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Electricity Supply Interruptions in the Philippines: Characteristics, Trends, Causes

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Abstract

Electricity serves as a vital input to modern economies. Many critical infrastructures such transportation, telecommunications, banking, among others, depend on continuous supply of electricity to perform their functions. However, as modern economies continue to move towards digitalization and adoption of technologies, part of the population still deals with electricity supply interruptions, which greatly hinders productivity. In this study, we analyzed the monthly interruption reports of Electric Cooperatives submitted to the National Electrification Administration to uncover some interesting trends related to electricity supply interruptions in the Philippines. The analysis provides a fundamental landscape for understanding the intricacies of supply interruptions for the benefit of formulating more appropriate and realistic policy recommendations for the power sector. It also sets direction for future research work. Overall, the results of this study show that the causes of electricity supply interruptions in the country can be broadly categorized into environment, supply, and technical issues.

Keywords: electric power industry, electric cooperatives, electric power infrastructure, power interruptions, electricity supply, energy policy

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1. Introduction

Electricity powers modern economies. It serves as a crucial input in the production process of many sectors and industries, and it allows households to be more efficient and able to devote time to more productive activities. As the world becomes increasingly dependent on electricity, the value of having a reliable supply becomes much more apparent. Studies explain that having a continuous supply of electricity is important because of the interdependencies between the power supply sector and critical infrastructure such as transportation, banking services, telecommunications, and the like; wherein a failure in the power supply system would greatly disrupt the operation of the whole economy (Poudineh and Jamasb 2017, Kjølle et al. 2012).

Electricity supply interruptions send ripple effects to other sectors of the economy, and this ultimately leads to economic losses. A major blackout that occurred in the United States in 2003, for instance, resulted to the stoppage of traffic lights and computer systems, disruption of train and subway operations, interruption of banking services, and cancellation of school and sports events (Min et al. 2007). Similarly, the Northeastern Interconnection power outage that occurred in Canada in 2003 constrained the following economic activities: banking services, wastewater treatment, traffic light operation, highway sign function, gas pumps, food distribution, internet services and firewalls; that affected around 50 million people (Public Safety and Emergency Preparedness Canada 2006). The cascading effects to many sectors of the economy tend to inflate the economic cost of a power failure, which several studies have attempted to quantify. The power failure in France that lasted for 2 hours and 15 minutes, was estimated to cost around 1 billion US dollars of lost production (Sanghvi 1982). Meanwhile, the electricity supply rationing in Ethiopia in 2010 has resulted to an economic loss equivalent to 3.1 percent of its GDP (Engida et al. 2011).

Electricity-dependent firms experience the direct impact of unreliable electricity supply. Studies (Bajo-Buenestado 2020, Steinbuks and Foster 2010, Oseni and Pollitt 2015) discuss that the revenue losses of firms stem from their inability to utilize their full production capacity because of electricity supply issues. Fisher-Vanden et al. (2015) found that the production cost of firms in China was 8 percent higher because of electricity shortages. The average output of manufacturing firms in India was also noted to be lower by about 5 to 10 percent due to unstable electricity supply (Allcott et al. 2016). The analysis of Grainger and Zhang (2019) similarly showed that unexpected power outages in Pakistan reduces the annual revenue of firms by 10 percent as well as their annual value-added to the economy by 20 percent. Unfortunately, the impact of unstable electricity supply also cascades down to the employees of the firms. Burlando (2014) showed evidence that the month-long power outage in Tanzania resulted to a temporary drop in working hours that eventually reduced the earnings of workers in electricity-dependent sectors.

The effect of unreliable supply of electricity likewise impacts household expenditures. When electricity is erratic, households tend to purchase generators, candles, kerosene, liquefied petroleum gas, and the like, increasing household monthly expenditure on alternative sources of energy. Households also experience loss of leisure time, inconvenience, and environmental costs (Meles 2020). Bhatia and Angelou (2015) note that a general consequence of unreliable power supply is the reduced electricity consumption of households, depriving them of the full benefits of having electricity connection. The study of Chakravorty et al. (2014) demonstrates how detrimental power outages are for household productivity, wherein he found that the non-agricultural income of households that did not experience power outage is actually 19.6 percent higher.

Taken as a whole, the socio-economic cost of unreliable electricity is certainly huge. Unfortunately, many provinces in the Philippines are still experiencing frequent electricity supply interruptions despite the reforms in the power sector. Over the years, the country was able to expand its power generation capacity, however, the fast-growing electricity demand is causing some major stress during peak-power demand months resulting to widespread blackouts and electricity supply interruptions. This study is a first of a two-part study that aims to uncover some interesting trends related to electricity supply interruptions in the country, and eventually examine how these events relate to some performance indicators of local economies. The main goal of this first paper is to characterize specific features of electricity supply interruptions, by addressing the following policy questions:

- How frequent do electricity supply interruptions occur in the country?
- Are there areas that experience greater electricity supply interruptions than others?
- What issues or challenges are causing these interruptions?
- What gaps are needed to be addressed to minimize electricity supply interruptions?

Having better knowledge on the characteristics of electricity supply interruptions and how they impact specific sectors of the economy will be useful in planning and policymaking with regards to public investments that would help avoid disruptive supply failures. This study will serve as a valuable reference for policymakers, stakeholders, researchers, students, and members of the general public interested in understanding the issues in the power sector that are affecting the reliability of electricity in the country.

2. Background

History and Structure of the Electric Power Sector

The Philippine electric power industry used to be dominated by the National Power Corporation (NPC). The NPC was initially created in 1936 as a non-stock public corporation, tasked to develop the country's hydroelectric power. In 1960, it was converted to a stock corporation wholly owned by the government by virtue of Republic Act (RA) 2641. To hasten the electrification of the whole country, especially in the rural areas, Presidential Decree (PD) 40 in 1972 identified the NPC as the authorized implementing agency of the State with the responsibility of setting up of transmission line grids as well as the construction of generation facilities in Mindanao and Visayas. Hence, the NPC owned and controlled majority of the country's power generating utilities and it also acted as the transmission operator and sells wholesale electricity to distribution utilities. Privately-owned generating facilities operating within the area embraced by a grid setup by the NPC were required to apply for a permit to remain in operation. These entities sell bulk of their generated power to NPC. In isolated areas not covered by the NPC, electric cooperatives, private utilities, and local governments were allowed to own and operate isolated grids and generation facilities but were subject to government regulation. Meanwhile, the distribution of electric power by the NPC was carried out by electric cooperatives, private utilities, local governments, and other entities duly authorized, under government regulation.

In the 1970s and 1980s, issues such as mismanagement, high debts and deteriorating services were affecting the electric power sector (ADB 2018). The shelving of the Bataan Nuclear Power Plant along with the slow development of alternative sources of power at the time, highly compromised the availability of electric power in the country. In the face of increasing public demand for electricity, these events eventually led to frequent power outages in the early 1990s that would last more than four hours a day, on average[1]. To mitigate the crisis, the government enacted RA 7648, also known as the Electric Power Crisis Act of 1993, which prescribes necessary and urgent measures to effectively address the issues. RA 7648 authorized the President to enter negotiated contracts related to the construction, repair, rehabilitation and maintenance of power plants, projects and facilities with the ultimate goal of increasing the country's total power generation capacity. The expansion of the Build-Operate-Transfer Law in 1994, further increased private sector participation in the construction of power stations. By 1997, the NPC signed around 37 government-backed Power Purchase Agreements with independent power producers (ADB 2018), expanding the country's power generating capacity.

In 2001, a move to revamp the electric power industry to achieve quality, reliability, security, and affordability of electric power supply in the country was facilitated through RA 9136 or the "Electric Power Industry Reform Act". The EPIRA law restructured the electric power industry into four main sectors, namely: generation, transmission, distribution, and supply (Figure 1). The *generation sector*, as opposed to pre-EPIRA period, was allowed to be competitive and open.

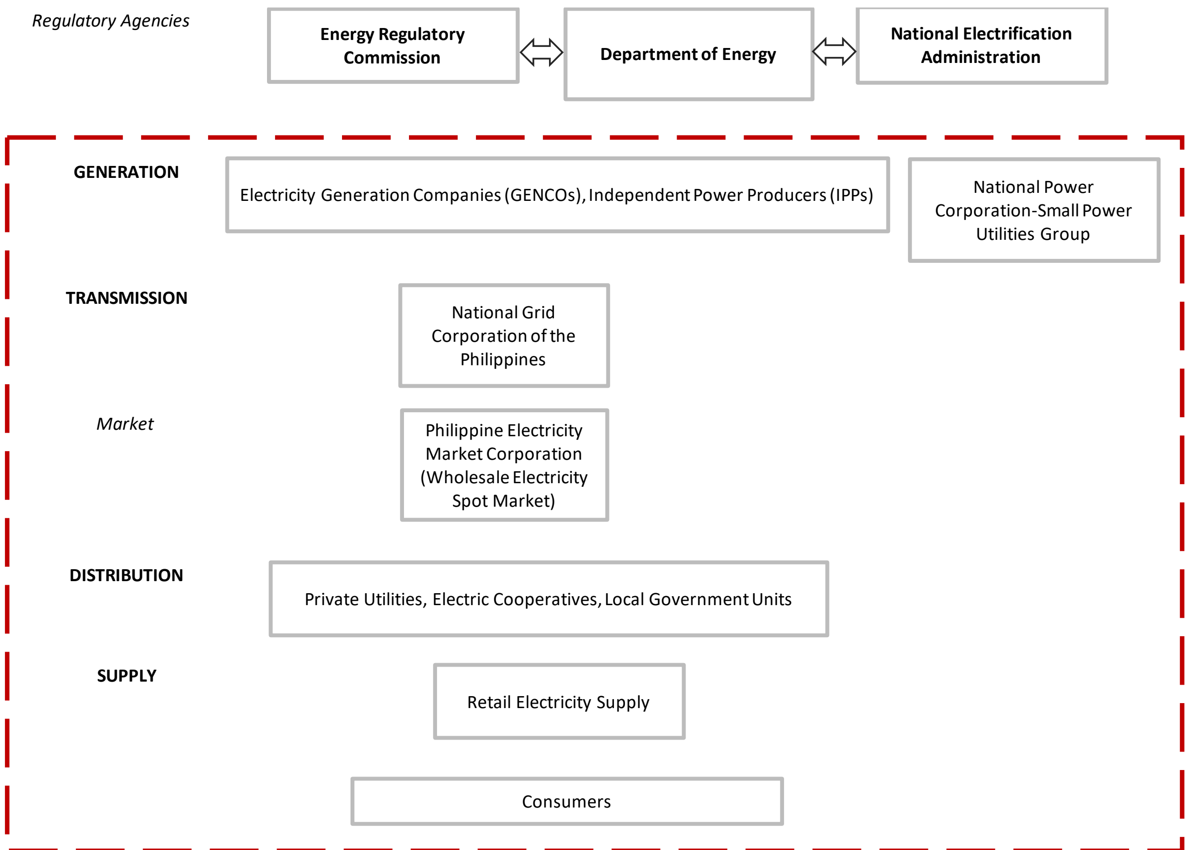
[1] (Ronald E. Dolan, ed. Philippines: A Country Study. Washington: GPO for the Library of Congress, 1993)

Power generation was no longer considered a public utility operation. Thus, companies engaged in power generation activities (ex. GENCOs, IPPs) were alternatively required to secure a certificate of compliance from the Energy Regulatory Commission (ERC) instead of a national franchise. The *transmission sector* remained a regulated common electricity carrier business, under the regulation of the Energy Regulation Commission (ERC). The electrical transmission functions of the NPC, i.e., the planning, construction, operation, and maintenance of high voltage transmission facilities including grid interconnections and ancillary services, were transferred to the National Transmission Corporation (TRANSCO) that was created under the EPIRA law. All NPC assets related to transmission operations, including the national franchise of NPC for the operation and transmission system and the grid were transferred to the TRANSCO. Conversely, all transmission and sub transmission related liabilities of the NPC were assumed by the Power Sector Assets and Liabilities Management Corporation (PSALM Corp.). TRANSCO is wholly owned by the PSALM Corp. At present, the National Grid Corporation of the Philippines (NGCP) is in-charge of the operation, maintenance, and development of the government-owned power grid through a concession agreement. The government retained ownership of the transmission assets through TRANSCO but has granted a 25-year franchise to NGCP. The NGCP started its operations in 2009. Meanwhile, the NPC remained as a government-owned-and-controlled corporation, but its mandate was revised to energizing off-grid areas and islands in the country through its Small Power Utilities Group (SPUG) power generating plants.

The *distribution sector* is still considered a common carrier business, which requires a national franchise. The Congress of the Philippines has the exclusive power to grant franchises to companies engaged in transmission and distribution of electricity. The distribution of electric power to end-users were assumed by electric cooperatives, private distribution utilities and local government units, subject to the regulation of the ERC. Finally, the *supply sector* is under the regulation of the ERC. All suppliers of electricity were required to obtain a license from ERC and prove their technical and financial capability as well as their creditworthiness.

A wholesale electricity sport market (WESM) was established under the EPIRA law. This market is composed of wholesale sellers and purchasers of electricity and is under the regulation of the Department of Energy (DOE). The WESM provides the mechanism for identifying and setting the price of electricity that are beyond the contracts of sellers and purchasers. Additionally, the EPIRA law allowed the National Electrification Administration (NEA), the government agency tasked to regulate electric cooperatives, to act as their guarantor for purchases of electricity in the WESM to support their credit standing. NEA's capital stock was increased to 15 billion PHP for this purpose. DOE was the main agency identified to supervise the restructuring the electric power industry. Its role is to come up with policies for the planning and implementation of a comprehensive program for the efficient use of energy. Part of its directive is to develop and annually update the Philippine Energy Plan and the Power Development Program.

Figure 1. Structure of Electric Power Sector under EPIRA



Electrification in the Philippines and the role of Electric Cooperatives

While the government highly recognizes the value of electricity in spurring development throughout the country, the emphasis of policies is generally towards expanding electricity access to the population and little attention has been given to improving the reliability of electricity supply. In 1960, it was declared a national policy to provide affordable and dependable electric power and facilities, especially in rural areas. The enactment of Republic Act 2717 was instrumental in realizing this goal, which led to the creation and establishment of the Electrification Administration (EA). Through RA 2717, the EA was authorized to (a) incur loans for the electrification of rural areas; (b) plan, coordinate and supervise production, transmission and distribution systems for electric power; (c) conduct studies/reports/investigations related to the status and progress of electrification in the country; (d) encourage and assist local governments and associations of electric consumers to take on the public service of electric power; and (e) publish and disseminate information related to electricity. This move was intended to facilitate agricultural and industrial development within the country. From its establishment until 1969, the EA was able to assist the creation 217 local distribution systems all over the country; though many of these did not survive due to technical, financial, and managerial issues (Patalinghug 2003). By 1969, the National Electrification Administration (NEA) was created to replace the EA and take on the national policy objective of total electrification on a coverage area basis, through RA 6038. To achieve the total electrification target, the government leaned on the electric cooperatives (ECs), following the success of two pilot studies conducted by the National Rural Electric Cooperative Association (NRECA) of the United States, funded by the U.S. Agency for International Development (USAID).

With RA 6038, ECs were effectively the government's partner in electrifying rural areas all over the country. NEA was tasked to support ECs in planning, developing, coordinating, establishing, operating, as well as maintaining, repairing, and renovating facilities that are required for supplying electricity service, among others. Since most ECs carry heavy financial burdens due to their non-profit nature, NEA was also mandated to make loans to ECs for the construction or acquisition of properties, equipment, machinery, fixtures, and materials related to generation, transmission, and distribution activities. Presidential Decree (PD) 269 further strengthened the capacity of NEA to deliver on its total electrification goal. Through this decree, NEA was converted into a government-owned and controlled corporation with borrowing authority and corporate powers. NEA's capitalization was increased over the years through loans and grants, expanding its lending powers that would ultimately benefit the development of industries or companies in the power generation sector. Presently, there are 121 ECs under the supervision of NEA. Majority of these ECs are in Luzon (Figure 2). Data also shows that ECs remain the core provider of electricity services for households outside of the National Capital Region (NCR), most especially in the Visayas island (Table 1).

Figure 2. Electric Cooperatives under the National Electrification Administration, by island group

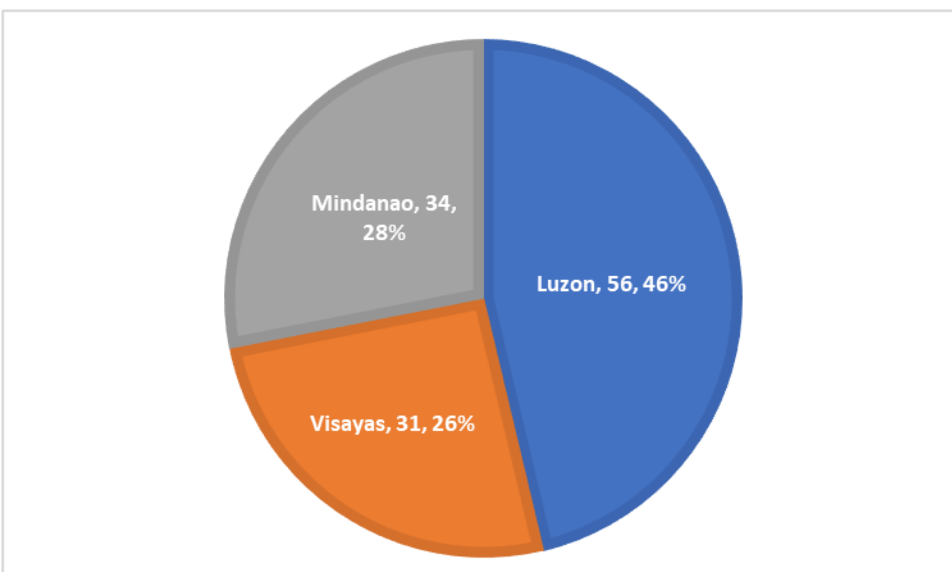


Table 1. Source of household electricity by island group, 2011

	Private Utilities	Electric Cooperatives	Others	Total
NCR	2,209,200	0	465,412	2,674,612
(in percent)	*82.6*	*0*	*17.4*	*100*
Luzon	2,705,004	4,711,182	962,615	8,378,801
(in percent)	*32.28*	*56.23*	*11.49*	*100*
Visayas	655,766	2,330,771	576,490	3,563,027
(in percent)	*18.4*	*65.42*	*16.18*	*100*
Mindanao	568,057	2,333,330	763,729	3,665,116
(in percent)	*15.5*	*63.66*	*20.84*	*100*
TOTAL	**6,138,028**	**9,375,283**	**2,768,246**	**18,281,556**
(in percent)	*33.57*	*51.28*	*15.14*	*100*

Source: Household Energy Consumption Survey

Electricity access in the country has vastly improved over recent years (Table 2). In 1991, only about 62 percent of households have electricity connection, majority of which resides in the NCR. Almost three decades later, household electrification rate stands at 93 percent in 2018, with much improvement in Visayas and Mindanao areas. Comparing based on broad regions, we note that Mindanao remains as the least electrified island group while Luzon is nearing 100 percent electrification. Expectedly, electricity connection improves with income, wherein poorer households appear to have lesser access to electricity. Moreover, their per capita spending on electricity is lower compared with richer households.

Table 2. Electricity access per capita spending by broad region and household per capita income quintile, 1991-2018

	% Households with electricity				Electricity spending per capita among households with electricity (in 2018 prices)			
	1991	2000	2009	2018	1991	2000	2009	2018
All households	61.7	76.6	85.7	93.1	…	2,357	2,636	2,866
By broad region								
NCR	96.6	99.5	98.9	97.6	…	4,735	5,514	5,100
Balance Luzon	67.6	82.1	89.3	95.8	…	2,167	2,481	2,889
Visayas	44.1	63.7	81.5	91.3	…	1,535	1,815	2,226
Mindanao	46.4	63.5	75.0	86.8	…	1,188	1,560	1,901
By household per capita income quintile								
1 - Poorest	24.0	38.4	59.9	83.3	…	414	435	633
2	44.0	65.4	80.9	92.3	…	721	849	1,204
3	64.0	85.7	91.9	95.0	…	1,230	1,462	1,974
4	81.9	94.8	96.7	96.8	…	2,196	2,642	3,198
5 - Richest	94.6	98.8	99.4	98.1	…	5,324	6,496	6,857

… - not available

Source: FIES various years

On a brighter note, the gap between rural and urban electrification appears to be narrowing (Table 3). Latest data from the World Bank indicates that almost 96 percent of rural population now have access to electricity compared to 98 percent of urban population. In 2000, the difference between the electrification rate between urban and rural areas is almost 30 percent. This was finally reduced to less than 10 percent after 2015, implying the government's progress towards its total electrification goal.

Electricity reliability in the Philippines

As the government strengthens its focus on providing access to the remaining un-electrified areas within the country, some indications of how unreliable electricity is affecting businesses are starting to emerge. Firm representatives signified in the latest World Bank Enterprise Survey that electricity continues to be one of the factors affecting the business environment in the Philippines (Table 4). Looking at the data more closely, we find that firms in the country are losing 0.8 percent of their annual sales, on average, due to power outages (Table 5). As a consequence, owning or sharing generators appears to be a defensive mechanism. The table likewise shows that more than 40 percent of firms in the Philippines are dependent on generators, where they source around 39 percent of their power supply. Generator ownership is particularly high in Metro Cebu at 66 percent. Generally, this information from the World Bank Enterprise Survey implies that doing business in the country is more costly due to unreliable electricity.

Table 3. Electricity access in the Philippines

	Access to electricity, rural (% of rural population)	Access to electricity, urban (% of urban population)	Access to electricity (% of population)
2000	61.7	89.8	**74.7**
2001	63.4	90.2	**75.7**
2002	65.1	90.5	**76.8**
2003	63.5	92.0	**76.6**
2004	84.5	91.3	**87.6**
2005	70.0	91.7	**79.9**
2006	70.0	92.3	**80.2**
2007	73.2	92.5	**82.0**
2008	74.6	93.7	**83.3**
2009	76.1	94.1	**84.3**
2010	78.3	93.9	**85.4**
2011	81.2	94.4	**87.2**
2012	80.7	94.7	**87.1**
2013	81.9	94.1	**87.5**
2014	84.6	95.7	**89.7**
2015	83.2	95.9	**89.1**
2016	88.1	96.6	**92.1**
2017	90.0	96.4	**93.0**
2018	91.8	97.4	**94.4**
2019	93.7	97.8	**95.6**
2020	95.6	98.2	**96.8**

Source: World Bank

Table 4. Business environment obstacles for firms in the Philippines, 2015

Factors	% of firms
Informal sector	20.0
Corruption	11.5
Access to finance	10.4
Tax rates	9.0
Electricity	7.9
Labor regulations	6.4
Access to land	6.0
Transportation	5.2
Trade regulations	5.0
Business licensing	4.5

Source: World Bank Enterprise Survey

Table 5. Select indicators on electricity, 2015

	% of firms experiencing electrical outages	No. of electrical outages in a month	Average duration of electrical outages (hr)	Average losses due to electrical outages (% of annual sales)	% of firms owning/sharing a generator	% share of electricity from generator	% of firms identifying electricity as a major constraint
All countries	50.6	5.3	4.1	4.0	32.1	17.4	30.8
East Asia and Pacific	46.3	4.8	3.6	2.9	33.1	15.5	17.1
Philippines	39.9	0.1	3.0	0.8	42.7	38.9	19.6
Manufacturing	44.1	0.1	4.6	0.9	39.7	41.2	26.4
Services	38.5	0.1	2.4	0.8	43.7	38.2	17.4
Calabarzon	27.2	0.0	4.3	1.2	36.0	55.6	14.2
Central Luzon	60.2	0.1	3.4	0.4	48.6	16.2	28.6
Metro Cebu	48.1	0.3	1.8	1.4	66.4	43.0	3.2
Metro Manila	56.1	0.0	3.2	0.2	34.8	30.0	30.0
NCR Excluding Manila	29.7	0.0	12.9	1.1	39.4	45.8	18.8

Source: World Bank Enterprise Survey

3. Data and Methodology

The main goal of this study is to characterize the nature of electricity supply interruptions in the country by specifically looking at the frequency of these events and employing trends analyses based on geographical areas and categorized causes of electricity supply interruptions. This primarily involves the collection of the monthly interruption reports (MIRs) of electric cooperatives which are submitted to the NEA for monitoring purposes. MIRs contain useful information such as start date of interruption, area affected, time of interruption, date and time restored, duration of interruption, number of affected customer and cause of interruption. It likewise covers several indices used by the NEA and the ERC to assess the distribution level power reliability in the country. First of these indices is the System Average Interruption Duration Index (SAIDI), which determines the total duration of power interruption for an average consumer, over a certain period of time. Another index is the System Average Interruption Frequency Index (SAIFI), which indicates the total number of times an average consumer experiences power interruption over a certain period. Lastly, the Customer Average Interruption Duration Index (CAIDI) assesses the average time it takes to restore the electricity power after an outage occurs, which is computed by dividing the SAIDI by the SAIFI index. The SAIDI, SAIFI and CAIDI are calculated by ECs on a monthly basis. Data from 2016 to 2020 were collected, processed, and analyzed.

Although there are quite a few types of distribution utilities in the country (Table 6), we focused on the data of the ECs under the NEA since they are the main provider of electricity to households outside the NCR (recall Table 1). Table 7 exhibits that there are 121 ECs under the supervision of NEA, and we were able to gather information from 37 utilities. The table shows that the distribution of our sample ECs was able to mimic the true distribution of total ECs based on broad region, however, not the distribution based on size. Nevertheless, our samples provided useful information for the analyses of this study.

Table 6. Distribution utilities in the Philippines

Type of Distribution Utility	Luzon	Visayas	Mindanao	Philippines
Private investor–owned utilities	13	6	4	**23**
Electric utilities under NEA	37	26	28	**91**
Electric utilities under CDA	7	2	-	**9**
Small power utilities group (SPUG-EC)	11	3	6	**20**
Local government unit–owned utilities	5	-	1	**6**
SPUGs under CDA	1	-	-	**1**
Multi-purpose cooperatives	-	2	-	**2**
TOTAL	**74**	**39**	**39**	**152**

Source: Department of Energy and National Electrification Administration

Table 7. Sample distribution of electric cooperatives

	Sample ECs	All ECs
Total (Count)	37	121
Broad region (%)		
Luzon	54	46
Visayas	22	26
Mindanao	24	28
Size (%)		
Small to Large	16	26
Extra Large	22	28
Mega Large	62	46

4. Findings and discussion

Frequency of power interruptions

From the industry perspective, the reliability of electricity can be gauged through metrics that depict power availability, duration, frequency, and extent of power outage[2]. Power interruptions are as either *momentary power interruption* – those that are less than or equal to 5 minutes; or *sustained power interruption* – those that go beyond 5 minutes. The System Average Interruption Frequency Index (SAIFI) is an important indicator because it specifies the total number of times an average consumer experience sustained power interruption over a certain period. Table 8 shows that in 2015, an average consumer of electric cooperatives in the Philippines experience around 7 power interruptions per year. This number was reduced to 5.7 times, in 2021. Data also suggests

[2] As discussed in Transforming the Nation's Electricity Sector: The Second Installment of the QER, January 2017.

that consumers of electric cooperatives in Luzon experience more frequent power interruptions than those in Visayas and Mindanao. Interestingly, we notice that electric cooperatives in the small, medium, large category as well as those in the mega-large category was able to minimize power interruptions from 2015 to 2021. Meanwhile, the reverse is observed for cooperatives in the extra-large category, recording more power interruptions in 2021 than in 2015. Lastly, it appears that insufficient supply of electricity to electric cooperatives is the main contributory factor to frequent power interruptions.

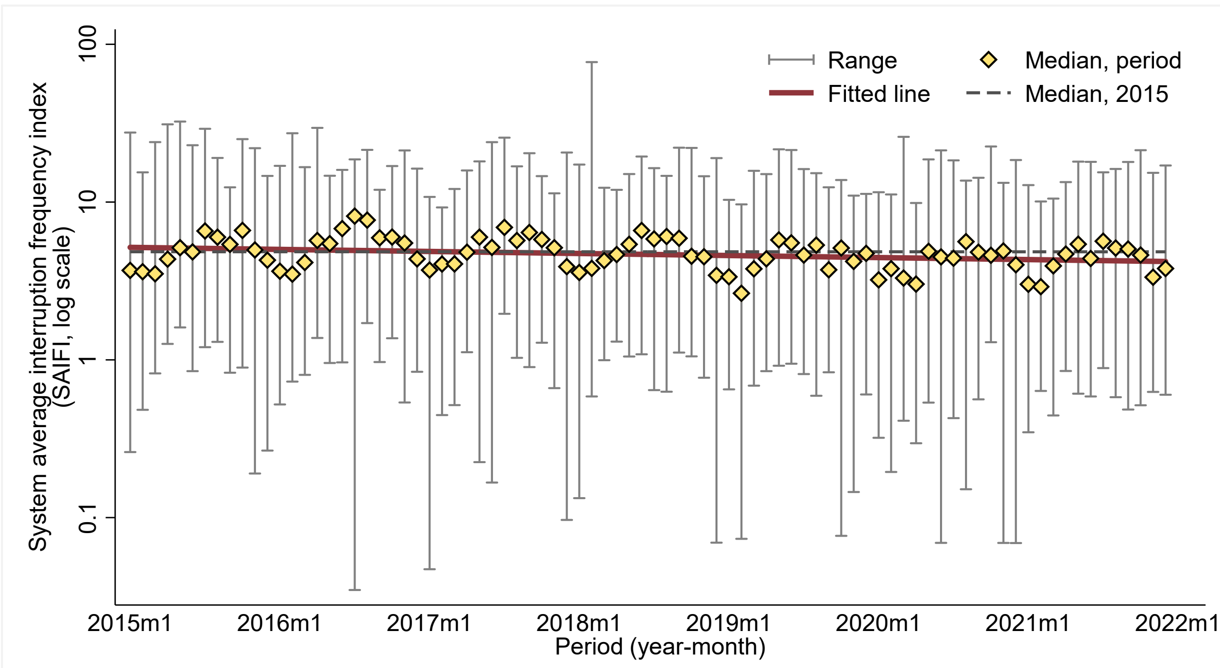
Table 8. System average interruption frequency index, 2015-2021

	2015	2016	2017	2018	2019	2020	2021
All sample	7.1	7.0	7.4	6.6	5.8	5.7	5.7
By island group							
Luzon	7.1	7.4	7.7	7.9	6.7	6.6	6.6
Visayas	6.8	6.7	8.7	5.3	5.2	5.5	5.4
Mindanao	7.2	6.3	5.6	4.8	4.5	3.9	4.1
By distributor size							
Small, Medium, Large	7.5	7.2	5.4	5.1	5.1	6.0	4.8
Extra large	6.2	6.4	7.4	7.8	6.6	6.9	7.6
Mega large	7.3	7.1	7.5	6.4	5.7	5.4	5.3
By interruption cause							
Human	0.1	0.1	0.0	0.0	0.1	0.0	0.0
Lightning	0.0	0.1	0.1	0.1	0.0	0.0	0.0
Major storm disaster	0.2	0.2	0.2	0.3	0.1	0.2	0.2
Scheduled	0.4	0.5	0.5	0.6	0.6	0.4	0.4
Trees	0.3	0.3	0.3	0.3	0.2	0.3	0.3
Overload	0.3	0.0	0.1	0.0	0.0	0.0	0.0
Error	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Supply	1.4	1.3	1.7	1.3	1.4	1.5	1.6
Equipment	0.5	0.6	0.6	0.7	0.7	0.5	0.6
Earthquake	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Others, N.E.C.	0.9	1.4	1.0	0.9	0.7	0.6	0.7
Unknown/Not stated	3.0	2.7	2.9	2.6	2.1	2.1	2.0

Figure 3 plots the monthly system average interruption frequency index from January 2015 to December 2021. Fitting a line to the data shows a decreasing trend for frequency of interruptions, over time. In Figure 4, we categorized the causes of power interruptions into four main groups namely: (1) supply – interruptions due to lack of power supply; (2) technical –interruptions due to technical issues; (3) environment – interruptions due to natural events; and (4) others – entries in the MIR that have not been explained or classified as prescribed. Panel A of Figure 4 shows the data for all regions, while Panels B, C, and D, present separate figures for Luzon, Visayas and Mindanao, respectively.

Aggregating the causes of power interruptions and categorizing them into four main groups, we notice that environmental factors, by and large, cause a big portion of the disruptions[3]. We also note that *major storm disaster* is the biggest issue among all environmental factors, which raises a concern since the Philippines is typhoon prone. Meanwhile, technical-related issues, when combined, constitute the second largest portion affecting power interruptions. Insufficient supply of power to ECs is also a big issue in itself, where utilities in the Visayas are suffering the most.

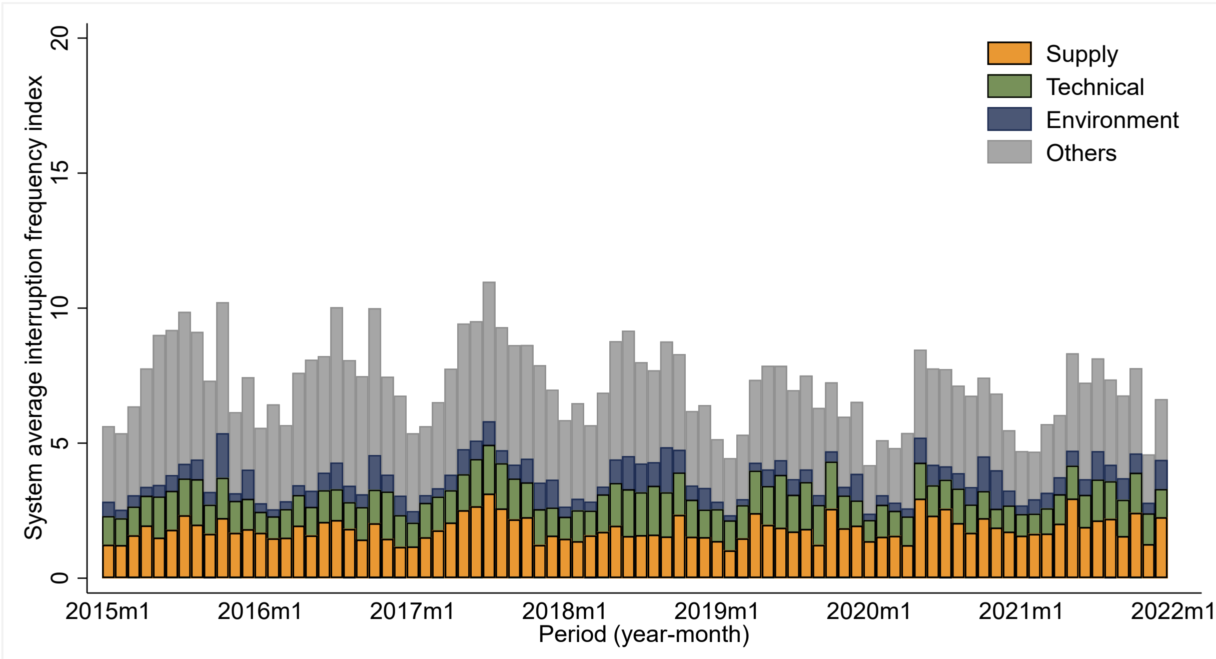
Figure 3. Monthly system average interruption frequency index, January 2015-December 2021



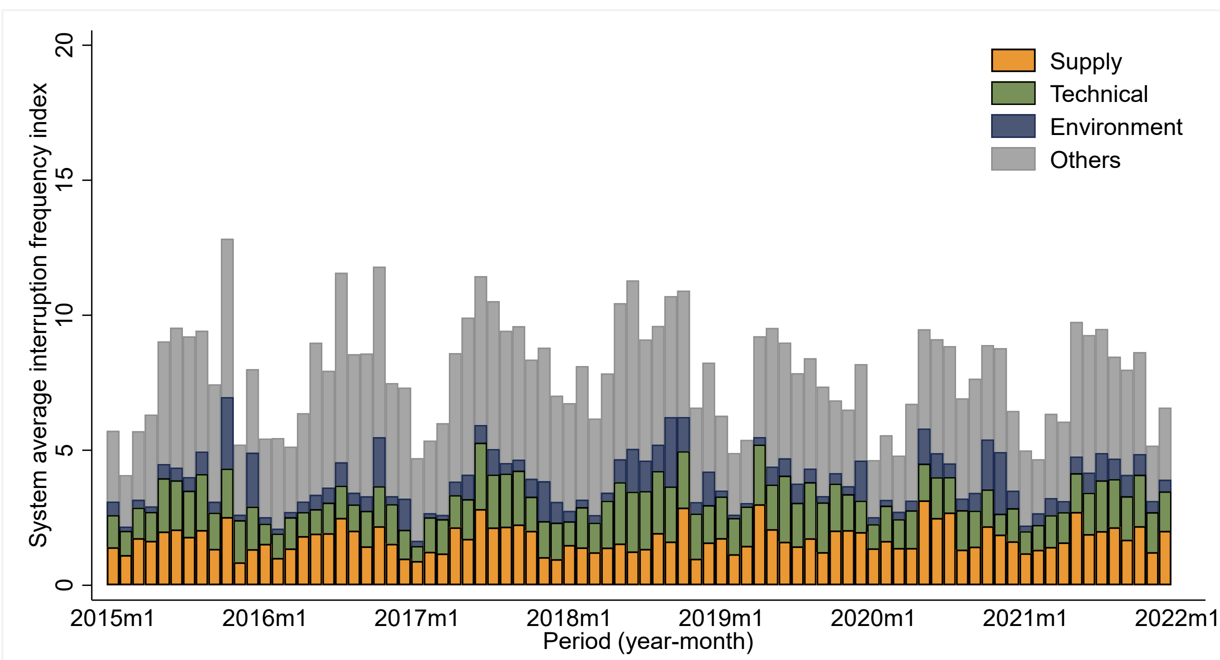
[3] We disregarded "Others" since these are uncategorized entries in the MIRs,

Figure 4. Monthly system average interruption frequency index by region and cause, January 2015-December 2021

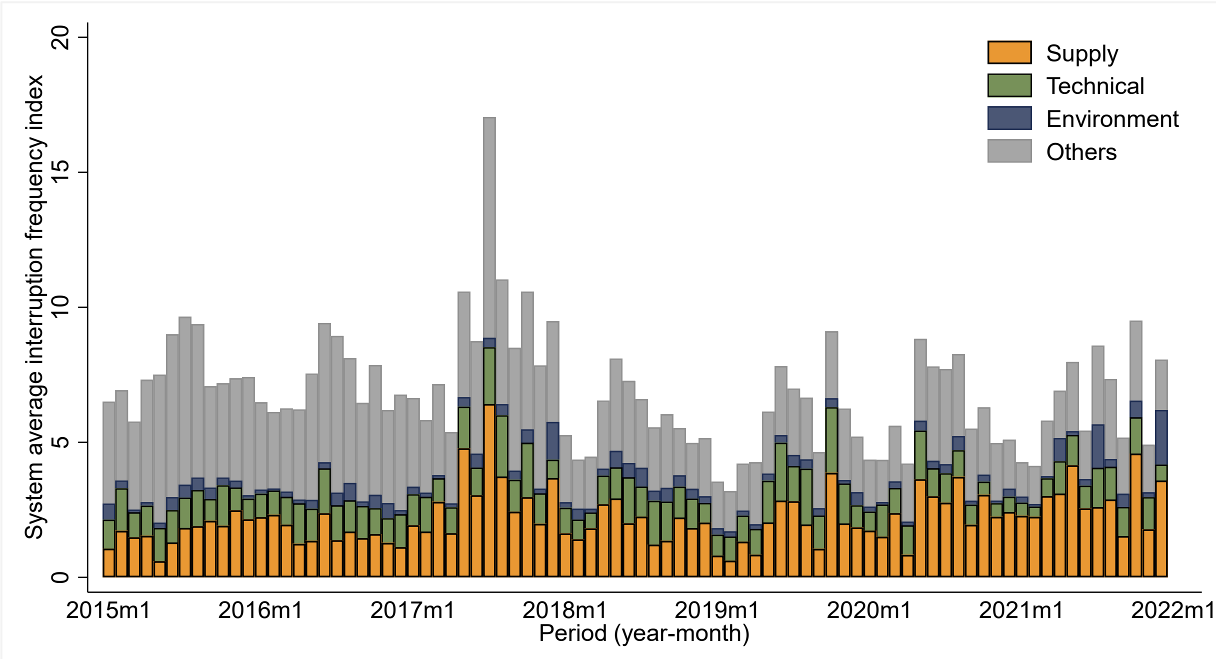
A. All regions



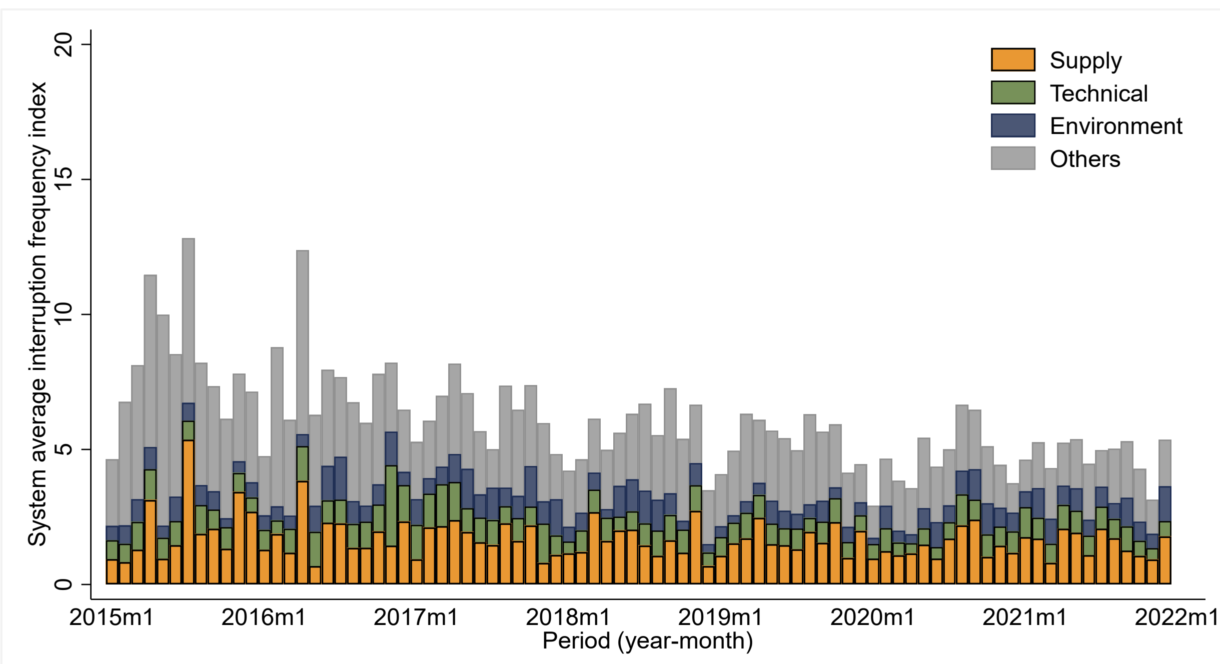
B. Luzon



C. Visayas



D. Mindanao



Duration of power interruption

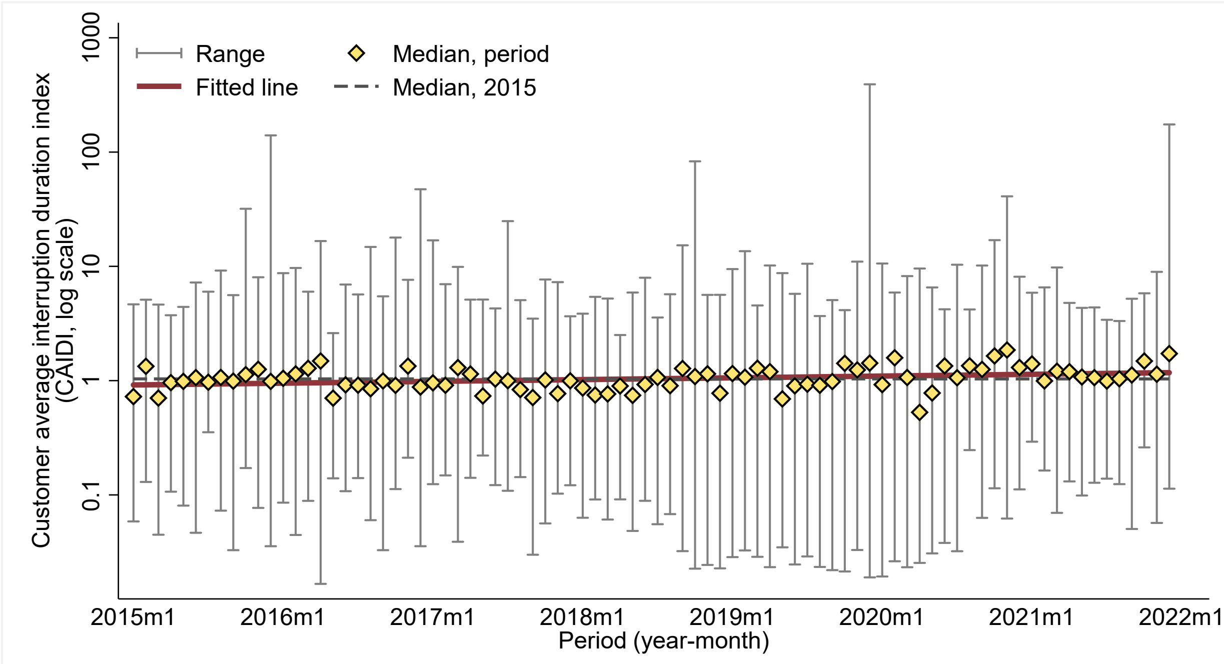
Power supply interruptions are disruptive to the economy and the longer they take, the bigger the damage becomes. The System Average Interruption Duration Index (SAIDI) is useful in determining the total duration of power interruption for an average consumer over a certain period of time. In Table 9, it is shown that in 2021, an average consumer of ECs in the Philippines experienced a total of 8.8 hours of no electricity. This figure is a relative improvement from that of 2015, at 11.3 hours. Comparing based on island group, we find that consumers in Mindanao experience the least number of hours with no electric power while consumers in Visayas endure the most. In terms of EC size, mega-large group appear to perform better that small, medium, large, and extra-large ECs in managing power interruptions. The top three causes of long power interruptions are (1) insufficient power supply, (2) major storm disaster, and (3) scheduled power interruption, which are prearranged for maintenance purposes.

Table 9. System average interruption duration index, 2015-2021

	2015	2016	2017	2018	2019	2020	2021
All sample	11.3	9.8	9.6	8.0	16.3	10.3	8.8
By island group							
Luzon	14.0	11.2	9.4	9.9	26.0	14.8	8.6
Visayas	7.3	7.8	13.3	5.1	5.6	5.8	10.4
Mindanao	8.8	8.6	6.7	6.5	4.4	4.5	7.8
By distributor size							
Small, Medium, Large	14.0	14.0	11.0	14.3	12.6	15.5	9.4
Extra large	16.1	11.1	8.1	7.5	49.8	17.2	9.8
Mega large	9.9	9.2	9.8	7.7	7.9	8.2	8.5
By interruption cause							
Human	0.1	0.1	0.0	0.0	0.0	0.0	0.0
Lightning	0.1	0.1	0.1	0.0	0.0	0.0	0.0
Major storm disaster	2.4	1.0	0.4	0.8	8.6	1.9	1.9
Scheduled	1.5	2.0	1.7	1.6	1.7	1.6	1.5
Trees	0.2	0.2	0.3	0.3	0.2	0.2	0.2
Overload	0.1	0.1	0.0	0.0	0.0	0.0	0.0
Error	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Supply	3.6	3.2	4.1	2.7	3.2	4.1	3.4
Equipment	0.3	0.4	0.3	0.3	0.3	0.3	0.3
Earthquake	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Others, N.E.C.	0.4	0.7	0.2	0.2	0.2	0.2	0.2
Unknown/Not stated	2.8	2.1	2.4	2.0	2.1	2.1	1.3

In Figure 5 we plot the monthly customer average interruption index from January 2015 to December 2021 to observe the trend it exhibits over time. We note a slightly increasing trend suggesting that the duration of power interruptions on average, are becoming longer over the years.

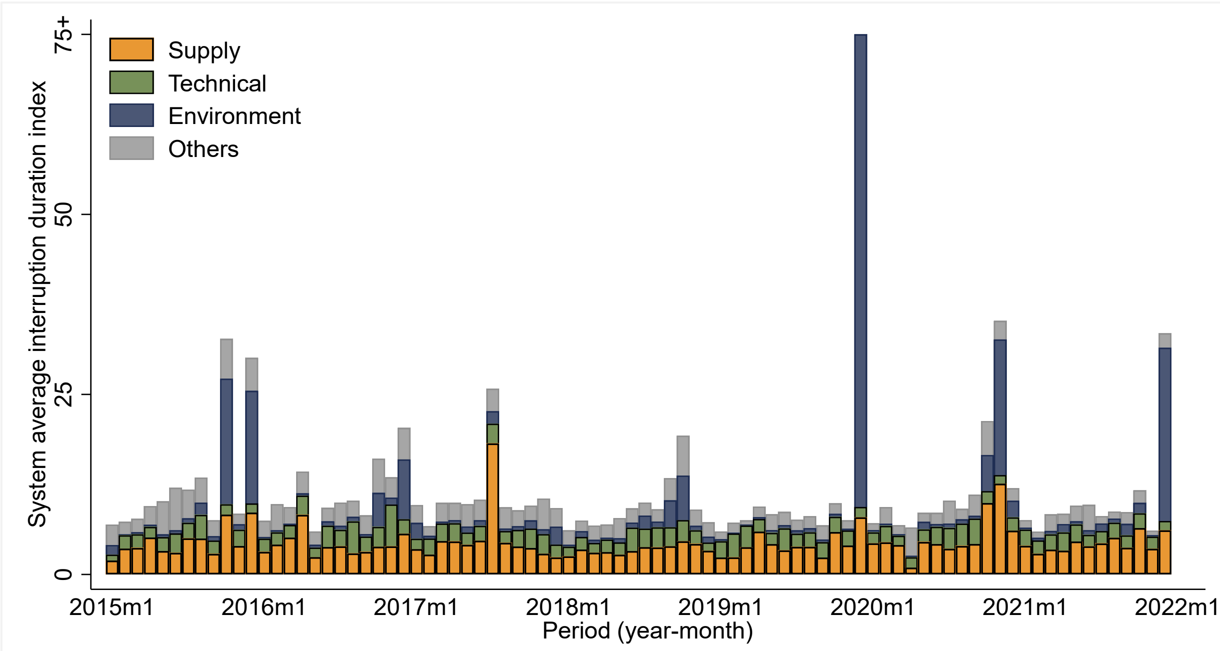
Figure 5. Monthly customer average interruption duration index, January 2015-December 2021



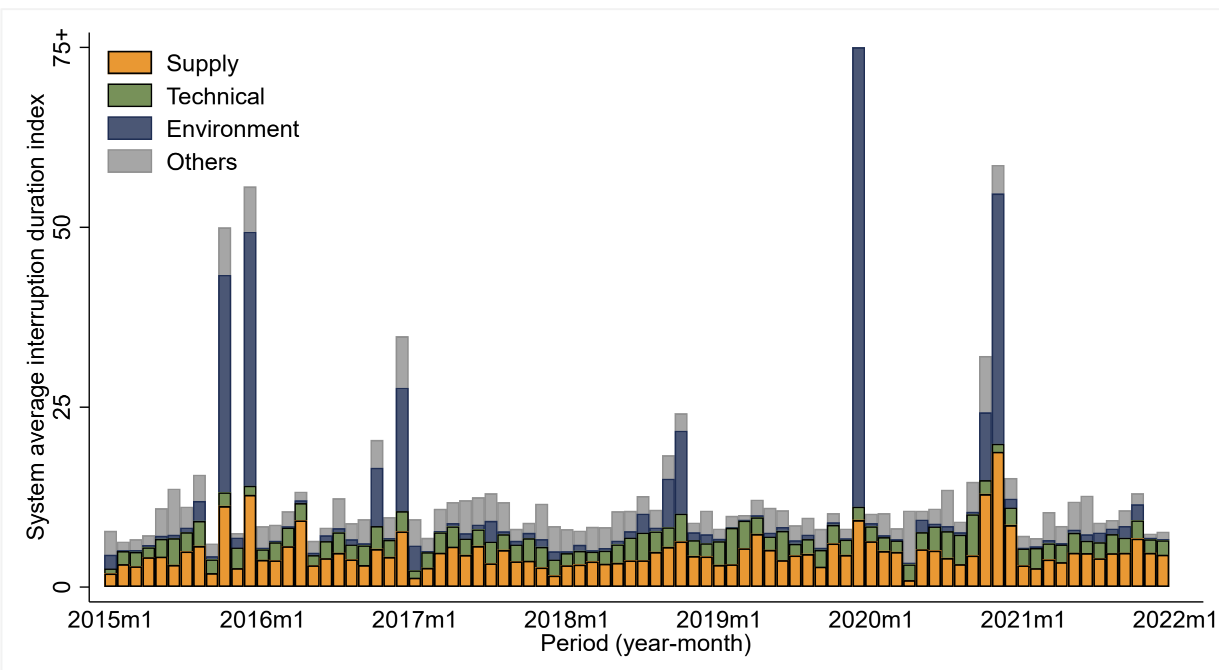
Conversely, Figure 6 shows the categorized general causes of monthly system average interruption duration from 2015 to 2021. Panel A, B, C, and D shows separate figures for all regions, Luzon, Visayas, and Mindanao, respectively. For aggregated data in Panel A, we see that long power interruptions are mainly caused by environment-related factors, especially by major storms. Comparing panels B, C, and D, we also observe that the impact of these natural events, which led to long power interruptions, are more concentrated in Luzon than in Visayas and Mindanao. Technical and supply issues remain as culprits for long power interruptions in all island groups, but Visayas appears that have a relatively bigger issue with insufficient supply of electricity especially during the year of 2017.

Figure 6. Monthly system average interruption duration index by region and cause, January 2015-December 2021

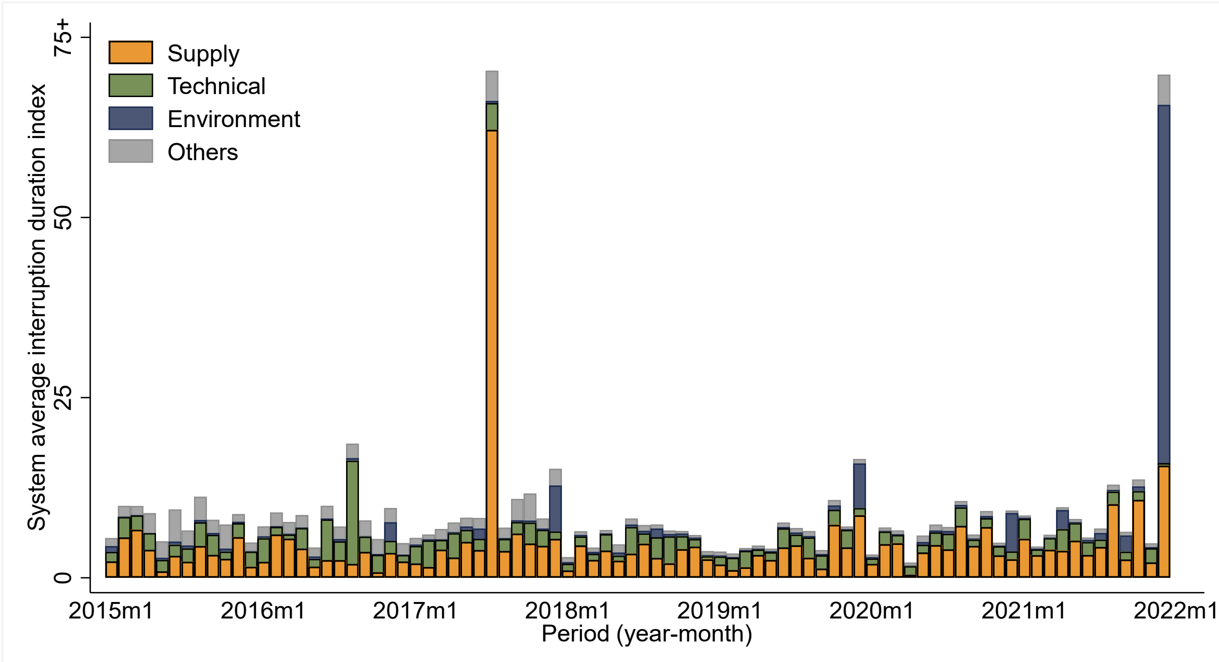
A. All regions



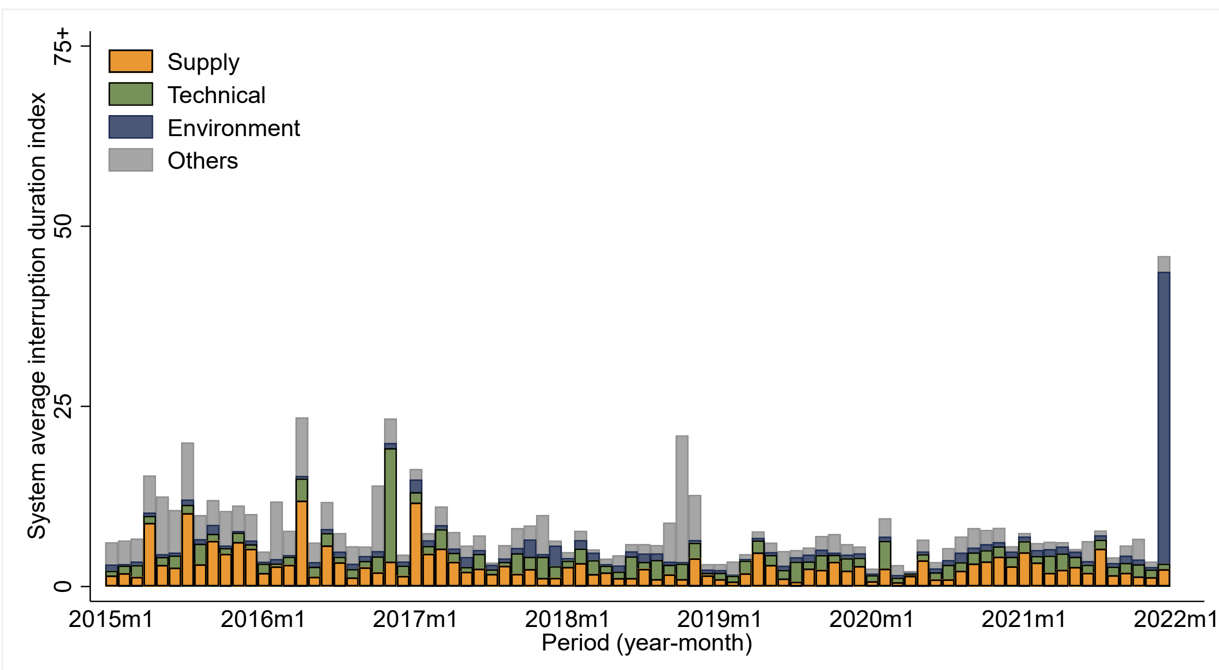
B. Luzon



C. Visayas



D. Mindanao



Power restoration

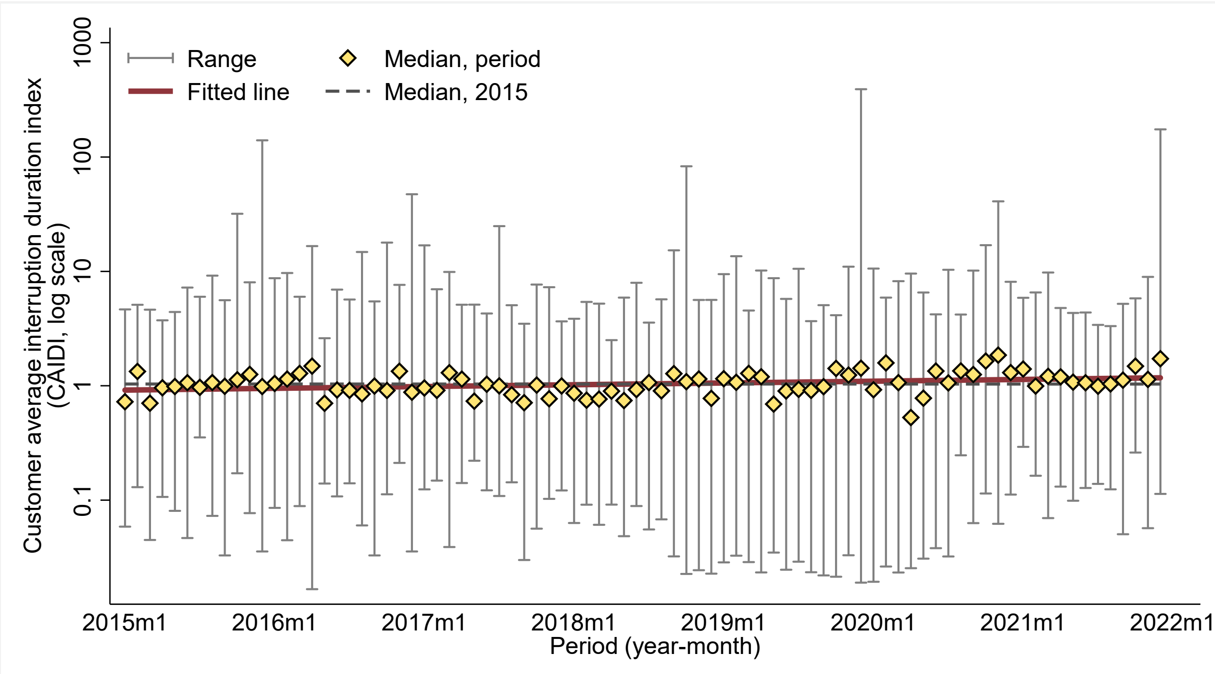
A way to mitigate the negative impact of an electricity supply interruption is to restore power at the shortest time possible. The Customer Average Interruption Duration Index (CAIDI) denotes the average time it takes to restore the electricity power after an outage occurs. This is computed by dividing the SAIDI by the SAIFI index. In Table 10 we show that in 2021, it takes about 1.5

hours to restore electricity after a power outage. ECs in Luzon island appear to have improved their efficiency in restoring electric power, over the years. Power restoration in the Visayas and Mindanao islands, on the other hand, seem to have weaken in 2021 than in previous years. In terms of size, the data suggests that mega-large ECs manage power restoration better than smaller ECs. There are years however (i.e., 2017, 2018, and 2021), where they were outperformed by extra-large utilities. Looking at specific causes of power interruption, we note that it takes the longest to restore electricity when the damage is done by a major storm disaster. Scheduled interruption for maintenance purposes likewise causes long power interruptions. Meanwhile, the monthly customer average interruption duration index plotted in Figure 7 is exhibiting an upward trend. This implies that over the years, it's taking longer to restore electricity when power outages occur.

Table 10. Customer average interruption duration index, 2015-2021

	2015	2016	2017	2018	2019	2020	2021
All sample	1.6	1.4	1.3	1.2	2.8	1.8	1.5
By island group							
Luzon	2.0	1.5	1.2	1.2	3.9	2.3	1.3
Visayas	1.1	1.2	1.5	1.0	1.1	1.1	1.9
Mindanao	1.2	1.4	1.2	1.4	1.0	1.2	1.9
By distributor size							
Small, Medium, Large	1.9	1.9	2.0	2.8	2.5	2.6	2.0
Extra large	2.6	1.7	1.1	1.0	7.5	2.5	1.3
Mega large	1.4	1.3	1.3	1.2	1.4	1.5	1.6
By interruption cause							
Human	0.7	0.6	1.0	1.2	0.4	0.6	0.7
Lightning	1.1	1.0	1.4	0.7	1.3	1.1	1.2
Major storm disaster	12.2	6.0	2.4	3.1	81.9	8.5	9.0
Scheduled	3.5	4.5	3.1	2.9	3.2	3.9	3.7
Trees	0.9	0.8	1.0	0.9	0.8	0.7	0.7
Overload	0.2	1.5	0.2	0.5	0.2	0.2	0.3
Error	0.9	1.4	0.5	0.7	0.4	0.3	0.6
Supply	2.6	2.5	2.4	2.1	2.3	2.7	2.2
Equipment	0.6	0.7	0.5	0.5	0.4	0.6	0.4
Earthquake	0.3	0.1	1.4	1.6	0.3	0.1	0.7
Others, N.E.C.	0.5	0.5	0.2	0.3	0.2	0.3	0.3
Unknown/Not stated	0.9	0.8	0.8	0.8	1.0	1.0	0.7

Figure 7. Monthly customer average interruption duration index, January 2015-December 2021



Magnitude of effect

Together with the information on the frequency and duration of power interruptions as well as the time it takes to restore electricity, it is similarly important to look at indicators that would provide the largeness of the effect of these interruptions. In Table 11, we present data on total electricity connection interruption, which is measured in terms of consumer-hours. The variable, *consumer-hours,* is a result of multiplying the number of hours duration of power interruption and the number of customers affected. Hence, the higher the figure, the bigger the impact. As shown in Table 11, the total electricity connection interruption is a large figure (391.6 million consumer-hours) in 2015 and has gone even larger in 2021 (441 million consumer-hours). Data shows that the effect of power interruption in more pronounced in Luzon than in Visayas or Mindanao. Expectedly, the disruption becomes bigger with the size of the utility. The bigger the EC, the more customers they have; thus, the more disruptive its power interruptions. Analyzing based on the cause of interruption, indicates that insufficient supply of power to ECs has the biggest effect on consumers.

Table 11. Total electricity connection interruption (in million consumer-hours), 2015-2021

	2015	2016	2017	2018	2019	2020	2021
All sample	391.6	353.0	361.0	355.9	757.7	496.3	441.0
By island group							
Luzon	264.7	216.4	190.9	237.6	650.3	381.5	227.9
Visayas	54.2	61.7	109.0	53.4	61.2	64.0	122.0
Mindanao	72.7	74.9	61.1	64.9	46.2	50.8	91.1
By distributor size							
Small, Medium, Large	26.5	27.8	21.9	31.9	29.3	38.0	24.4
Extra large	108.2	78.0	59.5	64.9	451.1	159.3	93.8
Mega large	257.0	247.2	279.7	259.1	277.3	299.0	322.8
By interruption cause							
Human	2.1	2.0	1.5	1.8	1.0	0.8	0.9
Lightning	1.6	2.0	2.8	1.4	1.3	1.4	1.5
Major storm disaster	81.2	34.9	16.0	35.6	399.2	89.8	94.7
Scheduled	50.6	73.0	63.4	71.7	80.2	74.6	73.6
Trees	7.7	7.5	10.7	11.3	8.6	9.7	8.4
Overload	2.4	1.8	0.6	0.4	0.2	0.1	0.2
Error	0.4	0.8	0.3	0.2	0.2	0.1	0.2
Supply	125.7	116.3	155.1	117.9	149.7	197.6	169.1
Equipment	10.1	13.5	12.0	14.2	13.9	14.6	14.2
Earthquake	14.4	24.0	9.0	10.5	7.2	8.9	11.2
Others, N.E.C.	95.4	77.1	89.1	90.4	96.3	98.8	66.9
Unknown/Not stated	0.0	0.0	0.4	0.5	0.0	0.0	0.1

Additionally, plotting the data in Figure 8, monthly electricity connection interruption signals an increasing trend over the years. The cause of this increase, however, cannot be determined in this simple plot since it is possible that the increase in consumers over time may have driven the trend upward. On a different note, we aggregated the data based on four main causes of disruption in Figures 9, where we found that environment-related issues, when lumped together, have the most impact on customers.

Figure 8. Monthly electricity connection interruption (in consumer-hours), January 2015-December 2021

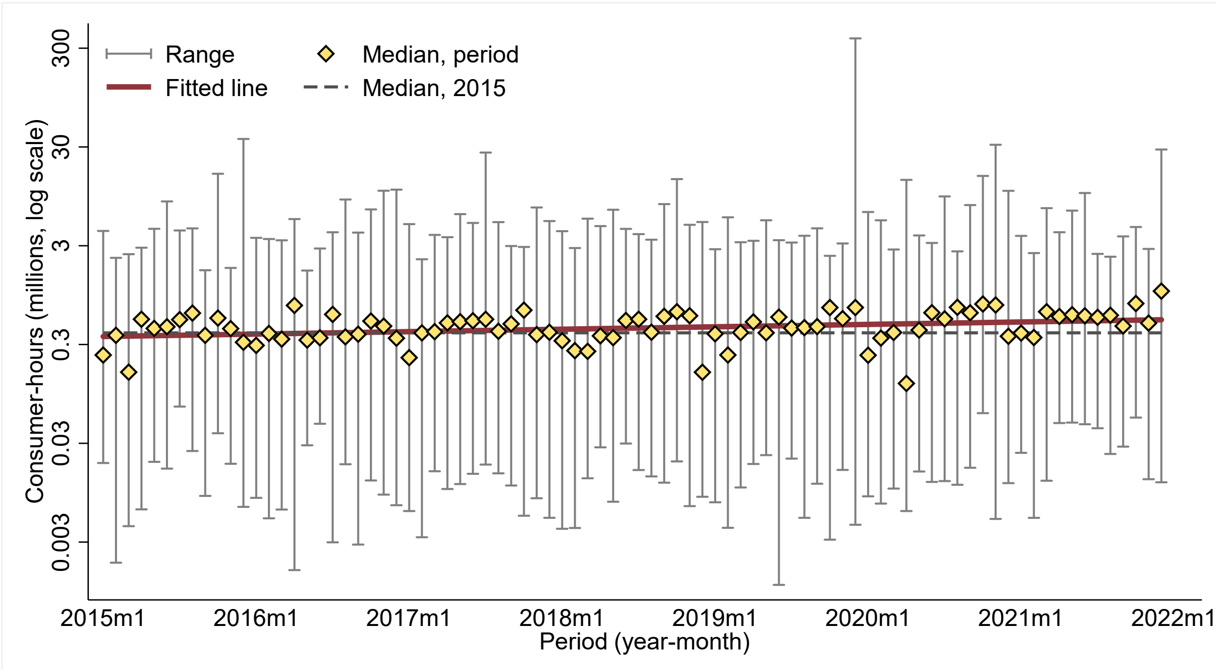
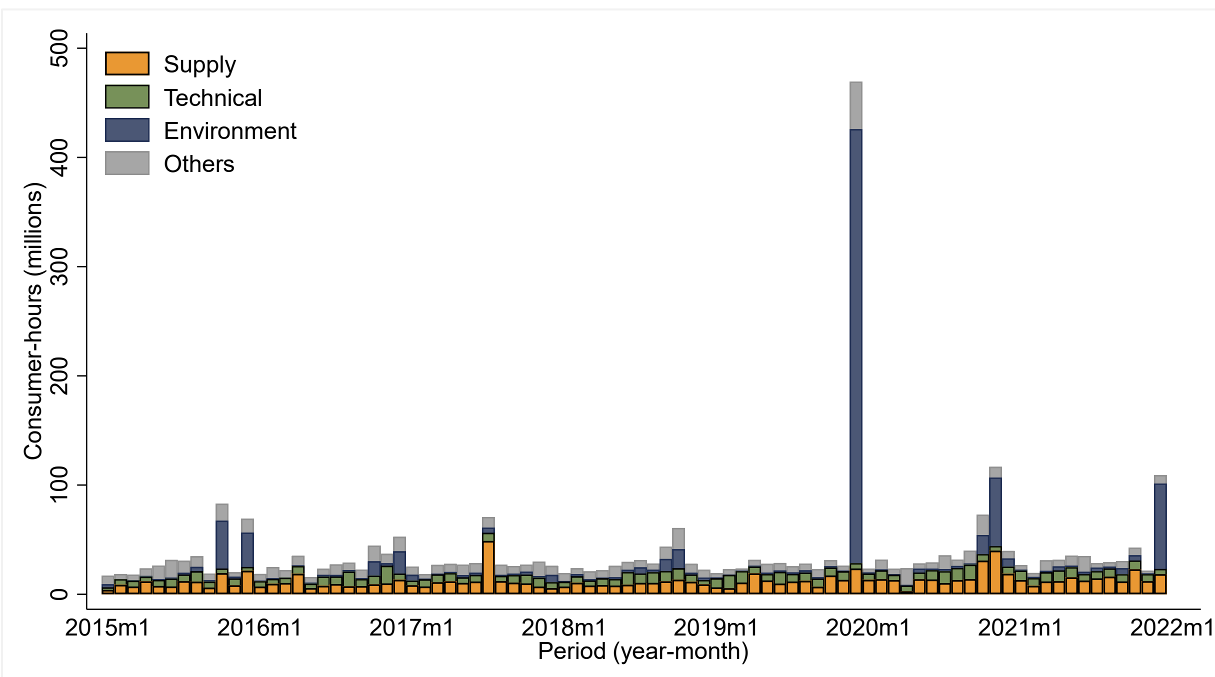


Figure 9. Monthly electricity connection interruption (in consumer-hours) by cause, January 2015-December 2021



Nature of problem

Since the data used for the analyses were sourced from ECs, it might be useful to check whether the issues we found were specific problems of electric cooperatives. Data from the 2011 Household Energy Consumption Survey, however, contradicts this idea, showing that the issues faced by electric cooperatives are actually very similar to that of the issues faced by other distributing utilities in the country. While in Figure 10, it appears as though private utilities are performing better than ECs, disaggregating the data based on island group as in Figure 11, suggests that in Mindanao, the performance of private utilities and ECs are somewhat similar when comparing based on household experience on power interruptions. At large, power disruptions remain an issue in many parts of the country, regardless of the type of distributing utility.

Figure 10. Issues with electricity by classification and type of distributing utility, Philippines

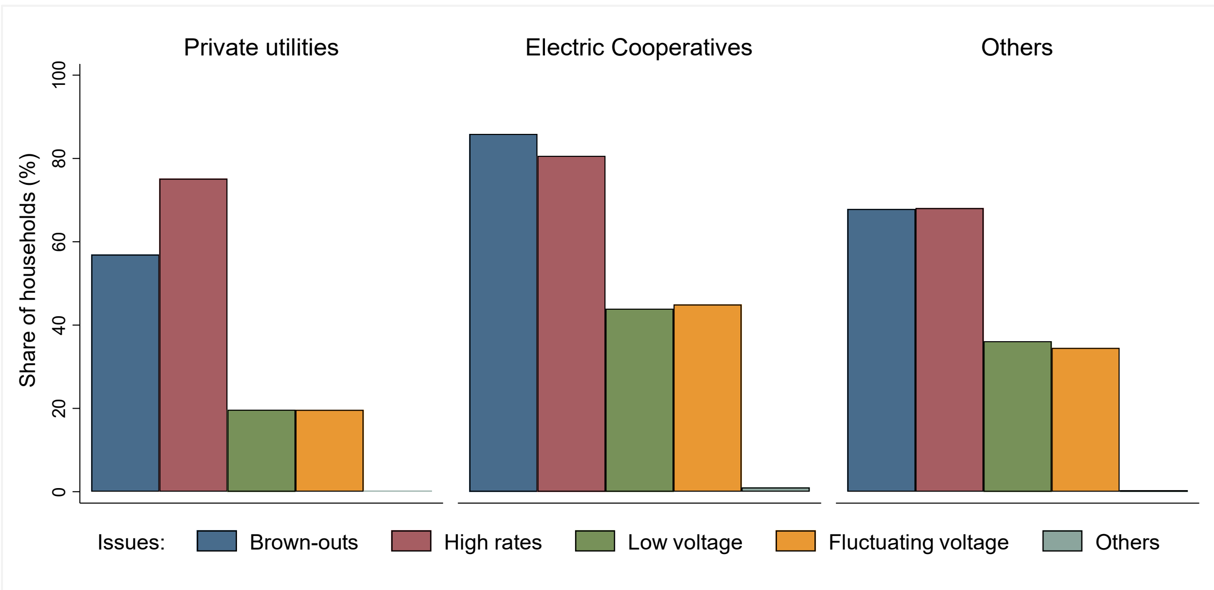
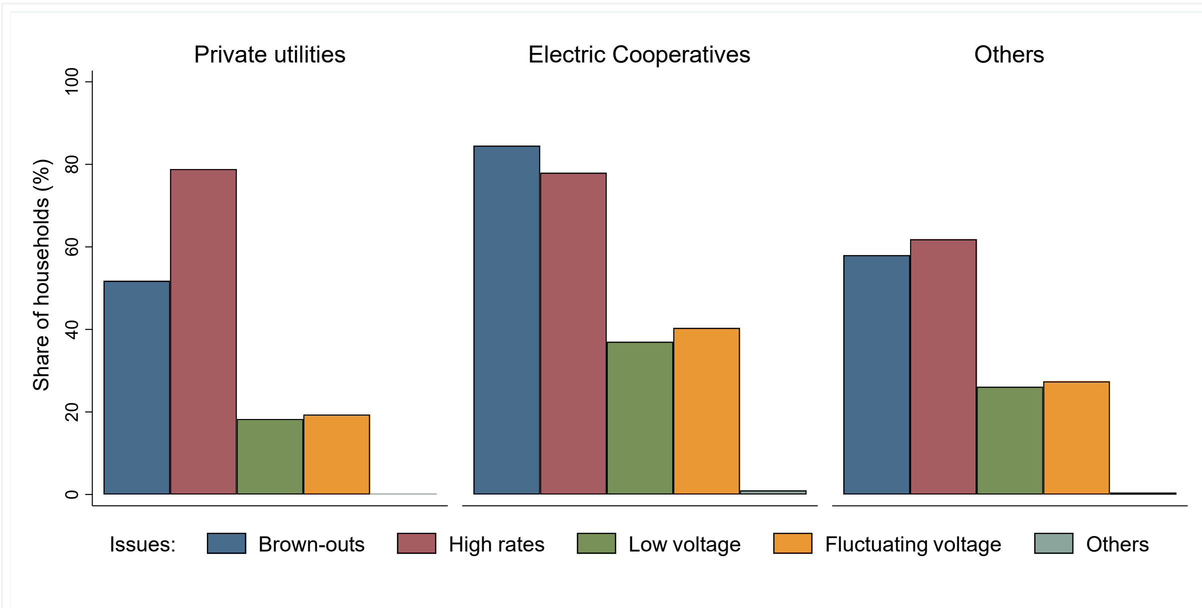
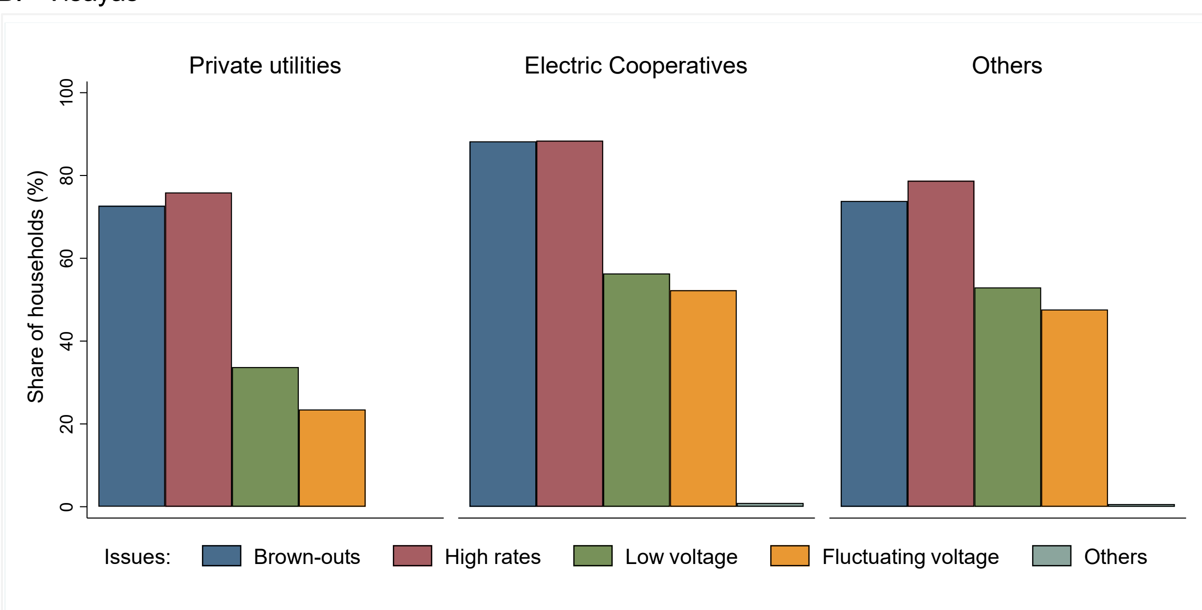


Figure 11. Issues with electricity by classification and type of distributing utility, by broad region

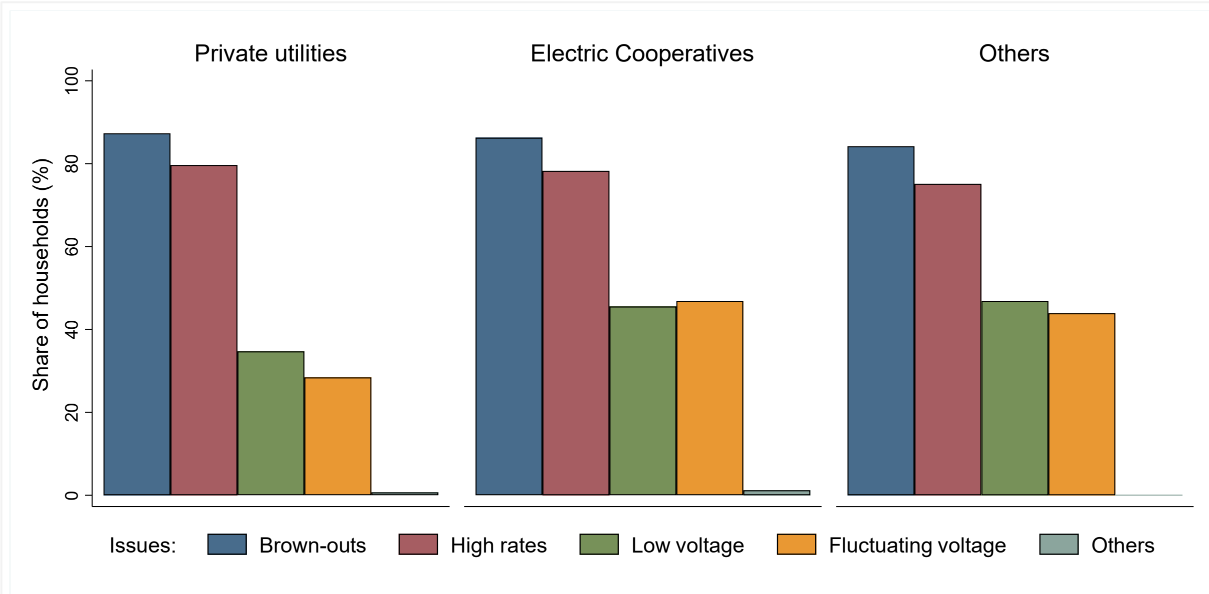
A. Luzon, excluding NCR



B. Visayas



C. Mindanao



5. Summary and policy implications

Electricity supply interruptions, despite the enormous disturbance it causes the economy, have historically received little attention from our policymakers. This study seeks to redirect this course by characterizing how electricity supply interruptions are actually experienced in different parts of the country. The analyses of this study have shown that in 2021, consumers on average experience around 5.7 power interruptions a year, translating to a total of 8.8 hours of no electricity. Aggregating based on island group, we found that consumers in Luzon experience more frequent power interruptions, while consumers in Visayas endure longer hours with no electricity. We also observed that among the list of causes, *insufficient supply* of power to ECs emerges as the main driver of frequent and long hours of power interruptions. Meanwhile, it takes around 1.5 hours to restore electricity after a power outage, and it also takes the longest to restore when the damage is done by a *major storm disaster*.

The analyses of this study put to fore several important findings. First, when causes of interruption are lumped together, we found that environment-related factors, the biggest being *major storm disasters*, cause a big share in frequent and long duration of power interruptions. This is quite concerning given that the Philippines experiences numerous typhoons a year. Concurrently, this begs the need to improve and climate-proof our power and electricity-related infrastructure to protect them from damages and shorten the duration of downtime after weather-related events. Second, insufficient supply of power remains a problem among ECs that is affecting many consumers. While the solution for such immense problem requires time and major resources, policies towards expanding the generation capacity as well as the access of ECs to more power supply should be prioritized. Third, it is evident from the data that technical-related issues hinder the continuous supply of electricity to consumers. Thus, improving the technical efficiency of ECs is a precondition to improving the reliability of electricity supply in the country. Finally, policies that are responsive to the needs of the electric power sector primarily requires good quality data. As seen in the analyses, a big portion of the causes of power interruptions are lumped into the *"others"* category since these entries have not been explained or cannot be classified under prescribed categories. Definitely, there is a need to improve reporting and data management for the consumption of researchers to better guide policymaking.

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