. education and income of head of household (Source: Pietrostefani et al. 2021)

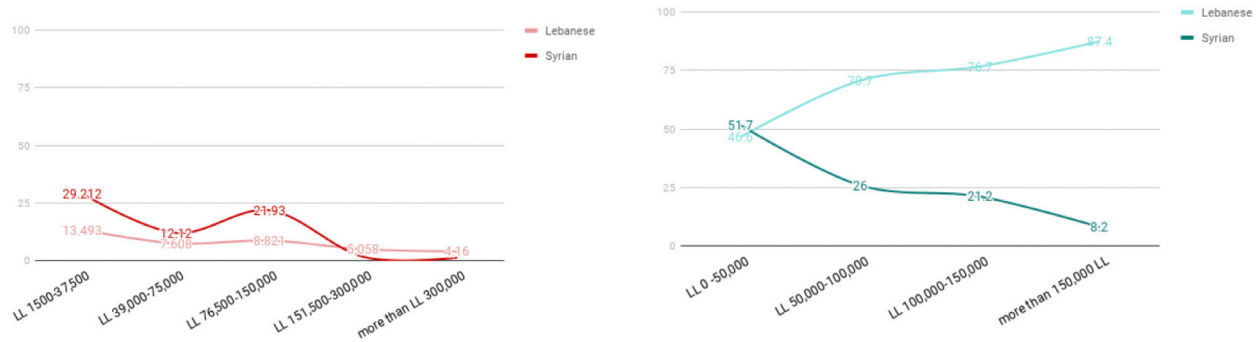

Figure 7. Household survey results from El Mina showing Lebanese and Syrians' expenditure on 5 amperes of private electricity (Source: RELIEF Centre & UN-Habitat, 2020; Pietrostefani et al., 2021)

These results show the interconnected nature of basic services, infrastructure, ethnicity and education, which contribute to residents' ability to get by and provide the foundations of a prosperous life. Investigating prosperity and its relationship to energy supply at the community (or meso) level show very different realities and nuances than aggregate data gathered at larger scales - as these two cases demonstrate. This comparison makes the case for locally led energy solutions, tailor made to each place and driven by the residents whose livelihoods are directly impacted. For example, the biggest barrier to RE energy supply in El Mina may be infrastructure access, whereas in Hamra it could be dependence on private generators. These factors need further interrogation to carve out pathways to prosperity that are locally specific but that also contribute to reducing national GHG emissions and reaching the 2030 goal.

3. RE SUCCESSES IN LEBANON

Future energy systems will need a combination of on- and off-grid hybrid technology, will be decentralised and will come up from the ground. Not only do they create a reliable energy network, but they also have knock-on benefits through new value chains and benefit the education, health and safety of communities.

In partnership with the MoEW, EDL, the Council for Development and Reconstruction and LCEC, the UNDP is managing the energy efficiency and RE demonstration project for the recovery of Lebanon (CEDRO) since 2007. Now entering its 5th phase, CEDRO aims to find cost effective and environmentally beneficial ways to transform the energy system (UNDP-CEDRO, 2021). Since 2007 more than 100 small-scale RE applications have been implemented nationwide including PV, micro-wind, solar PV street lighting, SWHs and ground source heat pump projects to both host and refugee populations.

In 2018 CEDRO completed 'Village 24' Initiative, the first community-led RE system in Lebanon (UNDP-CEDRO, 2018b). 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 utilise the net-metering policy. The electricity expenses have dropped 30% and the village no longer experiences power cuts (EuinLebanon, 2018). 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 (UNDP-CEDRO, 2018b). 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 (UNDP-CEDRO, 2018b).

Historically, Lebanon has been known for its entrepreneurial acumen (Ahmed & Julian, 2012). Data from the Global Entrepreneurship Monitor (2019) for 2018 shows that 21.6% of the 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 (Stel & Naudé, 2016). The reinforcement of family-owned business and entrepreneurs with connections to government (Stel & Naudé, 2016) limits the potential for new RE entrepreneurs by limiting the diversity of ideas and knowledge.

With the next generation coming of age there is a global shift in the social contract. Decisions must be made that acknowledge and account for the planet's finite resources. The millennial generation constitutes approximately 20% of the Lebanese population (Youth Policy, n.d.). Lebanese youth are challenging the status quo (Krastrissianakis, Smaira & Staeheli, 2019). They have already played an essential role in the growth in Lebanese civil society (AbiYaghi, et al., 2017) and are set to become power players in the region in the next 15 years. The millennial generation have grown up with power cuts as a daily presence and are finding creative ways to solve the energy crisis utilising the potential for RE technology. Lebanese based social enterprises which offer RE solutions are contributing to the growth in the solar energy industry. For example, millennial run OTB

Consult partnered with Greenpeace to equip young Lebanese and refugees living in Lebanon with the skills to enter the solar energy market (Greenpeace, n.d.). Lebanon's entrepreneurs have the capability to contribute to RE provision, supporting the rebuild of communities, the country and the next transformation phase that will be fuelled by the rise of robotics and artificial intelligence.

4. POLICY RECOMMENDATIONS AND CONCLUSION

The 2021 rendition of the IPCC's report on changing climate paints a dire picture for the whole planet's future in the coming decades. In the Lebanese context of financial crises, rising poverty, collapsed infrastructure and a failed, corrupt government, action on climate change can feel futile. The opportunity to solve the energy crisis in Lebanon while acting on reducing GHG emissions and human impact on the climate, however, are part-in-parcel, and cannot be delayed. The current energy situation in Lebanon is not only a heavy burden macroeconomically but 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 (Ahmad, 2020). The GoL should adopt and enforce more aggressive targets for RE to contribute to the 1.5C IPCC target. The current targets outlined in the NREAP are unambitious and do not reflect the successes and growth of the RE sector potential (UNDP-CEDRO, 2019). 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 (UN ESCWA, 2018). Institutional and legal reforms need to be implemented to encourage private sector investment in RE infrastructure.

Until this urgent action is implemented at the governing level decentralised 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 decentralised approaches (Institute for Global Prosperity, 2019). 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 (Dziadosz, 2018).

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 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.

Decentralisation 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. There needs to be policy recognition and research into the entanglement of energy provision shaping people's lives. Electricity provision drives people's quality of life and impacts everything from agriculture to transport, deeply imbedded in people's ability to build a secure livelihood. Therefore, tackling the energy crisis requires a whole-systems approach. One that recognises electricity as the driver of the emergence of prosperity as an assemblage (Moore and Mintchev, 2021) bringing new energetics in a place-based system driving positive change.

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