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How Energy Secure is the Philippines?

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How Energy Secure is the Philippines?

*Adoracion M. Navarro, Ma. Kristina P. Ortiz,
and Jethro El L. Camara*



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How Energy Secure is the Philippines?

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PHILIPPINE INSTITUTE FOR DEVELOPMENT STUDIES

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Abstract

Energy security is a comprehensive concept and pursuing it as a developmental goal entails first and foremost a clearer understanding of what it means. This study proposes six broad elements in assessing energy security, namely, sufficiency, reliability, resilience, affordability, accessibility, and sustainability. In assessing the energy security situation in the Philippines, the study employs an indicators-based assessment. The method involves defining, based on existing literature, specific energy security indicators (ESIs) corresponding to the mentioned six broad elements and then running some calculations and conducting trends analysis using available data. The analyses of ESI trends over time and comparisons with other countries in Southeast Asia reveal notable findings, most of which are pointing to the current energy insecurity of the Philippines. The study then offers recommendations to improve energy security in the country and suggests that each element of energy security be considered an area of future research. As a demonstration of further scrutiny of an aspect of energy security, the study also examines energy sufficiency further by forecasting electric power demand and comparing the forecasts with the government's outlook on generating capacity up to 2028. The results highlight the necessity of timely investments on additional generating capacity and an efficient government permitting system.

Keywords: energy security, energy self-sufficiency, energy reliability, energy system resilience, energy affordability, access to energy, energy sustainability, electricity demand forecasting, error correction model, elasticity-based model

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How Energy Secure is the Philippines?

*Adoracion M. Navarro, Ma. Kristina P. Ortiz, and Jethro El L. Camara**

1. Introduction

Energy security in the Philippines has been repeatedly expressed as a developmental goal in the Philippine Development Plan (PDP) and the medium-term energy sector targets presents the indicators that the government is looking at when assessing whether this goal is being met. But to be able to achieve energy security, we must first be clear about what we mean by this goal, the various aspects of it, and the indicators that we can use to measure and target it. Although energy security is defined in the PDP 2023-2028 as having three aspects, namely, affordability, accessibility, and reliability, we deem that there is a need for a more nuanced definition and understanding of the concept. Thus, in this study, we examine the various internationally accepted definitions of energy security and determine the common elements emerging from such definitions. We then use an indicators-based assessment method to check how energy secure the country is. We also employ a forecasting exercise applicable to a major component of final energy—aggregate electricity demand—to demonstrate the importance of getting the indicators right in order to minimize information asymmetry and generate appropriate investors' response.

1.1 Objectives

In this study, we aim to evaluate the energy security situation in the country by calculating various energy security indicators (ESI) based on internationally accepted definitions and latest available data. We also aim to demonstrate a forecasting model for one component of energy, that is, final electricity demand, and how the forecasting results can be used to assess one element of energy security, that is, sufficiency or ensuring that demand can be met by the committed power generation capacity. We also aim to derive policy insights and recommendations from our interpretation of the results of the ESI-based assessment and electricity demand forecasting.

1.2 Significance of the study

The significance of this study lies in its potential to address information asymmetry with respect to energy security. If this study could contribute to demystifying ESIs, it could nudge the energy bureaucracy to promote the production of a specific public good—an official and regularly updated set of energy security indicators. The potential impact is improved actions by energy stakeholders, including the private suppliers of energy products and services and the final consumers, toward improving our energy security and fueling our economic growth and development.

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1.2 Review of related literature

To be able to estimate appropriate ESIs and derive policy implications, we examine what the literature offers in terms of energy security measurement. We also examine one important aspect of energy security—that final energy demand and available supply must balance—and check the literature on final energy use forecasting, which is an important consideration in planning for supply that must be committed. We also deem it important to have correct assessments of energy security as well as sources of energy insecurity in order to reduce information asymmetry because such asymmetry could drive sub-optimal results in government policymaking as well as investor decision-making. We therefore explain also the applicable literature on reducing information asymmetry.

On energy security definition and indicators

The International Energy Agency (IEA 2023, par 1) defines energy security as “the uninterrupted availability of energy sources at an affordable price”. Further, the IEA explains that energy security as an objective has long-term and short-term objectives: the objective in the long-term is to ensure that timely investments come in to supply energy for economic development and sustainability (including environmental) needs, while the objective in the short term is to ensure that the energy system has the ability to react promptly to sudden supply-demand imbalances (IEA 2023). This implies that energy security can be measured by looking at medium- to long-term energy supply indicators vis-a-vis energy demand indicators and short-term energy system reliability indicators (e.g., instantaneous power grid reliability).

The World Energy Council (WEC), in its measurement of the World Energy Trilemma Index, considers energy security as reflecting "a nation's capacity to meet current and future energy demand reliably, and withstand and bounce back swiftly from system shocks with minimal disruption to supplies" (WEC 2022, p. 5). The United Nations Development Programme (UNDP) defines it as “the availability of energy at all times in various forms, in sufficient quantities, and at affordable prices, without unacceptable or irreversible impact on the environment (UNDP 2004, p. 42).” The WEC definition incorporates sufficiency, reliability and resilience, whereas the UNDP definition incorporates reliability, sufficiency, affordability, and sustainability.

A 2012 report by the Economic Research Institute for ASEAN and East Asia (ERIA), as finalized in Kutani et al. (2014), finds that the definition of energy security changes depending on the subject of (what is being protected), the threat against (against what is it being protected), and the measures for (who is doing what to protect it and with whom) energy security. Nevertheless, for purposes of the assessment of energy security in selected countries under the ERIA project, Kutani et al. defined energy security as “the securing of the amount of energy required for people’s lives, economic, social, and defense activities, among other purposes, at affordable prices” (p. 7, Chapter 2, Kutani et al. 2014). They also calculated ESIs, albeit calling each indicator an energy security index (which can be misleading as the concept “index” in economics, finance, or development policy is usually interpreted as composed of component indicators and calculated using a form of weighted averaging of the components). The approach in Kutani et al. is to list the ESIs by stages in the energy supply chain, namely, securing resources, securing a domestic supply chain, and managing demand. The study also added indicators for two additional features of energy

security—preparedness for supply disruptions and environmental sustainability. Given that some data are not uniformly available for the countries considered by Kutani et al., they had to discard in the final report some ESIs that were calculated in the 2012 report.

Although there is no attempt to calculate an overall energy security index, Kutani et al. (2014) presented a country-by-country comparison. The countries compared were Australia, New Zealand, and selected Asian countries, namely, Brunei Darussalam, Cambodia, China, India, Indonesia, Japan, Korea, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand, and Vietnam. To make the countries comparable, the study plotted five major ESIs, namely, self-sufficiency (including nuclear), total primary energy supply (TPES) diversity, power generation diversity, TPES-to-gross domestic product (GDP) ratio, and CO₂ emissions per GDP level and with five-year scenarios from 2020 to 2035. The study also cautioned the need for prudence in interpreting the presented pathways of the ESIs given the many underlying factors that change the statistics and recommended a periodic reevaluation of the ESIs.

As can be seen from the definitions above, international organizations attach different meanings to energy security but important elements emerge in their respective definitions. Broadly, these elements are: energy sufficiency, energy reliability, energy system resilience, energy affordability, and sustainability of energy production and consumption (where sustainability means without unacceptable or irreversible environmental impact). The Kutani et al. (2014) method also demonstrates how aspects of energy security can be measured using specific indicators. This study therefore contributes to the literature by finding out what ESIs corresponding to the mentioned broad elements of energy security are available in the Philippines and conducting an indicator-based assessment of the country's energy security situation. In addition, since access to energy by the whole population is still an issue in the Philippines, unlike in many countries where universal access is no longer a developmental goal, this study includes access by the population as another element of energy security. Moreover, this study differs from Kutani et al. (2014) in the sense that it considers other indicators that the latter discarded due to uneven availability of data across countries. Note that the five ESIs that Kutani et al. ended up using are focused only on the supply sufficiency and environmental sustainability elements. Given that data on the previously discarded indicators are available in the Philippines, this study did not ignore them.

On final energy use forecasting techniques

The individual effects of disruptions on energy demand on a long-term basis are difficult to measure but the aggregate effect is usually simulated in energy research literature using theoretically and empirically sound forecasting techniques. For instance, Fatai, Oxley and Scrimgeour (2003) analyzed New Zealand electricity demand based on econometric approaches such as the cointegration approach and the autoregressive approach, and then selected the model with the smallest forecasting error. The cointegration approach means examining whether there is cointegration or long-run relationship among the variables. On the other hand, the autoregressive approach involves checking if the past values predict future values. The study concluded that the autoregressive model has better forecasting performance in the New Zealand market than the cointegration model.

Forecasting electricity demand can also be done by employing a ready-made comprehensive model that considers all components of the energy sector and then later deriving the electricity demand component from the results. One such model is the Low Emissions Analysis Platform (LEAP), an international collaboration software tool developed by the Stockholm Environment Institute. The tool is being adopted by hundreds of organizations in more than 150 countries. In Raza et al. (2022), LEAP is used to model Pakistan's electricity sector demand for 2018-2030. Two electricity demand scenarios were used—the baseline scenario and the energy conservation scenario—and compared with the power generation potential. The aim is to support the government in assessing the required power capacity development and help alleviate potential energy crises.

In the Philippines, the Department of Energy (DOE) has been contributing to the literature on electricity demand forecasting but only in terms of results rather than techniques. Its forecasts are detailed in its periodic publications of the Philippine Energy Plan, but the forecasting equations are not being published. A contribution to the Philippine literature on electricity demand forecasting techniques is Danao and Ducanes (2018). In Danao and Ducanes, the econometric regression model used is an error correction model, which involves establishing first a long-run relationship and then specifying an error correction model that captures short-run dynamics. Using data for the period 1992-2014, the study shows that a long-run positive and inelastic relationship exists between the country's aggregate electricity consumption and income, where income is the country's GDP, and that income, electricity price and temperature have significant short-run effects. However, the study's forecasting model dropped electricity price in the long-run relationship because the results showed a positive sign for price, which is not consistent with the economic theory that as price increases, demand decreases. A variant of the Danao and Ducanes model was re-estimated in Fabella and Ducanes (2019), although the re-estimation is not for aggregate electricity demand for the country but for Meralco's franchise areas only.

This study contributes to the literature on electricity demand forecasting by using an error correction model using updated data and extending the forecasting exercise by projecting also the anticipated peak demand. Projecting peak demand is an important difference with the Danao and Ducanes (2018) study because the latter only projected the aggregate electricity demand or consumption. In planning for what generation capacity to commit, what is more important for the government and the private sector is actually the anticipated peak demand. The generation capacity that must be planned for in the future should be equivalent to the peak demand plus some reserves for contingencies and other technical requirements.

On the need to minimize information asymmetry in assessing energy security

Sources of energy insecurity, such as trade shocks or eruption of conflict in energy production areas, create uncertainty about future consumption prices and future cost of capital. The uncertainty, in turn, can cause firms to postpone investment decisions, and this highlights the importance of correct assessments of sources of energy insecurity. If the government is targeting a desired firm behavior, it should be able to provide timely country-level outlook. Otherwise, information asymmetry could drive sub-optimal results.

Information asymmetry exists when at least one party to a transaction possesses the relevant information while the counterparty is, or the counterparties are, experiencing information gaps.

Consider a scenario wherein a firm wants to invest in renewable energy and the government acts on permits and is giving the appropriate production support such as feed-in-tariff or priority dispatch. If the firm has incomplete or inaccurate information about the actions of the government, it might not make the appropriate investment level.

In economics, there are two basic models of information asymmetry — the adverse selection (“hidden information”) model and the moral hazard (“hidden action”) model. The classic study of adverse selection is provided by George Akerlof in his 1970 seminal paper on the “market for lemons”. The adverse selection problem is present when the information asymmetry is such that high-risk investors will participate in the market because the state cannot effectively distinguish between high- and low-risk investors. It can also occur when the party without information is worried about an unfair trade or transaction and thus will not participate in the market. On the other hand, moral hazard as a concept dates back to the 17th century and was revived in modern economics beginning with the 1963 work of Kenneth Arrow on the welfare economics of medical care. Moral hazard is present when an entity takes action that will increase its exposure to risk because it does not bear the full costs of that risk. An example is the possibility of over-investment in power generation capacity with the expectation that future electricity demand will be high, but the environment is such that a single firm does not have a good view of the aggregate demand because it is actually the state that can best provide the overall demand outlook.

In dealing with information asymmetry in energy markets, a typical advice is for the government to “fund the information” in order to minimize such asymmetry. For instance, the Allen Consulting Group (2004), in its advice to the Australian government regarding energy efficiency policymaking, explains that due to the public good characteristics of information and other market imperfections, information can tend not to be provided at an economically efficient level. Information failures can also come from lack of available information, the cost of gathering information, the accuracy of information, and the ability to act upon or use the information. Governments can therefore help by funding the provision of information directly as this reduces the costs of information search and information access for individuals and firms. This study therefore contributes to the literature by establishing the policy relevance of the indicator-based assessment of energy security and forecasting final energy use because these help minimize information asymmetry. The study also gives ideas to the government that an indicator-based assessment of energy security can be included in its activities that aim to “fund the information” needs of the private sector and thereby minimize information asymmetry.

1.3 Research method

We employ first an indicator-based assessment, which is a method that follows the maxim that managing something is difficult if we cannot measure it. The most common application of this is in medical science. A fairly recent example familiar to socioeconomic development specialists is the assessment of how countries are meeting the 17 Sustainable Development Goals formulated by the United Nations General Assembly. We selected the indicators used in assessing energy security based on ERIA (2012) and Kutani et al. (2014). We also supplemented the descriptions of ESIs from ERIA (2012) and Kutani et al. (2014) with descriptions from the DOE.

In projecting electric power demand, we apply an error correction model to an aggregate electricity consumption equation then apply data-driven assumptions on plant use, transmission losses and load factor to project the peak demand forecasts. We then add to the peak demand forecasts the reserve margin assumed in the Philippine Energy Plan 2020-2040 and compare the sum to the electricity supply outlook, that was in turn based on the latest committed capacities submitted to the government. Lastly, we formulate recommendations by assessing the policy implications of our results and identifying the needed actions from the government and the private sector, including civil society, to improve energy security.

2. Energy security indicators

The energy security aspects examined in the government’s development plan, the Philippine Development Plan (PDP) 2023-2028 are affordability, accessibility, and reliability (albeit with no indicators for affordability in the PDP Results Matrices). We are making a case for a more comprehensive view of energy security that is beyond what was covered by the PDP and covers other important aspects. Thus, in this section, we present an assessment of the country’s energy security based on indicators focusing on six important elements of energy security. These are sufficiency, reliability, resilience, affordability, accessibility, and sustainability. We present definitions and calculations of energy security indicators (ESIs) under these six broad categories and analyze trends to systematically assess the country’s progress in achieving energy security.

2.1 Energy security indicators implicit in the Philippine Development Plan

The PDP 2023-2028 stated that “Affordability, accessibility, and reliability are the three aspects of energy security” (p. 269, Chapter 12, National Economic and Development Authority (NEDA) 2022). We can also glean aspects of energy security indicators from the medium-term energy sector targets set in the PDP 2023-2028 Results Matrices. However, the indicators used in the Results Matrices are related to energy accessibility and reliability only. An affordability indicator is missing. The specific energy sector indicators, baselines, and targets in the PDP 2023-2028 Results Matrices are:

Table 1. Energy sector results indicators and targets in the PDP 2023-2028 Results Matrices

Results Indicator	Baseline		Annual Plan Targets					
	Year	Value	2023	2024	2025	2026	2027	2028
Proportion of households with access to electricity increased (% of total households)	2021	95.41	95.5	TBD	TBD	TBD	TBD	TBD
Electricity consumption per capita increased (kWh)	2021	804.21	897	945	996	1051	1110	1172
Share of renewable energy in the power	2021	22.4	24	26	28	30	32	33

Results Indicator	Baseline		Annual Plan Targets					
	Year	Value	2023	2024	2025	2026	2027	2028
generation mix increased (%)								
Power requirements met (in % available capacity over peak demand) ^a	2022	142.97	144.6	146	149.39	142.21	139.22	140.14

Notes: kWh = kilowatt-hour

TBD = To be determined

^a The PDP 2023-2028 Results Matrices also emphasized in the “Assumptions and Risks” that these numbers are assumed based on the DOE Power Development Plan 2020-2040, the implementation of the Grid Operation and Maintenance Program, the DOE List of Existing Power Plants as of October 31, 2022, and the timely entry of new power projects as indicated in the DOE List of Private Sector Initiated (Committed) Power Projects as of October 31, 2022. Off-grid generation and battery energy storage systems are not included.

Source: NEDA (2023).

Nevertheless, the PDP 2023-2028 main document recognized in the assessment part that affordability of electricity prices is a huge problem and one of the reasons why domestic manufacturing growth in the country is low. It also explained that the Philippines is highly sensitive to volatile fuel prices in the international market (NEDA 2022).

The PDP 2023-2028 also stated that accessibility in the form of universal electrification is yet to be achieved, especially because most of the entities mandated to provide electricity access to unserved and underserved areas are financially ailing electric cooperatives. In addition, the reliability of energy supply continues to be hampered by grid congestion, made worse by delays in transmission capacity expansion such as the Mindanao-Visayas Grid Interconnection Project (NEDA 2022).

On reliability of energy supply, the PDP 2023-2028 Results Matrices breaks down the baseline and annual targets for the “power requirement met” result indicator by island group, that is, Luzon, Visayas, and Mindanao (see Table 2 below).

Table 2. Baseline and targets in meeting the annual power requirement by island group

Result Indicator	Baseline	Annual Plan Targets					
	2022	2023	2024	2025	2026	2027	2028
Luzon							
Power requirement met (in % available capacity over peak demand)	134.19	133.32	139.88	145.14	139.55	137.93	143.41
Dependable Capacity (MW)	16,254	17,498.28	19,467.28	21,435.65	21,885.65	21,985.65	25,410.15
Projected Peak Demand (MW)	12,113	13,125	13,197	14,769	15,683	16,665	17,719
Required Reserve (MW)	1,820.52	1,861	1,892.68	1,926.76	1,963.32	2,002.60	2,004.76
Visayas							
Power requirement met (in % available capacity over peak demand)	149.57	174.96	163.07	166.26	155.16	145.17	135.53
Dependable Capacity (MW)	3,464	4,708.28	4,714.28	5,172.48	5,182.48	5,204.48	5,204.48
Projected Peak Demand (MW)	2,316	2,691	2,891	3,111	3,340	3,585	3,840

Result Indicator	Baseline	Annual Plan Targets					
	2022	2023	2024	2025	2026	2027	2028
Required Reserve (MW)	392.64	407.64	415.64	424.44	433.6	443.4	453.6
Mindanao							
Power requirement met (in % available capacity over peak demand)	185	172.31	159.85	153.09	141.71	139.29	128.75
Dependable Capacity (MW)	4,009	4,126.86	4,130.46	4,269.61	4,269.61	4,539.61	4,539.61
Projected Peak Demand (MW)	2,167	2,395	2,584	2,789	3,013	3,259	3,526
Required Reserve (MW)	386.68	395.8	403.36	411.56	420.52	430.36	441.04

Note: MW – megawatts

Source: NEDA (2023).

Note from the PDP targets that if the government would be able to maintain its timetable for energy development activities and the private sector would be able to follow its schedule of committed power generation projects, the Philippines could be assured of meeting its power requirements throughout the country until 2028. Luzon would expect to have higher available capacity over peak demand in the medium term, from 134.19 percent in 2022 to 143.41 percent in 2028. However, even if existing commitments would be followed, the available capacities over peak demand in Visayas and Mindanao could be lower by the end of the plan period, that is, from 149.57 percent in 2022 to 135.53 percent in 2028 in Visayas and from 185 percent in 2022 to 128.75 percent in 2028 in Mindanao. This reinforces the importance of completing the integration of the Luzon-Visayas grid with the Mindanao grid, the expansion of transmission capacity in congested corridors, and the modernization of the whole transmission system so that supply in surplus areas could be delivered to deficit areas.

2.2 Assessment of the latest estimates of energy security indicators for the Philippines

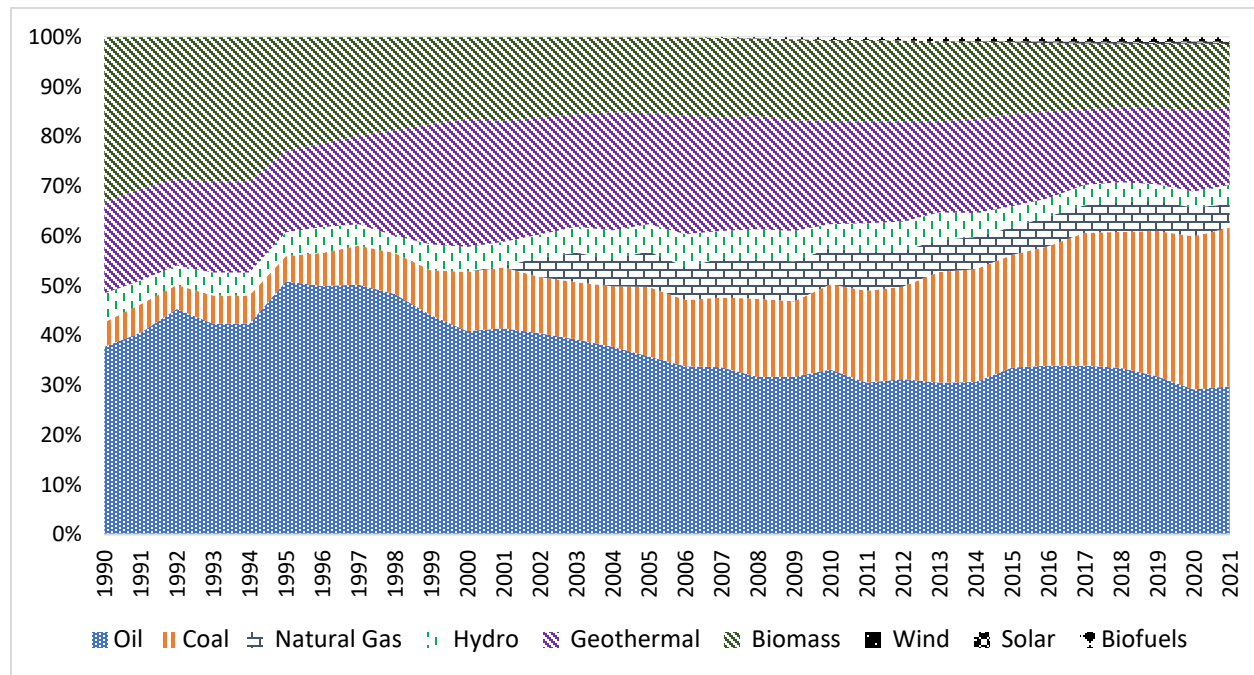
We present below the latest available estimates of ESIs for the Philippines. For some indicators, we relied on the historical energy statistics gathered from the DOE. For other indicators, we used data monitored by international organizations and then conducted cross-national comparisons, particularly in the Southeast Asia region. In most indicators, we used data from 1990 to 2021, but in other indicators and depending on data availability, we used time series outside that range.

2.2.1 Sufficiency

Energy sufficiency entails ensuring that energy sources are adequate for short- to long-term use. This is done through supply-side and demand-side measures. On the supply side, domestic resources need to be developed and when domestic sources are not enough, energy resources must be imported from overseas while ensuring that import sources are diversified to minimize market risks. On the demand side, strategies include managing demand through efficiency improvements.

The basic sufficiency indicator is the total primary energy supply (TPES) in the country. Overall, the Philippines' TPES is largely dominated by fossil fuels, which has a 66.5 percent share in 2021. Among fossil fuels, the share of coal has dramatically increased from 5 percent in 1990 to 31.9 percent in 2021, while that of oil decreased from 40 percent in 1990 to 29.8 percent in 2021 (Figure 1). The increase in the share of coal has been more evident starting 2002 and the succeeding years due to the continued expansion of the coal industry and the installation of new coal-fired power plants. The growing demand for coal mostly came from industries that switched to coal due to the high volatility of oil prices in the global market. The share of natural gas historically remained low, beginning at 0.3 percent in 2001 and ending at 4.8 percent in 2021.

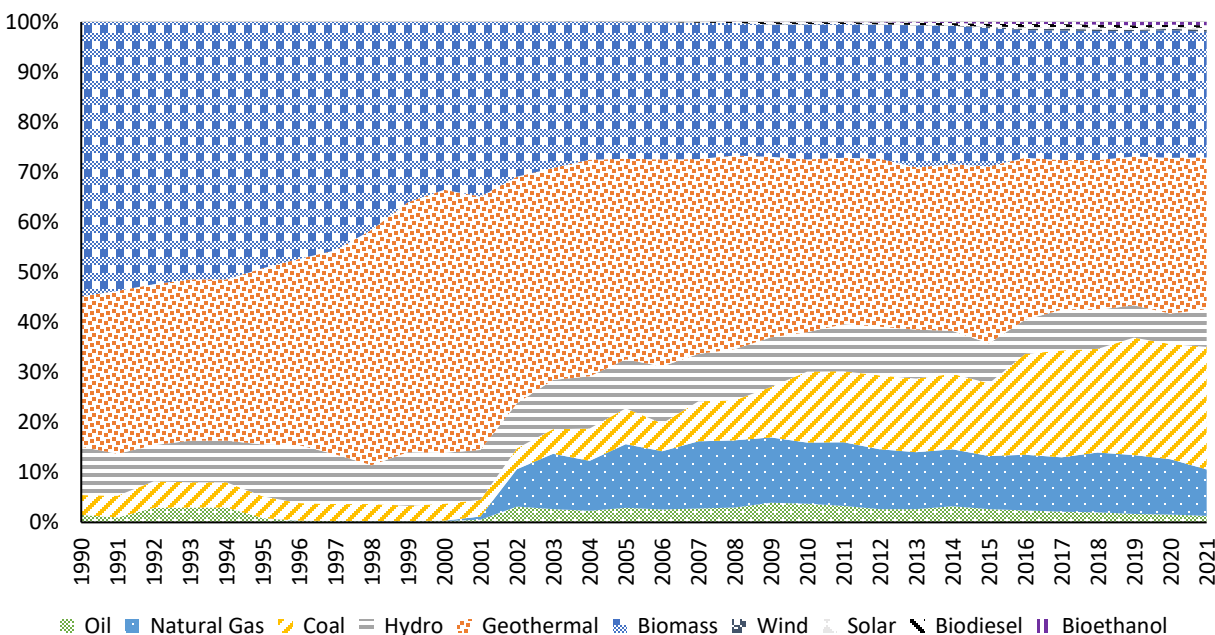
Figure 1. Total primary energy supply in the Philippines, 1990-2021



Source: DOE (2020; 2023a).

Some parts of this TPES are sourced from indigenous resources. Figure 2 shows how the composition of indigenous energy production has changed over the years since the 1990s. Biomass, geothermal, coal, and natural gas have dominated domestic energy production in recent years. While renewable energy has increased from 14,780 kilotons of oil equivalent (KTOe) in 1990 to 19,674 KTOe in 2021, the expansion of fossil fuel supply has been at a faster rate, thus leading to the sudden rise of its share in the last decade. Nevertheless, renewable energy production remains dominant relative to fossil fuel production. In 2021, the share of renewable energy was 65 percent and that of fossil fuel was at 35 percent. Renewable energy production is led by geothermal energy production at 30 percent. The other indigenous energy production in 2021 shares were: biomass, 25 percent; coal, 24 percent; natural gas, 9 percent; hydropower energy, 8 percent; oil, 1 percent; and the remaining 3 percent share is for bioethanol, biodiesel, solar, and wind.

Figure 2. Indigenous production (% share by source), 1990-2021

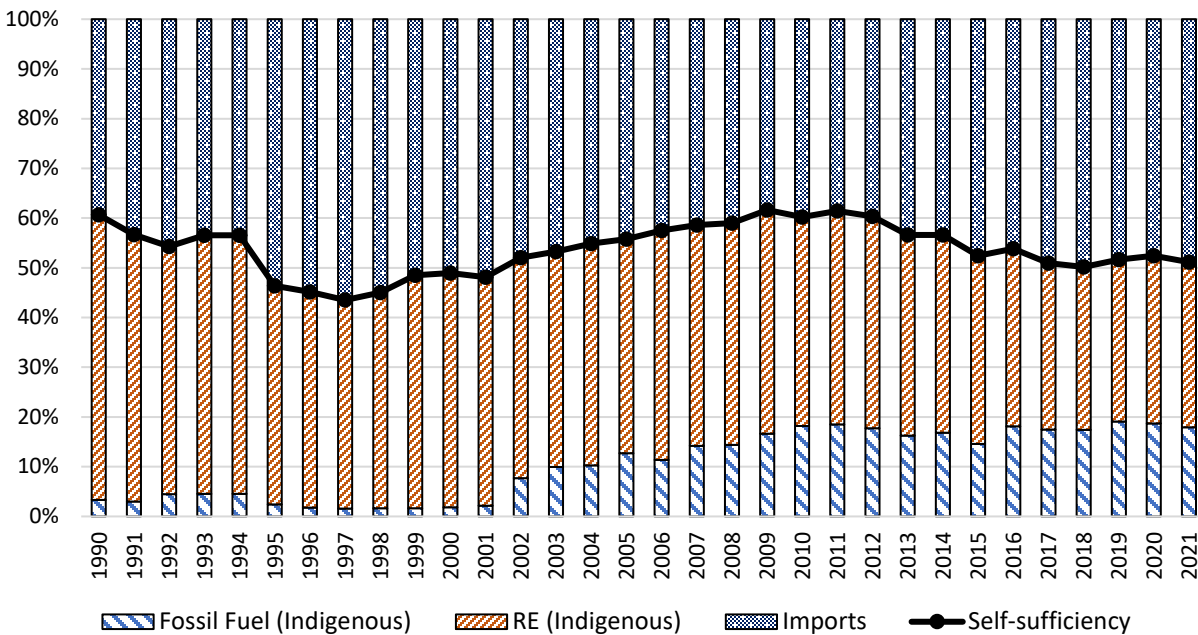


Source: DOE (2020; 2023a).

Given indigenous energy production, we can assess a narrower concept of energy sufficiency, that is, energy self-sufficiency. It pertains to the country’s ability to meet its energy demand through domestic sources of energy or without relying on external sources. The primary indicator for measuring it is the energy self-sufficiency ratio, or the share of the locally-produced energy in the TPES in the country. While the desired self-sufficiency ratio varies from one country to another, a move toward a higher ratio can lead to several advantages such as less exposure to the volatility in the prices of international energy sources, improvements in the energy infrastructure resulting from the expansion of domestic energy production, and reduced trade deficit due to lesser imports. Aiming for higher self-sufficiency necessitates greater investments in the energy sector, particularly investments on innovation and infrastructure to facilitate the development of indigenous resources such as renewable energy.

The Philippines' energy self-sufficiency ratio was at a high of 61 percent in 1990, then went on a downward trend until 1997. It increased again starting in 1998 and reached its highest point in 2009 at 62 percent, but recently, its trend is generally declining (Figure 3). Such decline is due to the country’s increasing reliance on both coal and oil imports. There was nevertheless a significant increase in the local production of coal in 2016 due to the discovery of large coal reserves, which amounted to about 221 million metric tons (DOE 2022a). Despite the growing reliance on imports, the government remains committed to exploring and developing the coal industry to contribute to the country’s energy self-sufficiency. As of May 2022, there are 27 ongoing coal-operation contracts, which consist of 21 projects on the development and production phase and 6 projects on the exploration phase, and 47 small-scale coal mining contracts (DOE 2022a). As of April 2023, there are 117 accredited coal traders (DOE 2023b).

Figure 3. Shares of energy sources and self-sufficiency ratio, 1990-2021



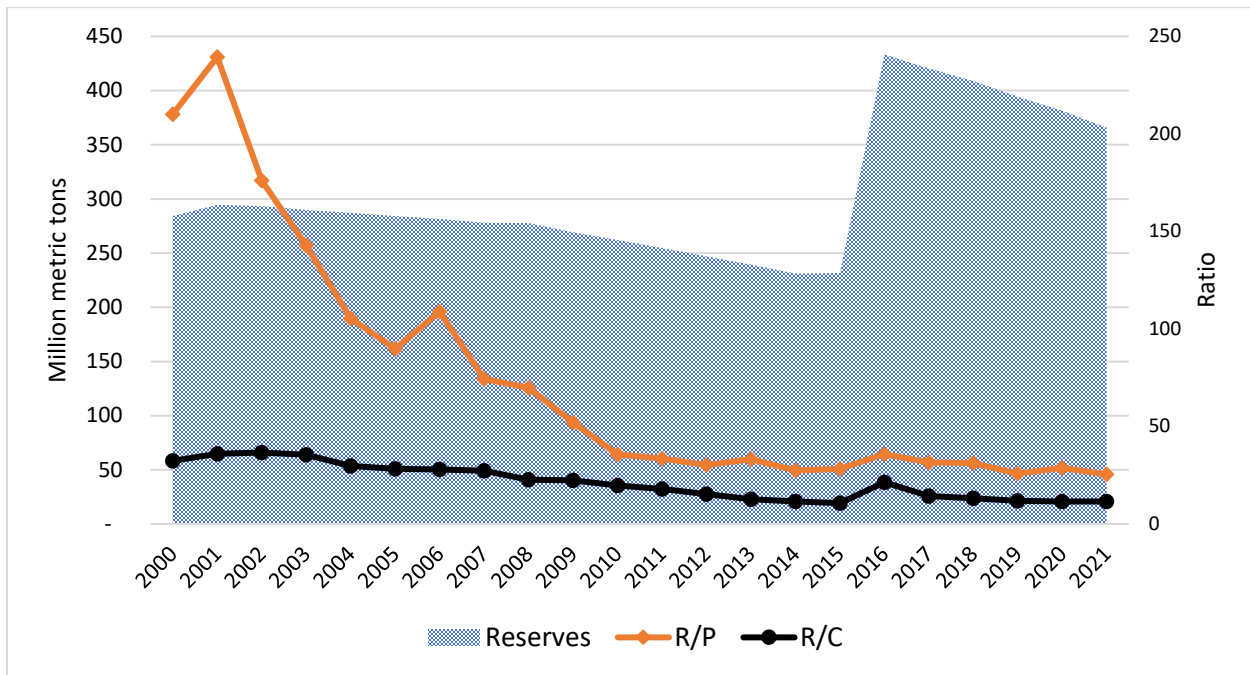
Source: DOE (2022b).

Other indicators that are related to energy self-sufficiency are the reserves-to-production ratio (R/P) and the reserves-to-consumption ratio (R/C). These ratios are used to assess the longevity of an energy resource by showing its remaining years' worth given certain rates of annual production and consumption. High ratios for an energy resource generally signal that large reserves are still available for the population in the succeeding periods. Low ratios, on the other hand, signal that the country is about to run out of that particular resource and unless new reserves are discovered, the decline will have adverse effects on energy self-sufficiency.

In this study, the data on reserves used are the total of Class A deposits, that is, the commercially recoverable resources or those that can be recovered with certainty, and Class B deposits, that is, the potentially commercially recoverable resources or those that can be recovered with a high probability of certainty. The third classification, Class C, refers to non-commercial and other known deposits (Philippine Statistics Authority (PSA) 2022a).

Figure 4 shows the country's low R/P and R/C ratios for coal. Although there was a sharp increase in aggregate reserves in 2016 and the R/P and R/C ratios slightly increased, the trend has been declining again and the ratios remain low. This implies that part of the demand has to be met by imported coal (Figure 5) as the available reserves dwindle.

Figure 4. Reserves-to-production and reserves-to-consumption ratios for coal, 2000-2021

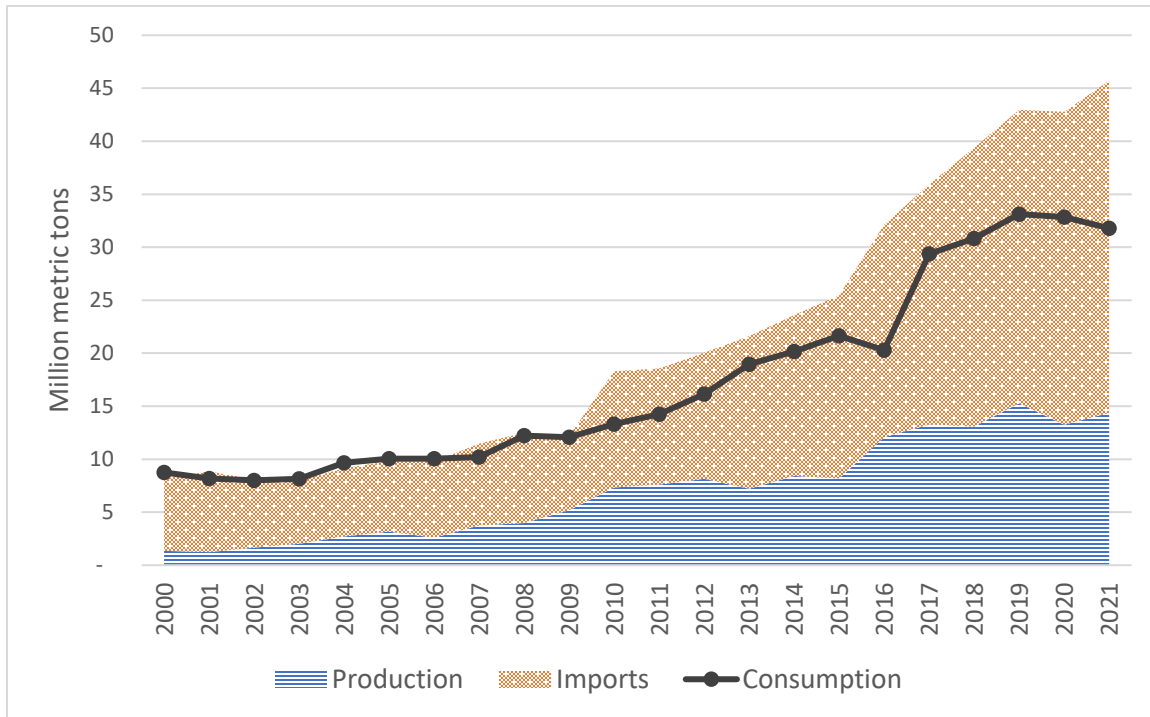


Note: Total reserves consist of Class A and Class B deposits.

Source: Reserves - PSA (2022a); Production and consumption – DOE (2022c) .

Figure 5 further shows how imported coal surged in recent years in response to the expanding demand for coal, while the increase in production from local sources remained slow. Reliance on coal imports has cost and uncertainty implications and this has to be managed not only by exploring other fossil fuel reserves but also by tapping alternative indigenous sources (such as various renewable energy resources) and by diversifying our import sources.

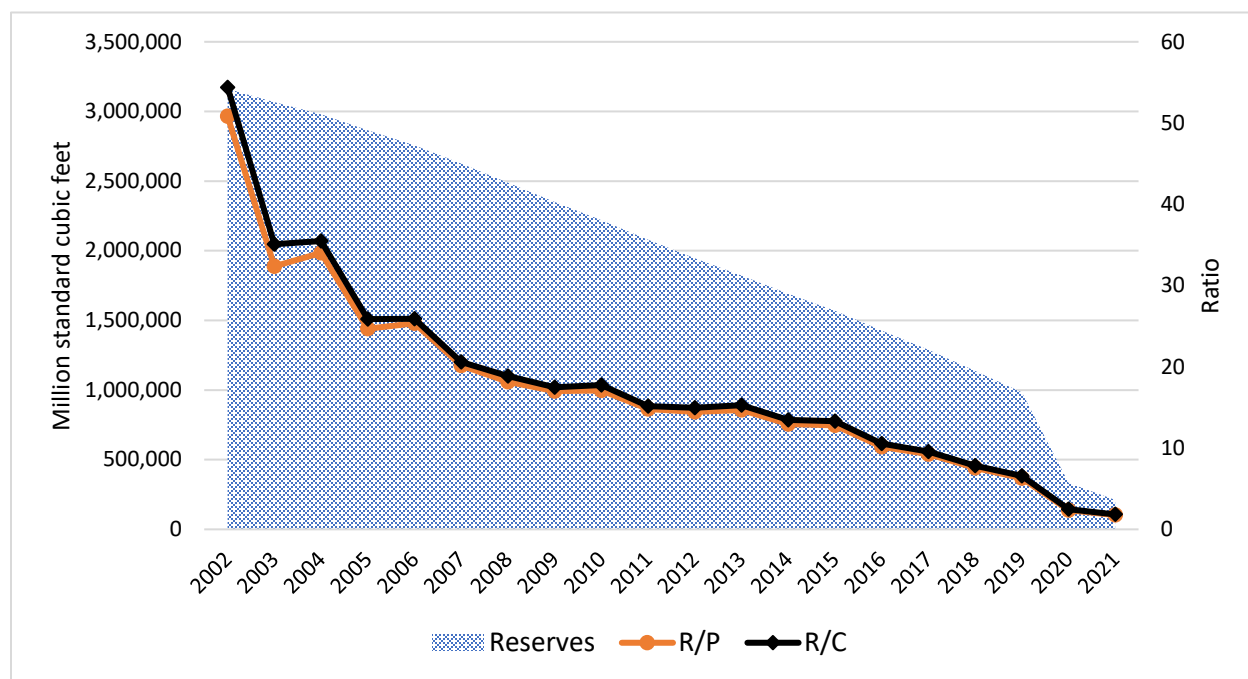
Figure 5. Demand for coal vis-à-vis supply by source, 2000 to 2021



Source of basic data: Production, imports, and consumption – DOE (2022c).

In the case of natural gas, as of 2021, both the R/P and R/C ratios recorded a value of 1.8 million standard cubic feet (mmscf) of reserves per unit of natural gas produced and consumed, respectively (Figure 6). This implies that about two years' worth of natural gas are left assuming that there will be no other additional proven reserves and the current consumption is maintained in the succeeding years and this consumption will not be supported by imports. As also shown in shown in Figure 6, the level of natural gas reserves dwindled steeply over the last two decades, and it may just be a matter of a few years before the reserves get totally depleted.

Figure 6. Reserves-to-production and reserves-to-consumption ratios for natural gas, 2000-2021



Notes: Total reserves consist of Class A and Class B deposits.

Source: Reserves - PSA (2022a); Production and consumption - DOE (2022d).

Since 2002, the Philippines has been relying on the Malampaya gas field for its local source of natural gas and the gas field reserves have been dwindling. However, according to the DOE, production from the gas field can still be stretched up to 2027 (DOE 2021a). Recently, the concession contract for the Malampaya gas field, which was supposed to expire on February 22, 2024, was extended by the government for fifteen years (that is, up to February 22, 2039) to allow the utilization of the remaining gas reserves and the exploration in nearby areas that may be able to provide incremental production (DOE 2023c). Given the dwindling reserves and the yet to be explored augmentation, the government started transitioning toward the use of imported liquefied natural gas (LNG) through the development of the necessary infrastructure facilities and formulation of gas industry policies. According to the DOE’s recently-crafted “Natural Gas Development Plan”, there are six LNG terminal projects in the pipeline, with investments amounting to PHP69.2 billion. These projects are currently being implemented and will continue in the next few years (DOE 2022e). Moreover, complicating the problem of depleting natural gas reserves is the tax treatment issue related to the Malampaya project, which has created uncertainties in future investments (see Box 1).

Box 1. The tax treatment issue in the Malampaya Natural Gas Project

Through Presidential Decree No. 87 (PD 87), the Philippine government can enter into contracts with local or foreign firms over exploration, development, and production of its indigenous petroleum resources. One such contract is Service Contract 38 (SC 38) signed in 1990, which is an agreement between the government, represented by the erstwhile Office of Energy Affairs (OEA), and Shell Philippines Exploration (SPEX)¹ to operate the Malampaya Natural Gas Project (MNGP). Under the agreement, the government assumes the contractors' income taxes as part of its 60 percent share in profits. This provision is supposedly designed to incentivize investments in the upstream oil industry, as much as constitutional limits allow. The Commission on Audit (COA) asserted that this effectively exempts contractors from paying income tax, an action that PD 87 does not explicitly authorize (COA 2015).

In its scrutiny of SC 38, the COA argued that the contract is not compliant with the limitations stipulated in PD 87, and through an effective income tax exemption clause, the agreement has allowed contractors to underpay PHP146.79 billion from 2002 to 2016. The DOE and the PNOC-EC have stood their ground on the validity of SC 38, asserting that the case is a "tax assumption" and not tax exemption, because the income taxes being required from SPEX and Chevron-Texaco have been assumed as part of the government's share. Moreover, they argued that if income taxes were taken from the contractors, the contractors would be left with less than the agreed upon share of 40 percent. But the COA maintained that PD 87 only requires a minimum 60 percent government share from the joint exploration and that the government is allowed to accrue more than 60 percent (COA 2018).

Even though the OEA (reconstituted later as part of the DOE²) consented to the provisions stipulated in SC 38 in 1990, it does not imply that all instrumentalities of the government will continue to agree with the provisions. As early as 2004, the COA questioned the inclusion of corporate income tax as government profits in the MNGP (Congressional Policy and Budget Research Department (CPBRD) 2011). The COA's legal scrutiny persists up to now, despite SPEX and other contractors winning the case in international arbitration (Velasco 2019). Nonetheless, the more-than-15-year long legal dispute between the COA and the contractors together with the DOE has cast a shadow on regulatory certainty in future petroleum exploration contracts.

Currently, the COA's interpretation on the invalidity of assuming the contractor's income taxes as part of the government's profit share is still being contested at the Supreme Court. Despite winning the international arbitration, the DOE and the contractors still need the Supreme Court's affirmation to treat as government profit share the income tax backpay being demanded by COA. The unsettled tax issue affects all other service contracts as the contested provision has always been part of the DOE's

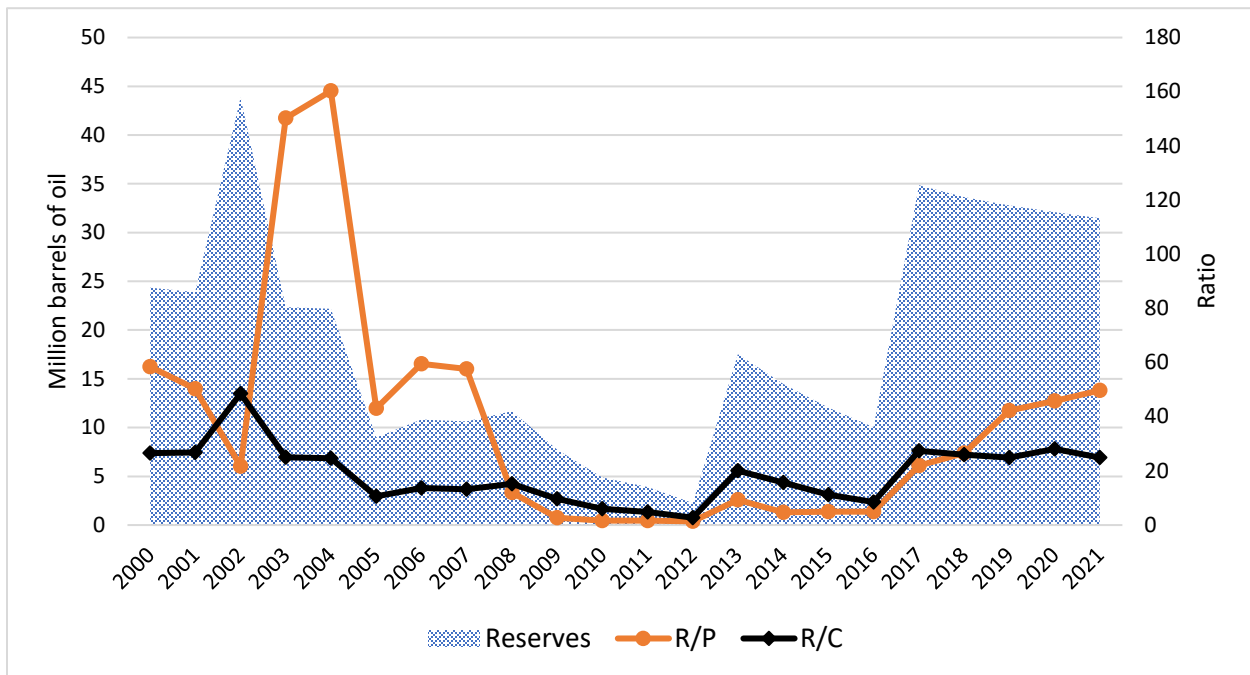
¹ The government-owned Philippine National Oil Company-Exploration Corporation (PNOC-EC) is a project partner with 10-percent stake. The project was operated by Chevron-Texaco until 2020, when both SPEX and Chevron-Texaco were bought by Udenna Corp. The ownership structure continued to evolve, with Prime Infrastructure Capital assuming full ownership and control of SPEX in 2022. At present, the project is owned by Udenna (45%), Prime Infrastructure Capital (45%), and PNOC-EC (10%) (CPBRD 2011; Burgos 2022).

²Through Republic Act 7638, the functions of the Office of Energy Affairs (OEA) and the Energy Coordinating Council were assumed by the DOE in 1992, and the OEA's rights, assets, and liabilities, including its agreements in the SC 38, were transferred to the DOE.

energy contracting program. The current contract template of the DOE, in fact, upholds the provision (Velasco 2019) but there is a waiver stipulating that the tax treatment shall be subject to the final Supreme Court decision (Velasco 2023). These circumstances essentially created uncertainty in investments for energy resource development. Navarro (2022) discussed that the uncertainty can be addressed by clarifying the regulatory framework and while the Supreme Court’s decision is pending, a draft legislation addressing the issue can already be initiated.

In the case of oil reserves, the recorded R/P and R/C ratios in 2021 are 50 barrels per one barrel of oil produced and 25 barrels per one barrel of oil consumed, respectively. The annual level of proven oil reserves has historically been erratic although it has steadily declined since the jump in 2017 (Figure 7). Production since 2017 has declined, thus, the higher R/P ratio in recent years. Meanwhile, the R/C ratio followed the direction of the trend of reserves, but the actual consumption level went up. Similar with the case of coal, the country continues to rely on imports to meet oil consumption. It must be noted that oil supply in the country is mostly comprised of imports (i.e., 98% of the total oil supply in 2021).

Figure 7. Reserves-to-production and reserves-to-consumption ratios for oil, 2000-2020



Note: Total reserves include Class A and Class B deposits.

Sources: Reserves - PSA (2022a); Production – DOE (2022f); Consumption – Energy Balance Table data were from the DOE through email on July 11, 2022.

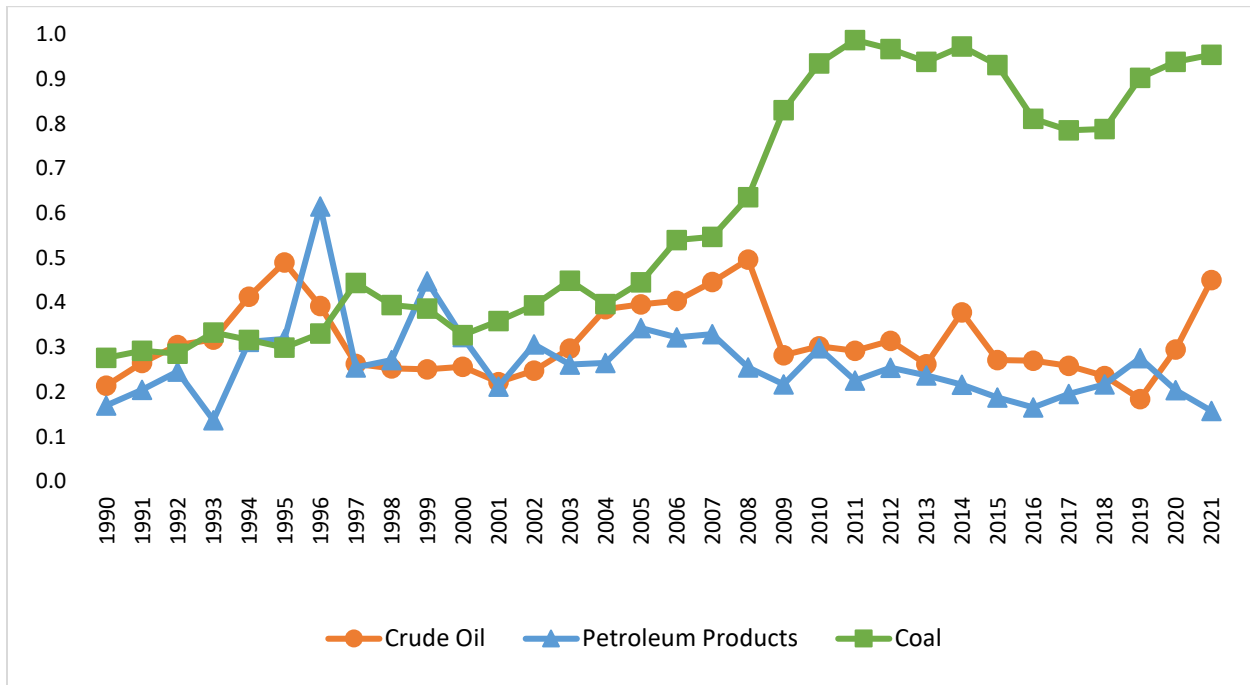
With increasing reliance on imports come energy insecurity due to uncertainty in external market forces. The primary strategy to deal with this is diversification of sources. Energy importing countries are considered more secure than others when they source energy imports from different countries and when there is no high concentration of sourcing from one country or from only a few countries. When one source country becomes unable to provide energy, the importing country that is not heavily dependent on that source can easily rely on other countries for imports. To measure the extent with which countries have diversified their import source countries, we follow Kutani et al. (2014)'s use of the Hirschmann-Herfindahl Index (HHI), which is a way of measuring the market shares of import source countries for a particular energy source.³ Being a measure of market concentration, the HHI ranges from 0 to 1. An HHI of 1 would imply that the energy supply is imported from only one country, and it would be closer to 0 once the supply is imported from more countries.

Figure 8 looks at the HHI of import source countries for crude oil, petroleum products, and coal in the Philippines from 1990 to 2021. Import sources of crude oil and petroleum products are relatively diversified throughout the years compared to that of coal, the sourcing for which has become significantly concentrated in recent years. Coal's trend towards concentration indicates the Philippines' trajectory of coal import dependence on Indonesia, which replaced Australia and China as the main sources of coal imports at around the turn of the millennium. This dependence on Indonesia's coal is actually risky given the Indonesian government's previous inclination to ban coal exports.⁴

³Formally, this is described as $HHI = \sum_{i=1}^n s_i^2$, where s refers to an import source country i 's share in a market for an energy source with n import source country participants.

⁴On December 31, 2021, the Ministry of Energy and Mineral Resources (MENR) in Indonesia required its domestic coal firms to supply a minimum of 25% of their approved coal production for domestic use with a selling price of 70.00 United States Dollars (USD) per ton, restricting firms that do not comply from exporting until they fulfill their obligations (Indonesia MENR 2021). Indonesia lifted the ban in February 2022 (Enerdata 2022), but it re-imposed the ban in August 2022 on coal firms that have neither complied nor reported their obligations to the MENR (Safety4Sea 2022).

Figure 8. Herfindahl-Hirschmann Index of import source countries by source of fossil fuel, Philippines, 1990-2021



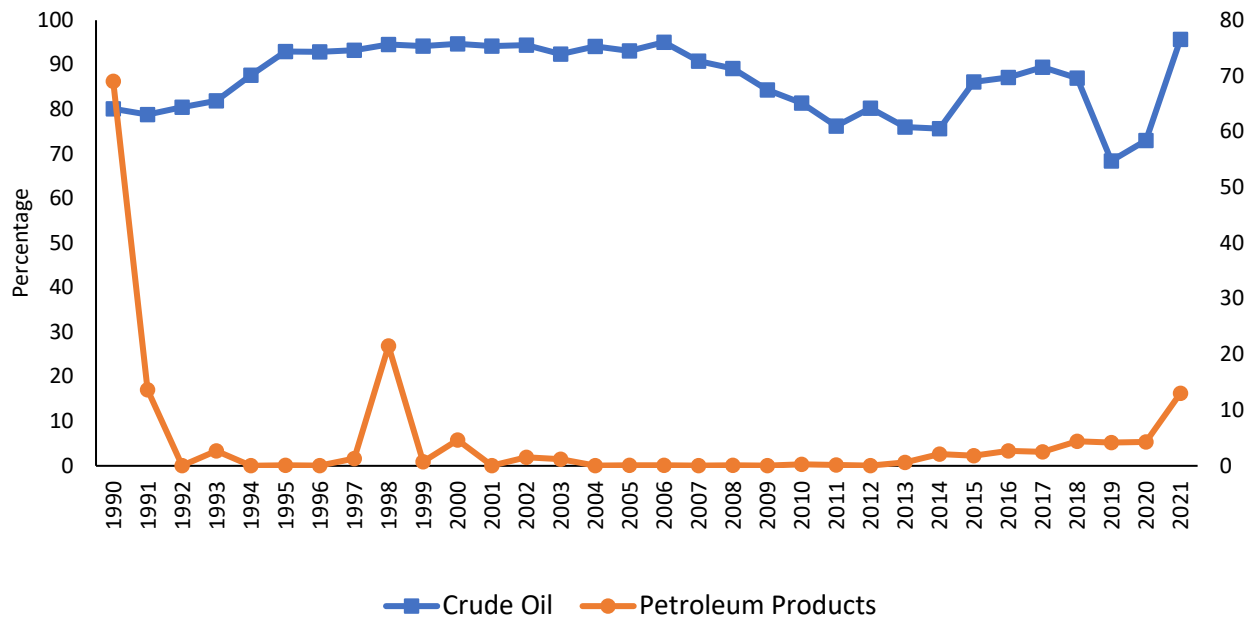
Source: Policy Formulation and Research Division of the DOE's Energy Policy and Planning Bureau (DOE-PFRD) (2022), PSA (2022b)

Market concentration may also be present when countries consistently rely on certain regions for their energy sources. The Middle East region, for instance, is a huge source of fossil fuel supply and will continue to be so as long as countries in the region find their reserves adequate and profitable as exports. However, given the geopolitical risks in the region, the energy security of countries that mostly import from this region suffers when far-reaching events like armed conflicts occur and cause indefinite energy supply disruptions.

Following Kutani et al. (2014), we measure the Middle East dependency of the Philippines as the proportion of imports from the Middle East to total imports per source of fossil fuel. A high proportion implies that the country is highly dependent on the Middle East for fossil fuels, leaving its energy supply pointedly tied to the geopolitical risks in the region. Figure 9 shows the proportion of imports from the Middle East to total imports in the Philippines for crude oil and finished petroleum products from 1990 to 2021. The Philippines sourced most of its crude oil requirements from the region throughout the years and Saudi Arabia stands out as the main source country, with crude oil imports from that country reaching as high as 80,620 thousand barrels in 1995. For finished petroleum products, the Philippines barely imported from the Middle East region except in 1990. Instead, the Philippines has been relying on China, Singapore, and Malaysia

given their significant refining capabilities relative to the Philippines.⁵ With the closure of Pilipinas Shell Petroleum Corporation (PSPC)'s refinery during the coronavirus disease 2019 (COVID-19) pandemic (PSPC 2020), the country's capacity to refine petroleum diminished further.

Figure 9. Proportion of Middle East imports to total imports (%) by source of fossil fuel, Philippines, 1990-2021



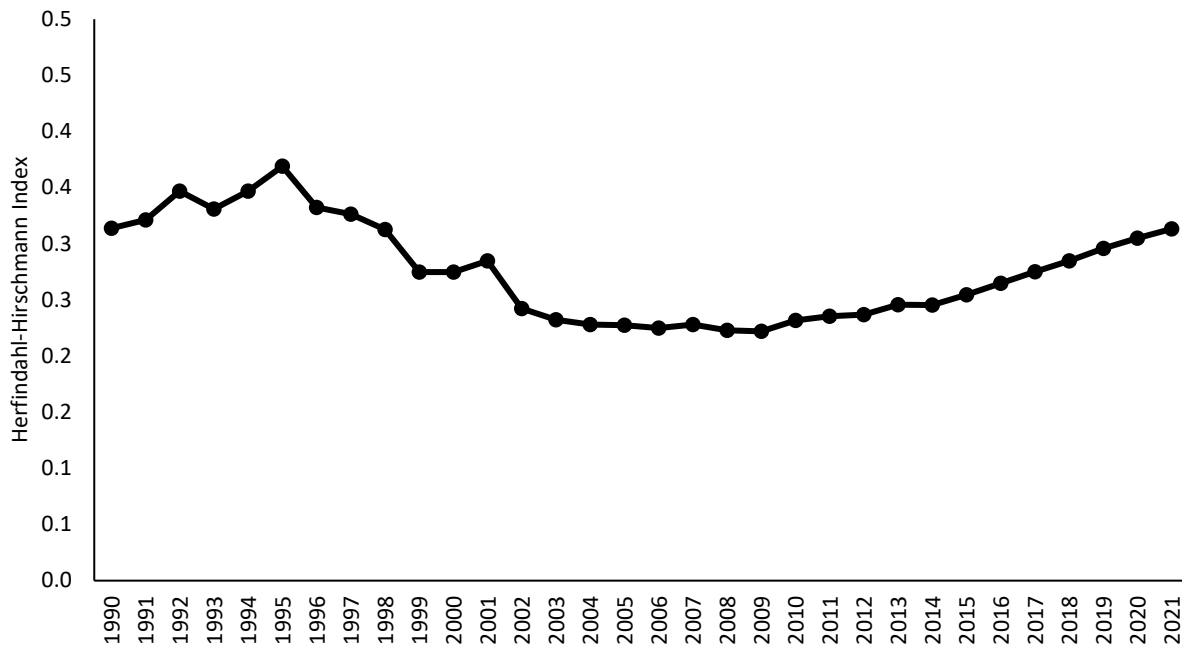
Source: DOE-PFRD (2022); PSA (2022a)

Figure 10 shows that the diversification of the Philippines' energy sources from 1990 to 2001 moved between the HHI range of 0.20 to 0.40. There is currently no agreed upon benchmark for HHI on the prudent diversification of energy import sources. But if assessments of industry competition are to be examined for an appreciation of HHI as indicator of diversification, the US Department of Justice and Federal Trade Commission (2010) provides thresholds of market concentration, as follows: HHI below 0.15 means unconcentrated market; HHI between 0.15 and 0.25 means moderately concentrated market; and HHI above 0.25 means highly concentrated market.⁶ Given this, the Philippines' HHI values indicate that its energy sources are highly concentrated on a few sources or inadequately diversified. Indeed, as shown previously, the Philippine relies on only a few countries for oil, coal and natural gas imports.

⁵ Compared to the Philippines' refining capacity of around 180,000 barrels per day (Petron n.d.), China has 17.5 million barrels per day (Bloomberg 2022), Singapore has 1.5 million barrels per day (International Trade Association 2021), and Malaysia has 880,300 barrels per day (US Energy Information Administration 2021).

⁶ We recognize that these thresholds come with empirical limitations (see Nocke and Whinston (2022) for a discussion). But our intention is to emphasize that the HHI remains a useful tool in assessing the risks to the Philippines' energy security using easily accessible data.

Figure 10. Herfindahl-Hirschmann Index of energy sources, Philippines, 1990-2021



Source: DOE (2020; 2023a).

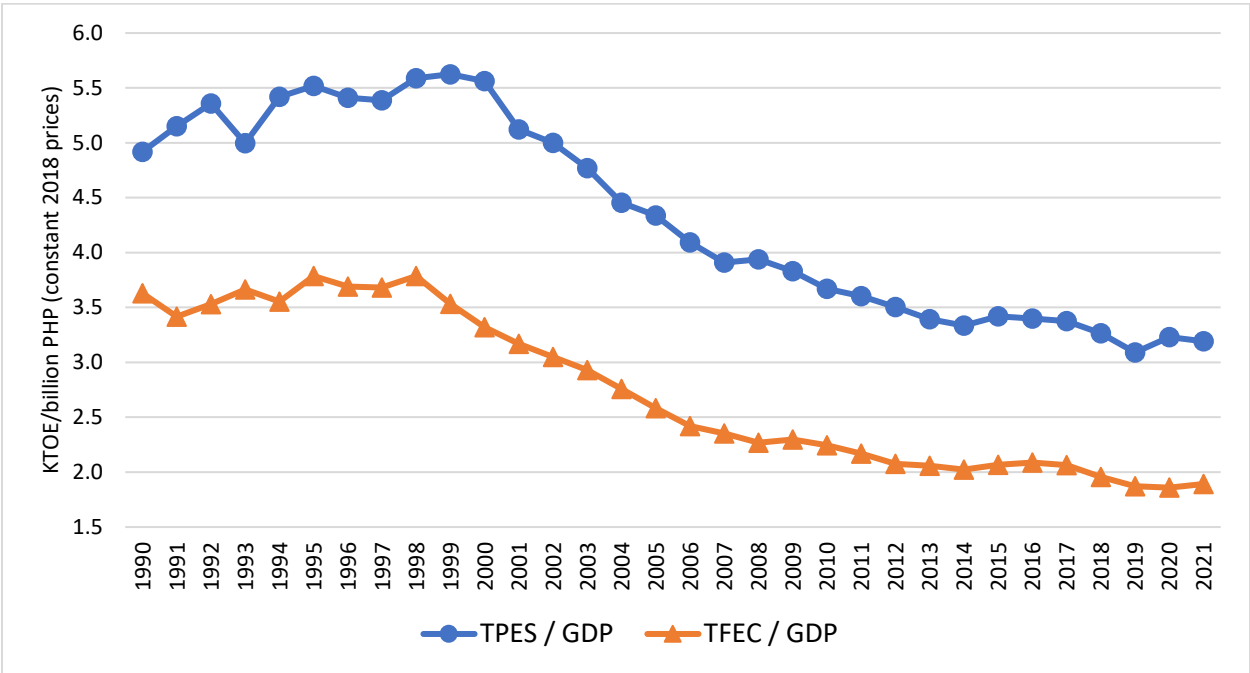
Another factor that contributes to ensuring energy sufficiency is demand management. Energy saved through demand management is additional supply made available to the overall system of energy flows. But in this respect, the primary strategy is not sacrificing or curtailing consumption but making energy use more efficient and reducing waste.

Kutani et al. (2014) used the TPES-to-GDP ratio and the total final energy consumption (TFEC)-to-GDP ratio as “energy efficiency” indicators.⁷ These can be considered measures of overall energy efficiencies in countries because high and increasing values of the TPES-to-GDP and the TFEC-to-GDP ratios mean that high and increasing amounts energy production and consumption are needed to produce one unit of economic output. The TFEC-to-GDP ratio considers only the final energy consumed by users and firms and excludes that which is used by the energy sector itself in producing final energy. The TPES-to-GDP ratio considers all forms of energy supply.

⁷ Some literature explain that energy efficiency is usually applied to individual activities. Technically, efficient energy is “the portion of total energy input to machine or system that is consumed in useful work and not wasted as useless heat or otherwise” (Islam and Hasanuzzaman 2020, Section 1.2.14). Energy efficiency adopts a bottom-up view of energy use whereas energy intensity adopts a top-down view, or energy efficiency is used when discussing the use of energy for specific activities and energy intensity is used when discussing the aggregated energy use of countries (Climate Policy Watcher 2023). For our purposes, we adopt the term “overall energy efficiency” to be consistent with Kutani et al. (2014).

Figure 11 presents the TPES-to-GDP and TFEC-to-GDP ratios in the Philippines from 1990 to 2021. Both ratios were generally increasing at the start but started to decline in the late 1990s. The TPES-to-GDP ratio declined from 5.62 KTOe/billion PHP in 1999 to 3.19 KTOe/billion PHP in 2021, and the TFEC-to-GDP ratio declined from 3.79 KTOe/billion PHP in 1998 to 1.89 KTOe/billion PHP in 2021. The decline in both ratios indicates increasing level of overall energy efficiency in the Philippines throughout the assessment period.

Figure 11. TPES-to-GDP and TFEC-to-GDP ratios, 1990-2021



Notes: The lower bound of the y-axis is changed from 0 KTOe/billion PHP to 1.5 KTOe/billion PHP to emphasize movement visualization. GDP figures are in 2018 constant prices; KTOe means kilotons of oil equivalent.

Source: DOE (2020); PSA (2022b)

We can also look at intensity in use when assessing efficiency. Comparing the Philippines with other countries in Southeast Asia, Table 3 looks at the intensity level of primary energy use in countries in the region from 2007 to 2015, with energy measured in megajoules (MJ) and GDP presented in purchasing power parity US dollars (USD PPP). In a region averaging 4.28 MJ/USD PPP in 2015, the Philippines with 3.10 MJ/USD energy intensity is efficient relative to most other countries. Along with Myanmar, it stands second to Singapore that had an energy intensity level of 2.40 MJ/USD in 2015. Furthermore, it is considered around two times more efficient than the most energy intensive countries in the region since Cambodia and Vietnam only achieved levels of 5.80 MJ/USD and 5.90 MJ/USD, respectively, in 2015. The generally declining trend of energy intensity for the Philippines also shows that with respect to energy demand management, the country has shown some progress in making its economic activities energy efficient.

Table 3. Energy intensity level of primary energy (MJ/2011 USD PPP), Southeast Asia, 2007-2015

Countries	Year								
	2007	2008	2009	2010	2011	2011	2013	2014	2015
Brunei Darussalam	4.7	5.3	4.6	4.8	5.5	5.4	4.4	4.7	3.7
Cambodia	4.6	4.3	6.2	6.1	6.0	5.8	5.6	5.6	5.8
Indonesia	4.4	4.2	4.4	4.3	3.9	3.9	3.7	3.7	3.5
Lao PDR	3.5	3.3	3.1	3.0	2.7	2.5	2.5	2.3	5.2
Malaysia	5.7	5.6	5.4	5.2	5.1	4.9	5.3	5.1	4.7
Myanmar	4.7	4.1	3.5	3.1	3.0	3.1	3.0	3.1	3.1
Philippines	3.5	3.5	3.3	3.2	3.1	3.1	3.0	3.0	3.1
Singapore	2.9	3.2	2.8	2.9	2.8	2.7	2.7	2.5	2.4
Thailand	5.3	5.3	5.4	5.4	5.4	5.4	5.6	5.6	5.4
Viet Nam	5.8	5.9	6.1	6.3	6.0	5.7	5.6	5.7	5.9
South-Eastern Asia	4.51	4.47	4.48	4.43	4.35	4.25	4.14	4.13	4.28

Note: MJ – megajoules; USD – United States Dollars; PPP – purchasing power parity

Source: World Bank (2018).

2.2.2 Reliability

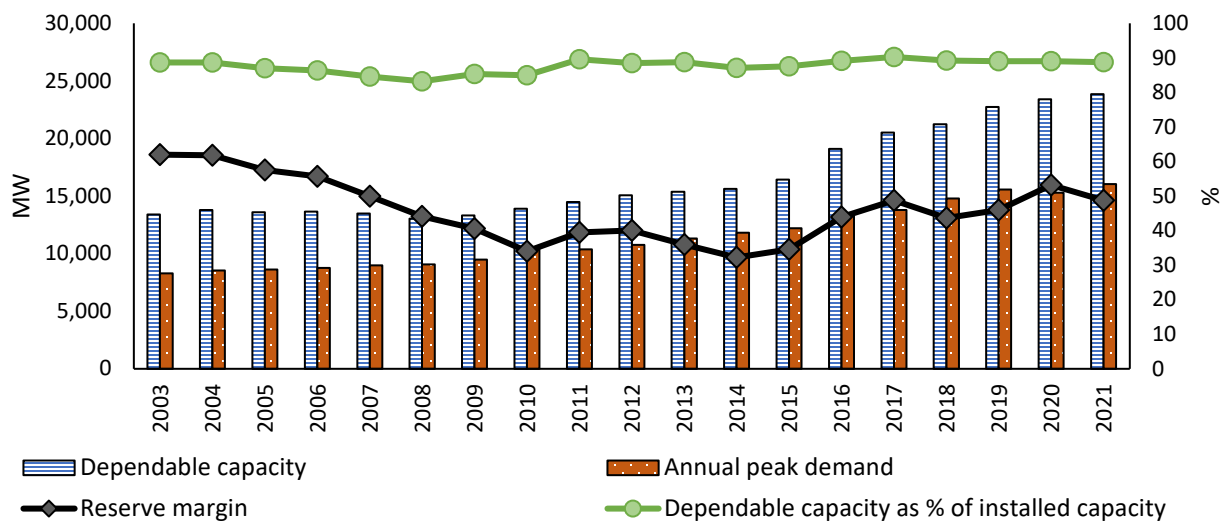
Energy reliability is the continuous availability of energy, or the assurance that it is accessible every hour, every minute and every second. Note that reliability can be distinguished from resilience (which is discussed in the next subsection) by emphasizing that the former is important in planning for the short-term of supply of energy whereas the latter is usually appreciated in planning for the long-term. Reliability as used in energy industry regulation is often applied to the electric power system. A reliable electric power system should be able to provide a continuous flow of electricity in every instant and should be able to immediately address short-term interruptions. Reliability can thus be assessed through indicators such as the reserve margin in the electric power system and the frequency and duration of power outages.

At this point, it helps to distinguish the terms installed capacity, available capacity, and dependable capacity as applied to country-level reserve margin calculation. Reserve margin as measured in Kutani et al. (2014) is the excess of a country's installed power generation capacity over peak demand. Installed capacity means the maximum capacity to generate power, or the sum of the nominal rated capacities of all generating units in the country. Note, however, that the total maximum generation capacity for a country can never be realized because power generating units' rated capacities are for "ideal conditions" and the operating environment can never be ideal for all power plants all at the same time. Anywhere in the country, generating units are always affected by factors such as temperature changes, operating constraints, and maintenance needs. That is why it is not practical to measure reserve margin in terms of installed (maximum) capacity.

In the Philippine government’s energy plans, the reserve margin is defined as the excess of available capacity over peak demand and a 25-percent threshold for the reserve margin is being adopted for planning purposes (see, for example, the Philippine Energy Plan 2020-2040 (DOE 2021a)). Available capacity means the amount of generated power that is offered for dispatch at the specific instant that power is to be used. But there is no record-keeping of historical available capacity in the Philippine grid. It is also difficult to estimate the annual available capacity as it depends not only on projected temperature changes and power plant maintenance schedules but also on unforeseen events like sudden generating unit breakdowns or sudden tripping of transmission lines. Thus, in tracking the historical reserve margin for trends analysis, it is more practical to use dependable capacity rather than available capacity. Dependable capacity is the projected estimate of power generation after accounting for scheduled maintenance needs and ambient limitations for certain periods of time. Generating companies submit data on the dependable capacities of their power plants to the DOE and the Energy Regulatory Commission (ERC).

In Figure 12 below, we show the reserve margin trend from 2003 to 2021, estimated based on the excess of dependable capacity over peak demand. The graph also shows the country’s dependable capacity, annual peak demand, and the dependable capacity as percentage of the installed capacity. From 2003 to 2021, the dependable capacity reserve margin had been consistently above 25 percent and the lowest was recorded in 2014 at 32.2 percent, which was dangerously close to the 25-percent threshold⁸ for available capacity reserve margin. In 2014, the dependability of power generation was severely affected by the Bohol earthquake and Super typhoon Yolanda that occurred in the latter part of 2013, as well as by the large decrease in coal generation due to unexpected outages of large coal power plants in 2014 (DOE 2014).

Figure 12. Dependable capacity, annual peak demand and reserve margin, 2003-2021



Note: MW – Megawatts. Reserve margin is computed as the difference between the dependable capacity and annual peak demand divided by the annual peak demand.

Source: DOE (2021b).

⁸ For planning purposes, the DOE uses 25 percent as reserve margin target (DOE 2021a).

The average annual growth of the country’s dependable capacity in the last 10 years was slightly faster than that of the peak demand. Dependable capacity grew by 5 percent and peak demand grew by 4.5 percent on the average annually. Meanwhile, dependable capacity as percentage of installed capacity averaged at 89.2 percent from 2017 to 2021; the lowest recorded was in 2008 at around 83.2 percent. On the surface, these trends seem to illustrate a consistently reliable energy supply in the country. However, the numerous occurrences of sudden power outages and rotational brownouts in recent years show otherwise. From 2019 to 2021, a significant number of yellow and red alerts were raised by the National Grid Corporation of the Philippines (NGCP). The DOE reported that in the Luzon grid alone, 46 yellow alerts and 16 red alerts were raised in 2019 and two yellow alerts in 2020 (DOE 2021c). Table 4 below shows in detail the annual total number of hours that the said alerts were declared in the Luzon grid and the Visayas grid from 2017 to 2021.

Table 4. Imposition of yellow and red alerts in Luzon and Visayas grids, in hours, 2017-2021

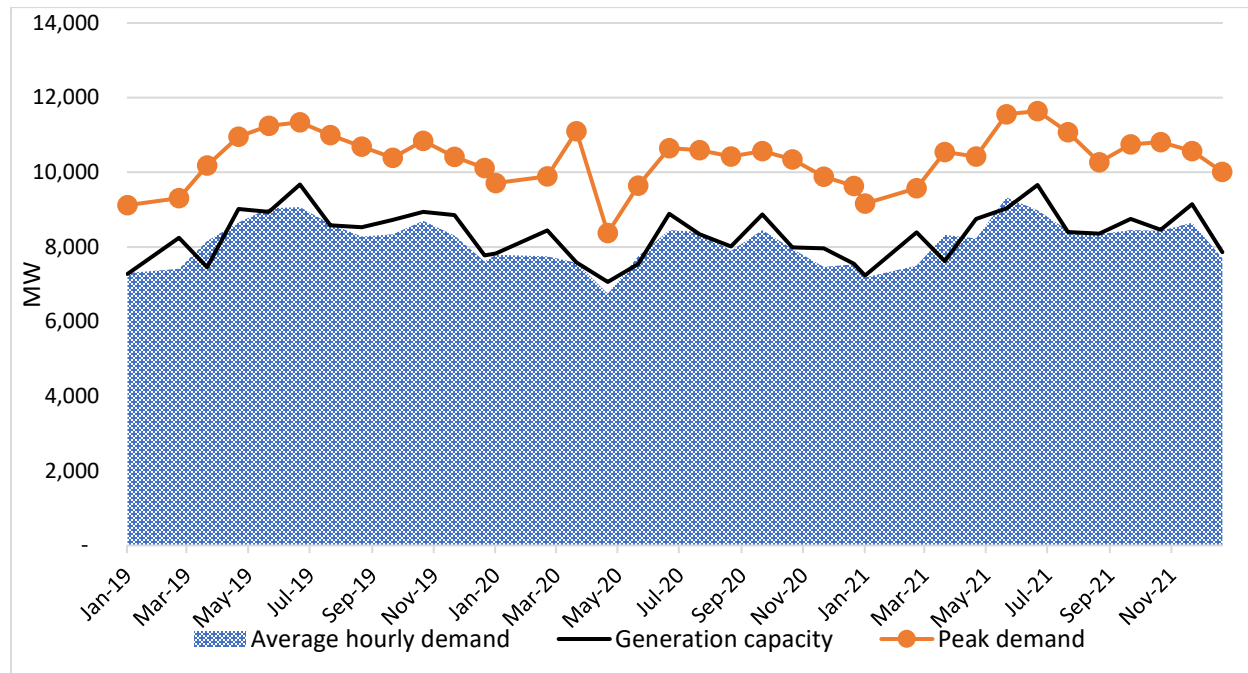
Year	Luzon		Visayas	
	Yellow	Red	Yellow	Red
2017	40.97	12.95	315.23	127.68
2018	27.68	-	421.12	37.47
2019	405.92	102.00	530.77	18.30
2020	8.52	-	17.17	1.97
2021	28.85	21.90	1.97	1.97

Note: The NGCP issues yellow alert when power supply is low and red alert when the supply is insufficient to meet the consumers’ demand and the transmission grid’s regulating reserve requirement (NGCP 2023).

Source: NGCP-System Operator as reported in Independent Electricity Market Operator Philippines (IEMOP) (2022).

In June 2022, frequent yellow and red levels were also raised in the Luzon grid. Unscheduled power plant outages and plant deratings were identified as the primary reasons, proving the reserve margin to be insufficient. Monthly data shown in Figure 13 below roughly demonstrate the recurring power issues as the gap between the peak demand and generation capacity consistently widens during the start of the summer season (e.g., March 2019, March 2020, and March 2021). This pattern affirms the challenges that the country has been facing in terms of power reliability.

Figure 13. Luzon’s monthly peak demand, capacity, and average hourly demand, 2019-2021



Note: Generation capacity was calculated using the NGCP’s data on monthly gross generation per plant and by grid. The data was converted from MWh to MW using the formula, *generation capacity = monthly gross generation (number of days in a month × 24)*. Average hourly demand was calculated by getting the average of the hourly demand by month data of the NGCP.

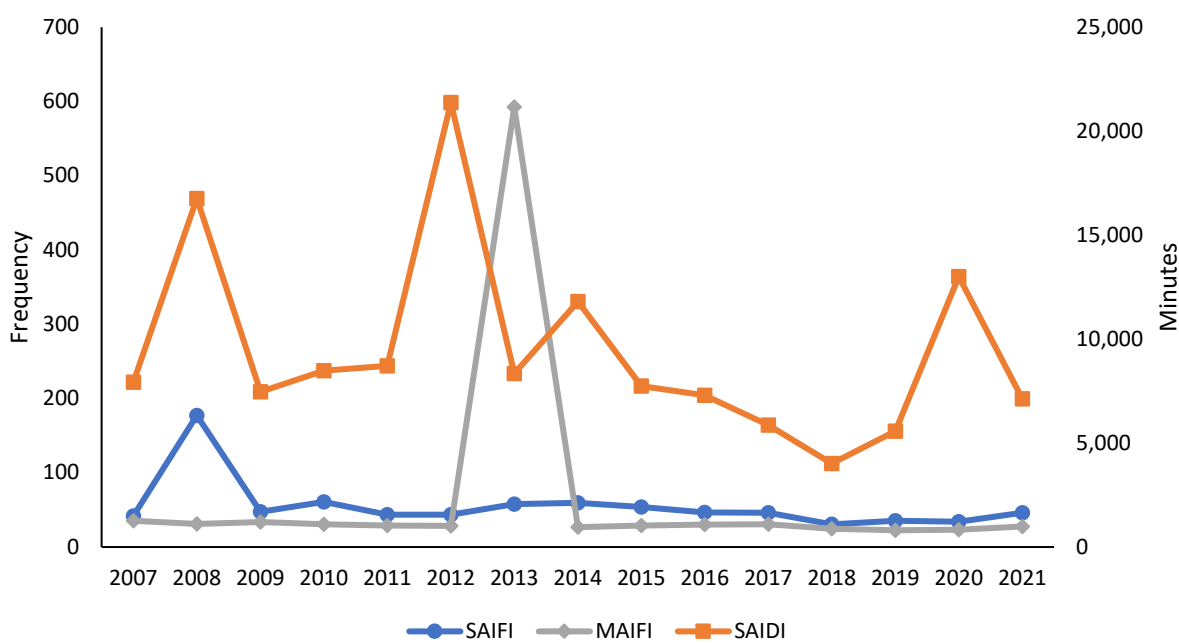
Source: NGCP (2023).

Aging power plants contribute to the problem. Many power plants in the country are already old and require more frequent maintenance and repairs, and oftentimes cause unscheduled power interruptions. The IEMOP reported in 2022 that 55.6 percent of the installed capacity in the country were from power plants that were built in 2003 or earlier (IEMOP 2022). According to the Philippine Energy Plan 2020-2040, there is supposed to be a policy for the decommissioning or retirement of power plants (DOE 2021a). The DOE has also made pronouncements that a policy on mandatory retirement of aging power plants will be prescribed but such policy has not yet been issued as of this writing.

At the distribution utility level, reliability indicators based on power interruptions are also being measured and are important for the regulator’s monitoring of distribution utility performance. These are indicators that measure the power system’s capacity to transmit and deliver electricity to its end-users with minimal, if not without, interruption. At the country level, these indicators can also be aggregated. For this purpose, we use indicators on frequency and duration of electric power interruptions, namely, the system average interruption frequency index, the system average interruption duration index, and the momentary average interruption frequency index.

The ERC defines the system average interruption frequency index (SAIFI) as the “total number of sustained customer power interruptions within a given period divided by the total number of customers served within the same period”, the momentary average interruption frequency index (MAIFI) as the “total number of momentary customer power interruptions within a given period divided by the total number of customers served within the same period”, and the system average interruption duration index (SAIDI) as the “total duration of sustained customer power interruption within a given period divided by the total number of customers served within the same period” (ERC 2001, p.32). Figure 14 shows these indicators from 2007 to 2021. In 2021, the annual SAIFI in the Philippines was 46.01 interruptions per customer, the MAIFI was 27.49 interruptions per customer, and the overall SAIDI was 7,122.32 minutes per customer.

Figure 14. SAIFI, MAIFI, and SAIDI in the Philippines, 2007-2021



Note: Primary y-axis (“Frequency”) refers to the SAIFI and MAIFI trends, while SAIDI refers to the secondary y-axis (“Minutes”).

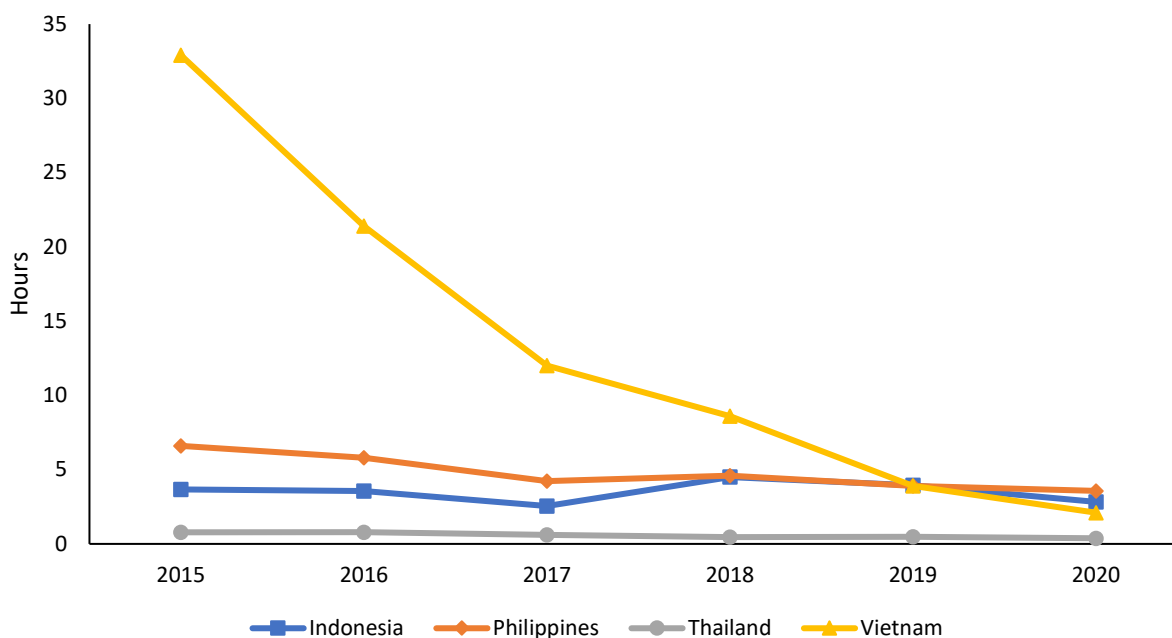
Source: ERC (2022).

Figure 14 also shows that in terms of SAIDI, there were spikes in 2008, 2012, and 2014. The SAIDI spike in 2008 coincided with a SAIFI spike, and the SAIDI spike in 2012 was followed by a MAIFI spike in 2013. ERC records of the reported power interruptions of distribution utilities show that in 2008, the sharp increases in SAIDI were due to weather disturbances (i.e., “major storm” category in the records) and other factors (i.e., labeled “all others” in the records). The increase in duration of power interruptions was particularly high in 2012 and distribution utilities' records show that the reason was “power supplier”. As this happened during the Mindanao power crisis, the power interruptions were most likely triggered by the insufficiency of power supply in Mindanao due to inadequate baseload capacity and unbalanced generation capacity mix (Navarro 2012). Although lower than the 2012 rise, SAIDI also increased in 2014; records show that the reason was “power supplier” again. In 2020, SAIDI increased due to simultaneous power plant

maintenance shutdowns, derated output of power plants brought about by line constraints, and delayed commercial operation of committed power projects due to the pandemic (DOE 2021b).

A comparison of the SAIDI of the Philippines with selected neighboring countries in Southeast Asia, namely, Indonesia, Thailand and Vietnam, shows that as of 2020, the Philippines has the highest SAIDI (Figure 15). The performance of Vietnam is remarkable as it was able to drastically decrease its SAIDI in five years and even surpassed that of the Philippines and Indonesia in 2020.

Figure 15. SAIDI among selected Southeast Asian countries, 2015-2020



Note: SAIDI refers to the average total duration of outages measured in hours experienced by a customer in a year.

Source: World Bank (2020).

2.2.3 Resilience

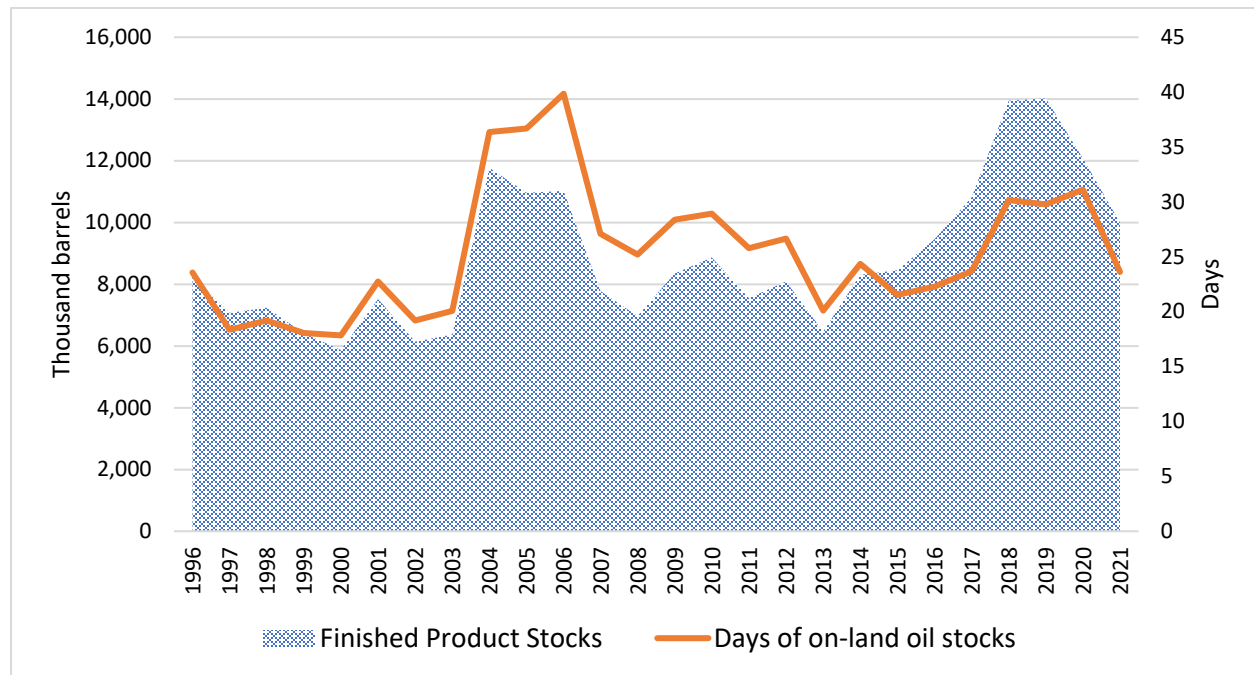
As related to energy security, energy system resilience means preparedness for supply disruptions and having the ability to quickly recover from such disruptions. In this sense, diversifying import sources to minimize exposure to market risk uncertainties and geopolitical risk is a strategy for building resilience. Having domestic strategic inventories or reserves that can be tapped to augment the supply shortfall in times of emergencies also contributes to a country's resilience to supply disruptions. As threats to energy systems can also come from extreme weather events, armed conflicts, and cybersecurity attacks, resilience-building also necessitates ensuring that the domestic supply chain infrastructure for delivering energy flows is developed and maintained well and has the necessary redundancies.

With respect to diversifying import sources, Section 2.2.1 above showed that the Philippines' HHI range of 0.20 to 0.40 implies that the country's energy import sources are not well diversified. Thus, strategies are needed to build the country's resilience to supply disruptions that may arise from market swings or geopolitical tensions. Diversifying import sources or tapping other import source countries is of course one strategy for building resilience. Another is ensuring that there are sufficient inventories or strategic reserves of the imported commodity. For countries with high dependence on oil imports, the days of on-land oil stock is a basic resilience indicator. The benchmark depends on the oil stockpiling policy of the country and the Philippines has no legislation on this yet. Kimura and Morikawa (2017) reported that Indonesia's Pertamina, a government-owned fully integrated energy firm which holds 87 percent of oil storage capacity in the country, has a 19-day stockpiling capacity.⁹ They also reported that Thailand obliges refineries to hold 21.5 days of crude oil demand and traders to hold 3.5 days of demand. In the Philippines, the 18th Congress proposed 30 days for minimum oil stock inventory (House Bill 10823 in the 18th Congress) and this is also contained in the DOE's Department Circular 2011-03-0002, which is currently being challenged by domestic petroleum industry players.

For lack of a definite benchmark, this study uses the Congress-proposed rule as a sort of tentative rule just to demonstrate the application to energy security analysis. Figure 16 below shows that from 1996 to 2021, there were only five instances (i.e., in 2004, 2005, 2006, 2018, and 2020) when the annual average ratio of the days of on-land finished oil products stock was more than 30 days. In 2021, the days of on-land oil stocks was recorded at 23.6 days only, which was almost the same as the level in 2017. Days of on-land oil stocks for a highly oil-dependent country like the Philippines is an important measure of resiliency as it gives an indication of how long a country can support oil demand without any replenishment. A slowdown in the flow of oil supply without a commensurate increase in the inventory implies a decline in the country's resilience to supply disruptions. The 2021 sharp decline in the days of on-land oil stocks in the Philippines due to supply constraints brought about by the COVID-19 pandemic is a case in point.

⁹ Other countries in the Kimura and Morikawa (2017) study are Malaysia and Singapore. Malaysia does not obligate oil stockpiling but the government does not consider it urgent as oil dependency was relatively low in the country. Singapore also see no need for an official stockpiling obligation since it is a trading hub for oil products. The overall storage capacity of independent tank companies and refineries in the country is huge and equivalent to 451 days of annual domestic demand.

Figure 16. Days of on-land oil stocks, 1996-2021



Note: Calculated by dividing Finished Product Stocks by the Average Daily Demand

Source: DOE-Oil Industry Management Bureau (2022).

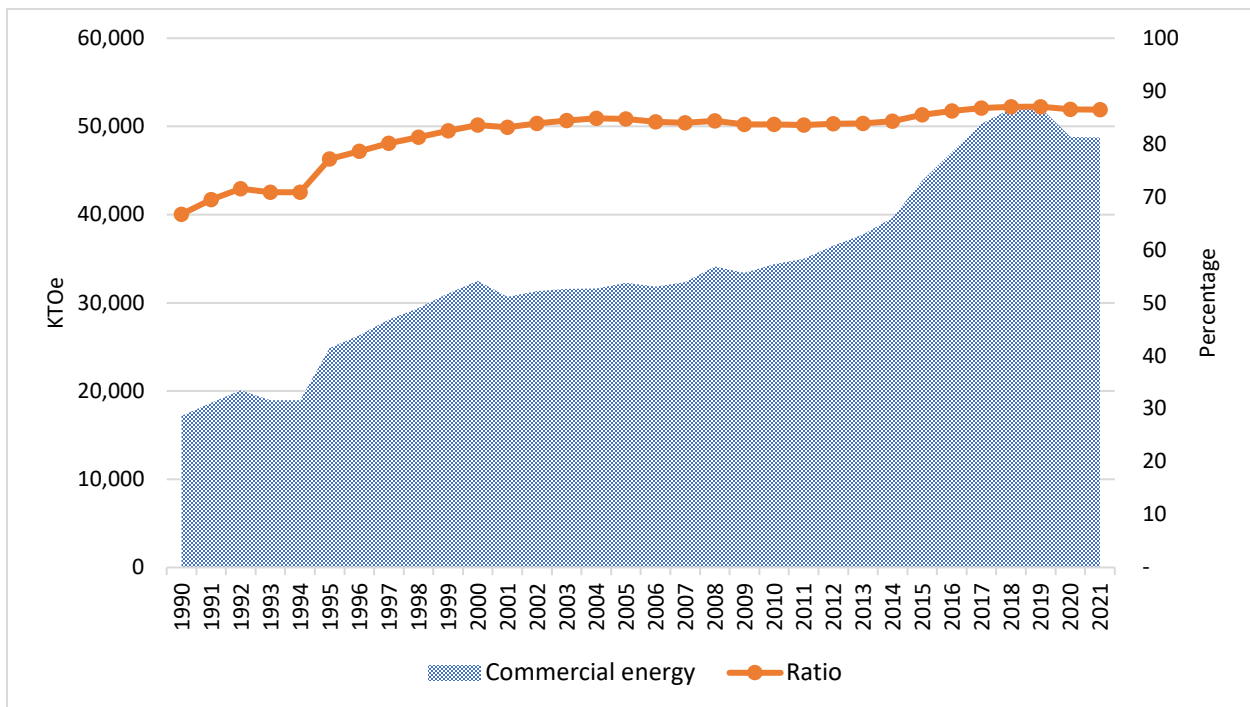
The extent of development of the domestic supply chain infrastructure is also a measure of resilience of a country’s energy system, specifically long-term resilience. It is difficult to measure this but ERIA (2012) used commercial energy access ratio given that it approximates the level of development of the domestic supply chain.¹⁰ It shows the overall capacity of the country to supply energy domestically aside from using electric power supply sources. The concept can be understood more fully by appreciating that there are non-commercial sources of energy, or energy that are usually available free of cost from nature, such as firewood, charcoal, agriculture waste, and animal waste. The so-called commercial energy are those which have formal pricing such as electricity, coal, and refined petroleum products. A growing access to commercial energy therefore implies improvements in the domestic supply chain infrastructure.

Figure 17 below shows that in 2020, the value of commercial energy as a proportion of TPES was 87 percent. The 1990-2020 data also suggest that the Philippines made steady but slow improvements in its domestic supply chain infrastructure development over the past three decades given the slight trend in the commercial energy access ratio. Looking at our neighbors' ratios suggest that the country must aspire to achieve a higher commercial energy access ratio and

¹⁰ The commercial energy access ratio was eventually discarded in the final report, Kutani et al. (2014), given the uneven availability of data across countries, but we deem it useful to include this indicator in the assessment for the Philippines since data are available and the results are meaningful.

develop its domestic supply chain infrastructure further. ERIA (2012) calculated that the commercial energy access ratios in the 2000s in China was 90.5 percent, in Japan 99.5 percent, in South Korea 99.9 percent, in Malaysia 98 percent, in Singapore 100 percent, and in Thailand 91.3 percent.

Figure 17. Commercial energy access ratio, 1990-2021



Note: Calculation of non-commercial energy (NCE) is made by subtracting input energy for transformation purpose from primary supply of solid biofuels. Then, the ratio is computed by subtracting NCE from TPES, divided by the TPES. According to the DOE, non-commercial energy is comprised of biomass and other related energy sources (e.g., charcoal, fuelwood).

Source: DOE-PFRD (2022).

There is a dearth of indicators on resilience from the ERIA (2012) report and the Kutani et al. (2014) study, but a recent critical review of energy system resilience strategies in Jasiunas, Lund and Mikkola (2021) explains that the resilience strategy depends on the threat to the energy supply or the energy systems. Examples that can be lifted from Jasiunas, Lund and Mikkola in the case of extreme weather events are strengthening the infrastructure even before the occurrence of the extreme weather event, restoring system performance and capabilities after the damage caused by the event, and adaptation techniques such as rebuilding damaged system components. Sample indicators that can be explored in the Philippine setting are indicators related to the extent of undergrounding of power lines, sufficiency of battery storage systems and short-term generator sets, and availability of funds for and speed of repairs of damaged systems. In future studies, a more in-depth investigation of the country’s energy system resilience should include these aspects.

2.2.4 Affordability

Energy affordability figured in the Philippine Development Plan 2023-2028’s discussion of energy security. Affordability as an element of energy security is also prominent in the IEA’s (2023) and Kutani et al.’s (2014) definitions of energy security.¹¹ Indeed, affordability is essential for end-users to feel more energy secure. Price as a signal of affordability is also the main information about the energy sector that end-users receive on a regular basis.

Even if energy can be supplied to end-users consistently and reliably, they will be energy insecure when prices become too high such that they can no longer afford to consume the usual amount of energy for their usual activities. To policymakers, this should suggest that there are problems in the energy sector that must be addressed; otherwise, the unaffordability of energy can lead to other kinds of problems like unmanageable inflation, surge in cost of living, and social unrest.

Table 5 describes the average retail prices for selected fuels in Southeast Asia in 2020. Compared with the average prices of selected fuels in the region (USD0.61/liter for diesel, USD0.60/liter for kerosene and USD0.63/liter for gasoline), the retail prices in the Philippines are higher for these selected fuels (USD0.72/liter for diesel, USD0.86/liter for kerosene, and USD0.95/liter for gasoline). Furthermore, the Philippines is among the countries with the highest prices of these selected fuels in the region. It has the highest price of diesel together with Indonesia and Thailand;; it has the second highest price of kerosene; and it has the highest price of gasoline.

Table 5. Average retail prices for selected fuels (USD/Liter), Southeast Asia, 2020

Country	Diesel	Kerosene	Gasoline
Cambodia	0.68	1.15	0.74
Indonesia	0.72	0.17	0.63
Lao PDR	0.87	-	0.67
Malaysia	0.44	-	0.40
Myanmar	0.52	-	0.55
Philippines	0.72	0.86	0.95
Singapore	0.33	0.33	0.31
Thailand	0.72	-	0.70
Viet Nam	0.53	0.48	0.71
Southeast Asia	0.61	0.60	0.63

Note: USD – United States Dollars.

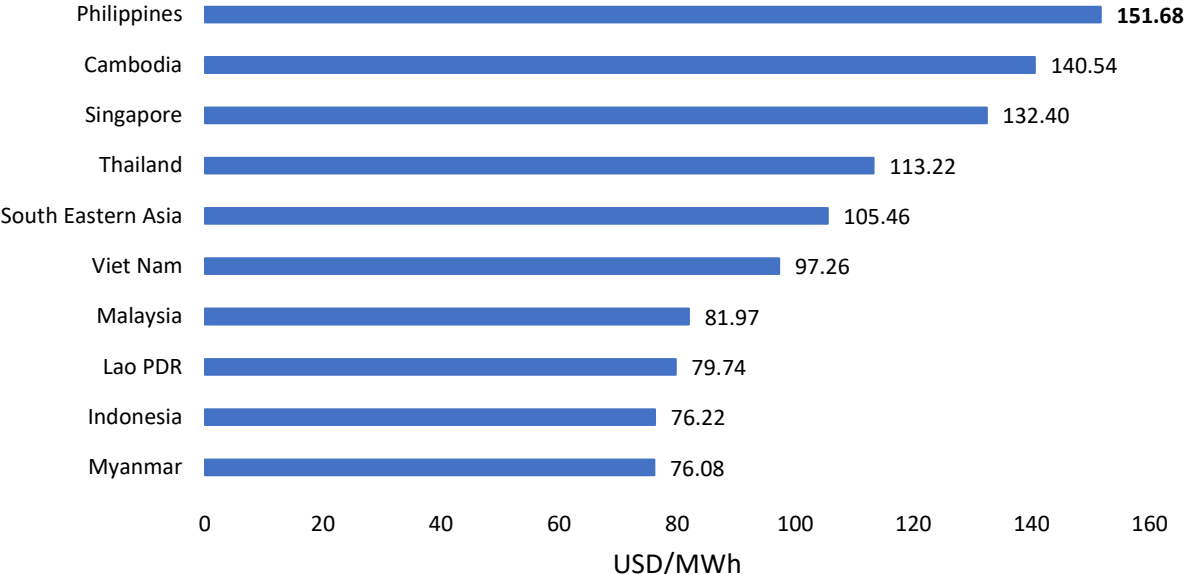
“-“ refers to unavailable data. There is also no available data for Brunei Darussalam.

Source: Climatescope (2021).

¹¹The IEA (2023) defines energy security as “the uninterrupted availability of energy sources at an *affordable* price [italics added].” On the other hand, Kutani (2014) defines energy security as “the securing of the amount of energy required for people’s lives, economic, social, and defense activities, among other purposes, at *affordable* prices [italics added]” (p. 7).

When it comes to electricity prices, the Philippines has the highest price in the Association of Southeast Asian Nations (ASEAN) region, as shown in Figure 18 below. As of 2020, the Philippines’ electricity price was highest at USD151.68 per megawatt-hour (MWh). It is around USD46/MWh higher than the regional average of USD105.46 /MWh, and it is around twice as expensive as Myanmar’s USD76.08 /MWh.

Figure 18. Average electricity prices (USD/MWh) in ASEAN, 2020

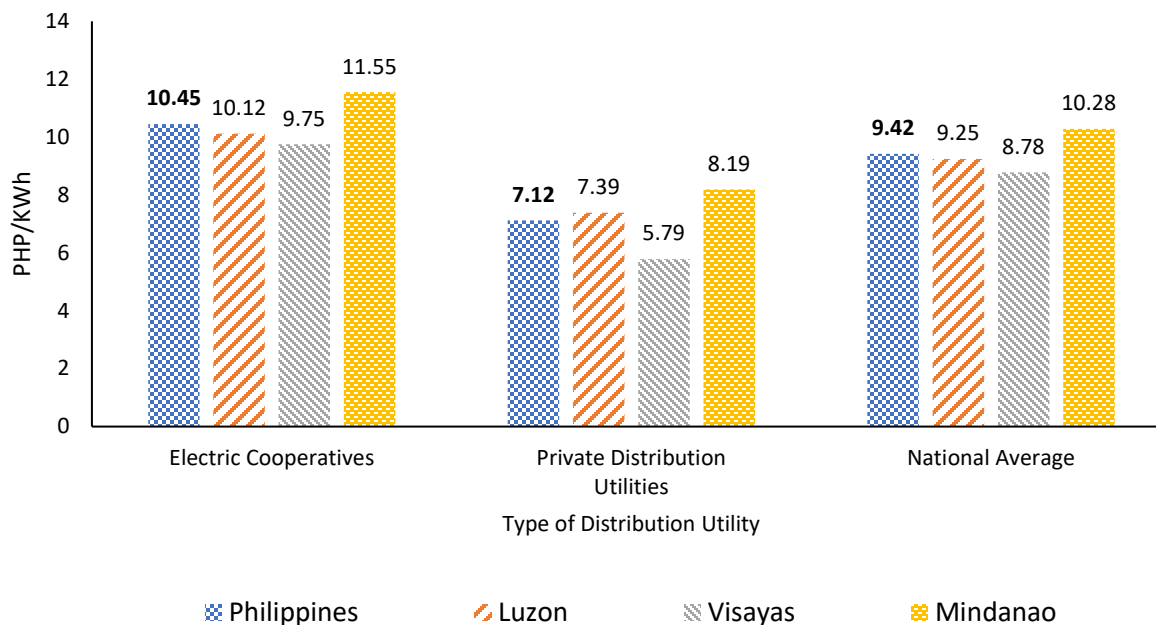


Note: USD – United States Dollars; mWh – megawatt hour.
 No available data for Brunei Darussalam.

Source: Climatescope (2021).

Figure 19 shows the average electricity rates by type of distribution utility per major island group in the Philippines in 2021. The average in the country is 9.42 Philippine Pesos (PHP)/kilowatt hour (kWh), with electric cooperatives (ECs) exacting around PHP3/kWh higher than what private distribution utilities charge. In all island groups, the average prices of electric cooperatives are higher than that of the private distribution utilities. Among electric cooperatives, average prices in Luzon are the lowest, and among private distribution utilities, average prices in Visayas are the lowest.

Figure 19. Average electricity rates by type of distribution utility per major island group (PHP/kWh), Philippines, 2021



Note: PHP – Philippine Pesos; kWh – kilowatt hour. Private Distribution Utilities data are as of March 2021; Electric Cooperatives and National Average data are as of December 2021.

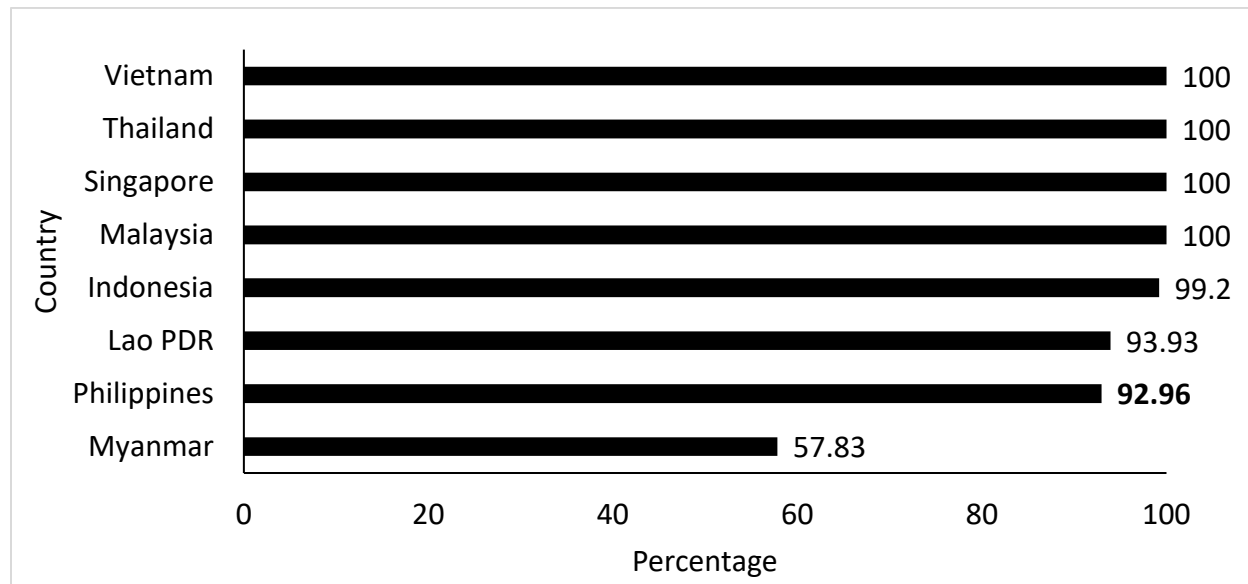
Source: DOE (2021d; 2023d).

2.2.5 Accessibility

Adequate access to final energy products is also essential for end-users to feel more energy secure. Note that universal access to electricity is almost a given in other countries as most of them, especially the advanced countries, had achieved universal access a long time ago. For developing countries that have not yet achieved universal access, expanding electrification rates is also in line with sustainability because this would mean reduced reliance on biomass (wood and charcoal) for cooking and kerosene for lighting and less health risks to the population, not to mention less carbon emissions being dumped into the environment.

Figure 20 details the national electrification rates of some of the member countries of the ASEAN in 2020. It shows that most countries have achieved universal access (Vietnam, Thailand, Singapore, Malaysia) or near universal access (Indonesia) to electricity. With an electrification rate of 92.96 percent, the Philippines is one of the three countries in the region that are still far from achieving universal access (the other two are Lao PDR and Myanmar). As there are still many areas in the country where Filipinos still use wood and charcoal for cooking and kerosene for lighting, more efforts to reach them are necessary.

Figure 20. National electrification rates (%) in ASEAN, 2020



Note: No available data for Brunei Darussalam and Cambodia.

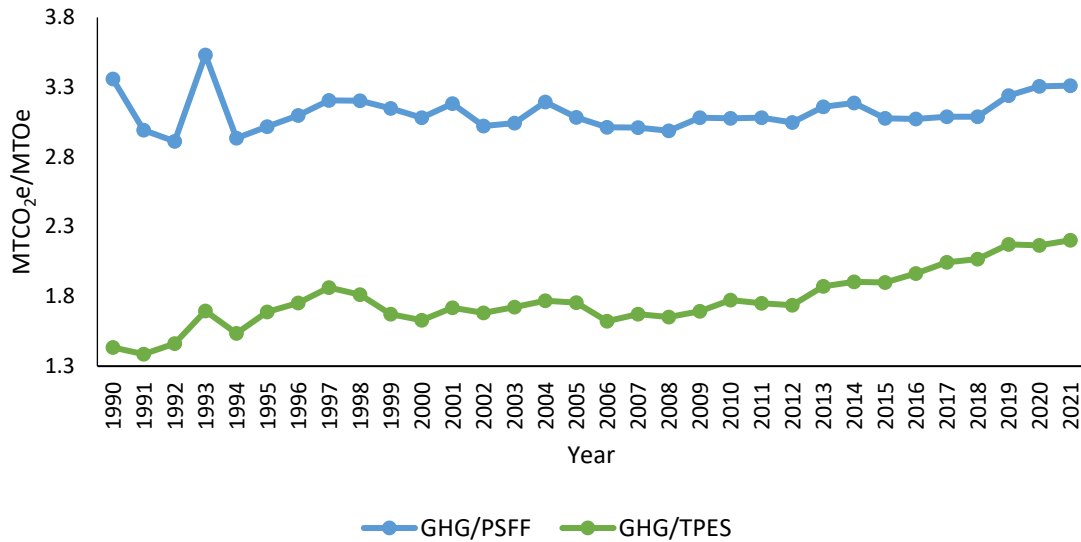
Source: Climatescope (2021).

2.2.6 Sustainability

When thinking of sustainability that values the welfare of future generations, an obvious consideration is long-term environmental sustainability. The usual country-level summary measure for this is the path of carbon dioxide equivalent (CO₂e) emissions. In the calculations and figures below, we look at the path of the Philippines’ CO₂e emissions as proportions of TPES, primary supply of fossil fuels, and GDP. We also examine the path of CO₂e emissions relative to population and compare the emissions with those in other countries in Southeast Asia.

Figure 22 presents the proportion of CO₂e emissions to TPES by metric tons of CO₂ equivalent (MTCO₂e) and the proportion of CO₂e emissions to primary supply of fossil fuel by MTCO₂e in the Philippines from 1990 to 2021. The path of CO₂e emissions to TPES (i.e., the GHG/TPES line in the graph) shows that through the years, the country’s level of emissions increased, from 1.43 MTCO₂e/MTOe in 1990 to 2.2 MTCO₂e/MTOe in 2021. Except for the slight uptick in 1993, the proportion of emissions to supply of fossil fuels (i.e., the GHG/PSFF line in the graph) was relatively stable through the years, implying the unchanging nature of the Philippines’ pollutive activities from its use of fossil fuels. The relationship between CO₂e emissions and fossil fuel activities is well-recognized, with the US Energy Information Administration (EIA) explaining that in 2020, fossil fuel combustion accounted for 92 percent of total US anthropogenic CO₂e emissions (EIA 2022).

Figure 21. Proportion of CO₂e emissions to total primary energy supply and to primary supply of fossil fuels (MTCO₂e/MTOe), Philippines, 1990-2021



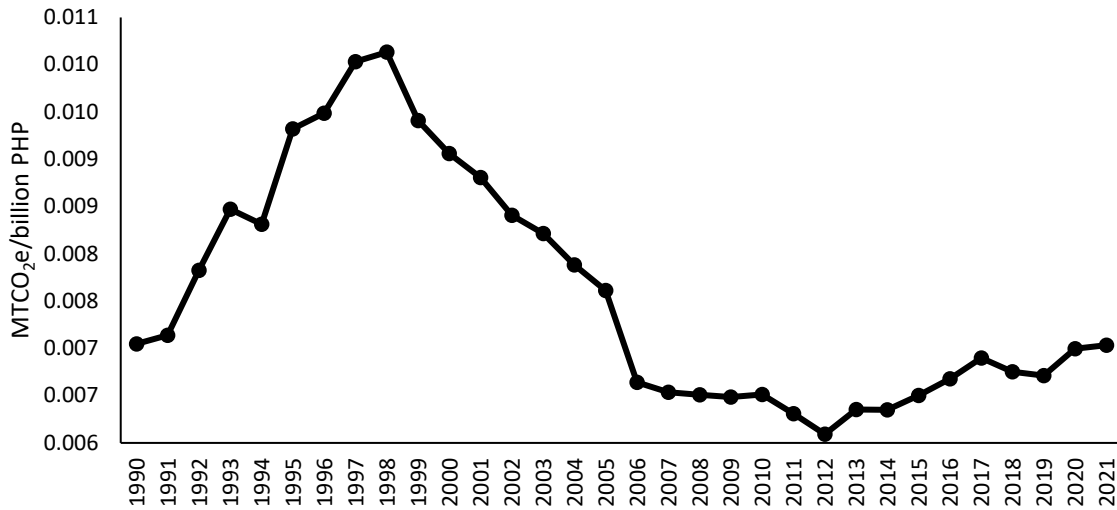
Notes: Lower bound changed from 0.0 MTCO₂e/MTOe to 1.3 MTCO₂e/MTOe to emphasize movement visualization.

MTCO₂e – metric tons of CO₂ equivalent; MTOe – mega tons of oil equivalent; GHG – Greenhouse Gas Emissions (interchangeable with CO₂e emissions for this study); PSFF – Primary Supply of Fossil Fuels; TPES – Total Primary Energy Supply.

Source: DOE (2020; 2023a).

Figure 22 details the proportion of CO₂e emissions to GDP by MTCO₂e in the Philippines from 1990 to 2021. As seen below, the proportion of emissions to GDP has varied throughout the years. It reached as high as 0.0101 MTCO₂e/billion PHP in 1998, then declined until it reached its lowest at 0.0061 MTCO₂e/billion PHP in 2012, but exhibited an uptrend in recent years. It stood at 0.007 MTCO₂e/billion PHP in 2021. This implies that although the country has reduced its emissions per output of economic activities, it has stagnated in achieving further progress.

Figure 22. Proportion of CO₂e emissions to GDP (MTCO₂e/billion PHP), Philippines, 1990-2021



Note: Lower bound changed from 0.000 MTCO₂e/billion PHP to 0.006 MTCO₂e/billion PHP to emphasize movement visualization.
MTCO₂e – metric tons of CO₂ equivalent; PHP – Philippine Pesos.

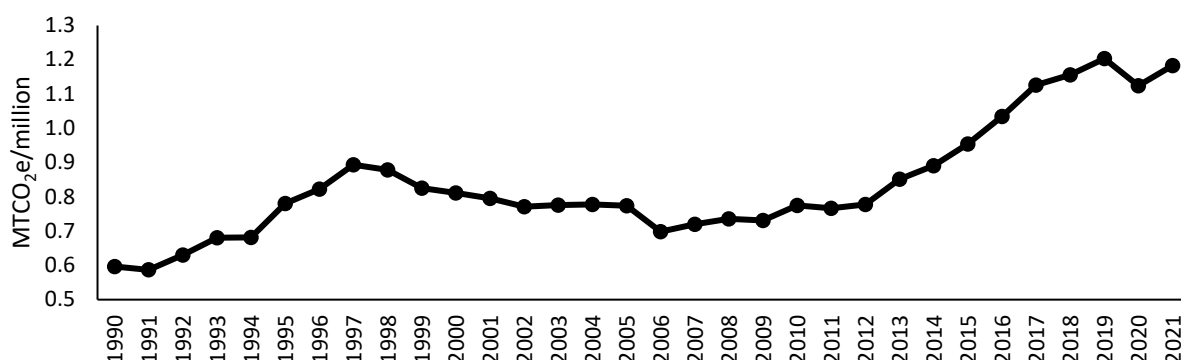
Source: DOE (2020; 2023a).

Figure 24 looks at CO₂e emissions per capita by MTCO₂e per million in the Philippines from 1990 to 2021. On average, Filipinos have increasingly produced more pollution than before, from 0.5967 MTCO₂e/million in 1990 to 1.1833 MTCO₂e/million in 2021.¹² Cognizant of this, different actors in the energy sector have tried to help curb energy demand and CO₂e emissions. The DOE, private distribution utilities, and electric cooperatives have provided information campaigns on energy conservation to the public through social networking sites, television, and leaflets, among others.¹³

¹²Lockdowns in 2020 also affected CO₂ emissions per capita (Ray et al. 2022), decreasing emissions to 1.0951 MTCO₂e/million in 2020. Like emissions to TPES, however, the emissions per capita in 2020 are still higher than 1990.

¹³In communication with the Department of Energy Policy Formulation and Research Division on August 4, 2022.

Figure 23. CO₂e emissions per capita (MTCO₂e/million), Philippines, 1990-2021



Note: Lower bound changed from 0.0 MTCO₂e/million to 0.5 MTCO₂e/million for emphasizing movement visualization.
MTCO₂e – metric tons of CO₂ equivalent

Source: DOE (2020; 2023a).

Table 6 describes the CO₂e emissions with respect to economic output in purchasing power parity dollar (PPP \$) among countries in ASEAN from 2010 to 2019. In a region averaging 0.21 kg of emissions per PPP \$ of GDP in 2019, the Philippines with 0.14 kg of emissions per PPP \$ of GDP pollutes relatively less per economic output compared with most other countries. Like Myanmar, it stands second to Singapore as a low polluter. Singapore emitted 0.08 kg of emissions per PPP \$ of GDP in 2019. Furthermore, it is considered around two times less pollutive than the most CO₂e intensive countries in the region, that is, Lao PDR and Viet Nam, which had 0.32 kg and 0.33 kg of emissions in 2019, respectively.

Table 6. CO₂e emissions (kg per PPP \$ of GDP) in ASEAN, 2010-2019

Country	Year									
	2010	2011	2011	2013	2014	2015	2016	2017	2018	2019
Brunei	0.23	0.22	0.21	0.21	0.21	0.25	0.29	0.28	0.28	0.25
Darussalam										
Cambodia	0.15	0.14	0.13	0.13	0.14	0.16	0.19	0.20	0.21	0.21
Indonesia	0.20	0.21	0.20	0.18	0.18	0.18	0.18	0.18	0.19	0.19
Lao PDR	0.12	0.12	0.10	0.12	0.11	0.21	0.34	0.38	0.35	0.32
Malaysia	0.35	0.33	0.31	0.32	0.32	0.32	0.30	0.27	0.27	0.27
Myanmar	0.05	0.05	0.07	0.07	0.08	0.09	0.10	0.14	0.13	0.14
Philippines	0.15	0.15	0.14	0.15	0.15	0.15	0.15	0.16	0.15	0.14
Singapore	0.11	0.11	0.10	0.10	0.10	0.09	0.09	0.09	0.08	0.08
Thailand	0.26	0.26	0.25	0.25	0.24	0.24	0.23	0.21	0.20	0.20
Viet Nam	0.32	0.30	0.27	0.27	0.27	0.32	0.29	0.27	0.31	0.33
ASEAN average	0.20	0.19	0.18	0.18	0.18	0.20	0.22	0.22	0.22	0.21

Note: kg – kilogram; PPP – purchasing power parity; GDP – gross domestic product
Source: Climate Watch (2020).

3. Electric power demand projection and supply outlook

Providing accurate and reliable forecasts on electric power consumption is important in helping policymakers ensure the sufficiency of the country's energy supply in the coming years. As an illustration of a practical analysis of an element of energy security, that is energy sufficiency, this section demonstrates the use of a particular forecasting model (error correction model) to project Philippine electric power demand in the medium term under three economic growth scenarios (i.e., "low", "middle" and "high" growth scenarios), and compares the results with those of the model usually used by the DOE (elasticity based model) in forecasting electric power demand. Given the demand forecasts from the demonstration model and the comparison model, the discussion then focuses on the assessment of the government's supply outlook from 2022 to 2028.

3.1 Forecasting methods and data description

Forecasting methods

The demonstration model, or Model 1, examines the long-run and short-run dynamics of causality among power demand, real GDP, temperature, and national average systems rates (i.e., average electricity prices) using an error-correction model (ECM). Error-correction representations are used once a long-run cointegration relation is detected, implying that a stationary linear combination exists among the identified variables. As such, the components cannot drift very far away from the equilibrium even with the inducement of exogenous factors such as economic shocks (Engle and Granger 1987; Lütkepohl 2005). This makes it a suitable basis for projecting future demand. In the literature on energy economics, the error-correction model is a known method used in understanding the interrelationship of energy-related variables in the long- and short-run, as well as in forecasting energy consumption (Suganthi and Samuel 2012). The model tests the long-run relationship of consumption and real GDP based on the Engle-Granger two-step method (Engle and Granger 1987). The first step involves the estimation of the long-run equation from which the residuals are generated. The residuals, which are measures of disequilibrium, are then tested for stationarity that confirms presence of long-run cointegration. Upon establishing a long-run relationship, the second step then estimates the single-equation error correction equation, which integrates the long-run and short-run dynamics of the model.

The comparison model, or Model 2, presents a simpler approach wherein forecasts are based on the average elasticity of electricity demand to real GDP. This is the usual approach of the DOE, as evidenced in various editions of the Philippine Energy Plan. In the Philippine Energy Plan 2020-2040, the DOE (2021a) reported different energy elasticities including that of electricity-to-GDP.

The forecasting in this study differs from what were previously done in the local literature (e.g., Danao and Ducanes 2018, Fabella and Ducanes 2019) because in both Model 1 and Model 2, we extend the analysis beyond the forecasting of annual electricity consumption by computing for the projected peak demand plus 25 percent¹⁴ reserve margin.

¹⁴ The 25 percent reserve margin is the target currently being used by the DOE in planning (DOE 2021a).

The first step involves computing the annual required gross power generation or the supply needed to meet the demand using the following derived formula:

$$\begin{aligned} gen_t &= y_t + loss_t \\ &= y_t + (16.482\% \times gen_t) \end{aligned}$$

Isolating gen_t ,

$$gen_t = y_t / (100\% - 16.482\%)$$

where gen_t denotes the required gross power generation in year t ; y_t represents electricity consumption forecast; $loss_t$ represents the plants' own use and transmission losses; and constant 16.482% is the assumed own use and transmission losses by generating power plants, which in turn is based on the DOE's 2021 Energy Balance Table report of 16.482 percent own use and transmission losses by plants.

Annual peak demand forecast ($peak_t$) is then calculated using the gross power generation forecasts (gen_t) with a load factor of 70 percent, the same load factor adopted in the Philippine Energy Plan 2020-2040. The formula is as follows:

$$peak_t = gen_t / (load\ factor \times 8,760\ hours).$$

After computing the annual peak demand, an additional 25-percent margin is added. The resulting figure then gives an estimate of the required annual supply of electricity that must be met by the existing dependable capacity.

These additional steps in the calculation are important because the peak demand matters significantly in planning for the supply that has to be committed in the coming years. If the peak demand plus the 25-percent reserve is very close to the dependable capacity, then the country will be in a precarious situation; that is, any sudden reduction of capacity due to emergencies and unscheduled shutdowns will result in low available capacity and grid alerts regarding the tight supply margin. It could also result in power interruptions if the supply inadequacy is not managed.

Data

The data used are annual observations from 1990 to 2021 on particular variables (see Table 7 for the list of variables). Another important difference of this analysis with Danao and Ducanes (2018) is the variable used for electricity prices. This study uses the national average systems rates, which are the averages of prices of all electricity distributors in the Philippines and not only that of the Meralco. Danao and Ducanes (2018) used only Meralco prices, which represents the electricity prices in Metro Manila and some parts of Luzon only.

Table 7. Definition of variables

Variable	Name	Definition
lesales (lny_t)	Electricity sales	Total electricity consumption by sector, excluding utilities' own use and power losses
lrgdp (lng_t)	Real GDP	Real gross domestic product, 2018 as base year
lrep (lnp_t)	Real electricity prices	Computed real national average systems rate using GDP deflator
ltemp (lnc_t)	Mean temperature	Mean temperature, national average

Notes: Covered annual data are from 1990 to 2021.
All variables are in natural logarithmic form.

Sources: electricity sales - DOE (2021b); nominal and real GDP (constant 2018 prices) - PSA (2022c); average systems rate - NEA (n.d.) and DOE (n.d.); temperature - World Bank (2021).

To forecast electricity demand using Model 1's parameter results, the 2022 to 2028 values of the independent variables listed above are assumed. For the real GDP (constant 2018 prices), the growth rate projections reported by the Development Budget Coordination Committee (2023) are used. Since the 2022 full-year GDP data is already available from the PSA, the actual data is used in the model. Table 8 below shows the GDP growth assumptions together with the computed real GDP.

Table 8. Real GDP growth projections, 2022-2028

Year	Low Growth (Scenario 1: "Low")		Middle growth (Scenario 2: "Middle")		High Growth (Scenario 3: "High")	
	Growth (%)	In PHP million	Growth (%)	In PHP million	Growth (%)	In PHP million
2022*	7.6	19,943,630.24	7.6	19,943,630.24	7.6	19,943,630.24
2023	6	21,140,248.05	6.5	21,239,966.20	7	21,339,684.36
2024	6.5	22,514,364.18	7.25	22,779,863.75	8	23,046,859.10
2025	6.5	23,977,797.85	7.25	24,431,403.88	8	24,890,607.83
2026	6.5	25,536,354.71	7.25	26,202,680.66	8	26,881,856.46
2027	6.5	27,196,217.76	7.25	28,102,375.01	8	29,032,404.98
2028	6.5	28,963,971.92	7.25	30,139,797.19	8	31,354,997.37

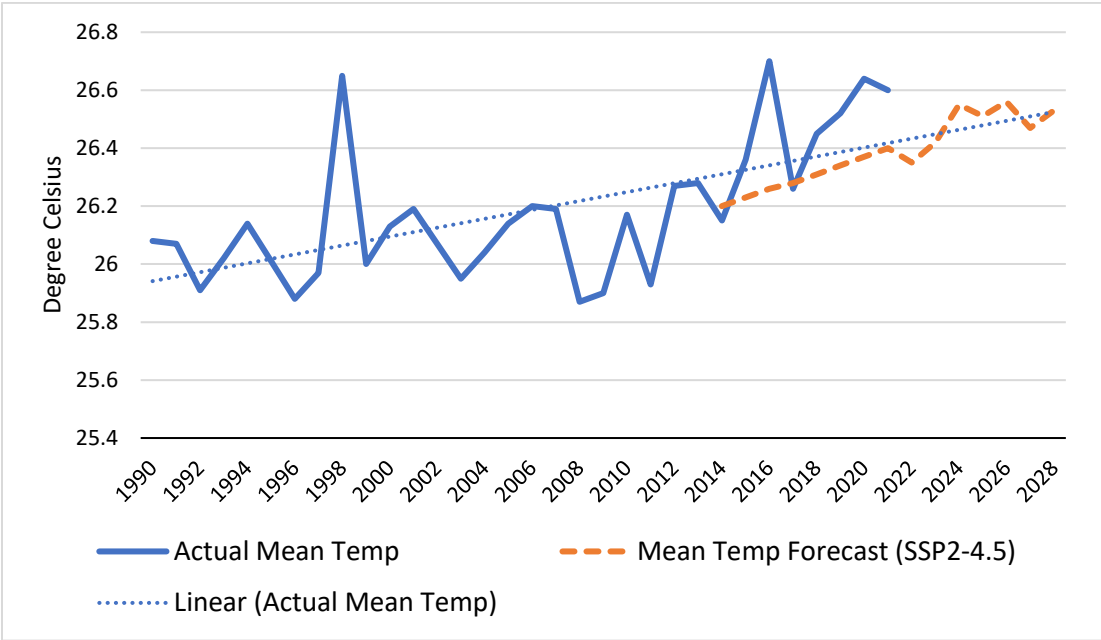
Note: *Using actual real GDP and growth rate reported by PSA (2023).

Source: Authors' calculations using the real growth assumptions of the Development Budget Coordinating Committee (2023).

For the national average systems rates, the forecast values are based on the compound annual growth rate (CAGR) of the actual series. The resulting growth rate is 0.271 percent, which was used to project the annual national average systems rate for the period 2022 to 2028.

For the national average temperature, the forecast values are gathered from the World Bank’s Climate Change Knowledge Portal (World Bank 2021). Figure 24 shows the actual trend of mean temperature in degree Celsius since 1990. The dotted line shows the World Bank (2021)'s forecast assuming its “middle of the road” scenario (Shared-Socioeconomic Pathways or SSP 2-4.5). The said scenario stays at around the current levels before starting to decline in 2050 but will not reach the temperature level required for net zero carbon emissions until 2100.

Figure 24. Mean annual temperature, Philippines, 1990 to 2021 and 2022 to 2028 forecast



Source: World Bank (2021).

Prior to the actual model estimation, the time-series variables are checked for presence of unit root. This is an important step in cointegration procedure as it captures the long-term relationship between non-stationary variables and those that are integrated of the same order, $I(d)$. Table 9 below reports the results of the two unit-root tests, the Augmented Dickey-Fuller (ADF) test and the Elliot-Rothenberg-Stock Dickey-Fuller GLS (ERS) test. The natural logarithm of the electricity consumption, real GDP, and real electricity prices are determined to be non-stationary series and are integrated of the same order, i.e., $I(1)$.

Table 9. Summary of unit root tests, with trend and intercept

	Augmented Dickey-Fuller Test			Elliot-Rothenberg-Stock Dickey-Fuller GLS (ERS)		
	Levels	1st difference	Order of Integration	Levels	1st difference	Order of Integration
lesales	-1.957	-5.114**	I(1)	-2.058	-5.053***	I(1)
lrgdp	-2.836	-5.179**	I(1)	-2.133	-5.127***	I(1)
lrep	-2.558	-5.294***	I(1)	-2.662	-5.040***	I(1)
ltemp	-4.394**	-7.356***	I(0)	-4.494***	-7.619***	I(0)

Note: Levels and first differences refer to the test statistic; ***Indicates the corresponding significance at 1 percent level; **at 5 percent level

3.2. Forecasting results

This subsection explains how our main model, the demonstration model, and the comparison model were applied. It also provides the forecasting results as well as the applicable statistical diagnostic tests.

3.2.1 Single-Equation Error Correction Model (Model 1)

The long-run relation of the single-equation ECM is expressed in this equation:

$$\ln y_t = \beta_0 + \beta_1 \ln g_t + u_t$$

where $\ln y_t$ denotes electricity consumption in natural logarithm in year t ; $\ln g_t$ denotes real GDP (at constant 2018 prices) in natural logarithm; and u_t stands for the residuals.

Using EViews 12, the cointegrating regression equation is estimated using the fully-modified ordinary least squares (FMOLS) regression method, with pre-whitened kernel approach and lag order based on Akaike information criterion (AIC) to enhance the efficiency of the parameter estimates (Christou and Pittis 2002). Table 10 presents the results. Consistent with expectation, real GDP is a strong predictor of electricity demand. The real electricity prices variable was no longer included in the cointegration test because even though it has been identified as a non-stationary series, it does not seem to be trending in a similar manner compared with the real GDP and electricity consumption (see Annex A).

Table 10. Estimates of the cointegrating regression equation

Variable	Estimate	Standard Error
lng_t	1.003***	0.079
constant	-5.41***	1.271
R^2	0.962	

Note: *** indicates statistical significance at 1 percent level.

Upon estimating the long-run equation, the Hansen Instability test is employed. Results confirmed that electricity demand and real GDP are cointegrated at the 1 percent significance level. The single-equation ECM (Model 1), which integrates the short-run and long-run dynamics of the model, is then estimated using the equation below:

$$\Delta lny_t = \alpha_1 \Delta lng_t + \alpha_2 \Delta lnp_{t-1} + \alpha_3 \Delta lnc_t + \lambda (lny_{t-1} - \beta_0 - \beta_1 lng_{t-1}) + \mathbf{d} + \epsilon_t$$

The equation includes the short-run effects of average temperature and electricity prices. In addition, indicator saturation variables, represented by \mathbf{d} , is added to deal with outliers. Presence of these outliers may indicate significant events that caused spikes in the residuals. After this, weak exogeneity is established for each of the conditioning variables to indicate that they are not related to the parameter of interest. Table 11 below shows that the other regressors are weakly exogenous, implying that they do not depend on the long-run disequilibrium, at the 5 percent level.

Table 11. Tests of weak exogeneity

	Δg_t	Δp_{t-1}	Δc_t
Constant	0.04***	0.0002	0.0005
\hat{u}_{t-1}	0.044	-0.079	0.009
F	0.335	0.341	0.19
R^2	0.011	0.012	0.007

Note: *** indicates significance at 1 percent level.

The results are consistent with expectation as lagged changes in the real GDP, electricity prices at lag 1, and mean temperature are strongly associated with electricity consumption in the short-run. The signs of the parameter estimates are also aligned with theory, that is, higher economic growth is associated with overall higher levels of consumption, higher electricity rates are associated with reduction in consumption, and higher temperature is associated with greater use of cooling appliances and, thus, electricity demand.

Table 12. Estimates of the single-equation ECM

	Estimate	Standard Error
Δg_t	0.6498***	0.0762
Δp_{t-1}	-0.1266**	0.0474
Δc_t	1.4248***	0.2711
constant	-1.1860**	0.2051
y_{t-1}	-0.3482***	0.0374
g_{t-1}	0.3075***	0.0366
i_{1992}	-0.1139***	0.0174
i_{1993}	-0.1051***	0.0162
i_{2001}	0.0491**	0.0139
i_{2003}	0.0749***	0.0136
$R^2 = 0.9328$		F-stat = 30.8388

Note: *** indicates significance at 1 percent level; ** at 5 percent level.

Using EViews 12's auto-detection of outliers feature, four impulse indicator saturation (IIS) variables (i.e., 1992, 1993, 2001 and 2003) are identified and included in the model. This feature allows users to accurately identify outliers without mis-specifying the model using the General-to-Specific model prediction algorithm (see Castle and Hendry 2019). The impulse indicator saturation variables for 1991 and 1992 are expected to have negative effect on electricity consumption because of the power crisis in Luzon in the early 1990s. Lastly, the positive spike in 2003 is likely to be due to the noticeable dip from 2001 to 2002, which was traced to the decrease in the electricity demand of the manufacturing sector (e.g., food, beverages and tobacco; textile and leather). The stability and residual tests are applied to the single-equation ECM and results show that the model passes all the statistical diagnostics (Table 13).

Table 13. Statistical diagnostics of the model

Test on Residuals	H_0	Statistic	p-value
Jarque-Bera Normality Test	Normal residuals	0.153	0.9264
Breusch-Godfrey Serial Correlation LM Test	No serial correlation	F-stat: 0.3118	0.7360
Breusch-Pagan-Godfrey Heteroskedasticity Test	No heteroskedasticity	Obs*R ² : 1.0045	0.6052
		F-stat: 0.3487	0.9463
		Obs*R ² : 4.0692	0.9068
Test on Stability	H_0	Statistic	p-value
Ramsey RESET	No specification error	0.3918	0.6996

The graph of the cumulative sum (CUSUM) test, which graphs the accumulation of differences between the actual values and estimated values, is inside the 5-percent significance level bounds, which further indicates the stability of the parameter estimates.

Figure 25. CUSUM test, Model 1

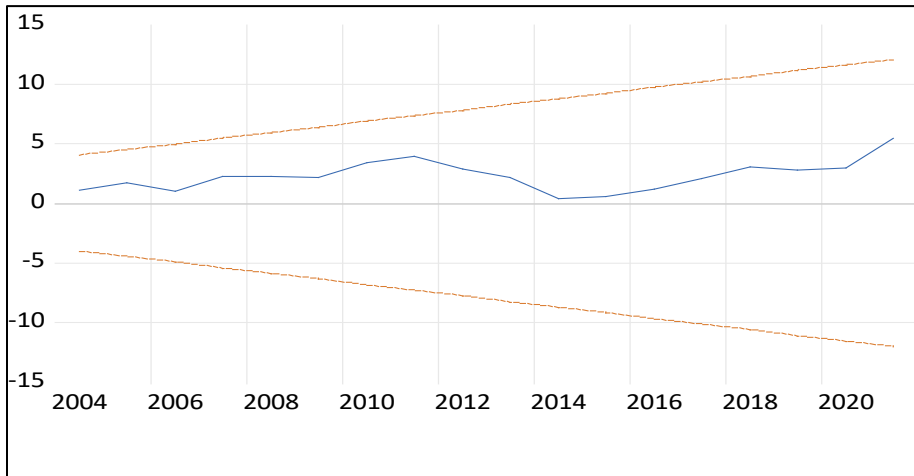
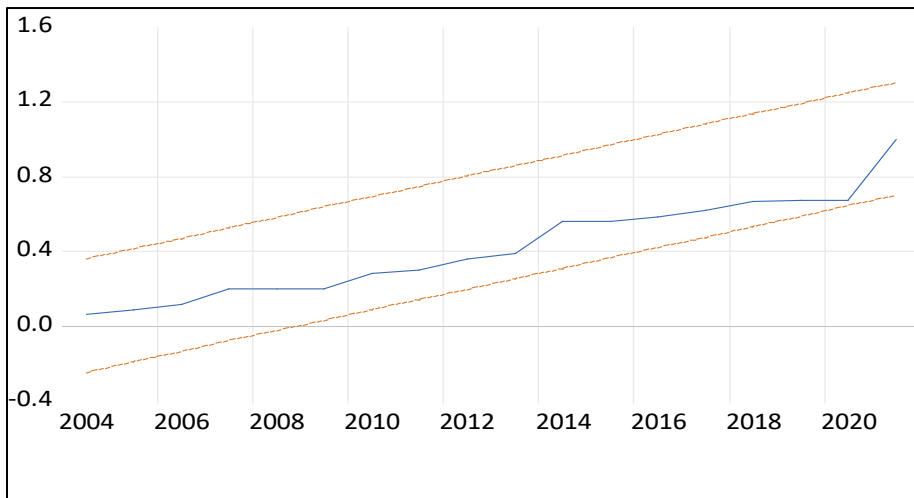


Figure 26. CUSUM of squares test, Model 1



3.2.2 Elasticity-based model (Model 2)

In the last two successively published Philippine Energy Plans, the electricity-to-GDP elasticity was reported as 0.9 in 2018 and 0.7 in 2020. In this study, the computed elasticity is 0.95, which means that electricity remains to be inelastic to GDP.

In the elasticity-based model, the equations use the non-logarithm form of the variables. Elasticity represents the ratio of the percentage changes of the involved variables, defined as:

$$elasticity = \frac{\frac{dy}{\bar{y}}}{\frac{dg}{\bar{g}}} = \frac{dy}{dg} \times \frac{\bar{g}}{\bar{y}}$$

In this case, the GDP-elasticity of electricity consumption is the percentage change in the quantity of consumption divided by the percentage change in GDP. Using Stata, the average elasticity is computed. From the regression equation,

$$y_t = \beta_0 + \beta_1 g_t + u_t$$

where coefficient, β_1 , represents the change in the mean of y_t given a unit change in g_t ,

$$\beta_1 = \frac{dy}{dg}$$

the average elasticity is computed by multiplying both sides by g/y at their means,

$$\frac{dy}{dg} \times \frac{\bar{g}}{\bar{y}} = \beta_1 \times \frac{\bar{g}}{\bar{y}}.$$

3.2.3 Summary of Model 1 and Model 2 forecasts

Table 14 below shows the summary of the results of forecasting using the two models and under three GDP growth scenarios. In general, Model 2 reflects higher electricity consumption forecasts than Model 1.

Table 14. Summary of electricity consumption (in GWh) forecasts, Model 1 and Model 2

	Model 1: Single-equation ECM			Model 2: Elasticity-based model		
	Low growth	Mid-growth	High growth	Low growth	Mid-growth	High growth
2022	88,264	88,264	88,264	95,032	95,032	95,032
2023	93,523	93,809	94,095	100,478	100,931	101,385
2024	99,495	100,294	101,094	106,715	107,923	109,131
2025	104,656	106,065	107,484	113,339	115,404	117,469
2026	110,811	112,942	115,098	120,375	123,409	126,443
2027	116,387	119,321	122,308	127,847	131,975	136,103
2028	123,513	127,385	131,350	135,783	141,142	146,502

Note: As stated earlier, the 2022 GDP used for projecting the 2022 electricity forecast is the actual GDP as reported by the PSA (2023), thus resulting in the same forecasts for all scenarios by model.

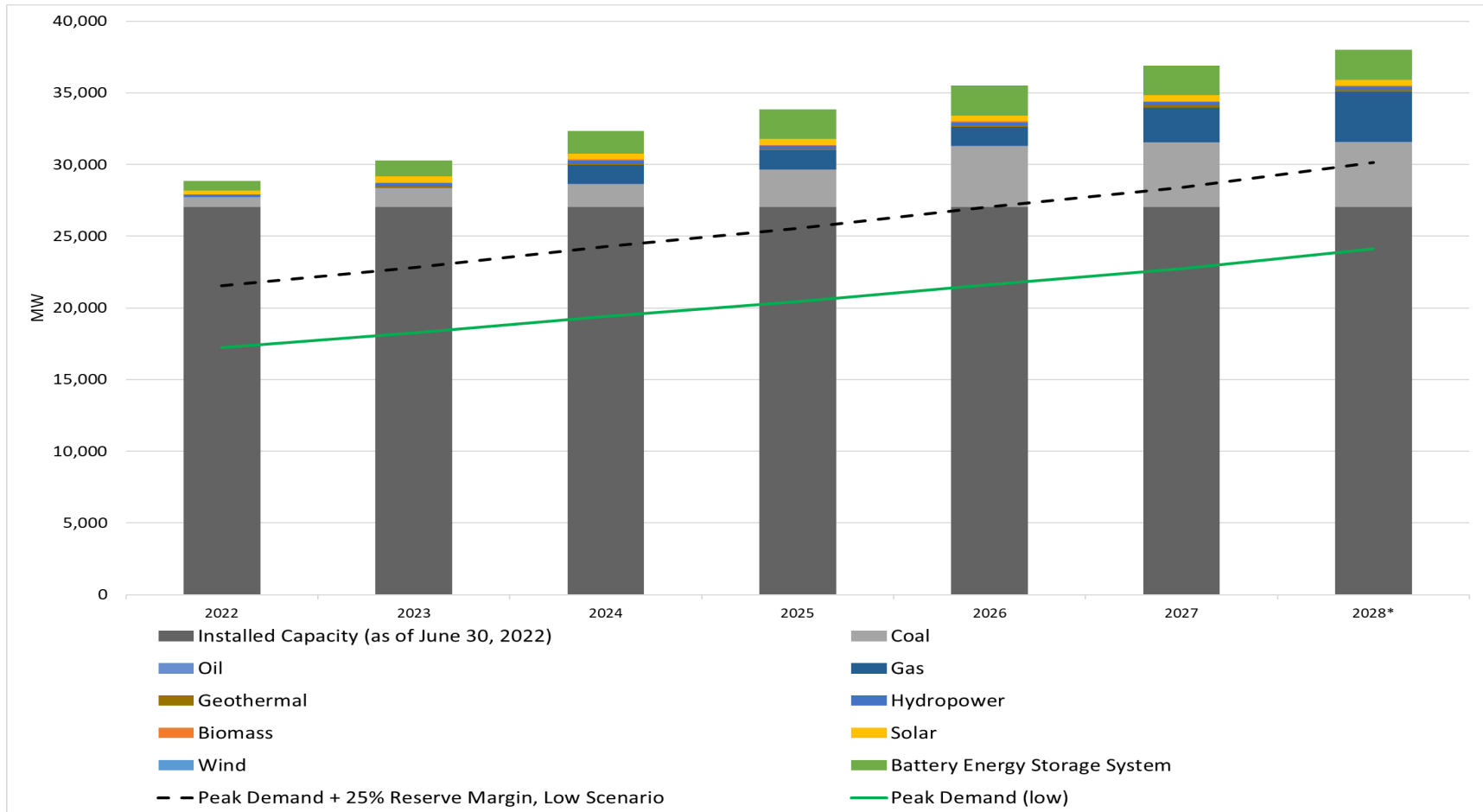
Source: Authors' calculations.

3.2 Comparison with the committed capacities

The graphs presented in this subsection illustrates the forecasts of annual peak demand and peak demand plus reserve margin vis-à-vis the expected overall supply of generated power, which is disaggregated according to energy source, in the medium term (i.e., up to 2028). As previously mentioned, the annual demand forecasts under Model 1 are generally lower than those under Model 2. To illustrate an indication of the accuracy of the electricity forecasts of the two models, the calculated annual peak demand for 2022 was compared with the actual non-coincidental peak demand for 2022, which is 16,569 MW. The estimate under Model 1 is nearer at 17,234.65 MW than that under Model 2 at 18,556.19 MW. Model 1 estimate is within an acceptable margin-of-error of 5 percent.

The figures below show the graphs of projected demand against anticipated supply for Models 1 and 2 under all GDP growth scenarios. The anticipated supply in this case is basically the existing installed generation capacity plus the committed generation capacities (DOE 2022g) stacked by type of technology. In all scenarios, the graphs paint a consistent message that Philippine electricity peak demand plus reserve margin will go up significantly such that in the next few years, the level will be beyond the existing installed capacity. The existing installed capacity is estimated to be breached in 2026 in the case of Model 1 low, medium and high economic growth scenarios, and earlier in 2025 in the case of Model 2 under all growth scenarios (because of the high forecasts arising from the use of the government's elasticity-based method). Recall that installed capacity, as defined earlier, is maximum capacity, which is never met simultaneously for all power plants. Note also that the operation of the Philippine power system depends on available capacity, which is lower than installed capacity, and recently, the grid has already been experiencing yellow and red alerts. The projections confirm the precariousness of the Philippine power supply situation and imply that short-term demand management will have to be relied on if some of the planned generating power plants for 2025 to 2026 operation would not be online as committed.

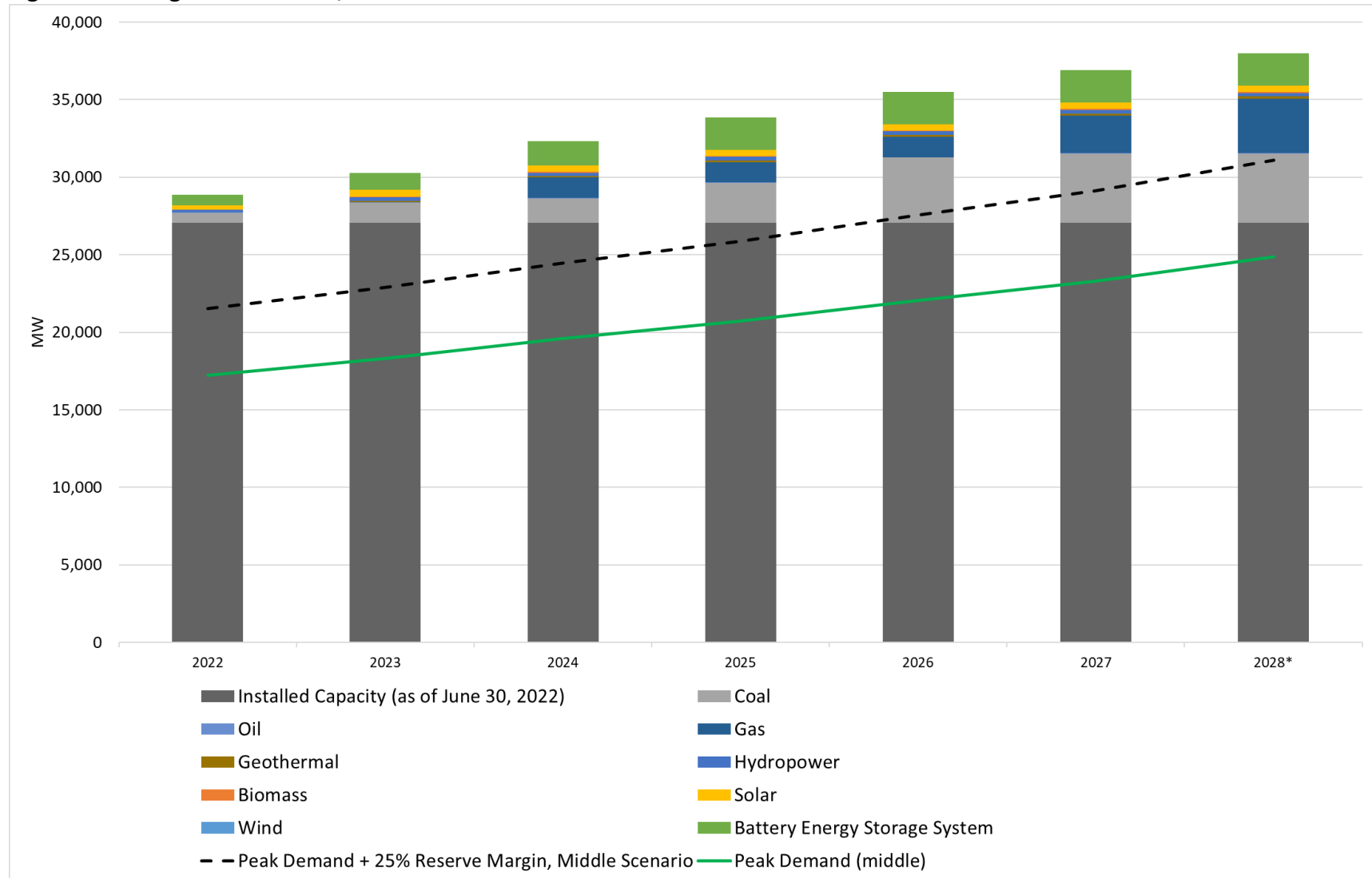
Figure 27. Low-growth forecast, Model 1



Note: * Committed capacity in 2028 is tentative (to be determined).

Source: Authors' calculations, using generation capacity outlook data from DOE (2022g).

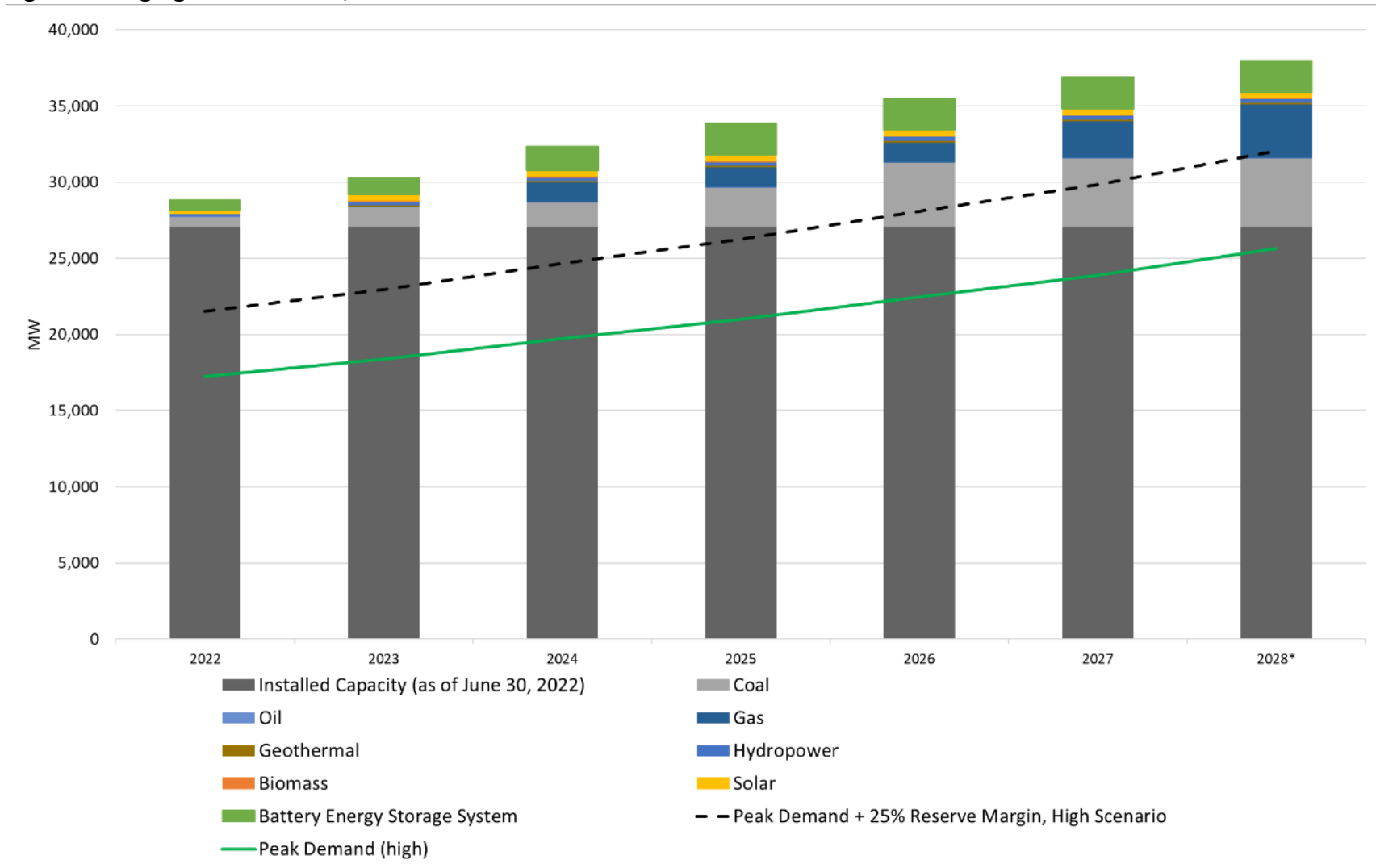
Figure 28. Mid-growth forecast, Model 1



Note: * Committed capacity in 2028 is tentative (to be determined).

Source: Authors' calculations, using generation capacity outlook data from DOE (2022g).

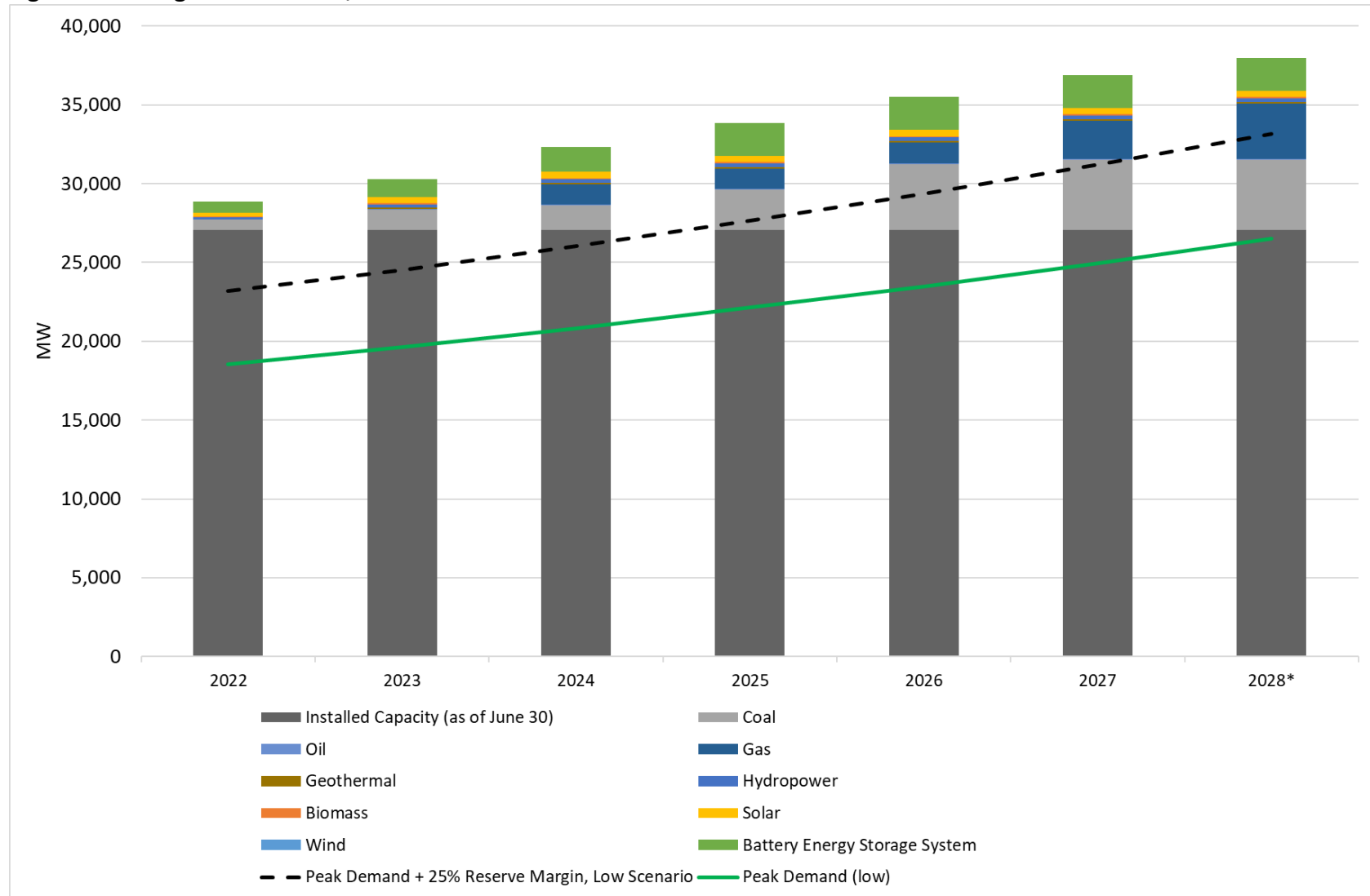
Figure 29. High-growth forecast, Model 1



Note: * Committed capacity in 2028 is tentative (to be determined).

Source: Authors' calculations, using generation capacity outlook data from DOE (2022g).

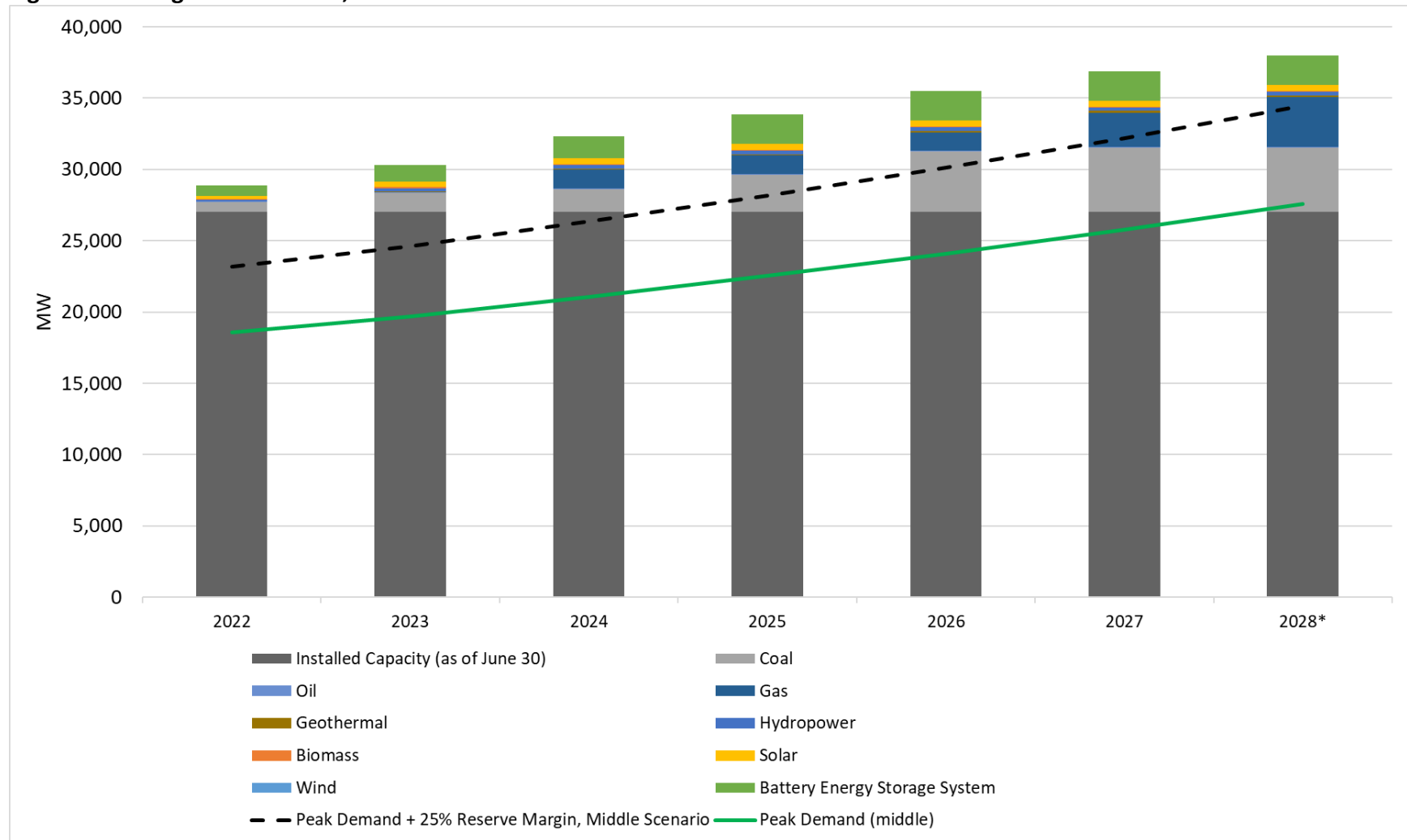
Figure 30. Low-growth forecast, Model 2



Note: * Committed capacity in 2028 is tentative (to be determined).

Source: Authors' calculations, using generation capacity outlook data from DOE (2022g).

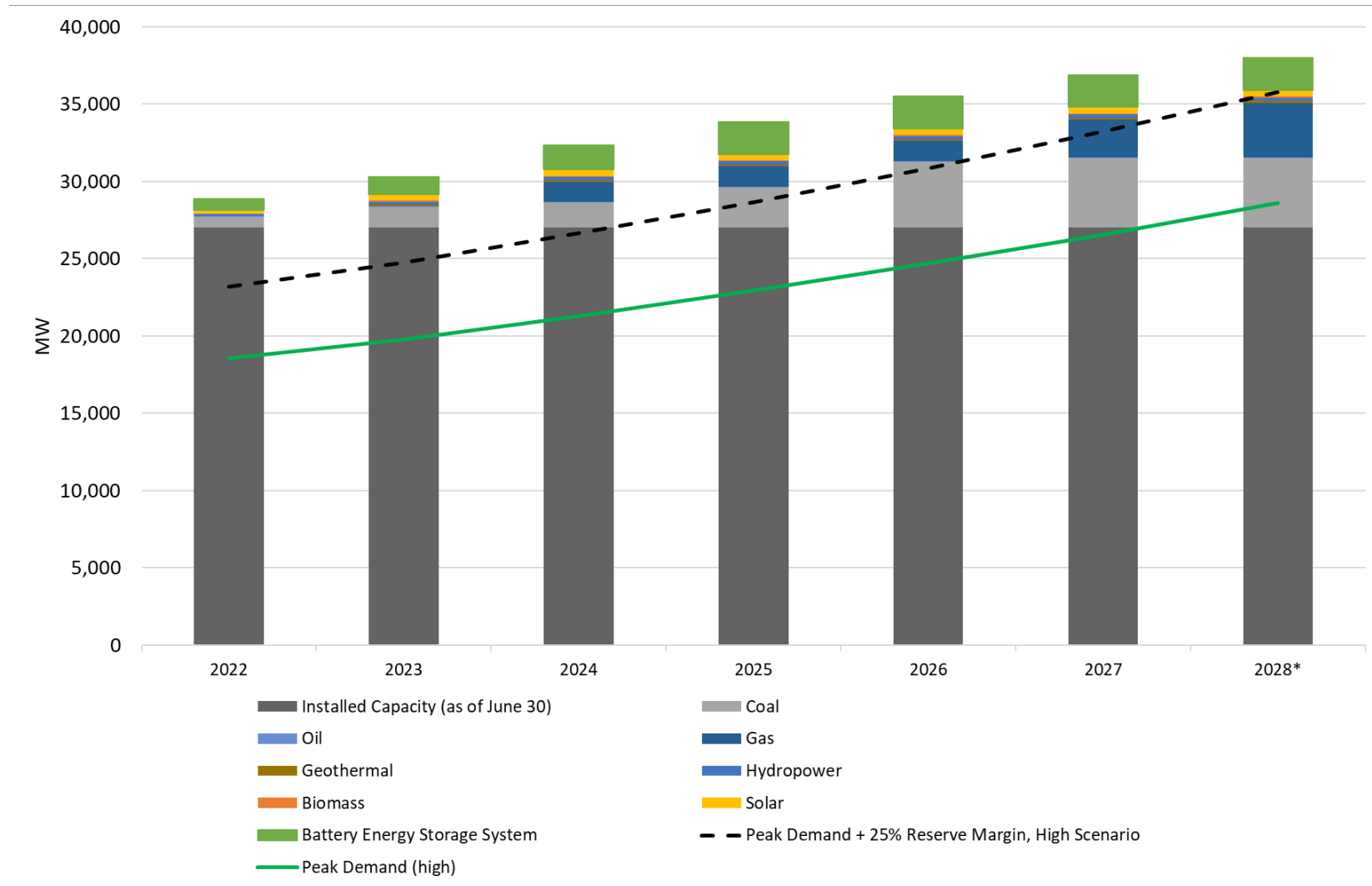
Figure 31. Mid-growth forecast, Model 2



Note: * Committed capacity in 2028 is tentative (to be determined).

Source: Authors' calculations, using generation capacity outlook data from DOE (2022g).

Figure 32. High-growth forecast, Model 2



Note: * Committed capacity in 2028 is tentative (to be determined).

Source: Authors' calculations, using generation capacity outlook data from DOE (2022g).

The estimated peak demand plus reserve margin by 2028 under the two models and all the economic growth scenarios are summarized below.

Table 15. Peak demand and reserve margin by 2028 (in MW), Model 1 and Model 2

	Model 1: Single-equation ECM			Model 2: Elasticity-based model		
	Low growth	Mid-growth	High growth	Low growth	Mid-growth	High growth
Peak demand	24,117.36	24,873.47	25,647.65	26,513.23	27,559.72	28,606.20
Peak demand plus reserve margin	30,146.70	31,091.84	32,059.56	33,141.54	34,449.65	35,757.75

Source: Authors' calculations.

The graphs and the numbers above imply that even under Model 1, which is returning lower forecasts but higher level of accuracy than Model 2, generating power plants coming online on the years that these were committed will be crucial. The results also highlight the necessity of continuously urging the private sector to invest in additional generating capacity to support economic growth and the urgency of pushing government instrumentalities to reduce bureaucratic red tape in processing and approving permits.

4. Policy insights and recommendations

Energy security has many elements. In this study, we made a case for viewing energy security more comprehensively than what is currently being done in Philippine government planning documents. Given our review of the literature on energy security definitions and indicators, we are recommending that the assessment of the country's energy security be based on these six broad elements: sufficiency, reliability, resilience, affordability, accessibility, and sustainability. The measurement of energy security will therefore have to depend on the calculations of indicators corresponding to these elements. As we have proven that data are available for specific energy security indicators and demonstrated that calculations and analysis of ratios, levels, and trends can be made, we are also recommending that going forward, responsible government agencies make similar kinds of calculations and analysis when assessing the country's energy security situation. Doing so will enable policymakers to have an evidence-based understanding of energy sector issues that need to be resolved.

In answering the question "How energy secure is the Philippines?", we employed an indicators-based assessment and it revealed notable findings. On sufficiency, despite the availability of indigenous sources of energy (especially renewable energy), our self-sufficiency ratio in the primary supply of energy is declining. Reserves-to-production and reserves-to-consumption ratios have also sharply declined and will continue to do so unless there will be additional commercially recoverable and highly likely recoverable reserves of energy resources. Our reliance on imports for our energy sources is therefore increasing. But for our major imported fuels, the indicators show that our import sources are not well diversified, making us vulnerable to the sudden

restriction of exports from the source countries or sudden swings in prices due to external market shocks and geopolitical risks. The demand side shows some progress. Trends in energy efficiency indicators related to consumption and production imply that demand management in the country is working.

On reliability, reserve margin based on dependable capacity is enough but there were many instances when the available capacity became so low and resulted in the reserve margin becoming tight. Power interruption is still a problem as indicated by the SAIFI and SAIDI which were higher than the standards set by the regulator. The commercialization of energy has been stagnant, suggesting slow improvement in the domestic supply chain infrastructure. On resilience, indicators suggest weaknesses. Our resilience to oil supply shocks is also low given the high concentration of our import sources and our low average daily inventory. Although the slight uptrend in the country's commercial energy access ratio suggests improvements in the domestic supply chain infrastructure, the improvements were slow, and the ratio is lower than what some of its neighbors in Southeast Asia have achieved.

Affordability of final energy use is a worse problem in the Philippines compared to its neighbors in the ASEAN. The Philippines is among the countries with the highest prices of diesel, kerosene, and gasoline in the region. Moreover, it has the highest electricity price in the region. Within the country, electricity prices on the average are lowest in the Visayas. Electric cooperatives tend to charge higher prices than private distribution utilities. Among electric cooperatives, those in Luzon tend to charge lower prices than those in Visayas and Mindanao. Among private distribution utilities, those in Visayas tend to charge lower prices than those in Luzon and Mindanao. On accessibility, most countries in the ASEAN have already achieved universal access or near universal access to electricity as of 2020, but universal access to electricity remains an elusive goal for the Philippines. Sustainability is also a concern as Filipinos on the average are currently on a high CO_{2e} emissions path. Nevertheless, a comparison with countries in the ASEAN shows that it is still among the low polluters in the region.

In line with the results of our indicators-based assessment, we offer additional recommendations. To reduce our heavy reliance on imports, the Philippines needs to develop further its indigenous sources. To reduce investment uncertainty, we recommend that the investment framework for upstream energy development be clarified. It can be through the crafting of policies that will enhance the principles and supplement the procedures laid down by Presidential Decree (PD) 87 and PD 1459, the laws providing the regulatory framework for upstream activities. The Philippines also needs to find ways to hedge against risks from low diversification of import sources. As the broader focus should be on sufficiency itself rather than simply self-sufficiency, the strategies should include not only boosting our indigenous production of energy but also diversifying our import sources to minimize risks of market disruption. As energy demand saved is additional energy supply, all stakeholders need to continue energy efficiency improvements in order to manage demand.

To improve the reliability of the power system, energy regulators need to enforce discipline in the contracting of ancillary reserves by the transmission operator and prudently act on the requests for infrastructure upgrades by the distribution utilities, especially the electric cooperatives. Infrastructure upgrades should also focus on improving the resilience of the power system to

disasters and cybersecurity attacks. There should also be more investments on the domestic supply chain infrastructure, including those related to electric vehicle utilization and natural gas industry development, to improve the overall resilience of the Philippines' energy sector. Specifically in the oil sector, resilience can be improved by ensuring that the country's inventory can withstand oil shocks.

Improving the affordability of energy products in the Philippines is a complex task and will need various solutions. Rigorous research on the factors influencing the market for each energy product and affecting the pricing of these products is necessary. Nevertheless, strategies that will help lower prices include promoting further competition in the electric power market and reducing the demand for petroleum by facilitating the clean energy transition in the transport sector. Pursuing universal access to electricity also involves many solutions. Strategies that will help include properly reckoning the unserved segment of the population in terms of number of households rather than merely in terms of barangays or sitios and then using household-based targeting in the current electrification programs. It will also help to identify factors that can fast-track the implementation of the microgrid systems law, which was approved in 2022 to accelerate the electrification of unserved and underserved areas. To improve environmental sustainability in the energy sector, measures geared toward a clean energy transition such as promoting preference for greener solutions among Filipinos and supporting Philippine industries through green finance will also help.

Elucidating the comprehensiveness of energy security as a concept entailed in this study the examination of its features or elements. One important conclusion for policy researchers and government agencies is that each element of energy security is by itself an area of future research that must be examined and monitored in the local setting. The first element, energy sufficiency, is examined further in this study by demonstrating techniques for forecasting electric power demand and comparing the resulting forecasts with power generation commitments. Our forecasts confirm the precariousness of the Philippine power supply situation at present and up to 2025, and 2026 in certain scenarios, if there will be no addition to the existing installed generation capacity. Our comparison of the forecasts with the government's supply outlook up to 2028 also underscores the need to ensure that the planned generating capacity will be online as committed and as scheduled. For this to happen, the private sector needs to continuously invest in additional generating capacity and government instrumentalities from the national to the local levels need to reduce bureaucratic red tape in the permitting process.

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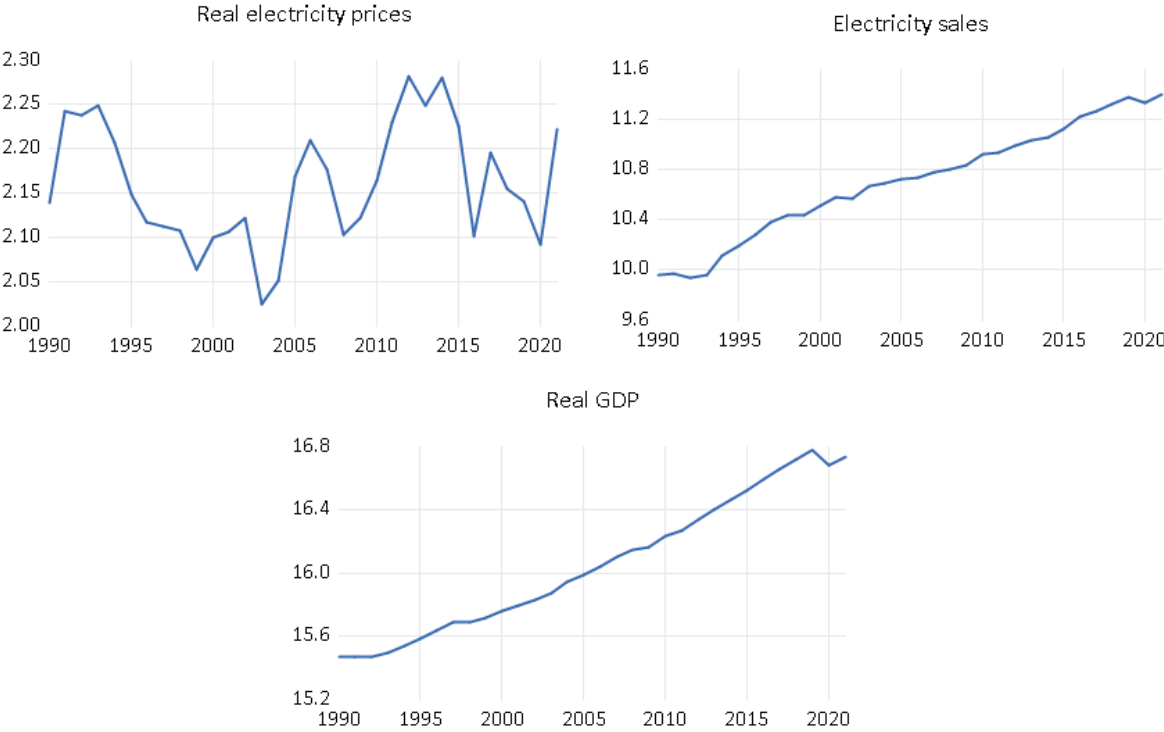
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Annex A. Real electricity prices, electricity sales, and real GDP trends, 1990-2021



Note: Trends are in their natural logarithmic form.