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ABSTRACT
Policymakers see decentralized electricity supply as a way to both decarbonize energy systems and to fill the gap of electricity access in many countries where strong growth leave the grid lagging behind. This article sheds some light on the case of countries such as Lebanon, where diesel-fueled decentralized electricity systems have existed for years and increasingly coexist with, rather than being replaced by, solar powered systems. It is based on a synthesis of public quantitative data and qualitative information gathered through surveys. The article argues that understanding such dynamics involves an analysis, not only of the technological and socioeconomic determinants of the adoption of decentralized energy technologies but also of the political struggles between the various actors, with a particular focus on corporate actors, and wealthy users. In addition, the article shows how different political temporalities play in reproducing or opening the assemblage of technologies and interests that shape the hybridized energy landscape. The article also shows that hybridization has repercussions on the energy configuration as a whole, both in the evolving market share of each technology but also by deeply fragmenting the access to electricity along social and territorial lines and by pushing essential private actors to disconnect from the grid. As a conclusion, the promises of sustainable transitions need to be critically examined in light of these trends.

Introduction

Energy decentralization increasingly features in many policy and scholarly accounts as a way to ease energy transition away from fossil fuels and, in some cases from the centralized grid itself (Lopez, 2019; Thombs, 2019). In developing economies where electrification is lagging behind, particularly in rural and remote areas, policymakers promote decentralized energy generation and distribution as a way to improve access to electricity in the absence of the grid (REN21, 2021; UNCTAD, 2017). These initiatives share an understanding of decentralized energy, seen mostly as harnessing renewable sources, with a strong emphasis on solar photovoltaics. This set of technologies is developing through public policies that organize coordination between public authorities, utilities, and private actors incentivized through norms, subsidies, and market instruments.

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However, the processes and the factors of energy decentralization remain understudied. In practice, many of the decentralized systems include fossil fuel-based gensets (Berthelemy and Béguerie, 2016; Jaglin, 2019). Both international organizations and social sciences energy studies have relatively overlooked cases where decentralized electricity generation and distribution have existed for years, as a from-below and unplanned response to chronic power cuts and electricity crisis, massively using diesel gensets such as in Nigeria, Iraq, Pakistan, Lebanon, etc. (Anwar, 2015; Dalberg/Access to Energy Institute, 2019; Istepanian, 2014). Often illegal and at the very least not monitored nor regulated by public authorities, these systems evolved over time into pervasive and entrenched socio-technical systems in (mostly) urban settlements (Abi Ghanem, 2017). Therefore, it is misleading to analyze this kind of energy decentralization observed in many Southern countries through the lens of transition. Rather it should be understood as a diversification of energy sources and technology, which then raises the question of their coexistence. The notion of hybridization encapsulates this reality, defined as "the coexistence and/or coproduction of infrastructure systems constituted by interrelating heterogeneous elements," which are characterized by the fact that they "generally overlap and co-exist rather than displace each other" (Coutard and Rutherford, 2016a: 11).

Recent research insisted on the necessity to understand hybridization not only through the heterogeneity of distinct socio-technical systems according to place and social groups, but also on their articulation and interplay at the level of urban configurations (Jaglin and Dubresson, 2021; Rateau and Jaglin, 2020). Beyond a comparative assessment of the technologies through their cost and their appropriation by users, this article shifts the focus on the political interests and the struggles between different groups of users and investors supporting these competing technologies. It argues that the changes in the energy landscape can be understood by unravelling the balance of power between the economic groups, by deciphering their political practices but also by understanding how shifting political and economic contexts create opportunities for emerging interests to destabilize incumbent actors. As a result, this article underscores the highly contested and unruly nature of this process.

The Lebanese case provides an opportunity to conceptualize this articulation of socio-technical and political factors in the hybridization of electricity configurations. In this country, diesel-based decentralized electricity systems have existed for more than 30 years as a backup solution for persisting grid failures. More recently, industrial and commercial firms, as well as wealthy households adopted new energy technologies (renewable energy generation, batteries, multisource systems), adding a new layer of complexity. The article highlights the constantly evolving assemblage of technologies, actors, norms, political and social practices that shape the process of socio-technical change. While identifying three trends of socio-technical decentralization in the electricity sector, it unpacks the diverging and conflicting interests at play and the political economy they shape. It allows us to understand how incumbent actors locked the electricity system in a suboptimal state, and to discuss how emerging actors try to take advantage of the changing conditions, due to the current crisis, to reshape it.

A Framework for Analyzing the Politics of Electric Hybridization

The field of urban infrastructure studies has opened up widely to Southern cities in the last decade which has led to significant challenges to the dominant paradigms (Coutard

and Rutherford, 2016b; Furlong, 2014; Jaglin, 2012). In the face of absent or failed conventional infrastructure (centralized networks of water provision, electric grid …), many scholars have developed new conceptualizations to make sense of alternative infrastructural initiatives where individuals, local communities, and sometimes local entrepreneurs, are the main actors as the state is mostly absent, both as a provider and as a regulator. These works take stock of the dominant urban poverty and widespread informality in which these initiatives are striving and of which they take advantage, because of flexibility, reactivity and agency, which led prominent scholar Abdulmaliq Simone to emphasize the power of "human infrastructure" (Simone, 2004). Looked at from a perspective of urban political ecology, this infrastructural landscape has been analyzed as "heterogeneous infrastructure configurations," which is used to contrast the uniformity of the modern infrastructure ideal and emphasize the "continuous change" it is undergoing (Lawhon et al., 2018).

In this context, the notion of hybridization implies the coexistence of many diverse decentralized systems interplaying between themselves and the grid (Coutard and Rutherford, 2016b). In this sense, it differs from the notion of infrastructuralization that accounts for a process of "stabilization," "perpetuation," and "extension" (through generalization) of socio-technical systems (Mathieu-Fritz, 2017: 321). Hybridization implies an increase in the degree of heterogeneity in the system. Technological innovations or adaptations and the socioeconomic differentiation at the level of urban configurations are recognized drivers of change (Rateau and Jaglin, 2020).

In addition to technological and socioeconomic factors, the political dynamics do weight in this process. Several researches examined the politics of decentralized energy systems and their ability to deliver sustainable futures in ecological as well as political terms (Adil and Ko, 2016; Burke and Stephens, 2018; Thombs, 2019). Nevertheless, they mostly focus on Western contexts, and seek to probe a relation between decentralized energy and democracy. They see politics as an outcome rather than a factor shaping the dynamics of electrical hybridization. Other research explored the politics of urban electric grids and how it reflects urban politics and struggles at large, and shapes it in return (Luque-Ayala and Silver, 2016). Here, we argue that it is beneficial to analyze more specifically the relations between the socio-technical arrangements that shape the hybridization process, and the political practices and forms of power actors involved in the hybridization process implement to sustain their interests.

The article asks the question: how do the political interests and practices associated with the various technologies of decentralized energy systems interplay to explain the evolution of the decentralized energy landscape? We analyze decentralized energy systems according to their socio-technical diversity (conventional grid, diesel-based generators' mini-grids, solar and hybrid mini-grids) and the socio-political profile of the users and investors interested in their development. We also examine the political interactions that take place between these actors, at several scales or in various arenas of action. First, we consider public policy instruments that shape the market (Lascoumes and Le Gales, 2007). The state and other stakeholders seek to introduce technological change through legal and financial instruments. This set of actions involves adapting the law and regulations by mobilizing administrative and political resources, mobilizing money lenders, and mobilizing local financial systems to support investments. The implementation of such programs needs to take into account the targeted publics,

and how these programs can take advantage of the new instruments (Rocher and Verdeil, 2019). Investors (companies and households) need to secure access to funding and expertise, which involve building trust with financial institutions and/or mobilizing political support (through clientelist relationships). Other political practices are aimed at controlling the functioning of certain infrastructure and to defend its market share. Particularly useful for understanding energy landscapes, Mitchell's conceptualization of "power from within the energy system" emphasizes the way actors gain an infrastructural power by implementing practices such as alliances, blockades, monopolies, or cartels to impose their interests and in some case impose technological lock-in (Mitchell, 2011: 12; Unruh, 2000; Verdeil, 2016). Eventually, we also take into account political practices which criticize and shame incumbent actors to legitimize new models (Hood, 2010). Advocating and streamlining new models, technically and financially, is part of the political game; it is a way to promote new actors and technologies knocking at the door.

In the article we analyze how political practices from incumbent players and newcomers shape the process of electric hybridization, which favor or curb the unfolding of various decentralized (renewable and fossil-based) technologies of generation and distribution.

Methods

The study of this complex and evolving situation relied on several research methods, both quantitative and qualitative. To understand the socioeconomic profiles of investors and users, we first collected quantitative data on the energy grid, and on the use of gensets and hybrid systems. In a country where official statistics are scarce and poorly reliable, it is a challenge. The national utility Electricité du Liban (EDL) does not publish annual reports. Ministerial policy papers constitute rare public sources providing figures, although they are possibly biased (Bassil, 2010; Ministry of Energy and Water, 2019). The administration for statistics published aggregated datasets on household and company characteristics, but with little information on electricity practices beyond an estimation of users of generators in 2007 and 2017 (Central Administration of Statistics [CAS], 2008; 2020). Several World Bank reports provided indirect data on generation and thus on gensets (Ahmad, 2020a; World Bank, 2008). For hybrid and renewable systems, we were able to access to databases compiled by the CEDRO initiative at UNDP and by the Lebanese Center for Energy Conservation (LCEC), the Ministry's arm for renewable energy in Lebanon. During a three-month internship at the LCEC in 2019, one of the authors, Alix Chaplain, was able to compute and map the 2018 database, which allowed for crossing variables. We updated it with the latest report (2019) (Jabbour and LCEC, 2021), while scattered data on 2020 and 2021 are available in the press and social media.

The qualitative part of the research focuses more on policy and politics. It combines surveys from two periods. First, one of the authors, Éric Verdeil, carried out several interviews in 2012 on the crisis of the Lebanese electricity systems with high-ranking policymakers and industrialists, providing insights on the policy about diesel-generators. In addition to this, since 2018, Chaplain carried out 93 fieldwork visits and interviews: 25 with suppliers of renewable equipment, 13 with representatives of international and non-governmental organizations, 14 with national political actors, two with banking

institutions, 19 with local elected officials or local public actors, seven with residential consumers, and, finally, 13 with industrial and commercial companies with renewable systems. We either recorded the semi-structured interviews or, in cases when the interviewee objected to being recorded, we took notes. The interviews dealt with the technologies in use, the perception of the market, and the policy regulations bottlenecks. Email exchanges and video-calls prolonged the first contacts during the COVID period, which limited the scope of the data collected.

Since October 2019, a series of dramatic events precipitated political changes in Lebanon and triggered an economic and financial crisis that deeply destabilized the electric sector, including the alternatives to the grid. This destabilization seems to have opened the door for new arrangements. Indeed, many new claims emerged to radicalize the shift towards new technologies and reshuffling the governance and actors' systems involved in the energy sector, while emergency investments in backup solar and hybrid systems seemed to prefigure a new energy future, although one still full of uncertainty. We tried to follow these changes during our fieldwork in the spring of 2021, and through continually reviewing press and online documentation. These results remain fragile both because of scarce data and ongoing changes.

Policy and Politics of Decentralized Electricity Generation

In Lebanon, the national electricity utility, EDL, never recovered from the damages during the Civil war despite important reconstruction efforts supported by international aid during the 1990s (Verdeil, 2009). Since the mid-2000s and until 2019, in the face of increasing demand, the power cuts that had been reduced to an average of 3–4 hours a day nationally, surged and reached up to 12 hours a day in some regions, depending on the season (Ahmad, 2020a). The crisis comes from a rising gap between demand and supply. It is estimated that unmet demand rose from 22 percent of the total demand in 2008 to 38 percent in 2018 (Ahmad, 2020a). The persisting under-supply resulted from the lack of investments in new generation capacity after 2002. The lack of maintenance of old turbines and the mismanagement of the grid, which resulted in high technical losses, explain the decrease of grid-tied capacity from 2,620 to 1,944 MW in 2019. An IPP gas turbine power plant as well as renewable wind farms and solar projects have been agreed upon but did not materialize yet (Ministry of Energy and Water, 2019). Political bickering over policy choices have prevented the multiple plans from producing the expected effects (Ayat et al., 2021; Hasbani, 2011; Moore and Collins, 2020; Verdeil, 2017). Only temporary and expensive solutions were implemented, such as the renting of barges run by a Turkish company with a 370 MW capacity (Bouri and El Assad, 2016). Designed for a few years, they were in operation until the termination of the contract in 2021, while the projects that were supposed to replace them have failed to materialize. Power cuts have become the new normal, and citizens and companies have developed responses to cope with them.

The Use of Diesel Generators and the Political Stakes of its Regulation

Diesel generators (DG) are the main component of these solutions. Anchored in the practice of more than 30 years, they were estimated to supply about 84 percent of the

Lebanese households in 2018, up from 61.5 percent in 2007 (CAS, 2008; 2020). First developed during the 1980s, they were at the time individual backup systems, sometimes extended to ones neighbors as a solidarity practice (Awada, 1988). However, over the years, they gradually became more complex and were integrated into collective practices. The sharing of cost, predominant at the level of buildings, went along with commercial practices that developed in the neighborhood or at the municipal scale, with mini-grids in use when the national utility cut its supply. Today they structure the daily life of Lebanese users, representing a backup but also a strong constraint on the organization of time with heavy financial and sanitary cost (Abi Ghanem, 2017; Verdeil, 2016). They also represent a sizable economic sector, estimated to provide 13,200 jobs and generating a revenue of 1.1 billion US$ for the commercial DG sector and 1,974 billion US$ for the imports and distribution of fuel as well as sale, distribution, and maintenance of the DG (Ahmad, 2020a). Estimations of generation from DGs amount to 8.1 TWh in 2018, representing 37 percent of the total electricity consumed in the country, up from 4.2 TWh in 2006.

However, the commercial DG sector is only the most visible part. The non-commercial (non-subscription based) self-generation indeed represented 4 TWh, i.e., 49 percent of the diesel-generation market in 2018. Most of its users are industries, big commercial companies as well as public or non-profit entities (army, education, hospitals, administration). According to Ahmad "some industrial users rely completely on DGs, even when EDL power is available, to avoid the risk of sudden power loss, which can be very costly" (Ahmad, 2020a: 69). In 2006, high voltage subscribers (mostly big firms) using their own DGs generated 67 percent of their electricity, estimated to 3.5 TWh (World Bank, 2008). This figure represented 83 percent of the self-generation sector. The increase of power cuts, pushing households and small companies to rely more on generators, explains the relative drop of industrial and commercial self-generation share.

Beyond individual and entrepreneurial strategies, public authorities' policies towards DGs represent an often-overlooked factor to account for their growth. The policy history we provide here relies on a synthesis of existing works, press analysis and interviews with policy officials. This policy shifted over the years from an ashamed and silent tolerance to an ambiguous recognition and policing. During the 1990s and until the middle of the 2000s, as public capacity increased and power cuts strongly decreased, generators were tolerated as a temporary and backward solution, soon to be replaced by conventional supply managed by EDL. In 2005, our first interviews on the subject showed that EDL and foreign consulting engineers were aware that big companies relied only on generators, but they considered it as foolish, economically unsustainable, and something that would soon disappear.[1] However, as unlawful as they were, local public authorities, namely the municipalities, responsible for security issues, governed them. Mayors ruled the location of generators in order to mitigate noise and fumes as well as monitor the use of publicly owned poles and streetlamps by generator wires. In some cases they even caped the price of generators' subscriptions and divided the area of service between different service providers (Gabillet, 2010). As the commerce of generators' subscription rose, complaints against the owners' commercial practices also grew. The word mafia became widespread to describe their behavior as they overpriced when local monopoly arose, undersupplied, or even used violent practices against discontents and potential competitors (Mohsen, 2012; OLJ, 2012; Verdeil, 2016).

Ministers Tabourian, Bassil, and Abi Khalil, who managed electricity from 2008 to 2018, devised a two-track policy for generators. On the one side, they singled out the practices of the market's biggest players. They used the word mafia mostly to stigmatize the companies importing fuel for the generators' market because of the huge profits they made. They considered these players, connected to strong political actors who sat in the government, as having vested interests. Because the development of centralized generation power plants supplying the grid would reduce the size of their market, they opposed the policy the Energy Ministers pushed. For instance, César Abi Khalil, then the Energy Minister's main advisor, cited the name of the head of the syndicate of fuel importers, who was also the treasurer of the Progressive Socialist Party (Personal Interview, 2012a). Other importers had political clout as well, as several press reports established. In addition, studies and press reports pointed out the unusually large numbers of companies when compared to other countries, which suggests the existence of a cartel to keep prices high (Ahmad, 2020a: 35; Ayoub, 2020; The Cradle's Lebanon correspondent, 2021). However, given their political strength, the ministers could not confront them directly, and they had to use an indirect strategy through the regulation of the small market's players.

On the other side, they indeed considered small local generators' owners as providing a welcomed service, but in need for regulation. The Water and Energy ministers started publishing a monthly reference tariff for private generators in October 2010, based on the fixed and variable costs of operating generators (OLJ, 2010) and monitored by the Ministry of Economy and Commerce. Both ministers then decided that generators' owners had to install meters to charge subscribers only for the electricity actually consumed (Hage Boutros, 2017, 2018). All this without legalizing the sale of electricity, which remained illegal and hence not subjected to VAT and other taxes. According to a senior advisor to the Energy Minister, this set of measures intended to reduce the profit margins of the generator's owners and above all, the fuel importers (Informal Discussion, 2018).

Strikingly, this policy for the subscription-based generators' sector left the self-generation practices of the manufacturing and commercial sectors untouched, despite the wide share of the market they represented. Self-generation indeed is legal. Industrialists and the managers of big firms suffered great losses from power cuts and high energy costs (World Bank, 2008: 20). Since the end of the 2000s, they increasingly criticized the Ministry of Energy's (lack of) reforms and offered their take, which among other suggestions included a stronger reliance on the generators capacity their firms owned. These ideas were highlighted during interviews conducted with Alain Tabourian, manager of a big manufacture of beverages (which, to avoid the fluctuations of the public grid, used the power it self-generated), and with Neemat Frem, the owner of a commercial and industrial holding and then head of the Lebanese Industrialists Association (Personal Interview 2012b, 2012c). Both were politically close to the Free Patriotic Movement (FPM), whose strong man Gebran Bassil was the Water and Energy Minister from 2010 to 2014. Alain Tabourian himself served as the Minister of Water and Energy between 2008 and 2009. He was representing the Tashnag Party, an ally of the FPM. Frem was a member of Parliament and belonged to the group led by the FPM. At the time, the government wanted to increase the capacity by building new power plants and meanwhile discussed the renting of the power barges from the Turkish company Karadeniz. Both Tabourian and Frem suggested that instead the government could have encouraged industrialists

to invest in new generators to generate and feed electricity to the grid. They saw this as a way to foster the development of the industrial sector through soft loans, for instance. Interestingly, a World Bank report already called for the government to clarify the legal status of "large self-generators" and to temporarily allow that "they … provide standby back-up capacity to the EDL system and sell electricity to EDL during certain periods" (World Bank, 2008: 21). These facts illustrate that interest for electric decentralization is not a marginal issue but a central one in the political economy. Beyond small scale practices and so-called mafias, essential economic and political actors had a stake in it. However, Bassil and his main advisor and future minister, Abi Khalil (2016–2019), disagreed with this option. They preferred to keep direct control over the sector through public procurement of new power plants. Their policy, however, did not marginalize DGs, which de facto have kept their central role in the energy system. As the electricity crisis deepened ideas to foster big consumers to generate their own energy, thanks to subsidies targeting the industrialists, came back in 2018–19, but were not implemented.

The Rise of PV and Hybrid Systems: Foreign-Funded and Market-Led Policy Tools

The other way to develop distributed electricity systems involves solar generation. The renewable energies in Lebanon are anchored in a complex governance system in which public bodies designed policies in close partnership with the banking sector and international players.[2] At the Copenhagen Conference in 2009, the Lebanese Government committed to increase its share of renewable energies in the energy mix up to 12 percent by 2020.[3] International and non-governmental organizations (World Bank, European Union, United Nations Development Programme [UNDP], and USAID) have pushed the Ministry of Energy and Water toward a greater decentralization of electricity delivery and have opened the path to renewable energies in Lebanon. As early as 2002, the UNDP launched several renewable projects, including the creation of the Lebanese Center for Energy Conservation Project (LCECP), then the Country Energy Efficiency and Renewable Energy Demonstration Project for the Recovery of Lebanon (CEDRO) in 2007 and the Small Decentralized Renewable Energy Power Generation Project (DREG) in 2014. Through grants and tenders, CEDRO and DREG were tasked to develop pilot projects for distributed renewable energy systems throughout the country. CEDRO is one of the main players in the decentralization of energy systems with investments amounting to more than US $ 41.4 million (Personal Interview, 2020).

In 2011 the LCECP became an institution affiliated with the MoEW and its main technical advisor, and shortly afterwards was renamed the LCEC. Initially funded by the Global Environment Facility, the LCEC also benefited from donations from the European Union, as well as from the Central Bank of Lebanon and the Lebanese government. In the absence of a national energy agency and independent regulatory authority, the LCEC filled a gap as a technical advisor for local and national actors, project manager or public policy designer for renewable energies and energy efficiency, in close partnership with international organizations and the Central Bank of Lebanon.

The banks also held a fundamental role until the financial collapse of 2019–20. The European Union and the Lebanese Government funded the National Energy Efficiency and Renewable Energy Action (NEEREA), a financing mechanism offering credit at a

very low interest rate. The Central Bank of Lebanon managed it, while commercial banks distributed the loans to investors. Until 2019, total investments in photovoltaic (PV) decentralized projects amounted to about 125 million US$, with 2,172 projects, 80 percent of them in the private sector. Fifty-nine companies were active on the market, with a total of 653 jobs (Jabbour and LCEC, 2021).

As a result of this set of policies, a wide variety of electrical systems emerged either on-grid or off-grid, legal or illegal, with generators or not, with batteries or not (see Table 1). Given that renewable energies and the grid in Lebanon are both intermittent, renewable systems require an additional source. Therefore, CEDRO designed a hybrid system with DGs and photovoltaic panels, which is crafted to cope with Lebanese peculiarities. This PV system operated on-grid when conventional energy is available and off-grid in fuel reduction mode during load shedding (See Table 2).

The LCEC 2019 survey provides a comprehensive picture of the market of decentralized solar PV systems. It experienced a strong growth between 2010 and 2019, with a capacity currently reaching about 78 MWp for 2160 installed projects. Fifty-four percent have been financed by NEERA, which shows the effectiveness of public

Table 1: Type of solar projects and Grid interaction in Lebanon in 2019

Project type	Capacity (MWp)	Capacity (%)	Definition	Gensets Status
Hybrid/Multisource	9.93	13	This refers to systems that involve the parallel operation of PV with one or more "grid-forming" sources (e.g. PV-Diesel) without any actual connection to the EDL grid.	Included
Off-grid with generator back-up	1.12	1	Same as off-grid, but the battery bank can be recharged by another generator (e.g. Diesel back-up genset).	Included
Off-Grid/Stand-alone/ Autonomous	3.76	5	These systems are standalone, working independently from a grid. Batteries are an integral part of this configuration. PV will feed the local loads and charge the batteries thereby ensuring a fully autonomous operation.	No (possibly present as back-up)
On-grid with batteries/ grid interactive/ dual-mode	5.39	7	These systems combine the features of the on-grid and off-grid systems as they operate like the former whenever the grid is present and switch to the operation of the latter should the utility's availability become compromised.	No (possibly present as back-up)
On-grid/Grid-tied/ Online	45.74	58	These systems require connection to the grid in order to operate. For decentralized systems, in the case where PV production is greater than the local demand load, the surplus is injected into the grid via net-metering. In times of blackouts, the PV system usually operates in parallel with back-up generators (most commonly diesel gensets).	In practice, gensets are most of the time included.
PV Pumping/Solar Pumping	12.71	16	These systems consist of a direct connection to a DC pump or through an inverter to feed an AC pump, instantly providing all the available power collected by the PV modules directly to the load. The system can be upgraded to include batteries.	No (possibly present as back-up)

Source : LCEC 2021 (2019 PV Status Report)

Table 2: Solar projects by sectors and grid interaction (KWp)

Sectors	On-grid/ Grid-tied/ Online	On-grid with batteries/grid interactive/ dual-mode	Hybrid/ Multisource	Off-grid with generator back-up	Off-Grid/ Stand-alone/ Autonomous	PV Pumping/ Solar Pumping	Total	%
Industrial	13996	348	3563	371	70	30	18378	33%
Commercial	8939	1631	784	145	774	20	12293	22%
Residential	4288	2019	1311	390	1240	22	9270	16%
Agricultural	261	161	76	13	121	4399	5030	9%
Public	2684	540	593	25	773	368	4983	9%
Educational	2119	299	172	30	12	60	2692	5%
Medical	2043		167				2210	4%
Non-profit	846	76	173	9	252	154	1509	3%
Total	35175	5074	6838	983	3242	5053	56365	100%

Source : LCEC database for the year 2018

support. The most active sectors are the industry, which accounts for 33 percent of the capacity, the commercial sector (22 percent), agriculture (13 percent) and the residential sector (13 percent). The remaining 21 percent are other tertiary customers (medical, education, public service, non-profit). Altogether, the sectors that run the biggest systems are the most capital intensive, with industry the first (on average 213 KWp), then hospitals (138 KWp), and finally, the commercial sector (50 KWp). Residential customers only stand at 9 KWp. They are mostly concentrated in the central Beqaa (Zahle district 21 percent), the districts of Byblos (9.7 percent), Metn (5.2 percent) and Kesrwan (5.1 percent) which constitute the northern part of Mount Lebanon and the suburbs of Beirut and the district of Saida (7.8 percent) (see Figure 1). These are the economically most advanced regions of the country, with the biggest companies.

The distribution of systems by type shows the overwhelming domination of on-grid systems (58 percent). It is easy to understand in the area of Zahleh which enjoyed at the time of the survey 24/7 service thanks to the special arrangement with the private concessionary company EDZ (Ahmad et al., 2020; Verdeil, 2019) and where grid-tied systems represent 90 percent of the total.[4] Other types of systems (off-grid, hybrid) constitute a good share of the total in other areas, but grid-tied dominates almost everywhere (53 percent on average). This is paradoxical and can only be explained by the fact that those systems are incorporating back-up generators for when the grid is off. Beyond the existence of a rising number of so-called hybrid systems, now representing 13 percent of the installed capacity, most systems include generators and, increasingly, batteries (20 percent).

The emergence of decentralized solar systems in Lebanon increased the technological complexity in the landscape and highlights a process of hybridization. It did not dislodge the dominance of gensets as the preferred alternative but rather articulated with it, with variations according to sectors and regions. This observation is coherent with the worldwide development of gensets, not only in countries plagued by electricity crisis but even in economies where grids work well (Arik, 2019).

Sociologically, the emergence of this new landscape relied on a set of actors and institutions very different from those involved in the diesel-based generation and distribution. They comprise international aid institutions, local experts advocating for renewable energy against fossil-fueled technology in the ministry, banks, and local installers. The economic weight of this sector remains far below that of the generators, with a

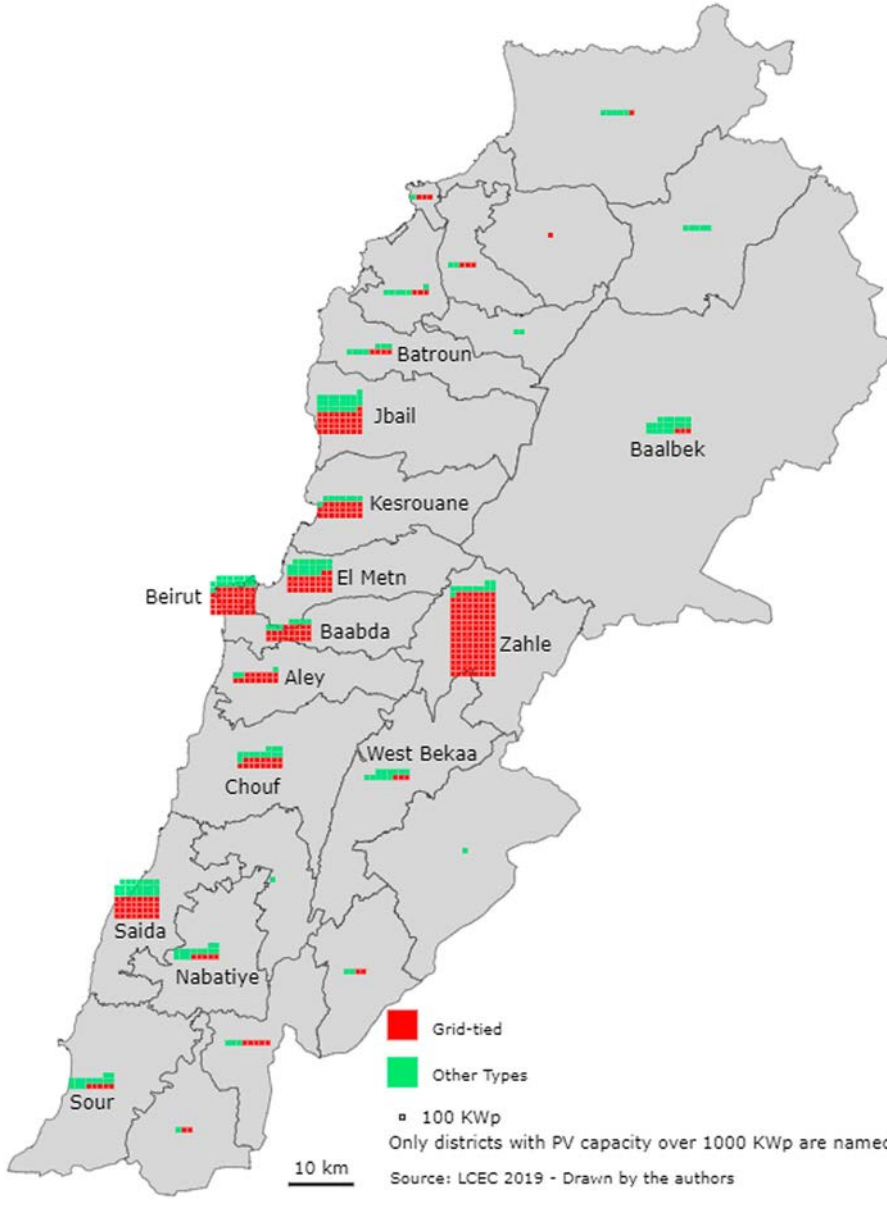

Figure 1. Map of PV systems in Lebanon in 2018

market of about 125 million US$ in the last 10 years to be compared to US$2 billion per year (Ahmad, 2020a: 9).

Resisting Hybridization: The Hurdles Facing Net-Metering Implementation

Adopted in 2011 by EDL's board of directors under the influence of the UNDP and the LCEC, net metering policy is an interesting illustration of hybridization, and the hurdles

it faces. Net metering is a technical and legal mechanism which allows for the exchange of electricity from a small decentralized renewable system to the conventional grid through a bidirectional meter. Although net metering was adopted as a national policy, the difference in its implementation between the national utility EDL and the private company Electricité de Zahle (EDZ) in its concession area raises questions about the interests of the grid's operators to support the decentralization of electricity.

In 2019, EDL accepted 135 net metering projects, a figure that can be compared to about more than 700 grid-tied systems in EDL-managed areas, even if not all may have applied (own calculation, LCEC 2019 database). By contrast, the number of net metering projects in the concession of Zahle reached 622 projects in June 2021 for a total capacity of 8MW (Ayoub and McCulloch, 2021).

Several reasons explain this discrepancy. With a 24-hour electricity supply, the Zahle area has an exceptional status in the Lebanese electrical landscape. Electricité de Zahle (EDZ) has been operating since 1923 in 16 municipalities and for 70,000 customers under a concession status, and has been distributing EDL power since the 1970s. In 2015 the private operator started its own diesel generation to overcome EDL outages, based on 66 rented generators for a total capacity of 60 MW (Ahmad et al., 2022; Verdeil, 2019). Thanks to this reliable supply of electricity, the net metering mechanism works particularly well in the concession because the grid can be used as a storage system and there is no need for additional systems (batteries or DGs). With an on-grid system with net metering, the bill is reduced by 30 percent up to 100 percent, meaning the total cancellation of the bill.[5]

Until 2019 EDZ was very involved in the development of net metering with a department dedicated to renewable energies. But since then, EDZ established a set of limits to preserve the company's economic model: a maximum of 30 percent of photovoltaic capacity can be exported to the grid for capacity greater than 100 kW.[6] Indeed, renewable self-production is a tool to smooth demand pics and, therefore, to limit a company's need to increase diesel production. However, the increase of self-consumption constitutes a significant risk of loss of income for EDZ because the consumption of equipped subscribers drops. EDZ employees cited the risk of overload and instability on EDZ's because of the injection of renewable energies as a reason for the move. However, the preservation of its economic interest remains a major factor.

Similar issues of economic balance between the interests of the prosumer and those of the grid operator emerge inside the national utility EDL. Integrating PV energy on the grid could be beneficial to EDL by reducing technical and non-technical losses and curbing the energy demand for the utility company. This could happen only if a set of interrelated conditions are met regarding the rate of solar energy exported into the grid, the cost of electricity production by EDL, conventional tariffs (currently highly subsidized) and transmission grid improvement (Ahmad, 2020b). Implementing such a win−win strategy is not easy, but could be achieved if the stakeholders cooperate.

Beyond these economic and political factors explaining EDL's unwillingness to support the net metering policy, the deteriorated condition of the monopoly prevents its successful implementation. Indeed, several visits and interviews carried out in areas served by EDL show that investors in decentralized renewable electricity systems had to wait for up to three years before EDL installed the net metering system. Meanwhile, the PV electricity generated was fed back into the grid for free. Interviewees cited

organizational shortcomings inside the utility that affect the operation of net metering, such as the absence of a department dedicated to renewable energies and the two years-delay in the billing process (bill collection and distribution). Furthermore, currently the EDL transmission grid is in poor condition and can only receive a limited renewable load.

Nevertheless, given the potential interest of net metering policy, several analysts and actors in the sector interpret the blockage in its implementation as resulting from the deliberate will to preserve the current functioning and to protect the interests of incumbent stakeholders.[7] Thus, if the deployment of hybrid diesel/PV systems with net metering is much more proactive within the perimeter of the Zahle concession, both examples show that the partial failure of net metering implementation is not only due to technical and organizational reasons but also due to the strategies incumbent actors implement to resist the way hybridization challenges their economic interests.

Lebanon's Multiple Crises: Contradictory Effects on the Dynamics of Electric Hybridization

Since 2019, Lebanon has entered turbulent times. The State defaulted on the public debt, with systemic consequences on the financial system, the society, and the infrastructure: the Lebanese lira has lost up to 95 percent of its value; the banking system is on the verge of collapsing and has frozen the accounts in foreign currency of the population; and more than 80 percent of the population is under the poverty line. In the face of this crisis, the Central Bank initially set up a subsidy scheme to support the import of essential resources vital for society and the economy, including fuel for the power plants and for the private generators. However, to limit the rhythm of the foreign currency reserves' depletion, the Central Bank imposed quotas for the imports of fuel, which increased the length of power cuts to unprecedented levels, with an average supply of 2–3 hours a day, and even total blackout for two days in October 2021. Meanwhile, DGs also suffered import restrictions, which led to shortages and cuts in their supply. All aspects of social and economic life have been affected, from water supply to hospitals, including the food supply chain and the Internet (Verdeil 2022). Since the spring 2021, the Central Bank has lifted the subsidies, which pushed tariffs up strongly, rendering them now unaffordable for large parts of the population. This crisis of fuel import, which also affected the import of gasoline, highlighted anew the power of the actors involved in the import and distribution of diesel. During the summer of 2021, they successfully implemented several blockades to push the government to increase prices in order to maintain their profits. Several press reports and analyses unraveled these tactics, grounded in the combined domination of the import facilities and distribution infrastructure (13 companies control 68 percent of fuel tank fleet in the country) (Ayoub, 2021). However, in the face of unaffordable bills, many customers have had to adapt and reduce their consumption (Abdallah, 2021), which in the long term will affect the income of this sector. The crisis, therefore, exposed at the same time the strong political power of the actors of the generators market but also their vulnerabilities.

The financial crisis also put an end to the NEERA program that supported the solar-based decentralized electricity systems. However, the dramatic reduction of public supply led many companies and households to invest in such systems in order to secure their

electricity supply. Despite the removal of the subsidy, the market kept on growing tremendously, with an addition of 11,2 MWp in 2020 (+14 percent), 100 MWp in 2021 (+100 percent) and expectedly 250 MWp in 2022 (El Khoury, 2022).

On the policy level, the political paralysis continued, fostered by two government resignations and lengthy consultations to nominate new ones, only to be stalled again by internal strife. Tariff reform, aimed to curb subsidies and the spiraling of debt caused by the deficit of EDL, was supposed to happen in 2019 after a seemingly political consensus about it was agreed upon. It has been postponed. Private investment in new power generation capacity is also on hold, even the agreed and awarded projects of wind power plants launched just before the crisis. International aid promised in the framework of the 2018 CEDRE program was conditioned on radical political reforms, including major changes in the governance of the electricity sector (tariff increase, procurement reform, creation of an independent regulator).

Nevertheless, debates and proposals for reform have never been so loud and present in the public sphere, underscoring the diversity of visions and interest for the future of the sector. We analyzed a representative selection of those publicly available visions in light of their position vis-à-vis the decentralization of energy generation and distribution (see Table 3). Beyond the socio-technical assemblage, this points to new articulations of political interests, as shown when one takes into consideration the sociology of their actors.

The bloom of visions and roadmaps for reforming the electricity sector rests on the mobilization of categories of actors who have remained marginal to the field until recently. They comprise academic experts involved in local think tanks, such as the Issam Fares Institute (IFI) for Policies at the American University of Beirut; different groups of entrepreneurs from the renewable electricity sector, already striving due to the market of decentralized solar equipment installation; and experts with a more financial background, linked to various segments of the Lebanese private business milieu, including the banking sector. Noteworthily international aid agencies such as the World Bank, the UNDP or the German Konrad-Adenauer Foundation funded several of these plans. Their authors somehow compete for the attention of the foreign lenders who conditioned their funding for the electricity sector on the implementation of reforms.

Almost all projects clearly endorsed long-awaited changes such as the creation of an independent Energy Regulation Agency (ERA), the corporatization of the national utility, and the necessity to increase centralized electricity generation with a combination of gas fired power plants and solar and wind centralized farms. However, they vary regarding the degree of decentralization of electricity generation, the technologies that might be involved, the commercial mechanisms of distribution as well as the funding of those new capacities. All plans support the development of renewable electricity generation and net metering. However, some proposals, such as Ali Ahmad's report and the Future Energy Leaders, support a strong share of distributed electricity generation and emphasize the role private owners of diesel-based based generation can play in this move, which implies recognizing their business and accepting the use of diesel for a few transition years. Both also favor municipal generation with a similar mix of technologies. In both plans, the national utility would remain the single buyer. In contrast to this, other proposals think of decentralized electricity generation through renewable only. Several reports advocate peer-to-peer energy trading and electricity wheeling. There is

Table 3: Review of recently published plans for reforming the Lebanese sector and promoting electricity decentralization
Source : Authors' compilation (press, online report, interviews)

Scenarios	Network of actors	Instruments	Funding	Energy mix - Role of renewable energies	Degree of hybridization and sociotechnical model
"*Distributed Renewable Energy Law*" *currently being drafted*	UNDP, ERBD and Academic Cristina Abi Haidar: Donors & Partnership with the Ministry of Energy and Water (MEW) and the LCEC	Renewable electricity exchange market between individual private players through the conventional grid: *P2P + net metering + RE equipment leasing*	Private sector: small scale suppliers and prosumers	Promotion of renewable energies at the individual scale and for small-scale projects	Public management of the sector with centralized power plants (1) and the integration of small-scale distributed renewable projects in the national grid (2) → Centralized regulation/ no local autonomy
"*An alternative emergency plan for Lebanon: integrating diesel and PV systems in virtual power plant operations for EDL*", *February 2021*	"Future Energy Leaders": engineers from the Lebanese private sector (RE suppliers), organization initiated by the World Energy Council and hosted by the MEW and the LCEC	Feed-in tariff and licensing policy for hybrid PV-diesel mini-grids connected to MV substations of the national distribution grid	Launch of the project by the EBRD, the WB and the Hariri foundation, and then investment by private actors and municipalities (high profitability)	High penetration of distributed renewable generation at the municipal/neighborhood scale: 4 GW of decentralized solar PV in 2025 i.e. the removal of 80% of existing neighborhood diesel generators	Articulation between distributed hybrid PV/Diesel mini-grids owned by private investors or municipalities (1) and thermal centralized production on the national grid (2) → Partial decentralization and privatization of electricity production and distribution, within a nationally regulated framework
"*Distributed Power Generation for Lebanon: Market Assessment and Policy Pathways*", *May 2020*	Ali Ahmad: Academic, World Bank consultant	Market mechanisms and licensing policy to upscale and integrate decentralized solar PV systems to existing distributed diesel generator capacity (commercial or municipal)	Lucrative investment for private actors and municipalities in renewables	High penetration of distributed renewable generation on a municipal/neighborhood scale: partial replacement of existing decentralized diesel-based generators → hybrid local generation	Articulation between distributed hybrid PV/Diesel mini-grids (1), the centralized national grid (2) and small-scale distributed renewable systems (3) → Private and decentralized generation and distribution (local regulation), coexisting with the national grid (national regulation)
"*Lebanon's Electricity Sector – Leapfrogging to Higher Penetration of Renewable*", *May 2019*	LFRE, Strategy&, AUB: NGO founded by business leaders, bankers, lawyers, engineers. Opposition to MEW and LCEC policies	Public tenders for production licenses for large-scale solar farms on public land and medium-scale farms on private land (local suppliers such as schools)	Funding by aid agencies (WB) and large private investors (IFC)	High penetration of large-scale renewables (up to 47% by 2030 i.e., 6.1 GW of green energy out of a total capacity of 10.5) and development of distributed solar PV on school roofs (450 MW)	Articulation between utility-scale solar and wind generation (1), distributed and collective renewable production (2) and natural gas power plants (3) → Technical decentralization of energy systems within a nationally regulated framework
"*Unbundling Lebanon's Electricity Sector*", *September 2021*	IFI (M. Ayoub, P. Rizkallah, C. Abi Haidar): academic experts. Voiced opposition to MEW policies	Holistic reform of the sector (ERA) and corporatization: up to 60% of production and 40% of distribution to private actors who hold shares in public companies	IMF and private investors	Increase of centralized production through PPP with natural gas and renewables	Articulation between centralized natural gas production (1), centralized solar farms (2) and decentralized small-scale renewable energies (3) → Centralized electricity sector with the participation of private actors under national regulation

(*Continued*)

Table 3: Continued.

Scenarios	Network of actors	Instruments	Funding	Energy mix - Role of renewable energies	Degree of hybridization and sociotechnical model
"*Bridging the banking crisis to crowdfund electricity reform in Lebanon*", *October 2021*	Carol Ayat: Former Banking and financial expert, Lebanese Oil and Gas Initiative, recently affiliated to IFI / AUB & IMF influence Voiced strong opposition to MEW policies	Creation of private companies for production (GENCOs through BOT) and distribution (DISCOs through PPP), but the transmission remains with EDL	Lebanese depositors invest their local dollars through a bank-intermediated crowdfunding system	Baseload relies on natural gas-fired power plants (2.7 MW) and then development of large-scale renewable energy projects (4.2 MW, I.E 30% by 2030)	Decentralized and private distribution companies (local management) and private production fed into the national grid → Financialization, corporatization and privatization of the sector
« Mitigating the darkest hour: Lebanon's struggle for power », July 2021	Jessica Obeid: Independent consultant, former employee of the UNDP. Regularly voiced critics of MEW policies	Holistic reform of the sector, increase in generation through PPP and increase in tariffs (to encourage large consumers to switch to renewable energies)	Private investors (competitive procurement)	Baseload relies mainly on thermal power plants but promotion of small-scale distributed renewables to curb energy demand for EDL	Articulation between centralized production with 3 thermal power plants (1), one renewable station (2) and the decentralized development of small-scale renewable energies (3) → Conservation of the public sector but corporatization with private companies which sell electricity to EDL

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Carol Ayat, "Bridging the banking crisis to crowdfund electricity reform in Lebanon" : https://www.aub.edu.lb/ifi/Documents/publications/research_reports/2020-2021/20211020_comprehensive_solution_to_the_lebanese_electricity_sector_report_pdf.pdf

also a divergence between the plans that support the monopoly of the public utility as a single buyer and distributor, and others that support decentralization through private distribution companies (DISCO) or municipalities, even with the possibility of local autarky, which comes in line with projects of political decentralization, as advocated by some political parties such as the Kataeb Party. It is to be noted, however, that the owners of (former) concessions, in Zahle or Jbeil, also promoted such schemes of territorial electricity autonomy, based on license for local generation (with thermal technology) and distribution, in the recent past, aside from the projects of political decentralization (Verdeil, 2019).

Discussion

Politics Shaping Hybridization

Table 4 synthetizes the results of the research. It distinguishes three distinct trends of energy decentralization that coexist and interplay one with the other and with the conventional grid. The first one, historically and quantitatively, is the widespread use of diesel-generators in Lebanese society. Private actors and inhabitants, individually or collectively, implemented temporary and makeshift solutions in search of energy security and profit, based on fossil-based technologies (DGs). This resulted in largely unexpected transformations, which now represent deeply embedded interests and material systems. Rather than seeing only the actions of non-state actors, it is, however, essential to stress that public authorities played a role at several levels: by tolerating and implicitly governing those initiatives, both nationally and locally, and by not regulating the importers' cartel practices, several of which were connected to leading political parties (Abdallah, 2021).

Despite this dominant form of a decentralized electricity system, several actors moved to streamline renewable energy systems, by promoting the technologies and adapting them to the intermittent character of the grid, by elaborating a legal framework and enabling its funding. This group of actors has nevertheless diverse social and political interests, from engineers and entrepreneurs pushing ecological solutions to international organizations seeing in sustainable technologies a way to reform the electricity sector, and to banks finding in foreign and soft loans a new safe and profitable market. However, in this model, the monopoly of the national utility was never contested and the LCEC conversely always hoped EDL would adopt and adapt to these new technologies. This, however, never really happened and the public company resisted this decentralization, whatever the reasons: lack of human resources, fear of suffering unbearable financial consequences, or hidden pressures of vested interests attached to the status quo and the profits attached to it.

The 2019–20 crisis strongly destabilized the existing balance of power. While the collapse of the national utility has exposed the enduring political power of diesel-importers and diesel-generators, it has at the same time underlined their inability to provide full energy security, specifically at an affordable cost. The system supporting the development of decentralized renewable systems collapsed as well. However, even if at higher cost, decentralized renewable systems have thrived throughout the crisis. New stakeholders are trying to push for a radical reshuffling of the Lebanese electricity sector that would

Table 4: Actors and politics associated to electric hybridization processes
Source : Authors

Hybridization process	Actors	Source of political power and kind of politics
Diesel generators as backup for grid's failures	Big company owners (industry / commerce / service buildings)	Availability of capital => investment in generators / lobbying for legalizing private decentralized generation and distribution
	Neighbourhoods' generators owners and suppliers	Ability to enforce local monopoly (alliance with local powers)
	Diesel importers	Practices of cartel (alliance with national political players) to control prices and extract rent. Suspected practices of disrupting reforms of electricity to defend the cartel's monopoly over imports
Solar-based technologies to generate electricity to complement the grid or back up its failures	LCEC, official public agency advising the govt	Streamlining technological models + Elaborating legal framework + Networking funding organizations
	International money lenders + Local banks + Central Bank	Designing / supplying concessional funding schemes
	Companies, organizations and wealthy customers investing in solar techs	• Convincing banks + mobilizing political network to access funding/ aid • Adjusting connection and consumption practices to optimize profit
Solar-based technologies as vehicle for partial or almost total autonomy from the grid and from diesel-based generators	Think tanks Policy experts and tech entrepreneurs	• Critical assessment of previous malfunctioning electric system (blaming and shaming) • Elaboration of alternative legal and financial frameworks enabling decentralized generation and distribution • Advocacy in the press and towards foreign aid agency and foreign government

provide more sustainable supply in the future. They offer various visions and represent different interests competing for political and financial resources, particularly those offered by foreign agencies. However, their potential alliances with stakeholders belonging to the former assemblages of interests still remain unclear. Also, the degree of decentralization of the future system and its regulation still remains undecided, between a single-buyer model and a more liberalized market allowing dealing and peer-to-peer exchange as well as authorizing decentralized generation and distribution of privatized utilities.

Well beyond a planned transition, the Lebanese situation represents a case of hybridization of the electric sector, with an unstable landscape that shows contradictory trends. However, the situation cannot be described as an assemblage of "continually assembling, disassembling and re-assembling" actors and socio-technical solutions" (Kumar et al., 2019). It rather exhibits the strength of capitalistic interests taking advantage of the loopholes and failures of public policies. The private sector, both as investors in diesel generation or solar and hybrid systems, as well as the resellers and installers of these systems, is a major driver of change. The transformation toward the addition of

renewable is more advanced for the big consumers (private or public) than for ordinary residential users. DGs will long remain a major electricity source. Such an unplanned and uncontrolled landscape, even if it allowed the country to survive and even at times develop without a well performing electricity system, resulted in many bad externalities, in terms of cost, environmental pollution, as well as illegal practices detrimental to the public budget and to transparency. Another consequence needs to be emphasized: growing social and territorial inequalities.

The Political Outcome of Continued Electric Hybridization: Social and Territorial Justice On- and Off-Grid

Lebanon's electricity sector constitutes a clear illustration of the failure of the modern infrastructural ideal, in particular the ideal of social and territorial cohesion (Coutard, 2008). The World Bank warned long ago that social inclusivity through progressive tariff of EDL was not ensured, due to the weight of the fixed part of the electricity bill (World Bank, 2009). In addition, geographic inequalities of load shedding resulted in bigger amounts of subsidy per capital for the regions enjoying the better coverage, which happen to be Beirut, its suburbs, already among those economically thriving in the country (Verdeil, 2018). The sustained development of hybridization explains the constant reinforcing of social and territorial inequalities. For instance, the strong cost of unsubsidized generator subscriptions is more strongly felt in the underserved regions and also has socially regressive effects for the most disadvantaged part of the population (World Bank, 2009). The increase of power cuts and of diesel prices aggravated the situation.

The trend towards decentralized renewable systems is reinforcing the social and territorial polarization, marginalizing the North of the country and other remote and disadvantaged areas (See Figure 1). Upfront investment costs, despite the fall of PV and batteries, render hybrid systems out of reach for most ordinary citizens and even for many small firms and communities, which struggle with inflation affecting all sectors of everyday life. In 2019, 1 kWp of PV cost 935 US dollars based on the exchange rate of 1,500 LBP/$ dollars (Jabbour and LCEC, 2021), and much more when one accounts for devaluation. Recent surveys highlighted this cost constraint (Ayoub, 2021).

International experiences in countries exhibiting features similar to Lebanon show that in addition to cost and tariff, the rise of decentralized generation also challenges tariff equalization, a tool for social and territorial inclusivity public utilities usually ensure. In Pakistan, the chronic power cuts since the 1990s pushed exporting industries to develop self-generation (based on natural gas rather than on diesel). Initially the government supported these investments, which alleviated the need for reinforcing the grid and new centralized generation units. It created mechanisms for reselling electricity. However, this move had politically heavy consequences: not only were the state utilities loosing revenues from key customers, but "historically cross-subsidized agriculture and small-domestic consumer's electricity needs" were under threat of tariff hikes potentially spurring protest and this policy was gradually reversed between 2002 and 2008" (Anwar, 2015: 139). The rise of PV systems in South Africa represents a similar threat to municipal-led redistribution practices through infrastructure (Jaglin, 2022). In Jordan, solar self-generation pushed big customers to disconnect from the national grid (Obeid,

2019). In Lebanon, high and middle voltage customers, as well as higher bracket residential customers also cross-subsidize small customers. The government's planned tariff hike aimed to minimize the effect for low-consumption subscribers. The fairness of this measure was conditioned on the decrease of bills from generators. Under continued hybridization and the perspective of big customers gradually moving out of the grid, the possibility of funding subsidies for low-subscription customers from the utility's revenues seems uncertain, even more when one accounts for the drastic devaluation that affects the disappearing middle class (Nucho 2022).

Conclusion

The Lebanese case helped unpack the relations between politics and hybridization of the electric system, which results in the uncontrolled addition of decentralized technologies with potentially destabilizing effects on electricity configurations. It showed that political groups and interests shape the trajectory of the electricity sector by undermining the policy reforms and defending or advancing their own agendas and socio-technical solutions. Contradictory and conflictual policy processes combine with energy-security and profit-driven attitudes by private actors, resulting in wide-scale changes in the energy landscape. The continued process of hybridization increases the social and territorial polarization while weakening the instruments of solidarity in favor of disadvantaged groups, thus heightening political tensions. The article also showed that moments of strong political crisis may destabilize the existing interests and open the door for changes, which represents an opportunity to move towards a more sustainable and fair energy configuration. The political and socio-technical complexity will most probably remain the defining feature of the energy landscape and policymakers have to take it into account as well as the messiness that comes with it, rather than assuming a swift move to sustainable solutions. This lesson presumably also applies to the situations of neighboring countries such as Syria, Yemen, the Palestinian Territories, and Iraq (Ahmad, 2020b; Fischhendler et al., 2022; Harajli et al., 2020), but also other countries enduring public utilities crises, or tensions, and uncontrolled diversifying of energy technologies such as Pakistan, Nigeria, South Africa or Jamaica (Anwar, 2015; Jaglin, 2022; Pilo', 2022; Rateau and Jaglin, 2020).

Notes

1. Interviews, EDL, 2005.
2. Data collected while hosted at the LCEC from February to May 2019.
3. Since 2018, the target is to meet 30 percent of total primary energy consumption from renewables energies by 2030.
4. In this paragraph, the figures come from calculation on data from the 2018 LCEC database, which we were authorized to access.
5. Interview with two officials of EDZ, 03/19/2019 and 06/8/2021.
6. Interview with two officials of EDZ, 03/19/2019 and 06/8/2021.
7. A supplier of renewable systems told us: "Of course, I can find technical blocking to explain the problems of net metering to you. But if you dig deep the problem is never technical, but always political because there are interests in the non-functioning of the system especially with fuel," Beirut, 03/14/201.

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