Towards an Affordable and Reliable Grid with Energy Transition (TARGET)

Alberto Dalusung III[1,2], Jephraim Manansala[1,2], Marion Lois Tan[1,2], Angelika Marie David[1,2], Mila Jude[1,2], Ferdinand Larona[1,3], Christian Melchert[1,3], Richard Antonio[1,3], Judit Hecke[1,4], Mathis Rogner[1,5]

[1] Clean, Affordable, Secure Energy for Southeast Asia (CASE) Project – Philippines
[2] Institute for Climate and Sustainable Cities (ICSC)
[3] Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH – Philippines
[4] NewClimate Institute
[5] Agora Energiewende

Abstract

In the old traditional sense, power, and the plants that produce it, can be categorized based on the type of demand they serve (baseload, intermediate, peaking). Baseload power is an energy resource that provides the minimum amount of electric power required by the load demand to remain operational 24/7. Intermediate and peaking power plants address the highly fluctuating needs of the load demand during peak hours. Despite the high variability in load requirements, heavy investments over the past decade have been poured mostly into baseload coal to support the country's economic development that lead to a reduced share of Renewable Energy (RE). This report compiles and analyzes energy data from various institutions of the Philippine energy sector and other research findings to assess the reliability and viability of coal and variable Renewable Energy sources (vRE) from the past four years. The objective of this report is to provide evidence that shows how advancing the energy transition is the economic way forward. By providing this evidence, relevant stakeholders and audiences may be better informed and initiate dialogues on how government and other regulating bodies can implement policies and mechanisms to aid in structural change for efficient RE integration into the grid.

Keywords: Energy Transition, Renewable Energy, Wholesale Electricity Spot Market, Data Analytics

Introduction

As of 2021, the RE share has dropped to only 21% from 45% in 1990 and 35% in 2008. In the 2019 energy mix, power generating technologies based on fossil fuels, such as coal, natural gas, and oil, accounted for almost 80% of the power generation energy mix, with emerging power generating technologies, such as solar and wind, accounting for less than 3%.

This could be attributed to the heavy investments given to baseload power plants that lead to the rapid construction of coal-fired power plants in the last decade. Baseload is the minimum level of demand on a grid within a period, typically a day. As seen in Figure 1, the required baseload amount is set during the off-peak hours of a day.

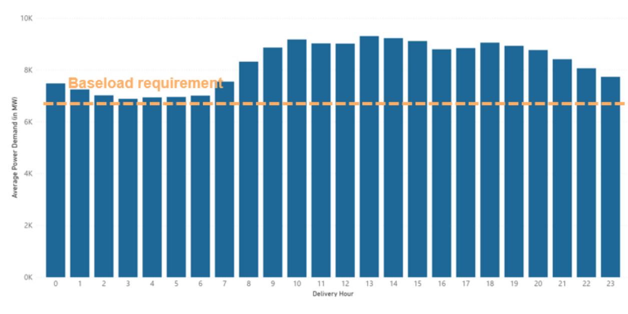

Figure 1: Average Hourly Power Demand in Luzon 2019

Power, and the plants that produce it, can be categorized on the basis of the type of demand they serve (baseload, intermediate, peaking). To meet the baseload requirements of the demand, a baseload power plant is often preferred since it supplies the power necessary while staying operational 24/7.

However, it should be noted that baseload power plants should remain constant at the rated level based on the minimum amount of power required by the load throughout the day. It would not be economically feasible to operate baseload plants based on the load's peak demand since the demand is highly variable. Intermediate and peaking power plants address the highly fluctuating part of the load demand during peak hours, complementing the baseload power plants.

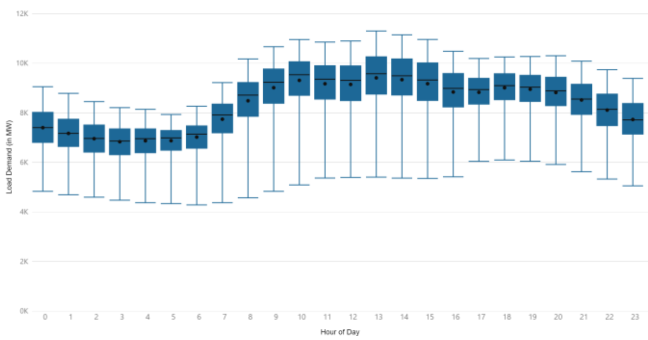

Figure 2: Boxplots of Hourly Power Demand at Luzon in 2019

The fluctuations in the Philippine load demand are significant throughout the day. As shown in Figure 2, it ramps up at mid-day and at early evening. In the Luzon grid in particular, the power demand difference between peak and off-peak hours is roughly about 3,000 MW. Moreover, looking at the body of the boxplot in Hour 13, we can see that 50% of the time, the data points vary by about 1,500 MW, which shows that the demand is dynamic. This necessitates the grid to have a mix of generators that can cope with the demand variability while still providing round-the-clock electricity. This is not achievable by investing heavily in generators that can only provide the baseload requirement.

Because of this baseload-centric way of thinking, the current market structure has leaned more favorably toward fossil fuel technologies. Wholesale Electricity Spot Market (WESM) data shows fossil fuel sources make up the majority of the market share either through bilateral contracts with distribution utilities (DUs) or through spot market bids [9]. Moreover, financing for merchant RE is difficult due to current requirements from private financial institutions [10].

The coal moratorium declared by the Philippine Department of Energy (DOE) is in line with the latest National Renewable Energy Plan, which no longer recommends new baseload coal power plants in the next 20 years. However, the moratorium does not stop coal power plants already in the planning and construction pipeline that were approved and committed to prior the moratorium announcement on October 27, 2020. According to the latest figures from DOE Philippines, a total of 6,937 MW committed capacity and 7,974 MW indicative capacity of baseload plants are currently in the works, with most of them (4,421 MW of committed and 2,190 MW of indicative projects) being coal-fired power plants .

Given the current scenario, this report aims to provide evidence showing how advancing the energy transition is the economic and practical way forward. Specifically, this work debunks the perceived reliability of coal-fired power plants due to being baseload power plants and the perceived unreliability of variable renewable energy (vRE) plants due to their intermittency.

Moreover, this work debunks the claim that an energy transition is not viable and not practical in a developing country like the Philippines because of preconceived notions on coal and vRE’s costs.

Framework and Methodology

The researchers have evaluated various data sources from the Independent Electricity Market Operators of the Philippines (IEMOP), National Grid Corporation of the Philippines (NGCP), and the DOE.

The bulk of datasets used are actual operational data of the WESM that is procured from IEMOP. Datasets used in this study are as follows:

- Market Prices and Schedules
- Generation Market Bids and Offers
- Generator Weighted Average Price
- Marginal Plants
- Market Clearing Price
- System Operator Advisory Logs

Moreover, the publicly available datasets used are listed below:

- NGCP hourly load demand
- NGCP system peak demand

- NGCP grid generation per plant type
- DOE list of existing power plants
- DOE list of committed power plants
- DOE list of indicative power plants
- Prices in the global commodity markets

This work follows the conceptual framework described in Figure 3. After gathering the datasets from various sources, the researchers stitched the data together by appropriate attributes to observe them from a broader perspective and establish the correlations and dependencies between parameters such as costs, power output, and events. Research and reports by established institutions were also used as a point of reference or as supporting materials.

Figure 3: Conceptual Framework

Unless otherwise specified, all analyses are based on historical and actual energy data that were processed using analytics and simple descriptive statistic measures such as taking the average over a relevant period. The details are elaborated in each section of this paper.

Finally, this report aims to provide an evidence-based analysis by presenting the data and the relevant findings as objectively as possible.

Results and Discussion

A. Additional baseload coal is no longer what the Philippines needs

Due to the nature of baseload requirement, these coal plants must run at that same level the whole day, every day during their operation. And based on current data, this is not how they operate today.

Looking at the current energy mix (Figure 4), we can see that coal-fired power plants ramp up during the daytime and ramp down during the nighttime. This ramping up and down is also pertained to as cycling; which for an inflexible coal-fired power plant to operate this way comes with a disadvantage.

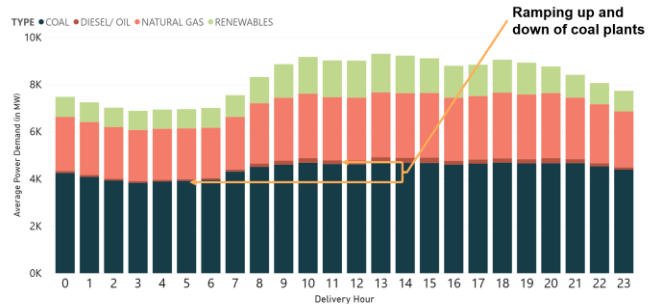

Figure 4: Average Hourly Energy Mix in 2019

Cycling can have a considerable impact on the reliability and cost of coal plants [11]. The largest coal power plant in the Luzon grid, Sual Coal-fired Power Plant Unit 2, is under cycling operation regularly and has also experienced 17 outages in the past 2 and a half years (Figure 5). This shows Sual Unit 2 has had an intermittent operation as they experience recurring unintended outages that are evident even before the pandemic.

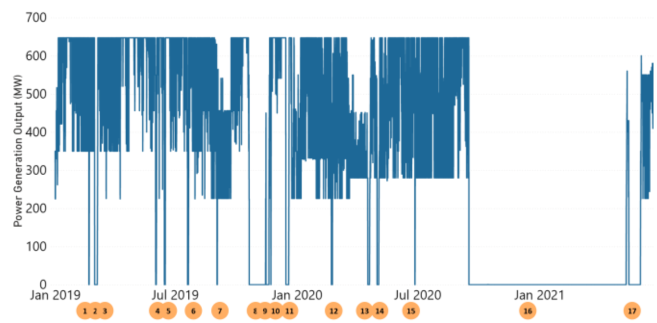

Figure 5: Power Output of Sual Unit 2 from Jan 2019 to June 2021

Note: Yellow markers indicate outage instances

Data also show that this is not an isolated case since other coal plants also exhibit intermittency. To view the prominence of these observations with coal plants as a whole, the average planned and unplanned outage duration of the prominent coal plant technologies was computed (Figure 6) and was benchmarked on the 2021 allowable outage duration limit established by the ERC.

Results show that the average Circulating Fluidized Beds (CFB) and Pulverized Subcritical Coal (PSC) coal plants have historically exceeded this allowable limit of 32.3 days and 44.7 days, respectively. On average in the past four years, CFB and PSC have exceeded the allowable limit by 25 days and 20 days, respectively.

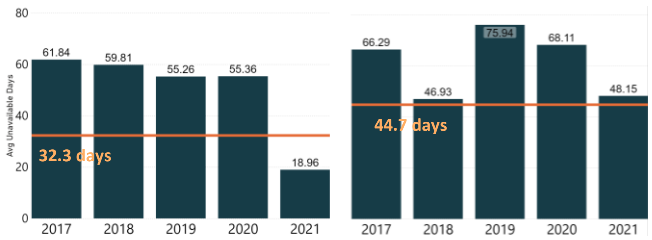

Figure 6: Outage Duration for Circulating Fluidized Beds (left) and Pulverized Subcritical Coal (right)

Note: Yellow line indicates maximum allowable duration limit; 2021 data is only up to June 2021

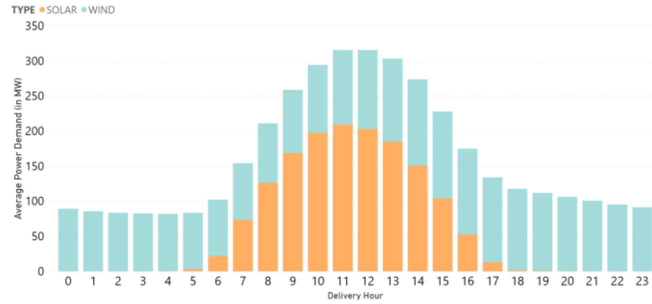

Figure 7: Average Daily Generation Profile of Solar and Wind Plants at Luzon in 2019

Lastly, since coal plants cannot ramp up and down easily and quickly, it is impossible to dispatch only them during peak periods when the grid needs the most power. In short, when we have too many baseload power plants, we will have too much power when we do not need it and not enough when we do.

B. Variable RE sources are reliable because of their high availability and predictability, and can be further realized with the appropriate system design and policies

While it is true that vRE cannot cover the baseload power demand round-the-clock – this was never the intended purpose of vRE. Rather, since vRE sources coincidentally generate power during peak hours, they can conveniently provide power during this crucial time.

This availability of the vRE generated power at the right time is amenable to a more cost-effective grid operation (Figure 7). Furthermore, if enough vRE plants were installed in the grid, existing coal-fired power plants would no longer need to ramp up and down, possibly reducing the intermittency observed today.

Additionally, Figure 8 shows the average unavailability duration of vRE plants is significantly lower than that of coal (considering only solar's operational hours to be 7am to 5pm). This shows that these vRE plants do not need extended outages to be maintained and do not experience recurring outages during their operations.

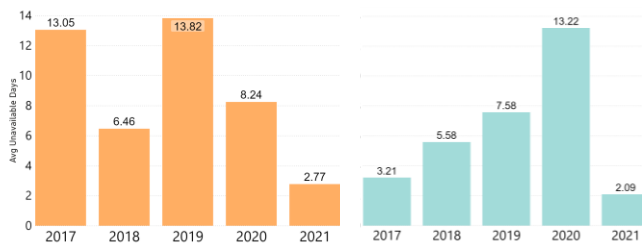

Figure 8: Unavailability Duration of Solar Power Plants (left) and Wind power plants (right)

From the published data of IEMOP, vRE plants in the grid have consistently outperformed forecasting accuracy standards (Table 1). A low forecasting error means that we are better able to determine the power generation loading of the vRE sources – and thus, we can better dispatch the right mix of the most cost-effective power generations at any point in time.

Table 1: Aggregate Performance of Must Dispatch Generating units per Technology [15]

	Region	Actual Performance: MAPE 2019	MAPE 2020	MAPE 2021 YTD	PERC95 2019	PERC95 2020	PERC95 2021 YTD
Solar	Luzon	5.42%	3.67%	3.94%	15.34%	14.98%	16.81%
Wind	Luzon	6.30%	6.18%	5.84%	17.43%	18.29%	17.80%
Solar	Visayas	5.87%	3.48%	3.89%	17.99%	15.40%	17.93%
Wind	Visayas	9.87%	8.52%	7.70%	28.15%	25.17%	21.86%

Note: Acceptable values for Mean Absolute Percentage Error (MAPE) and Percentile 95 (Perc95) of the forecasting error are set to 18% and 30%, respectively.

There could still be intra-hour variability and fluctuations for vRE sources from natural events that can cause deviations from its hourly dispatched power generation output. However, these issues are not impossible to mitigate. These fluctuations are often evident from the point of view of an individual plant or a local area, which is not the practical way of looking at it. Variability in power output is highest for a singular wind or solar plant. But at a system level, their variability and fluctuation tend to cancel out (Figure 9).

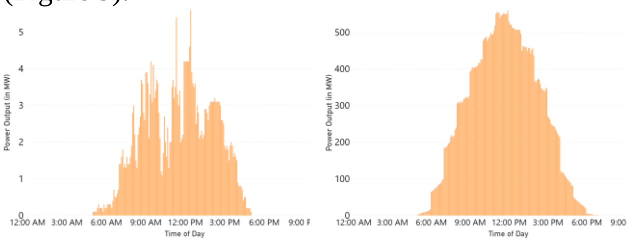

Figure 9: Variability of an individual solar plant (left) and the aggregate of solar plants (right)

The power system is interconnected; thus, we need to view this issue on a system level. On this level, an improved system design such as utilizing geographic diversity, forecasting accuracy, and technologies that allow more system flexibility could mitigate these deviations. Additionally, studies in other grids have shown no significant increase in contingency and regulating reserve requirements are needed for integrating a larger share of RE in the grid (10% wind share in New York and 27% wind share in Minnesota) [20]. By just upgrading some operational practices, vRE capacity can be integrated quite smoothly.

Moreover, in the Philippines, the system design and policies are already in place for implementation – such as the transition from an hourly to a 5-minute dispatch, more advanced forecasting techniques, the planned reserves capacity market, consumer option programs, more flexible generating plants, and many more. Thus, the Philippines would only need to implement these policies to help us realize a much greater vRE penetration in the system.

C. Coal is not the most cost-effective and has hidden costs tied to it

About 81% of the coal consumed in the Philippines in 2019 is imported, of which 90% came from Indonesia. The high dependence on imported fossil fuel is a threat to the Philippines' energy security since the electricity price is vulnerable to the volatility of the fuel prices in global markets. Data has shown the price to fluctuate significantly over the past year (Figure 10). In fact, the price of coal has tripled from the start of this year alone.

Figure 10: Price of Coal (USD / Ton) in the Global Markets from 2009 to 2021 [27]

Moreover, the Philippines' energy regulatory practice allows automatic fuel cost pass-through in these power plants. This provision signifies that consumers bear the additional cost whenever the cost goes up in the world market.

Lastly, operational data shows that due to the intermittency and unreliability of coal-fired power plants, significant increases in the electricity price occurred when they were unavailable. In fact, we can see that whenever the Sual Unit 2 experiences outages, the generating price of electricity in the merit order more than doubles in price (Figure 11).

This observation signifies the hefty cost that consumers have to pay in response to the unreliability of these plants. But even with the increased prices, note that rotating blackouts were still experienced during the Summer of 2021. This difficulty only adds to the burden that is already imposed to the consumers.

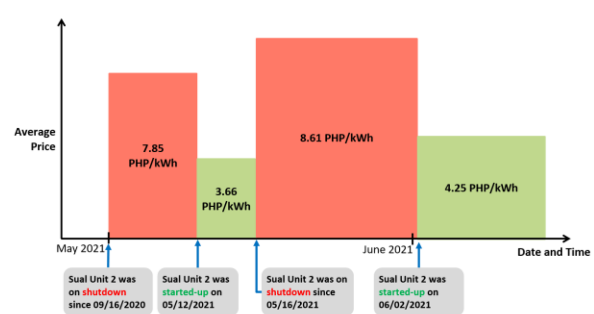

Figure 11: Sual Unit 2 Timeline of Operation vs. Price of Electricity in the Spot Market during Summer 2021

D. Variable RE sources are among the cheapest and have historically reduced the price of electricity

The Philippines is rich in indigenous wind and solar resources. The DOE identified tens of thousands of MW of renewable energy capacity in its Competitive Renewable Energy Zones (CREZ) [32]. This indigenous aspect makes vRE amenable to a more cost-effective grid operation since it is not prone to price volatility of the global markets.

Table 2: Cost Parameters of Different Power Generation Technologies in the Philippines [36]

	Capital Costs (USD/ kW)		Fixed O&M Costs (USD/ kW)		Variable O&M Costs (USD/MWh)	
	2016	**2030**	**2016**	**2030**	**2016**	**2030**
Circulating Fluidized Bed Coal	1809	1809	40	40	9.3	9.3
Subcritical Pulverized Coal	1607	1607	79	40	9	9
Supercritical Pulverized Coal	1921	1921	102	33	6.4	6.4
Ultra-supercritical Pulverized Coal	2300	2300	46	46	6.4	6.4
Solar PV (on-grid and off-grid)	1583	1040	44	8	0	0
Wind (on-grid and off-grid)	1996	1538	69	46	0	0

Moreover, Table 2 shows that the capital and fixed operating expenses of vRE generating technologies in the Philippines are already currently cheaper than coal-fired power technologies. Additionally, the forecasted costs of these vRE power plants are expected to go down further in 2030, compared to coal-fired technologies that are expected to maintain their price in the next decade.

From the spot market perspective, the Generator Weighted Average Price (GWAP) skyrockets during the peak hours and normalizes during off-peak hours. This significant price increase has resulted in the rolling average GWAP reaching and exceeding the ERC secondary price cap trigger of 9,000 PHP / MWh. This is an indication that the grid lacks power plants that can specifically address the peak hours. Currently, it resolves by dispatching expensive generators to meet this peak demand.

Based on the WESM merit order mechanism, the order of the dispatch to meet the demand is based on the price of the different generators. Since RE are among the cheapest, they are always the first in line to be dispatched, including during peak hours. Because of this, existing RE plants help mitigate the increases in settlement price.

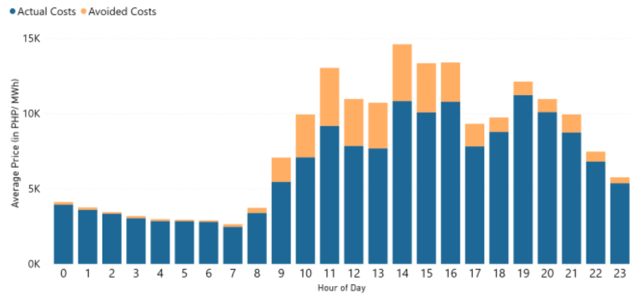

Figure 12: Actual Settlement Price of Electricity vs. Avoided Cost due to RE in 2019

Using actual data, a scenario with no RE installed in the grid was generated using the prices of the next-in-line plants in the merit order. This scenario experienced much greater peaks in prices due to the lack of cheaper generators in that period. This signifies that the existing operating RE units effectively reduced the cost of electricity by 28% during peak hours despite having less than a 3% share in the energy mix. These findings show the significant cost-saving potential of more plants in the energy mix.

Conclusion

This report proves the incompatibility of coal plants for the current needs of the Philippine energy system. Primarily due to their unreliability which then leads to additional costs to consumers. VRE showed significant potential, as seen from their current performance being consistently available during peak demand and cost-savings. Projections have also shown it to become even cheaper and promote flexibility in the grid, benefitting consumers as long as appropriate system designs and policies are enacted.

The findings in this paper confirm existing initiatives undertaken by the government. One of these initiatives is in the latest edition of the Philippine Energy Plan, stating the country envisions achieving a 35% and 50% share of renewable energy by 2030 and 2040, respectively [35]. This move is further supported by the energy transition policies and mechanisms spearheaded by the DOE (i.e. Renewable Portfolio Standards, Green Energy Option Program, Coal Moratorium, etc.).

The Philippines' position on climate change issues has always been on climate justice, considering that the country is a victim rather than an initiator of all of these climate impacts [39]. However, while the Philippines is only a minor contributor to Greenhouse gas emissions, this report shows that the energy transition is still beneficial to the country since renewable energy technologies now prove to be economical, practical, and what our system needs.

Ultimately, evidence has shown that advancing the energy transition is the economic way forward, that it can pave the way for affordable and reliable energy for the Philippines, and that its compliance with the environmental concerns are just an added co-benefit to this initiative.

References

[1] E. E. Patalinghug, "An Analysis of the Philippine Electric Power Industry," in International Conference on the “Challenges to Development: Innovation and Change in Regulation and Competition”, Mandaluyong, 2003.

[2] DOE, "Key Energy Statistics 1990-2018," Taguig, 2018.

[3] "Republic Act No. 9513 An act promoting the development, utilization and commercialization of renewable energy resources and for other purposes," Congress of the Philippines, Manila, 2008.

[4] "Advisory on the Moratorium of Endorsements for Greenfield Coal-Fired Power Projects In Line with Improving the Sustainability of the Philippines' Electric Power Industry," 22 December 2020. [Online]. Available: https://www.doe.gov.ph/announcements/advisory-moratorium-endorsements-greenfield-coal-fired-power-projects-line-improving?ckattempt=1. [Accessed 16 November 2021].

[5] A. R. Dalusung, Interviewee, Technical Working Group RE Developer of National Renewable Energy Board. [Interview]. November 2021.

[6] DOE, "Summary of Committed Power Projects as of 31 October 2021," 2021.

[7] DOE, "Summary of Indicative Power Projects as of 31 October 2021," 2021.

[8] IRENA, From Baseload to Peak: Renewables Provide a Reliable Solution, 2015.

[9] D. Rivera, "Meralco launches bidding for 850 MW renewable capacity," Philippine Star, Manila, 2022.

[10] V. Sunio, J. Mendejar and J. R. Nery, "Does the greening of banks impact the logics of sustainable financing? The case of bank lending to merchant renewable energy projects in the Philippines," Global Transitions, vol. 3, pp. 109-118, 2021.

[11] National Association of Regulatory Utility Commissioners, "Recent Changes to U.S. Coal Plant Operations and Current Compensation Practices," 2020.

[12] Energy Regulatory Commission Res 10, Annex A – Rules for the Interim Reliability Performance Indices and Equivalent Outage Days per Year of Generating Units, 2020.

[13] OECD and IEA, Getting Wind and Sun onto the Grid: A Manual for Policy Makers, 2017.

[14] Energy Regulatory Commission, Grid Management Committee, "Procedures for the Monitoring of Forecast Accuracy Standards for Must Dispatch Generating Units," Wholesale Electricity Spot Market, 2017.

[15] IEMOP, Monthly Report on the Monitoring of Forecast Accuracy Standards for Must Dispatch Generating Units, 2019-2021.

[16] F. Dekking, C. Kraaikamp, H. Lopuhaä and L. Meester, A Modern Introduction to Probability and Statistics, Springer-Verlag London, 2005.

[17] A. D. Mills and R. H. Wiser, "Implications of Wide-Area Geographic Diversity for Short- Term

Variability of Solar Power," in 2011 IEEE Power and Energy Society General Meeting, Detroit, 2010.

[18] R. Kempener and E. Borden, "Battery Storage for Renewable: Market Statues and Technology Outlook," IRENA, 2015.

[19] Philippine Electricity Market Corporation, "Increasing Penetration of vRE Resources and The Reserve Market," 2018.

[20] NREL, E. Ela, M. Milligan and B. Kirby, Operating Reserves and Variable Generation: A comprehensive review of current strategies, studies, and fundamental research on the impact that increased penetration of variable renewable generation has on power system operating reserves, 2011.

[21] Electricity Reliability Council of Texas, "Analysis of Wind Generation on ERCOT Ancillary Services Impact Requirements," 2008.

[22] R. Fares, "Renewable Energy Intermittency Explained: Challenges, Solutions, and Opportunities," 2015.

[23] USAID, DOE, "Greening the Grid: Solar and Wind Grid Integration Study for the Luzon Visayas System of the Philippines," USAID, 2018.

[24] USAID, Grid Integration Series: Impact of Variable Renewable Energy on System Operations, 2020.

[25] IRENA, "Innovation landscape for a renewable-powered future: Solutions to integrate variable renewables," International Renewable Energy Agency, Abu Dhabi, 2019.

[26] DOE, "2019 COAL IMPORTATION based on the ETAs of submitted CoC applications as of 31 December 2019," 2019.

[27] Trading Economics, "Coal 2021 Data | 2022 Forecast | 2008-2020 Historical," 2008. [Online]. Available: https://tradingeconomics.com/commodity/coal. [Accessed 19 October 2021].

[28] Trading Economics, "Natural gas 2021 Data | 2022 Forecast | 1990-2020 Historical," 1990.

[29] DOE, "Executive Order No. 226 The Omnibus Investments Code of 1987," 1987.

[30] Board of Investments, Department of Trade and Industry, "Incentives for Energy Sector," in Energy Investment Forum, Taguig City, 2018.

[31] N. Sarma, "Future of Coal: The stranded asset problem," Observer Research Foundation, 2020.

[32] NREL, DOE PH, NGCP, USAID, "Grid Planning and Competitive Renewable Energy Zones (CREZ) in the Philippines," 2020.

[33] "DOE launches offshore wind roadmap project," Philippine News Agency, 2021.

[34] "Offshore Wind Outlook 2019: World Energy Outlook Special Report," International Energy Agency, 2019.

[35] DOE, "Philippine Energy Plan (PEP) 2020-2040," DOE, 2021.

[36] USAID, "Building Low Emission Alternatives to Develop Economic Resilience and Sustainability Project (B-Leaders)," 2018.

[37] Asian Development Bank, "Handbook on Battery Energy Storage System," Mandaluyong, 2018.

[38] Lazard, Lazard's Levelized Cost of Energy Analysis - Version 15.0, 2021.

[39] "Cusi Reiterates DOE Position on Climate Justice, Energy Transition and Order in the Power Industry," DOE, Taguig, 2021.