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Reforming Venezuela's electricity sector

Options and priorities for rebuilding a collapsed system

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Summary

- In Venezuela, as around the world, the supply of reliable and affordable electric power is not just another service: it underpins the provision of vital humanitarian and social services, as well as of public goods such as water, healthcare, urban transport and education. In addition, Venezuela's recovery from economic collapse and its return to growth as well as its future economic diversification will all depend on the reconstruction of the electricity sector.
- This research paper examines the state of Venezuela's complex electricity crisis within the context of the severe political, economic and humanitarian challenges that the country faces. In doing so, the paper explores four central issues:
 - The balance between reconstructing Venezuela's historic electricity system and building new systems. Urgent humanitarian needs and the demands of Venezuelan citizens call for the restoration of electricity supplies. Taking this into account, this paper presents potential 'quick wins', some of which may involve installing local temporary generation units around centres providing humanitarian relief or critical services.
 - How to focus on healthcare, water supply and other public services. Rebuilding Venezuela's electricity sector will need to prioritize the restoration of essential public services. This process should not be delayed by broader institutional and management reform. For this reason, a first step should require a project manager and technical team tasked with assessing and overseeing emergency repair or installation.
 - How to integrate electricity systems into energy policy to restore energy production. To support future economic growth, electricity sector reform will need to be developed in coordination with the government's broader energy policy, and should take into consideration not only restoration and production, but also integration across different energy sectors. One key component of this coordination should be a focus on exploring ways to capture flared or vented gas for on-site or pipeline supply for electricity generation, especially around energy production centres.
 - The need for and the timing of unbundling Venezuela's centralized, state-centric electricity system: The regulation of the state-concentrated and centrally managed electricity supply system, as well as the day-to-day management of the state-owned CORPOELEC, will need to be reformed and unpacked. The aims of this process should be: to better incorporate technical professional standards in relevant industrial practices; to recruit technically qualified personnel; to inject market incentives into management and investment; and to provide investors with the necessary transparent and predictable regulatory and legal framework.

- Drawing from these questions, previous studies, interviews with stakeholders and lessons from case studies of Iraq and Romania, the paper outlines a series of phases for reconstruction. Those phases take into account the different priorities of, and the funding and investment requirements and possibilities available from, multilateral banks and private investors.
- The paper concludes with a series of recommendations regarding the incorporation
 of more sustainable, less carbon-intensive and more local options for Venezuela's
 future electricity sector. One such option will involve the capture of flared and
 vented gas at the country's energy production centres, both to make those
 units more self-reliant and to reduce the country's significant carbon emissions
 from gas flaring.
- Given the sheer range of stakeholders, local experts and engineers, potential donors and advisers, and private sector interests and investors that will need to be involved in the reform process, the paper's primary recommendation is for a broad discussion about the contours of the current electricity crisis. It is the authors' hope that this paper can contribute to that process of open, honest discussion and collaboration.

01 Introduction

Understanding the reasons for the complex, multifaceted collapse of Venezuela's electricity sector is an essential first step in developing a plan for its reconstruction. The second step is determining priorities.

In Venezuela, as around the world, the supply of reliable and affordable electric power is not just another service: it underpins the provision of vital humanitarian and social services, as well as of public goods such as water, healthcare, urban transport and education. In addition, Venezuela's recovery from economic collapse and its return to growth – as well as its future economic diversification – will all depend on the reconstruction of the electricity sector. Credible progress on restoring the power supply and the communication of realistic plans are essential for re-establishing political stability in the country.

Although the primary focus of this research paper is to look forward, understanding the history of the power sector in Venezuela - and the decline in its capacity and reliability - is a useful starting point for developing the immediate and long-term solutions to the current acute electricity crisis. Examples of issues central to this process are the balance of hydroelectric and thermal generation assets, their status and relationship with the grid, and the regulation of the state-run monopoly supplier CORPOELEC. These elements have been deeply intertwined in the steady collapse of Venezuela's state across multiple sectors, further complicating the recovery of the electricity sector and the formulation of necessary policy corrections. Analysis of the history, both before 1998 and more recently, is essential to understand the root causes of the decline, and the specific faults in the current system and policy approach. Chapter 2 of the paper describes the devastated condition of the existing electrical system across the sector – from generation, to transmission, to end use, to pricing, to management and to regulation. These aspects are explored with the explicit aim of identifying not just the priorities for a top-to-bottom repair and reform, but also the stages of that reform.

The power sector is part of the broader Venezuelan economy. As such, in order to achieve reform it will have to compete for financial resources for reconstruction and operation, as well as for priority treatment when it comes to difficult political decisions, such as rationalizing subsidies and reducing theft and corruption. Furthermore, in rebuilding the country's existing electrical infrastructure, or in upgrading or replacing equipment, Venezuela will need to ensure that it manages carbon emissions. With these considerations in mind, the paper explores three principal questions.

- First, what are to be the priority actions during an initial 'emergency' phase, when the electricity sector is key to humanitarian relief operations but is also in competition for resources?
- Second, during a 'repair' phase of rebuilding infrastructure, what are the potential choices: are all assets to be recovered, or have their decline and the availability of other options opened up new possibilities? Are there ways the recovery can be carried out so as to conform to climate ambitions and commitments to reduce greenhouse gas emissions?
- Third, what is the best way to lay the groundwork for the necessary long-term reform of the sector, in terms of institutional management, market incentives, and oversight and regulation? Rather than proposing an idealized end state of a well-functioning and fully reformed market, this paper will focus on the key steps that will enable both the start of the reform process, with the initial participation of private sector investors in cooperation with the state, and compatibility with the clean energy transition.

Given sufficient political will within the current regime, some of these processes could begin now – especially those addressing acute humanitarian needs stemming from the lack of electricity. With support and oversight from appropriate international entities (such as the UN) and governments, actions such as a professional and independent evaluation of Venezuela's electricity requirements could be implemented with immediate effect. Such independent technical evaluations would help to identify and address sector deficiencies in generation and transmission affecting healthcare and water supply systems. They could also provide the basis for a process of rebuilding critical infrastructure.

This paper draws from several analyses conducted on the electricity sector by multilateral banks, the private sector and local experts, as well as from private interviews conducted with individuals who have worked on the topic in various capacities.

Energy needs in Venezuela are both dire and complex, and the rebuilding of such a complicated sector (especially in the face of other, competing, demands, both for reform and for international assistance and investment in the country) calls for up-to-date information, which is limited at present, but which would enable a wider understanding of the situation. As this paper is derived from multiple analyses and sources, it does not seek to provide specific answers. Instead, the intention is to generate a broad, neutral discussion around existing conditions, urgent demands, reform priorities and the general goals of electricity sector recovery, when the latter is possible. It also reflects the current limited state of knowledge on the electricity sector. To this end, this paper underscores four related, central, issues for debate and broader analysis:

- Reconstructing Venezuela's historic electricity system vs building new systems: Urgent humanitarian needs and the demands of Venezuelan citizens call for the restoration of electricity supplies. Taking this into account, potential 'quick wins' have been suggested, some of which may involve installing local temporary generation units around centres providing humanitarian relief or critical services. In other areas, local community 'microgrids' may offer more sustainable long-term options.
- A focus on healthcare, water supply and other public services: Given the extent of the existing – and growing – humanitarian crisis in the country, rebuilding Venezuela's electricity sector will need to prioritize the restoration of essential public services. This process should not be delayed by broader institutional and management reform. For this reason, a first step should require a project manager and technical team tasked with assessing and overseeing emergency repair or installation.
- Integrating electricity systems into energy policy, and restoring energy production: To support future economic growth, electricity sector reform will need to be developed in coordination with the government's broader energy policy, and should take into consideration not only restoration and production, but also integration across different energy sectors. One key component of this coordination should be a focus on exploring ways to capture flared or vented gas for on-site or pipeline supply for electricity generation, especially around energy production centres. Capturing these gases will reduce Venezuela's greenhouse gas emissions, and has the potential to help 'jump-start' the country's economy until its economic base can be expanded.
- Unbundling Venezuela's centralized, state-centric electricity management system: The regulation of the state-concentrated and centrally managed electricity supply system, as well as the day-to-day management of the state-owned CORPOELEC, will need to be reformed and unpacked. The aims of this process should be: to better incorporate technical professional standards in relevant industrial practices; to recruit technically qualified personnel; to inject market incentives into management and investment; and to provide investors with the necessary transparent and predictable regulatory and legal framework. An initial unbundling and the establishment of effective regulatory structures do not need to be conflated with a potentially difficult political debate on privatization, though structures should be consistent with facilitating new commercial investment – for example, by independent power producers.

02 The present state of Venezuela's electricity sector

The reasons for the decline in generation and delivery are multiple. One of the major constraints to recreating an electrical system may be overcoming the 'legacy mindset' that seeks to wholly rebuild the historic system.

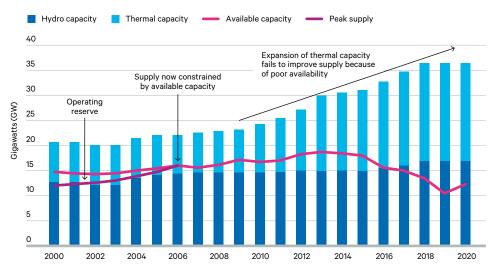
Although news reports have focused on the recent power crisis, the present configuration of Venezuela's electricity system can be traced back to decisions taken in the early 2000s. Between 1980 and 2000, the country's annual electricity consumption almost tripled, from around 30 to 88 terawatt hours (TWh).¹ That demand was met by means of the expansion of hydroelectric generation, while thermal capacity remained broadly flat. However, as early as 2002/03 there were supply shortfalls, driven by an increase in electricity theft and by drought conditions which reduced rainfall levels in reservoirs supplying hydroelectric plants. This led to a policy reversal from the mid-2000s onwards, in which hydropower capacity remained steady while demand growth and system resilience were shifted to thermal plants, where capacity was nearly doubled.² The strategy was to use the flexibility of thermal plants to manage rainfall variations as well as draw on their location close to centres of demand to manage grid unreliability. However, as Figure 1 shows, such a strategy is only effective if these plants are available. In addition, the focus

¹ U.S. Energy Information Administration (2004), *Country Analysis Briefs: Venezuela*, www.eia.gov/international/content/analysis/countries_long/Venezuela/archive/pdf/venezuela_2005.pdf.

² Latin American Energy Organization (OLADE) (2020), *Energy Outlook of Latin America and the Caribbean 2019*, http://www.olade.org/en/publicaciones/energy-outlook-of-latin-america-and-the-caribbean-2019.

on thermal capacity meant that Venezuela did not develop the use of solar and wind renewables, which were increasingly deployed in the region from 2015. None of the estimated 50 megawatts (MW) of wind capacity is thought to be operational.

Figure 1. Venezuela: installed and available generating capacity and supply, 2000–20



Sources: Lara, M. and Aguilar, J. (undated), 'Venezuelan Electrical Recovery Plan', presentation; Latin American Energy Organization (OLADE) (2020), *Energy Outlook of Latin America and the Caribbean 2019*, http://www.olade.org/en/publicaciones/energy-outlook-of-latin-america-and-the-caribbean-2019; and estimates by the authors.

In recent years, broad and rolling blackouts have crippled Venezuela's electricity system – and with it, the country's economy and the provision of critical services including healthcare, drinking water supply, public transport and education. The reasons for the failures are multiple: poor maintenance, insufficient effective investment, a lack of market incentives, excessive state intervention, the declining professional capacity of CORPOELEC, and a failure to anticipate and respond to challenges arising from the existing system's generation mix.

Hydroelectric capacity constitutes just less than one-half of installed generating capacity, with gas and diesel/fuel oil accounting for a little more than a quarter each.³ Historically, however, to minimize operating costs and save fuels for export in exchange for hard currency, hydropower supplied a large share of generated power relative to other assets – typically two-thirds or more. In 2010 this policy of overrunning hydropower, combined with drought conditions, corruption and incipient availability problems at thermal plants, led to rolling blackouts to save power and rebuild water levels behind dams. A similar situation occurred in 2016, with blackouts of four hours per day over a 40-day period, and government employees being ordered to work a four-day week.

³ U.S. Energy Information Administration (2019), *Country Analysis Executive Summary: Venezuela*, 7 January 2019, www.eia.gov/beta/international/analysis.php?iso=VEN; Honoré, A. (2016), *South American Gas Markets and the role of LNG*, Oxford Institute for Energy Studies, www.oxfordenergy.org/publications/south-america n-gas-markets-role-lng.

The power crisis escalated in 2019, with a widespread blackout between 7 and 14 March that affected all 23 states, Caracas and the neighbouring Brazilian state of Roraima. The prolonged power outage had significant humanitarian consequences across the healthcare, water supply and public transport systems, as well as disrupting industry, the commercial and retail sectors, and oil production.

Unconfirmed reports placed the blame for the blackout on a fire in uncut vegetation under a high-voltage transmission line from the Guri Dam to population centres. Other observers have emphasized a wider lack of maintenance and system management. Guri accounts for 10 gigawatts (GW) out of roughly 36 GW of total installed capacity. Whatever the ultimate cause, the outcome was damaged substations and water turbines at the dam.

At approximately 10.5 GW, the capacity that was actually available nationally in 2019 was less than one-third of total installed capacity, with a disproportionately sharp decline occurring in thermal generating capacity.⁴ The extent of the damage to the grid, coupled with a lack of technical capability to repair and manage both the system and the prevailing fuel shortages, led authorities in 20 of Venezuela's states (notably excluding the district of Caracas) to implement power rationing. Unscheduled blackouts continue to be common, particularly in western regions. On 1 March 2020 a blackout extending across 14 states was reported; in 2021 ongoing load-shedding was being used to reduce demand to match available capacity, although supply to Caracas has been prioritized. More recent reports indicate that load-shedding has spread to Caracas.

A number of analyses of the state of Venezuela's electricity sector have been undertaken, many containing proposals for its reconstruction. These have included a section dedicated to electricity in the National Assembly's 2015 policy agenda, Plan País,⁵ and two Inter-American Development Bank (IDB) reports on Venezuela which included analyses of the electricity sector (*A Look to the Future for Venezuela*⁶ and – more within the context of constraints to Venezuelan businesses – *The Venezuelan Enterprise: Current Situation, Challenges, and Opportunities*, which were published in 2020 and 2021 respectively).⁷ While these reports agree on the economic and humanitarian cost of the current state of Venezuela's electricity service, Plan País⁸ and the IDB diverge in the priorities and strategies for rebuilding the system, each of which has different implications for the cost of restoring the electricity system. Analysts also differ in the degree to which they attribute the 2018/19 blackouts primarily to poor maintenance, and in their interpretations of the broader problems of drought (stemming from worsening climate change) and excessive reliance on hydropower – which then minimizes critical questions on asset prioritization

 $Inter-American\ Development\ Bank,\ https://publications.iadb.org/en/venezuelan-enterprise-current-situation-challenges-and-opportunities.$

⁴ Gabel, E. and Cardenas, C. (2019), 'Venezuela Power: Blackouts underscore national electricity crisis', IHS Markit, 31 October 2019, https://ihsmarkit.com/research-analysis/venezuela-power-blackouts-underscore-national-electricity-cris.html.

⁵ Plan País (2020), *Electricidad: ¿Cómo vamos a resolver el colapso eléctrico de Venezuela? [Electricity: How are we going to solve Venezuela's electrical collapse?*], June 2020, https://db1fe89e-8172-4a44-804c-6aae6df8a86a. filesusr.com/ugd/002151_726f552b74c44b608873d82b55dce007.pdf.

⁶ Abuelafia, E. and Saboin, J. L. (2020), *A Look to the Future for Venezuela*, Inter-American Development Bank, Discussion Paper N° IDB-DP-798, https://publications.iadb.org/publications/english/document/A-Look-to-the-Future-for-Venezuela.pdf.

⁷ Saboin, J. L. (2021), The Venezuelan Enterprise: Current Situation, Challenges and Opportunities,

⁸ Plan País (undated), 'Propuestas' [Proposals], https://planpaisvzla1.com/propuestas.

when rebuilding the country's broader electrical system. In their similarities and differences, these studies reveal the need for flexible innovations to address short-term priorities and urgent needs, both in management and in providing fast relief for humanitarian demands. As one analyst told the authors of this paper,⁹ the goal needs to be not 'rebuilding the Rolls-Royce' system of the past, but adapting the existing infrastructure to new technologies in order to meet immediate needs and take up opportunities while realistically addressing constraints.

Several in-country experts have estimated that the first three years of reconstruction will require funding of approximately \$13 billion.

The differences between recreation and adaptation and quickly meeting urgent needs will affect cost expectations. Several in-country experts have estimated that the first three years of reconstruction will require funding of approximately \$13 billion. The totals – and at least the publicly available details – indicate a tendency to focus on rebuilding past infrastructure.¹⁰ The proposed amounts also point to a tension between the state of the existing infrastructure, ambition, available finance and the practicality of efficient execution. The IDB's 2020 report *A Look to the Future for Venezuela* estimates the cost of improvements to the electricity sector for the first five-year period at \$7.1 billion, with the minimum funds necessary for the first year estimated at \$217 million, potentially increasing to \$1 billion if funding becomes available. These costs would include provision for activities aimed at improving generation, transmission and distribution.¹¹

Part of the response to these issues of cost and priorities will depend on the state of Venezuela's electricity sector at the point when policy, institutional and legal/ regulatory reform are possible, and political will exists. For now, there is no complete, detailed picture of the state of the system: this gives rise to one priority requirement for the future – a project manager with technical support, as proposed in the IDB's 2020 report.¹² Such a body will be necessary to collect data on critical areas of relevance, such as the condition and maintenance of equipment and infrastructure; technical capacity in CORPOELEC, and its local staffing levels; losses of electricity through theft; subsidy structures and their impact on services; and areas of urgent humanitarian need. In addition, this body would help to establish rules and processes for the procurement of materials and services.

Such is the imperfect picture, compiled from multiple sources – including, but not limited to, the sources mentioned above – of the causes of the current collapse of Venezuela's electricity sector. As mentioned earlier, to understand and eventually address this collapse, it must be understood within the context

10 Ibid.

⁹ Interview with authors, September 2021.

¹¹ Abuelafia and Saboin (2020), *A Look to the Future for Venezuela*, p. 40. **12** Ibid., Appendix, p. I–7.

of the collapse of the Venezuelan state. This failure is deeply rooted in the country's political deterioration, and has resulted in a politicization of the government, the deterioration of the monopoly on the legitimate use of force, an inability to make and enforce effective policies, and an increase in corruption and criminality. These broader factors will present multiple challenges for the reconstruction and reform of the state and of the country's electricity sector, as well as for the effective ongoing maintenance and management of the electricity system. Within these broad themes, the following specific issues exist.

- Degraded generation and transmission: In recent years, capacity in both generation and transmission has been seriously degraded and will need to be either rebuilt or, in some cases, replaced. According to the IDB reports, this includes the central command and control centre for the system. While a detailed picture (site by site, or by regional grid) is not available, there is evidence that such is the current status of some units and regions. According to one report, produced by a group of local energy professionals, by 2019 there was a national deficit in generation of 900 MW. If deficits resulting from transmission difficulties are included, Venezuela's total electricity deficit in 2019 was 1,640 MW. This shortage has occurred even as the country's gross domestic product has contracted by an estimated two-thirds in the past seven years. Generation at both hydroelectric and thermoelectric plants has experienced problems. According to the same report, because of difficulties at hydroelectric facilities, including drought and maintenance issues, availability plunged from 65 per cent of total generation capacity in 2006 to 48 per cent by 2015.¹³ In the case of thermoelectric generation, by 2019 the system was operating at only 40 per cent of capacity. Some of that generation capacity included plants that originally had been configured to rely on natural gas, but that had been obliged (due to a lack of capacity to produce the cleaner alternative) to burn diesel and fuel oil, both of which have also been in short supply.¹⁴ With respect to transmission, the same report identifies a number of systems that are carrying far smaller amounts than intended, or that are disabled altogether. The latter include lines in San Gerónimo and La Horqueta, as well as the installations around Guri, three cables that cross Lake Maracaibo, lines from Tablazo-Cuatricentenario, and transmission systems from Occidente and the Costa Oriental del Lago Maracaibo.¹⁵
- Professional capacity: A number of interviewees have highlighted that the poor management of the sector has been driven by political decisions. This is undoubtedly true and supports the conclusion that recovery can only occur with the restoration of competent management with political support. According to several sources, this is also true at operational level, on the ground.

¹³ The cited report was prepared by subject-matter experts with proven professional experience in power generation in Venezuela, and was shared with the authors of this research paper on the condition of anonymity.14 Ibid.

¹⁵ Ibid.

Technicians are often underpaid, underqualified and underequipped, leading to difficulties and setbacks in maintenance and repair, as well as in some cases to injury and death.

- Corruption: While it is difficult to separate from management incompetence and the politicization of the sector's governance, there is evidence that corruption has played a part in the Venezuelan electricity crisis. High-profile examples include the estimated more than \$2 billion spent on the expansion of the 1.4-GW Termozulia combined-cycle gas turbine (CCGT) plant in Zulia state and the \$9.4 billion budget for the 2.3-GW Tocoma dam, both of which are not generating. A 2018 report by Transparencia Venezuela concluded that, of the projects initiated between 2000 and 2014 that were supposed to generate a capacity of 17.5 GW, only 4.3 GW were commissioned, and their excess costs could be as high as \$14.6 billion,¹⁶ or more. As a result, projects and infrastructure listed as currently available may amount to less than the capacity commissioned because of a subsequent lack of maintenance, grid connection breakdowns and the lack of fuel.
- Theft: In addition to the corruption in investments, construction and the maintenance of key assets, there is also the challenge of electricity theft a historic problem that predates the current government. According to Plan País,¹⁷ an estimated 40 per cent of electricity generation is lost to theft, and the state only collects a 'negligible' amount of revenue for the electricity provided to users.¹⁸ While addressing the issue of small-scale individualized or community theft may not be a priority in the first stages of reform and renewal, bringing informal users under the formal grid as paying customers will be essential in later stages in order to build a sustainable system.
- Sector governance: Venezuela's current system of oversight and management of the country's electricity system does not conform to international best practices. Many of the problems experienced in the sector are parallel to the institutional problems and dysfunction that exist in the state oil and gas company, Petróleos de Venezuela SA (PDVSA). While in May 2020 a new president was appointed to the state-owned electricity company, CORPOELEC (the post was previously occupied by the minister of electrical energy) the direction of Venezuela's sole electricity body is still not independent from the state. Since 2007, CORPOELEC has both operated the high-voltage grid and run generation and local distribution assets, with no effective oversight of its operations. A power grid is a natural monopoly, so international best practice is for the transmission system operator (TSO) to perform the role of balancing the system: it should be separate from the system itself and closely regulated, so that generation and supply entities can access the power market and compete for business. This best practice separates the operation of the transmission system from the ownership of the grid or other assets. Even in a state-owned system, it is possible to have a separate and regulated TSO. Any long- or even medium-term reform of the

¹⁶ Saturno, S. (2018), Venezuela en apagón: desinversión, falta de mantenimiento y desfalco' [Venezuela in blackout: disinvestment, lack of maintenance and embezzlement], Transparencia Venezuela, https://transparencia.org.ve/project/epe-ii-estudio-sector-electrico.

¹⁷ Plan País (undated), 'Propuestas' [Proposals].

¹⁸ Authors' interview with local analyst. Information was shared with the authors on condition of anonymity. Interview took place in October 2021.

sector will require the unbundling of these roles, not just for the management of the sector, but also in terms of soliciting investment, regulating the sector and injecting market incentives to build a more transparent, flexible and sustainable electricity system.

- Supply instability: The status of generation and transmission assets is highly uncertain, with frequent reports that thermal units, hydropower turbines and key grid connections are being poorly maintained or have suffered damage. Available capacity is currently estimated to be as low as 34 per cent of total installed capacity. For thermal assets, available capacity could now be as low as 2 GW, or just 10 per cent of installed capacity.¹⁹ Typical capacity utilization rates on a well-maintained and -operated system will vary with the type of generation assets, but average and peak utilization rates of around 40 per cent and 70 per cent respectively are worldwide industry norms. This indicates that the current system could generate around double its current peak output after repairs, maintenance and improvements in management capability and fuel availability.
- Drought risk: In the future, operational costs may be higher than in the past, if capacity utilization of hydropower assets is lowered and that of gas/oil assets is increased to reduce the risk associated with drought.²⁰ The current system design is such that thermal assets should provide the supply flexibility to mitigate drought risk. However, with effective grid operation it should be possible for most future capacity additions to be augmented with intermittent renewables (wind and solar) rather than just with gas/oil assets while maintaining system stability and improving resilience to drought conditions by utilizing the ability of hydro assets to store energy. In the longer term it should be possible to retire first oil then gas assets as they reach the end of their operational life, replacing them with renewables.
- Excess demand: Electricity prices to end-consumers are heavily subsidized, at an estimated cost of \$3.0 billion-\$3.8 billion per year. In practice, the subsidy rate is close to 100 per cent, with tariffs in devalued local currency having been frozen since 2002. This leads to excess and wasteful demand: at its peak in 2013, per head electric power consumption in Venezuela was around double that in neighbouring Colombia. In addition, much of Venezuela's oil industry relies on grid supplies of power. Typically, international oil and gas producers have on-site power supplies, often running off co-produced gas. This lowers demand on the grid, forces oil producers to bear the full capital and operating costs of production and reduces flaring.
- A fragmented (and fragmenting) electrical system: An increasing number of individual businesses and better-off communities are relying on individual electricity generation.²¹ Partly, this is due to the breakdown of the market economy, stemming not just from the nationalization of CORPOELEC but the shift to a state-centric economy more generally. While these individual off-grid

21 Saboin (2021), The Venezuelan Enterprise.

¹⁹ Ibid. and the aforementioned study, which was likewise shared with the authors on the condition of anonymity. **20** Werrell, C. and Femia, F. (2019), 'Venezuela: Drought, Mismanagement and Political Instability', The Center for Climate & Security, 7 February 2019, https://climateandsecurity.org/2019/02/drought-mismanagement-and-political-instability-in-venezuela.

solutions may be understandable, they reflect a potentially worrying trend: unequal access to electricity for those who can pay for their own. The existing situation is one in which those with the means – businesses and communities – fund their own electricity generation, leaving those that remain on the grid with unreliable supply that they cannot afford to improve. Given the likely slow process of electricity sector reform in the future, this model is likely to expand. There are several risks.

The case of Iraq (see Box 1) can provide useful insights into the potential pitfalls for Venezuela in terms of the recovery and rebuilding of the electricity sector, and of financing the reform process. In Iraq, the most accessible generators are fuelled by diesel, which creates more pollution than other options (in terms of carbon emissions, air quality and noise) and also incentivizes theft in low-income communities.²²

Box 1. The case of Iraq: the pitfalls of recovery, rebuilding and financing

There are lessons to be learnt from the experience of Iraq, although it should be recognized that no two countries' situations are completely analogous.²³ After the 2003 war there was slow growth in annual electricity generation: since 2010 this has more than trebled, from 41.7 TWh to 131.3 TWh in 2020,²⁴ notwithstanding setbacks such as the struggle against Islamic State (ISIS) in 2014–18. Despite these gains, Iraq continues to suffer from 'brownouts' (restrictions in the availability of power) and load-shedding, particularly in summer, with the result that businesses and residential customers that can afford it have turned to costly and polluting diesel standby generators. The installed capacity of Iraq's generation fleet is sufficient to meet even the summer peak in demand, but a number of policy and implementation failures means that there is a shortfall.

The key lessons relevant to Venezuela are as follows:

Improve coordination between the oil and gas and power sectors, particularly in terms of gas supply. Iraq produces 32 billion cubic metres (m³) of gas²⁵ but still flares around one-half of this, owing to a shortage of gas treatment facilities and pipeline infrastructure: this particularly applies to associated gas produced within the southern oil fields. Iraq imports gas from Iran (via the Iraqi border province of Diyala) to supply power plants in the Baghdad area, while simultaneously flaring in the south. World Bank Global Gas Flaring Reduction Partnership data for 2020

²² It should be noted that the privately funded local electricity generation described here is different to the publicly supported renewable microgrids that are proposed later in this paper. In addition to using environmentally friendly means of generation, the microgrids are publicly coordinated, and therefore broadly accessible to local communities. 23 Mills, R. and Salman, M. (2020), *Powering Iraq: Challenges facing the electricity sector in Iraq*, Friedrich-Ebert-Stiftung, https://library.fes.de/pdf-files/bueros/amman/16923.pdf; and Mehdi, A. and Al-Saffar, A. (2020), *Compounding crises: Iraq's oil and energy economy*, Oxford Institute for Energy Studies, https://www.oxfordenergy.org/publications/compounding-crises-iraqs-oil-and-energy-economy.

²⁴ BP (2021), *Statistical Review of World Energy 2021*, https://www.bp.com/en/global/corporate/energy-economics/ statistical-review-of-world-energy.html.

²⁵ Mehdi and Al-Saffar (2020), Compounding crises.

indicates that Iraq flared a total of 17.4 billion m³ in that year (ranking second behind Russia) and Venezuela 8.6 billion m³ (ranking sixth).²⁶ However, in terms of gas flaring intensity (i.e. the volume of gas flared per barrel of oil produced) Venezuela's ratio was roughly four times as high as that of Iraq in 2020.²⁷

- Concentrate on regulatory and structural reform to improve grid operations as well as encourage investment in generating capacity. While gross generating capacity in Iraq can theoretically meet peak demand, it fails to do so for combined reasons of poor maintenance, fuel availability and grid bottlenecks. While there are a number of technical failures, it is relevant that regulatory reform is not consistent with international best practice. The federal Ministry of Electricity has regional (North, Central, Euphrates and South) supply, transmission and distribution companies without a strong independent TSO. This results in both a fragmented approach to grid investment and barriers for commercial investors in generation capacity. By way of contrast, the semi-autonomous Kurdistan region, while maintaining a monopoly on transmission and distribution, has been more successful in attracting investment from independent power producers for generation purposes by providing them with access to a regulated and unified regional grid.
- Take early steps to address subsidy reform. In Iraq, subsidies are estimated to cover around 75 per cent of power sector costs, resulting in a \$12 billion per annum drain on state resources and a demand growth rate of 10 per cent per year. Transmission and distribution losses, including theft, are estimated at 40–50 per cent of output, compared to a global average of 8 per cent.²⁸ Many middle-class Iraqi consumers still have to meet high electricity costs because they rely on private 'neighbourhood' diesel-fuelled generators to supplement the grid. Anecdotes suggest that the entrenched position of the 'generator mafia' is preventing effective reform by lobbying the government to maintain subsidies including on diesel, allowing it to be sold at below market prices.
- Exploit renewable resources from the start. Iraq has some hydropower capacity, particularly in its northern provinces and in Kurdistan, but the country is prone to drought risk and maintenance is a widespread issue. Distributed and large-scale grid-connected solar has good potential and is well matched to the summer demand peak, but, apart from small projects and street lighting in Baghdad, deployment has lagged behind the opportunity presented by the fall in costs over the last 10 years. In September 2021 it was reported that the Iraqi government had entered into contracts for solar projects with the French company TotalEnergies and the Chinese state-owned Power China.²⁹

28 Mills and Salman (2020), Powering Iraq.

29 Gross, A. and Cornish, C. (2021), TotalEnergies signs contracts worth \$27bn for oil, gas and solar in Iraq', *Financial Times*, 5 September 2021, https://www.ft.com/content/9e0f98c5-11f0-4ccb-a0e2-b0ff1df9ca1c.

²⁶ World Bank (2020), 'Individual Flare Sites – Gas Flaring Volumes (mln m3/yr) for 2020', https://www.ggfrdata.org. 27 Ibid.

03 Making sense of multiple demands and limited time

Recreating a functioning, accessible electricity sector will require a focus on priorities and 'quick wins'. Addressing the humanitarian crisis, and determining which assets can be rebuilt quickly and economically and which will require new, modern technology, have to be at the top of the list.

> As discussed earlier, the needs and priorities for the restoration of electricity in Venezuela are multiple, and not all of them can be tackled at the same time. Given the complexity of these demands, it will be essential to establish sets of tasks within specific timeframes. Some of the more immediate priorities will need to address humanitarian crises, while others will be longer-term, such as reforming and rebuilding the institutional, legal and regulatory framework for managing the electricity sector. All of this will need to occur as the Venezuelan government seeks international technical and financial assistance and investment from the private sector; many of them will overlap. Table 1 endeavours to group these priorities and tasks. The intent is not to convey a timeline or strict chronology where one set of work needs to be completed before another can begin. In many cases these tasks will need to be conducted in parallel.

Table 1. Priorities and options for action

| Options by priority area | Enabling actions |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Priority: Humanitarian needs – hospitals, schoo | ols and potable water |
| Identify immediate humanitarian priorities Integrate mobile units (rented or permanent) when appropriate Prioritize repair/rebuilding vs new-build options Identify focus areas (e.g. Zulia and Nueva Esparta states, the Andean region and the Central control region) | Establish technical review and procurement unit in advance, before political conditions are conducive to allowing the emergency recovery phase to begin Start an early dialogue with international donors on funding availability |
| Priority: Institutional reform – overcoming stru | ctural and professional decay |
| Establish independent regulatory office/ advisory unit Map generation and transmission requirements Identify new energy sources, including renewables and captured gas Conduct an analysis of the ways in which electricity requirements and reform are to be integrated into broader energy reforms | Create a legal framework for multi-, bilateral and private sector investment in the power sector Identify funding possibilities, including blended and green finance Establish the conditions for the return of Venezuelan sector professionals |
| Priority: Subsidy reform – making the system s | ustainable |
| Take early action to ensure that large businesses pay the full cost of their supply The oil sector should pay the cost of its supply, but in return should be paid for supplying gas Carefully roll back subsidies for small businesses, essential public services and retail consumers | Calculate the realistic cost of generation and transmission – this should be high enough to remunerate new investments Integrate plans for subsidy reform with broader social reforms, such as in wages and transport costs |

Source: Authors' compilation.

Options for rebuilding/restoring service

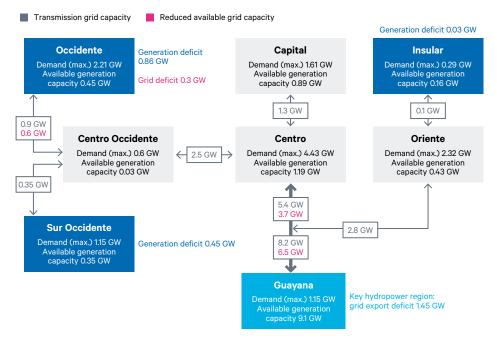
Balancing the use of remote renewables with a degree of grid dependency

Certain types of renewable generation assets are – and will necessarily continue to be – located away from centres of demand. In the case of Venezuela, the most obvious examples are hydroelectric dams which are located on remote rivers. (In contrast, thermal assets tend to be located near to centres of demand, many of which are clustered in the eastern parts of the country.) In future, the optimal location for wind generation is likely to be the northwest coast of the country, for example on the peninsulas of the Paraguaná, in Falcón state, or in La Guajira, in Zulia state³⁰ – both of which are distant from the centres of highest demand. Greater flexibility can be exercised in locating solar installations, depending on land availability. This means that the present and future configuration and status of the high-voltage grid will play a critical role in balancing the system.

³⁰ Venezuelanalysis.com (2010), 'Wind Generation to Represent 10% of Electricity Production in Venezuela by 2025', 11 April 2010, https://venezuelanalysis.com/news/5265.

Figure 2 illustrates the view represented in one report of the status of the electricity network and the key regional control centres and centres of demand in 2018, highlighting the surpluses and deficits across the grids.³¹ In that year, the Guayana region was constrained in its ability to supply the overall system because of grid damage: the situation is thought to have worsened due to the damage which resulted from the 2019 blackouts (as described above). Apart from in Guayana, available generation capacity was below maximum demand, but – apart from in Occidente, Sur Occidente and Insular – there was sufficient grid capacity to bridge the supply gap, if the overall system were adequately supplied. This indicates that repairs to the grid from Guayana and to Occidente should be given priority, as well as repairs to generation assets in the control regions of Occidente, Sur Occidente and Insular.

Figure 2. Key control regions and centres of demand in Venezuela's electricity supply network 2018, by surplus/deficit



Source: Study conducted by Venezuelan experts, 2019. Note: Deficits and surpluses are calculated taking available grid capacity into account.

Note. Denotes and surpluses are calculated taking available grid capacity into accou

Supplementing existing infrastructure

One report identifies a number of key areas in which the placement of rapid-response generation (*generación de respuesta rápida*) should be a priority.³² The analysis bases its recommendations for the placement of such generators on a series of factors, including: the greatest need for electricity; the possibility for fuel to be delivered; access to transmission and distribution networks, and the capacity to repair them when necessary; and the possibility for installing large generation units to achieve economies of scale. Based on the report's criteria, the states with the greatest needs

³¹ The cited report was prepared by subject-matter experts with proven professional experience in power generation in Venezuela, and was shared with the authors of this research paper on the condition of anonymity. **32** Ibid.

and offering the most favourable opportunities for rapid-response generation are Mérida, Nueva Esparta, Táchira, Trujillo and Zulia.

It should be noted that the recommendations contained in this research paper are based on a different set of priority factors, including the existence of significant humanitarian needs and of opportunities for co-produced gas in oil-producing areas. In some cases, this may involve renting units, although this should only be done within the framework of an analysis of long-term options and cost-effectiveness. As the following argument demonstrates, there are viable attractive options that draw on renewables.

Options for small, ready-to-use units for local needs

One option that is now both technically and economically attractive in the Venezuelan context is the complete local electricity system, or microgrid. A microgrid uses small generators sited close to where the electricity is used, with a distribution network sometimes under local control. The system may use diesel or gas-engine generation, often in cogeneration mode – i.e. generating not only electricity but also steam or hot water – or even trigeneration, adding an absorption chiller for refrigeration and air-conditioning purposes.

Using technologies that can be small, modular and portable, and that can be installed quickly, microgrids are rapidly assuming a significant role in humanitarian relief measures across the wider region.

Renewable self-generation or microgrid generation may include solar photovoltaic (PV) panels, small-scale wind turbines or even, in suitable locations, microhydropower systems, coupled with batteries to extend operating hours. A microgrid may have a back-up connection to a larger high-voltage system, but the microgrid will usually be capable of operating in 'island' mode, with no such connection. Microgrids can be set up rapidly and operate independently. They are therefore especially valuable for emergency circumstances and critical loads such as hospitals and water-supply plants.³³ Other suitable locations include universities, hotels, airports, ports, military bases, shopping centres, and indeed entire neighbourhoods and villages. Microgrids have also demonstrated impressive resilience in difficult conditions, keeping a locality's lights on during storms and hurricanes.³⁴

Using technologies that can be small, modular and portable, and that can be installed quickly, microgrids are rapidly assuming a significant role in humanitarian

³³ Hirschbold, M. and Haun, A. (2019), *How new microgrid designs help hospitals increase resilience, cut costs, and improve sustainability*, Research Paper, Schneider Electric, https://microgridknowledge.com/wp-content/uploads/2020/05/998-20588515_GMA-Hospital-microgrids.pdf.

³⁴ S&C Electric Company (2018), *Is a microgrid right for you*?, Research Paper, https://microgridknowledge.com/ wp-content/uploads/2020/05/Is-a-Microgrid-Right-For-You.pdf; Baier, M., Bhavaraju, V., Murch, W. and Teleke, S. (2017), *Making microgrids work: Practical and technical considerations to advance power resiliency*, Research Paper, Eaton, https://microgridknowledge.com/wp-content/uploads/2020/05/Making-Microgrids-Work-to-Advance-Power-Resiliency.pdf.

relief measures across the wider region. They have been deployed with particular success, for example, in Puerto Rico, after the destruction caused in September 2017 by Hurricane Maria. Their deployment not only helped to provide an emergency response, but also served to decentralize the electricity grid, making it more sustainable.

Box 2. Restoring a damaged system: the example of Romania in the 1990s

Before the collapse of the Ceaușescu regime in 1989, Romania resorted to the central planning of its energy system, with disastrous results - much as the government of Venezuela has done in recent years. In the 1980s President Nicolae Ceaușescu decreed that Romania was to achieve 'energy independence'; but the country's decisions increased its dependence on fuel imports, and fuel had to be imported in exchange for hard currency, which was already scarce in the country. A vast bureaucracy was assigned to establish quotas, and to allocate fuels and electricity to producing exports and to various industries, with punishments being imposed when quotas were missed or exceeded. Decisions were made centrally, often by those without the necessary competence to make them. The population, which was left out of the quota system, suffered. Power generation plants were old and inadequately maintained, with no spares. The country's functional generation capacity was far below the nominal capacity, and the thermal plants created severe pollution - much like their present-day Venezuelan counterparts. Official information about the system was either falsified or simply not available. Skilled engineers existed (as they do today in Venezuela): while they knew what work should be carried out, they were not permitted to do it, and were effectively forced to lie.

After the fall of Ceauşescu in December 1989, the new government, with the help of the EU and the European Bank for Reconstruction and Development, reorganized the energy sector into an array of government departments with separate responsibilities, appropriate competence and a degree of independence: a model that could potentially be adopted by Venezuela. In the case of Romania, however, the various departments failed to communicate effectively with each other, well into the 1990s: the habit of secrecy proved hard to break. On the other hand, individual engineers had the freedom at last to express their opinions and to disagree openly with each other. Active debate on energy policy became lively, even heated.

An important step was to clean and clarify official statistics on the energy and electricity sector, and to make these statistics public. During the reconstruction, efficiency was a central theme for the government and for reformers, with the message being that improving supply made little sense if users were still wasting it. To this end, the government created the Romanian Agency for Energy Conservation, which published data and identified opportunities for improvement across supply and use, working with multilateral banks, international corporations and private investors on individual projects. The lesson for Venezuela is that a high degree of efficiency can be achieved at low or no cost, simply by inculcating a culture of switching off appliances and general 'good housekeeping': however, such a culture of efficiency is hard to promote if electricity is free at the point of use. The establishment of fair and equitable tariffs was a sensitive and difficult political challenge in Romania, and needed to be pursued slowly. Much the same will apply in Venezuela.

Funding: a critical issue

Before considering recommendations for policy priorities, it is essential to identify potential sources of funding to support the multiplicity of requirements faced by Venezuela in planning the rebuilding and recreation of its electricity sector. In the early emergency and repair phases (see Introduction) the electricity sector will need to compete with other humanitarian priorities for limited multilateral development bank (MDB) funds. In the longer term, in preparation for reform and new-build phases, it will be necessary to attract commercial investment into the sector, probably in a blended model that incorporates MDB political risk cover. However, this will only be possible if legislation is developed that enables key governance and regulatory reforms to be enacted: these reforms should include the establishment of an independent TSO that enables generation companies to access customers and bankable offtake agreements, as well as a plan to phase out subsidies. In mid-2021 the International Energy Agency (IEA) set out key steps to supporting the financing of the energy transition in emerging and developing economies: these included examples from the Latin American region.³⁵ Coordination with oil and gas sector plans will be important to secure fuel supply and to ensure the sector either pays the full economic cost of power supply or reduces the load on the system by installing on-site generation. At the same time, the aggressive incorporation of plans for the restoration of existing renewable energy sources and the integration of new ones may open up the possibility of the involvement of international financial institutions and private sector 'green finance' sources.

Box 3. Energy access and displacement in Venezuela

Over 5.4 million Venezuelans live outside their country of origin: the current wave of displacement is the largest in the recent history of Latin America and the Caribbean.³⁶ While there are relatively few internally displaced people in the country at present, more than 32 per cent of Venezuela's population is estimated to be moderately or severely food-insecure. Malnutrition and hunger are rife.³⁷

Sustainable Development Goal (SDG) 7 ('Ensure access to affordable, reliable, sustainable and modern energy for all') commits the world to achieving universal access to modern energy services by 2030. However, refugees and displaced people are among those most likely to be left behind.³⁸ Many of the Venezuelans who have crossed borders to seek refuge in informal settlements in Colombia, Brazil and elsewhere are likely to encounter issues finding fuel to cook food, as well as electricity to facilitate a wide range of tasks from lighting their homes to charging their mobile phones and powering

³⁵ International Energy Agency (2021), *Financing clean energy transitions in emerging and developing economies,* IEA Flagship Report Extract, https://www.iea.org/reports/financing-clean-energy-transitions-in-emerging-and-developing-economies.

³⁶ Inter-Agency Coordination Platform for Refugees and Migrants from Venezuela (2021), *Refugee and Migrant Response Plan 2021*, https://rmrp.r4v.info. See also Office of the United Nations High Commissioner for Refugees (2021), 'Venezuela Situation', https://www.unhcr.org/uk/venezuela-emergency.html.

³⁷ World Food Programme (2019), *Venezuela Food Security Assessment*, https://reliefweb.int/sites/reliefweb.int/files/resources/Main%20Findings%20WFP%20Food%20Security%20Assessment%20in%20Venezuela_January%20 2020-2.pdf.

³⁸ Grafham, O. (ed.) (2019), Energy Access and Forced Migration, Oxford: Routledge.

their businesses.³⁹ Current surveys suggest that those who are internally displaced within Venezuela – as well as those remaining at risk of displacement – are struggling with many similar challenges, particularly with obtaining power and fuel for cooking.

In the past, energy requirements have rarely been factored into humanitarian response.⁴⁰ But this is beginning to change at global level, as humanitarian agencies begin to ramp up efforts to implement sustainable energy provision in their operations, especially where there is government support and available financing linked to national SDGs and climate resilience.⁴¹ This paves the way for collaboration with national and local governments. Host country policy measures and donor interventions can create favourable conditions for energy projects, for example by providing clarity about whether settlements and camps can – or will – be connected to a national grid. Another way is by encouraging the creation of large-scale renewable energy assets which can power humanitarian operations and eventually be transferred to the ownership of national and state governments, and local communities, as has occurred in Jordan, Kenya and elsewhere.

Note: Thanks go to Owen Grafham, assistant director of Chatham House's Environment and Society Programme, for this analysis.

Establishing priorities

It is no exaggeration to state that Venezuela's electricity crisis is multifaceted and complex, and its resolution will require several issues to be addressed simultaneously. Key areas of focus will include rebuilding the basic functions of an operating state, such as a professional public administration; depoliticizing the security forces; and establishing the independence of key institutions such as the judiciary, the central bank, and the public accounting and statistics offices. Nevertheless, there is a general set of semi-phased priorities, given the urgency of humanitarian requirements, the demands of ramping up energy production to restore the economy and to generate hard-currency export earnings for the government, and general public needs – such as transport and education services, and regular access to electricity for citizens, not least to renew their faith in government. The capacity of the national government to provide accessible electricity to key business sectors and to citizens will be one of the key criteria by which Venezuelan citizens will evaluate that government's legitimacy and decide whether to give it their political support.

Figure 3 presents an illustration of the key phases into which the reform process could be organized. The text which follows provides additional detail on each phase.

³⁹ Lehne, J., Blyth, W., Lahn, G., Bazilian, M. and Grafham, O. (2016), 'Energy services for refugees and displaced people', *Energy Strategy Reviews*, 13–14, pp. 134–46, https://doi.org/10.1016/j.esr.2016.08.008; Global Platform for Action (2020), 'Helping the UN cut down on fossil fuels by de-risking energy service contracts', 8 September 2021, https://www.humanitarianenergy.org/news/latest/helping-the-un-cut-down-on-fossil-fuels-by-de-risking-energy service-contracts.

⁴⁰ Lahn, G. and Grafham, O. (2015), *Heat, Light and Power for Refugees: Saving Lives, Reducing Costs*, Chatham House Report for the Moving Energy Initiative, London: Royal Institute of International Affairs, https://www.chathamhouse.org/sites/default/files/publications/research/2015-11-17-heat-light-power-refugees-lahn-grafham-final.pdf.

⁴¹ Global Platform for Action (2021), 'Leaving (really) no one behind: Energy Access in Fragile and Conflict Affected Areas', 5 July 2021, https://www.humanitarianenergy.org/what-is-the-gpa/resources-and-tools/ leaving-really-no-one-behind-energy-access-in-fragile-and-conflict-affected-areas.

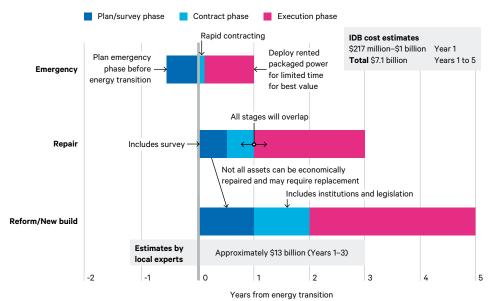


Figure 3. The electricity sector reform process: an indicative timeline

Sources: Plan País; IDB (2020), A Look to the Future for Venezuela; and authors' estimates.

- Recovery phases: Simultaneous recovery phases (labelled in Figure 3 as Emergency, Repair and Reform/New build) will run in parallel; within these broad strands, shorter phases dedicated to planning and surveying, contracting and execution will overlap, or will have flexible boundaries. They should not be seen as sequential. Nonetheless, it is useful to describe tasks as belonging to such phases, because they have different time horizons, and actions are likely to be allocated to different groups: for example, the project manager tasked with emergency and repair work will not be the same one who is tasked with considering and drafting proposals for legislation to facilitate long-term reform.
- Emergency phase (to be initiated immediately upon transition, in the first year):
 - In order that 'emergency' actions can be initiated immediately upon transition, it would be helpful if high-level planning and survey work is completed in advance of transition, as indicated in Figure 3. As well as identifying priority locations for temporary power generation, this work should include a finance plan and draft contract structures. Providers of temporary power units have indicated that those units could be deployable within months, if there is a clearly articulated requirement backed up with available finance. The IDB has recommended the establishment of a project management team to oversee this process. One possibility would be to explore the use of public–private partnerships to accelerate investments and developments in these areas.
 - An independent study conducted in Venezuela identified priority states and regions for the deployment of rapid-response generation: specifically, in Nueva Esparta and Zulia states, the Andean region and the Central control regions.⁴² These broadly correspond to the deficit regions denoted in Figure 2, with

⁴² The cited report was prepared by subject-matter experts with proven professional experience in power generation in Venezuela, and was shared with the authors of this research paper on the condition of anonymity.

the addition of Centro Occidente, where there is very limited availability in generation capacity. There is likely to be a tension in terms of affordability between rapid response generation to supply the grid and an approach where temporary power is targeted for specific critical installations such as hospitals and water-pumping facilities. The scale of the generating units is different in each case: the output of a typical standby generator supplying a large hospital is 2–3 MW, while a unit with an output of 15 MW upwards would be required for a typical grid installation. Because of the high cost per megawatt hour (MWh) of rented temporary power, any deployment should be linked to a clear plan to refurbish assets and phase out temporary power provision. If a generating asset is needed for long-term use, it is better value to purchase rather than rent.

- Faults on the grid between the Guayana and Centro/Oriente control regions are preventing the supply of 1.45 GW, or around 12 per cent of current peak supply, of low-cost hydroelectric power to the wider grid (Figure 2). Investigating possibilities for quick-win repair options should be a priority, as should restoring the capability of the national dispatch centre to manage the grid.
- Repair phase: medium-term (first three years):
 - The repair phase should begin with a thorough stocktake of the operational status of the current system and the identification of areas where capacity-building, providing spare parts, carrying out repairs and supplying fuel could make an immediate difference. As mentioned earlier, some of these steps could be initiated if there is sufficient political will within the government, as well as agreement within the international community to support such efforts. Consideration should be given to retaining the IDB-proposed project management team for this work to facilitate coordination with the emergency phase.
 - Plans should be executed to repair and refurbish the current system, including the completion of any viable assets that are part-built (e.g. Tocoma). Termozulia is a key CCGT asset but its maintenance status is unclear. Contractual disputes may complicate these processes. If assets cannot be economically repaired, this should be recognized and longer-term replacement options evaluated, including solar and wind. Hydroelectric assets may take longer to repair than thermal assets. Although safety reviews are needed at some dams, grid connections could be restored relatively quickly.
 - Coordination with oil and gas plans is a key part of this phase, as some assets are inoperable because of fuel shortages. Where possible, gas should displace diesel/fuel oil on both environmental and economic grounds. This may involve selective investment in gas infrastructure. The justification for this investment is strengthened if it can be linked to reductions in flaring – here, the World Bank Global Gas Flaring Reduction Partnership could be supportive. The expectation should be set that the oil and gas sector should invest in on-site generation, particularly where co-produced gas is available.

- Although subsidy reform is a long-term project, immediate steps can be taken towards reducing subsidies for industrial and commercial users. Reducing non-technical losses would also be helpful in laying the groundwork for subsidy reform, even if many formal accounts pay only nominal charges. In 2017 the independent study cited above estimated that 35 per cent of supply went to residential customers and 28 per cent to industrial or commercial users, with losses accounting for the remaining 37 per cent.⁴³ Progressive increases to a wholesale tariff of \$25–\$35 per MWh should recover current operating costs without encouraging grid disconnection, although higher tariffs may be needed to remunerate new investment in generation and grid-strengthening.
- Reform and new build phase: long-term (five or more years):
 - The focus of the reform and new build phase will be the regulatory and governance reform that provides the framework for an electricity sector that is self-financing and provides good value for customers, and where both replacement and new capacity are consistent with the objectives of the global energy transition. As indicated by Plan País, the regulatory and governance changes are likely to need a new Organic Law of the Electricity Sector, although an emergency regulation may suffice during the above, shorter-term, phases. The development of the legal framework regarding electricity provides two important opportunities. The first is to better integrate electricity sector reform with the reform of the legal framework to ensure coherent, productive coordination across those sectors. The second is political: rewriting the fundamental legislation that guides both sectors to improve productivity and delivery for citizens may provide a unique opportunity for political cooperation and consensus-building.
 - Best practice in international governance for electricity generation, delivery and management is widely understood as a system that is largely independent of political preferences by the state or by private owners. Key building blocks include a ministry to set high-level policy, an independent regulator for the sector, an independent TSO to run the natural monopoly of the grid, and state or private corporations providing generation and distribution, preferably with competition (especially in generation). Currently all these functions lie within the remit of CORPOELEC, where the minister of electrical energy was also president until May 2020. While the full unbundling of CORPOELEC is likely to be a long-term project, it is suggested that establishing an independent TSO should be an early priority to facilitate progress.
 - Long-term subsidy reform is critical for the sustainability of investment in the sector: the example of countries such as Iraq shows that if this issue is not addressed early in the process, investment becomes beholden to government budget pressures and oil price fluctuations. In the medium-term repair phase it is suggested that industrial and commercial customers should be moved progressively to tariffs that recover the cost of supply. However, for retail customers there is a more delicate balance, between ensuring affordability

⁴³ The cited report was prepared by subject-matter experts with proven professional experience in power generation in Venezuela, and was shared with the authors of this research paper on the condition of anonymity.

for the poorest while also ensuring that high charges for the middle class and wealthy do not incentivize them to go off-grid – and to not then be concerned about broader access to quality service. The IDB has set out the challenges in arriving at a fair and sustainable tariff structure, as well as how to balance fixed and variable charges.⁴⁴ Given Venezuela's chronic historical deficiencies in bill collection in this sector, greater attention will need to be devoted to establishing an effective and fair structure for assessing and collecting fees.

 Venezuela must plan for future investment in generation capacity, particularly in wind and solar power, which could improve system resilience to drought conditions and reduce both oil consumption and carbon emissions. As mentioned above, green finance funding – potentially combined with other sources – is a resource which in the future Venezuela could tap, both for the restoration of its hydropower sector and for upgrading the energy mix to integrate solar and wind power. The IEA, in its 2021 Hydropower Special *Market Report*,⁴⁵ highlighted that the share of generation accounted for by hydropower across Latin America is relatively high, at 45 per cent compared to a global share of 16 per cent, but cautioned that any expansion should be selective and should prioritize projects that can store energy, rather than those exposed to drought risk, which particularly affects run-of-river projects. In Venezuela, some initial research has been carried out on the potential for solar installations in the northwest, and there are two non-operational wind assets in Falcón and Zulia states. For both solar and wind renewables, the principle of using auctions to promote competition for supply has been used successfully across the Latin American region in Brazil, Chile, Colombia and Mexico, but such success is dependent on the ability of these renewable sources of electricity to access the market and bankable offtake.⁴⁶ Because most wind resources tend to be located on the coast, far away from centres of demand, investment in those facilities will have to be coordinated with investment in grid strengthening. In the long term, as liquid-fuelled thermal assets reach the end of their economic life, their generating capacity should be replaced in the form of renewables. The same may apply to gas-fired assets: however, there is only an environmental gain if any gas displaced is not flared.

A common theme among the analyses discussed in this paper is that historic mismanagement on the part of Venezuela's regime is the sole source of unreliability in the country's electricity system. That view, however, may not take into account other factors, such as progressive climate change or the availability of new technology options, and could hinder consideration of how to achieve certain improvements in the future. Examples might include strengthening the grid, better integrating hydropower and intermittent renewables such as wind and solar, establishing smaller units within microgrids, reducing future dependence on thermal assets as they reach the end of their lives, and improving resilience to climate change.

⁴⁴ Cavallo, E., Powell, A. and Serebrisky, T. (2020), *From Structures to Services: The Path to Better Infrastructure in Latin America and the Caribbean (Executive Summary)*, Inter-American Development Bank, https://publications. iadb.org/en/from-structures-to-services-the-path-to-better-infrastructure-in-latin-america-and-the-caribbean-executive-summary.

⁴⁵ IEA (2021), *Hydropower Special Market Report: Analysis and forecast to 2030*, https://www.iea.org/reports/ hydropower-special-market-report.

⁴⁶ IEA (2020), Renewables 2020: Analysis and forecast to 2025, https://www.iea.org/reports/renewables-2020.

04 Recommendations

The first step in the inevitably long process of rebuilding Venezuela's electricity sector will be to initiate a dialogue with the multiple stakeholders, aiming to develop a flexible programme of priorities for electricity and to plan how it can be integrated with energy production.

> In conducting the background research for this paper and interviewing key informants, three key observations emerged. The first was how much remains unknown about the current operational state of Venezuela's electricity system. Even the information contained in the most recent studies (such as the two IDB reports cited above) risks being out of date, since there are known to have been developments that indicate the further degradation of the system. In addition, official statistics and reports are generally unreliable. The second notable point is the complexity and uniqueness of Venezuela's electricity crisis: more broadly, this reflects the overall collapse of the Venezuelan state, but there are a number of sector-specific issues. These include equipment malfunction and misuse; a lack of maintenance; corruption; the use of inappropriate fuels to power thermal plants; drought, which has affected the country's considerable hydro base; the insufficient capacity among both technical staff and state management; and the centralized, politicized state-centric structure that oversees the entire system - and does so within the context of the dire humanitarian crisis that the country is suffering. The third significant factor is the sheer range of stakeholders, local experts and engineers, potential donors and advisers, and private sector interests and investors that will need to be involved in the reform process.

For this reason, an initial recommendation is that a process of broad discussion about the contours of the current electricity crisis in Venezuela will need to be relaunched. This will include consideration of the actors that will need to be involved, the potential pitfalls (some of which may well parallel those described in the case studies on Iraq and Romania – see Boxes 1 and 2) and options for upgrades and 'easy wins'. This is a discussion that – even given what is still unknown about the current context – can start immediately. As a first priority, participants will need to focus on the points that follow.

- Discuss with MDBs priorities for the power sector and resources that may be available, taking into account other humanitarian objectives. Ahead of any project start, formulate an emergency plan with agreed financing and a contracting strategy that can be implemented by a dedicated project management team in the first couple of months, when there is political will.
- Ensure close integration between plans for the oil and gas and power sectors, particularly plans for gas supply.
- Identify critical gas treatment and pipeline infrastructure repairs and flaring reduction opportunities. The former should include repairing the grid from Guayana control region, operating the Termozulia CCGTs, completing the Tocoma dam and restoring grid control operations at the national dispatch centre.
- Plan for the long-term reform of the structure and regulation of the sector, including necessary legislation. However, certain immediate actions should be prioritized for quick implementation, such as unbundling CORPOELEC and forming an independent TSO.
- Make an immediate start on eliminating subsidies for commercial and industrial customers, and indicate the path for assessing and collecting tariffs for residential customers. Any effort to roll back subsidies, however, should be done in a carefully calibrated fashion so as not to increase pressures for the country's debilitating hyperinflationary crisis and reduce access to electricity for small businesses and individual consumers. Plans for residential customers will take time and will require consultation to avoid a disproportionate impact on the poorest.
- Finally, it will be important to set the expectation that new electricity generating capacity, with the possible exception of gas that is low-cost or diverted from flaring, will consist of solar or wind renewables. The standards regarding renewable generation should be established before auctions are initiated, to ensure that the bids and costs are competitive. Liquid-fuelled thermal assets should be phased out at the end of their economic lives on cost and environmental grounds, and hydro assets should be operated, but with an eye towards drought risks.

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