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EVENT SIGNIFICANCE

Infrastructure collapse and network interdependence: lessons from Lebanon's blackout[1]

Eric Verdeil

On Sunday 10 October 2021, the complete blackout on Lebanon's public power grid made the headlines in the international media: several power plants had stopped running because they had run out of fuel, and the small remaining output was no longer enough to keep the network in balance. Électricité du Liban (EDL), the national state-owned electricity company, had long warned this collapse was inevitable should it not be able to import more fuel. However, some Lebanese people expressed their surprise on the internet that this should make it onto the front page:[2] for them, this was hardly news since, for months and even years, the public operator had been providing only a few hours of power a day, and most of their electricity came from private generators. Last summer, even these alternative solutions began to experience disruptions as they too were affected by fuel shortages and rising supply costs.

To understand this energy crisis we need to understand the interplay and amplification of these failings, against the backdrop of a major political and financial crisis which the World Bank regards as one of the three most serious in the past 150 years (World Bank, 2021). This extreme situation provides us with an opportunity to examine what the functioning of infrastructures owes to the interdependence of networks (the subject of this *Flux* issue) by situating ourselves more specifically in the field of study that deals with infrastructures in crisis (Graham, 2010). The Lebanese crisis firstly illustrates the close interweaving of different socio-technical networks, the interdependence of which is asymmetrical in nature: the collapse of one network has systemic consequences, highlighting, in this case, the centrality of electrical energy. But interdependence also concerns the resources necessary for the proper functioning of infrastructures, more specifically here, fossil energies, which determine the production of electricity, both public and private (Coutard, Florentin, 2022). Finally, the Lebanese case allows us to examine the networks' embeddedness in "macro-structural dynamics", particularly the international gas and oil markets, but also the capital market.

We can thus show the uniqueness and importance of the Lebanese case. Firstly, the slow timescale of this crisis compared to the sudden disasters (climate-related—floods, cold waves, earthquakes—or simply technological in nature) that have affected advanced countries highlights a network structure that is paradoxically hyperconnected (Barles, Guillerme, 2016) in order to cope with chronic failings. It also points to the extent to which the neglect of infrastructures has become a mode of political domination over the last fifteen years, which echoes the observations of Fregonese (Fregonese, 2020). Lebanon's network-interdependence crisis further shines a light on a geographical as well as energy characteristic of this small country: its lack of energy autonomy and dependence on imports, mainly of fossil fuels. The corollary of this argument is to place the functioning of infrastructures within a political economy where the cost of energy is dependent on the exchange rate, which is itself in sharp and deep decline due to a debt largely produced by an unregulated consumption of imported energy. Before we address these points, let us return to the factual unfolding of the Lebanese infrastructure crisis by taking a step back in time, before detailing the recent acceleration.[3]

From the slow degradation to the systemic collapse of the public power grid

The complete power outage experienced by the national company Électricité du Liban is part of a long process of degradation which dates back to the Lebanese civil war (1975-1990). However, until 2006, reconstruction investments had led to improvements and to full supply in the capital, while power cuts in the rest of the country averaged only three hours a day. Since then, a halt in investment in new capacities and

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the deterioration of existing facilities, even as demand has continued to grow, has resulted in increasing rationing. The country has not lacked restructuring plans and reforms, but it has lacked the political consensus needed to implement the solutions on the table (Verdeil, 2009; Hasbani, 2011). Disagreements over the location and financing of proposed power plants; controversies over tenders and suspicions of corruption in favour of the ruling parties; procrastination about setting up a body for regulating the sector; short-term but costly solutions (renting barges equipped with diesel turbines); confessional polemics about good and bad users; refusal to increase tariffs which were otherwise far too low to ensure financial equilibrium, resulting in a deficit that accounted for 43% of the country's public debt—all kinds of pretexts have been used, in good or bad faith, to block the reforms and prevent the much-needed investments (Verdeil, 2017a). Political competition took precedence over the minimum consensus required to restore the electricity infrastructure to an acceptable operational level, at a time when the World Bank classified Lebanon as an upper-middle-income country.

The deterioration of output capacities has accelerated in recent years, even as the government's increasing difficulty in meeting its debts has meant that the funding available for EDL's fuel imports has been limited, further exacerbating the production and distribution crisis. The blackout in October 2021 was due to the fact that the available capacity (270 MW) was no longer sufficient to balance the grid, even if a rotating rationing system was used. In 2019, the available capacity was between 1,500 and 2,000 MW (Ministry of Energy and Water, 2019), while demand was estimated at over 3,000 MW. Throughout this period, it is the largely informal private sector which has ensured continuity thanks to domestic, collective, or commercial generators. Their output capacity is around 37% of that of the country, and 82% of households are connected to them (Ahmad, 2020; Central Administration of Statistics of Lebanon (CAS), 2020).

Throughout the summer, another emerging feature of the Lebanese infrastructure crisis was the inability of these private electricity suppliers to meet the demand created by the deterioration of the public electricity supply caused by fuel-oil shortages. In an attempt to cope with the very rapid devaluation of the national currency (since late 2019), the Central Bank had set up a system for subsidising fuel purchases (petrol and fuel oil) which involved import quotas. As the latter were quickly reached due to demand, shortages spread, fuelling a black market with prohibitive prices. Generator owners therefore reduced their output and increased their tariffs. A second, technical, factor played a similar role: generators cannot run continuously and must be allowed to rest for a few hours every day. In effect, the whole summer was marked by unusual and increasingly long cuts in supply from these groups, both to buildings (where they are a self-managed collective service) and to neighbourhoods (where providers offer a subscription-based commercial service).

These cuts were felt much more keenly by the population, not only because of their length, but above all because of the chain of disruptions caused to several other services around which daily life is structured. This included disruptions to the cold chain, which affected both individuals who were forced to shop much more frequently because they could not use their refrigerators, but also the distribution network, particularly small shopkeepers, some supermarkets, and, more worryingly, the leading logistics warehouses of the distribution networks. Hospitals themselves had to cope with this increase in power outages, with dramatic consequences for the continuity of vital systems such as oxygen supply, as well as for the storage of certain medicines, not least vaccines at a time when Lebanon was facing a fourth wave of COVID-19 and was doing its best to get the population vaccinated.

Other critical infrastructure too was affected by these power cuts with dual effect. This is firstly the case of the supply of drinking water (Unicef, 2021), where electric pumping is required at several points in the water supply chain. Thus, within water-treatment plants and distribution infrastructures, pumps are needed to fill some reservoirs or water towers, not least because the network is characterised by intermittent supply and irregular pressure. As public drinking-water utilities ran out of fuel, they could no longer operate their generators, resulting in unusually long outages in the water supply system. On the other hand, customers' lift pumps feeding individual rooftop storage tanks,

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which are needed to make up for outages and dips in pressure, were also affected by power cuts, both on the grid and generators. People had to store water in their homes when it was available, just as they did during the civil war. The water was becoming less and less safe to drink. Already, a large proportion (70%) of households buy bottled water or *gallons* (Central Administration of Statistics of Lebanon (CAS), 2020). This service became even more essential but was threatened by shortages and made unaffordable by the rising prices of these products. The internet and telephones, especially mobiles, also experienced service disruptions for the same mixture of reasons: a lack of supply by the public network and of generators normally used as backup when the former fails (Alameddine, Jawhar, Ricour-Brasseur, 2021).

At the same time, daily movement was also affected because of fuel rather than electricity shortages. Service stations, affected by import restrictions, only provided minimum service, leading to numerous queues and sometimes dramatic conflicts and accidents (Hage Boutros, 2021). In mid-August, the explosion of a fuel truck stopped for smuggling petrol in the Akkar region killed more than forty and injured many others as people rushed to take out the last few litres left in the tank after the army's intervention. These panic reactions and queues grew on the eve of each announcement of price increases due to the gradual reduction in subsidies. Public transport, which is generally very inadequate and provided only by private and largely informal bus fleets (Samaha, Mohtar, 2020), came up against similar obstacles. As official tariffs did not increase at the same rate as prices were adjusted (not to mention the black market), supply fell sharply. Drivers spent long hours trying to fill up. Fuel shortages also had an impact on the waste-collection sector, leading private operators to reduce or even discontinue their rounds. Rubbish began piling up in the streets (OLJ, 2021). This was reminiscent of previous health-crisis episodes caused by the closure of the main landfill in 2015, and the subsequent saturation of the temporary outlets that have since been set up and extended several times along the coast (Verdeil, 2017b). Although the causes were not the same, this chain reaction underscored the lack of lasting solutions to the problems affecting the management of infrastructures.

This account illustrates two forms of systemic collapse of the infrastructure services serving Lebanon and its cities in particular. The first one is the dependence of infrastructure networks on electricity supply, in a rather classic way in what is a modern and fully electrified society. The second type of collapse is linked to fuel shortages. It is itself the main, but not the only, cause of the collapse of electricity networks, while bringing other, non-electrified, services, such as transport and waste collection, to a halt. The country's energy dependence, especially on imported fossil fuels, seems to have been an aggravating factor in this crisis, the unfolding of which nevertheless underscored the existence of intersecting mechanisms of interdependence, which were brought to light by the simultaneous or gradual disruption of these energy flows. Based on these initial observations, I will now try to put the Lebanese crisis into perspective, drawing some additional lessons on the interdependence of its networks.

Collapse and resilience in a hyperconnected society

First of all, the crisis occurred despite the fact that in Lebanon there are standard practices for preparing for and adapting to this regime of chronic disruption to the functioning of essential infrastructure. The omnipresence of generators, mentioned above, is a first symbol of this, as well as the existence of water tanks in buildings, or the commonplace use of technologies such as UPS (Uninterruptible Power Supply) intended to protect IT infrastructures from sudden outages or voltage variations. Lebanon can paradoxically be described as a hyperconnected society (*hyper-networked* or *hyperlinked*, both terms are used) in the sense suggested by Barles and Guillerme (2016) in their analysis of the dual water supply network in Paris: drinkable and non-drinkable. This configuration is characterised by loyalty to the distribution of resources via a network, while at the same time integrating off-network mechanisms out of a desire to secure supplies, which is a central element in Lebanon, and to preserve resources, which is missing from the Lebanese context.

For Barles and Guillerme, this duplication of circuits is a resilience factor in the face of the alarming prospects of climate change. However, using the notion

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of resilience is controversial in Lebanon. Even though the term is complacently used in the press, particularly the international one, in order to praise the tinkering and patching up that citizens have engaged in since the civil war, thereby allowing society to cope with a recurrent crisis that is not linked to environmental change but to political and economic factors, several analysts have been critical of it. Thus, according to Mouawad (2017), it is above all those in power who have proven their resilience in the face of the crises experienced by the country, which should have otherwise led to their fall long ago. Indeed, these crises seem to actually strengthen the political elites, while political mobilisations against the collapse of infrastructures—such as the Tala'at Riyatikun ("You Stink") movement protesting against the failure of waste collection and storage in 2015—have not been able to bring about real political change. The impoverishment of the population and the migratory exodus[4] that have hit the country are anything but signs of resilience, in the sense of regaining balance, but rather of a lasting social collapse which, one imagines, will be hard to recover from. Thus, the infrastructure-duplicating mechanisms put in place at the initiative of citizens have themselves proven to be powerless, or overwhelmed, due to the country's extreme energy dependence on imports. The structural collapse has therefore also shown the limits of interdependence as resilience, and forces us to clarify under what conditions its use could be justified.

Thus, real resilience would lie not only in this duplication of infrastructure, but also in the ability to tap into local energy resources. Alix Chaplain's PhD research is currently exploring the development of energy-security practices in Lebanon through self-generation by means of solar power and batteries, the combination of which (including generators) is giving rise to hybrid systems. The crisis, despite the financial difficulties it has entailed, seems to be speeding up the appropriation of these technologies, which represent a new form of energy security, combining off-grid and new local networks (*mini-grids*), while connection to the public grid remains possible. In this respect, these developments constitute a new duplication of circuits. This trend goes hand in hand with a high degree of social and territorial fragmentation. Only the largest companies and the most affluent citizens can equip themselves with these systems (Chaplain, Verdeil, submitted), while a few municipal initiatives have started to emerge, reflecting an already-existing but now amplified logic of territorial fragmentation (Chaplain, 2021; Verdeil, 2016; Verdeil, Féré, Scherrer, 2009). In this respect, reducing the systemic effects of network interdependence through these duplications seems to go hand in hand with a network fragmentation that could have serious consequences for the unity of society. The corollary of infrastructure resilience organised on a reduced territorial scale is a reduction in state-organised solidarity mechanisms, an argument which echoes the criticisms levelled at the resilience paradigm (Djament-Tran, Le Blanc, Lhomme, Rufat, Reghezza-Zitt, 2011; Jaglin, Dubresson, 2021).

Interweaving infrastructure networks and financial flows

A second observation about the Lebanese infrastructure crisis concerns the close connection between the financial crisis and the collapse of networks. In late 2019, the country openly entered a brutal financial crisis, the symptoms of which were a 90-95% devaluation of the Lebanese pound against the US dollar on the "secondary" market and the state defaulting on part of its debt set to mature in March 2020. This financial crisis had been predicted by many analysts and took by surprise only ordinary citizens, who had been misled by the reassuring words of politicians and financial officials. The interesting point for our purposes is that a large part of the public debt was linked to the recurrent operating deficit of the state-owned EDL, which the state offset annually to the tune of one to two billion dollars. Taking into account the interest due on this part of the debt, financial analysts estimate that over the last thirty years, but especially from the mid-2000s, EDL has been responsible for 46% of the public debt. The operating deficit has mainly been caused by a tariff that barely covers 30-40% of the cost price, while operating losses account for 40% of the output (25% of which are "non-technical" losses, that is, unpaid or stolen) (Ayat, Haytayan, Obeid, Ayoub, 2021). Added to this waste is the low efficiency of the production units and the use in these plants of a very expensive fuel (diesel oil) instead of alternatives such as natural gas.

Failure to use this fuel is certainly due, since 2011, to various geopolitical

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events: the gas pipeline has been cut off since the outbreak of the Arab revolutions, first between Egypt and Jordan because of regular attacks between 2011 and 2013, then in Syria where the war, the insecurity in this country, as well as the embargo imposed on the regime in Damascus have prevented its rehabilitation and operation. However, to be quite precise, it should be noted that Lebanon had not paid some Egyptian bills in 2009-2010 (Razzouk, 2011): it is not only physical flows that were disrupted but also capital flows. Finally, the recent onset of the infrastructure crisis was, as mentioned, the result of import limitations that were imposed on both EDL and generator owners precisely because of the financial crisis and the reduction in the Central Bank's foreign-exchange reserves.

In these circumstances, it needs to be strongly emphasised that the serial collapse of the networks was not essentially and solely due to the disruption in material and energy flows caused by scaling, synchronisation, or geopolitical problems, but was fundamentally a political economic issue within Lebanese society, as well as between Lebanon and the outside world. Over the last twenty years, the de facto subsidisation of electricity and the long-term overvaluation of the currency have encouraged energy consumption that, thanks to its disconnection from production costs, has been paradoxically less constrained than the extent of power cuts might suggest. Reminding us of the embeddedness of the issues related to the functioning of the networks and their interdependence with local and international financial circuits means restating the lessons taught by urban-political-ecology authors, who stress that natural flows are indissociable from money and power flows, with the circulation of materials and energy necessarily leading to the circulation of capital (Swyngedouw, 2006). The disruption to the circulation of capital is a possible, and in this case essential, cause of the serial collapse of the networks. This underscores the fact that network interdependence needs to include financial networks and the circulation of capital in its scope of analysis. This is consistent with work analysing the relationship between development, financialisation, and infrastructure debt, which nevertheless focuses more on the repayment of debt by infrastructures than on its accumulation due to infrastructure failings (Furlong, 2019; Furlong 2020).

The slow timescale of the infrastructure crisis and political domination

To conclude this analysis, it should be noted that the timescale of the collapse of the Lebanese networks differs greatly from that of many infrastructure crises. This has consequences for the governance of infrastructures and urban societies. Infrastructure collapse is generally analysed in the literature as the consequence of a sudden and brutal shock, whether climatic (as in New Orleans after Katrina, in New York after Sandy, or in Texas during the winter of 2021), seismic, caused by forest fires (as in California in the past few summers), or resulting from a blackout such as the one that hit the Northeastern United States in 2003 (Luke, 2010). In some studies, the chain-like collapse of networks is actually an anticipation of a possible future, such as the catastrophic infrastructural impact of a 100-year flood in Paris (Gleyze, Reghezza, 2007). This projection into the future remains linked to a short-term event, even though its occurrence is considered inevitable. The occurrence of a disaster sometimes leads to investigations which retrospectively reveal the existence of problems that were not dealt with even though they were known to certain actors, and highlights the existence of structural inequalities in relation to risk, which are part of well-identified patterns of domination, for example in studies on environmental inequalities (Keucheyan, 2014).

The collapse of Lebanon's networks as illustrated by the series of events of last summer, which were preceded by warning signs stretching over a decade, is characterised by a much slower timescale. Certainly, severe shocks may have increased its infrastructural vulnerability. Thus, the explosion of 4 August 2020 in the Port of Beirut further weakened the network by destroying the dispatch centre co-ordinating the network located at the company's headquarters, which had started operating only a few years earlier. The event forced EDL engineers to start and shut down power plants the old-fashioned way by telephone (Hage-Boutros, Ricour-Brasseur, 2022). But what is most striking is the highly predictable nature of this collapse and the inaction of successive governments. Rather than interpreting this crisis as the result of a paralysis linked to a blocked system of political regulation,

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it should be seen, in a more radical way, as the manifestation of a form of domination achieved not through the violence of weapons but through slow environmental violence. Sara Fregonese (2020) has already suggested analysing the recent environmental crises in Lebanon, from the 2015 waste crisis to the 4 August explosion in Beirut, through the prism of "extractive violence", bringing together rentier accumulation for the benefit of a political class that largely overlaps with the economic elite, the slow environmental violence of pollution, and culpable negligence in the face of destructive assemblages of hazardous materials. The collapse of infrastructure networks has compounded these environmental crises and prolonged their duration. It subjects the population to chronic violence resulting from a lack of maintenance, exposure to pollution caused by generator fumes, diseases caused by spoiled food from refrigerators that no longer work, or the asphyxiation of patients deprived of oxygen, not to mention the degradation of daily life due to the constraints brought on by scarcity. This infrastructural neglect amounts, according to Fregonese, to a reassertion of the elites' dominance over ordinary citizens stripped of the right to essential services.

Post-collapse prospects

The question posed by such an analysis is whether systemic collapse, both infrastructural and environmental, helps reinforce domination or, on the contrary, constitutes a tipping point, a sudden gaping hole in the power structure. Such a turning point can indeed be analysed as providing a motive for revolt, but also as a space for applying micro, partial but alternative and autonomous solutions to the political system, and therefore as the vector for mobilised groups taking back control. A recent study on the handling of COVID-19 in Lebanon highlights the existence of such alternatives in areas other than energy, but also their great fragility (Harb, Gharbieh, Fawaz, Dayekh, 2021). Conversely, will the collapse force citizens to urgently go back to endless tinkering, the daily maintenance and reinvention of which would divert political energy from imagining collective alternatives? A situation that would also deprive them of the prospect of solidarity, the hope of which the networks continue to embody?

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Notes

(1) I thank Monica Biberson for the translation, which was funded thanks to grant no. ANR-17-CE05-0002 from the Agence nationale de la recherche.

(2) For example, on Twitter, Bissan Fakih on 10 October 2021: https://twitter.com/Bissan_Fakih/status/1446969515741429762.

(3) This article is more of a discussion of this event within this journal's section, rather than an academic paper. It uses sources gathered over nearly fifteen years of research into Lebanon's electricity issue, drawing on previously published results as well as new material which is being examined as part of the Hybridelec project funded by the ANR (ANR-17-CE05-0002).

(4) According to the United Nations Economic and Social Commission for Western Asia, from 2019 to 2021, multidimensional poverty increased from 42% to 82% (ESCWA, 2021). Structural emigration is estimated at 1 to 1.5 million Lebanese, compared to an estimated national resident population of 3.84 million. It has risen sharply in recent years, although no exact figures are available (Central Administration of Statistics of Lebanon (CAS), 2020; De Bel-Air, 2017; El Bacha, 2019).

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