Research Brief on Energy

Office of Senator Win Gatchalian

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Version 1

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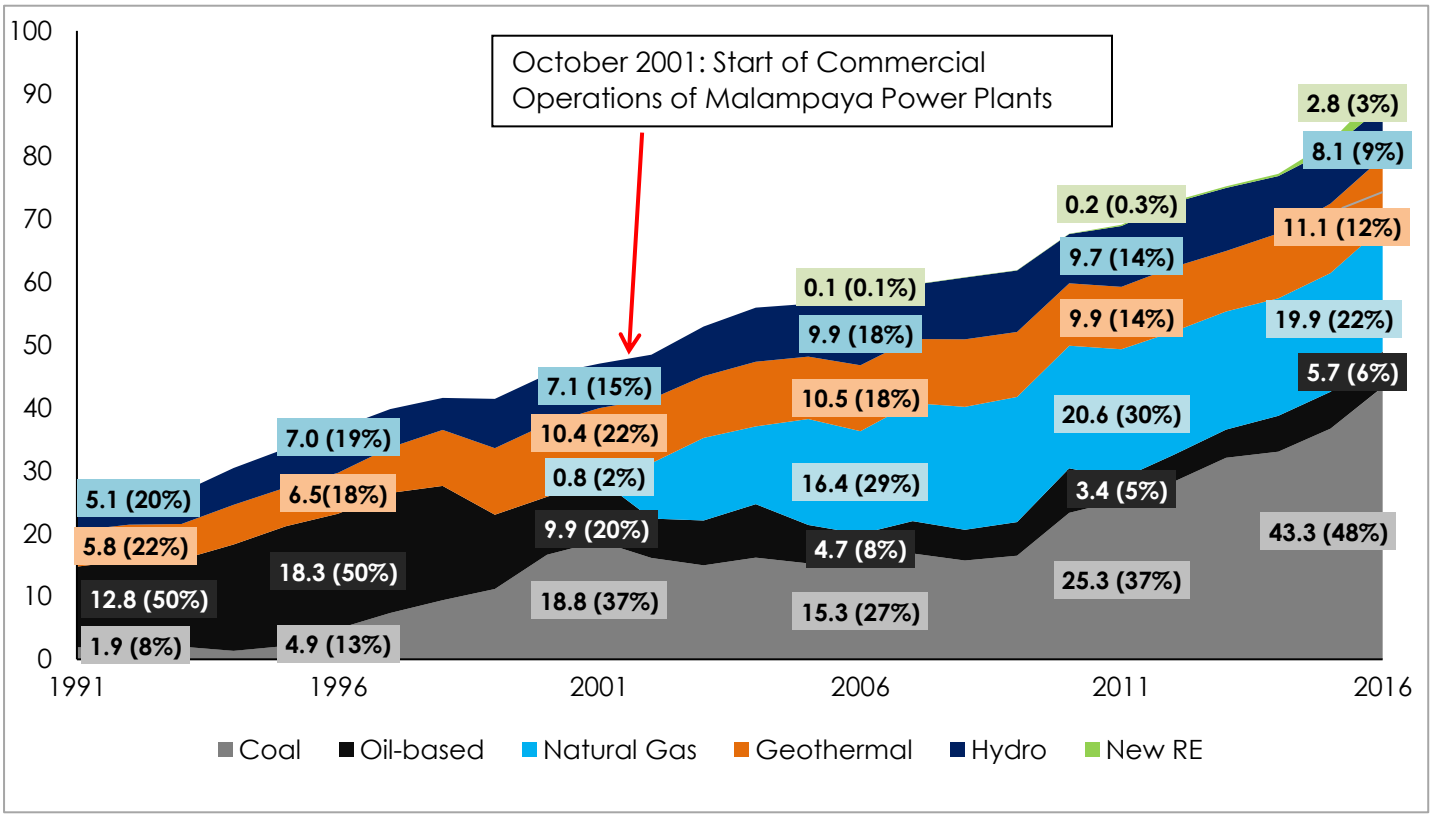
Philippine Natural Gas Outlook

Philippine Natural Gas Statistics

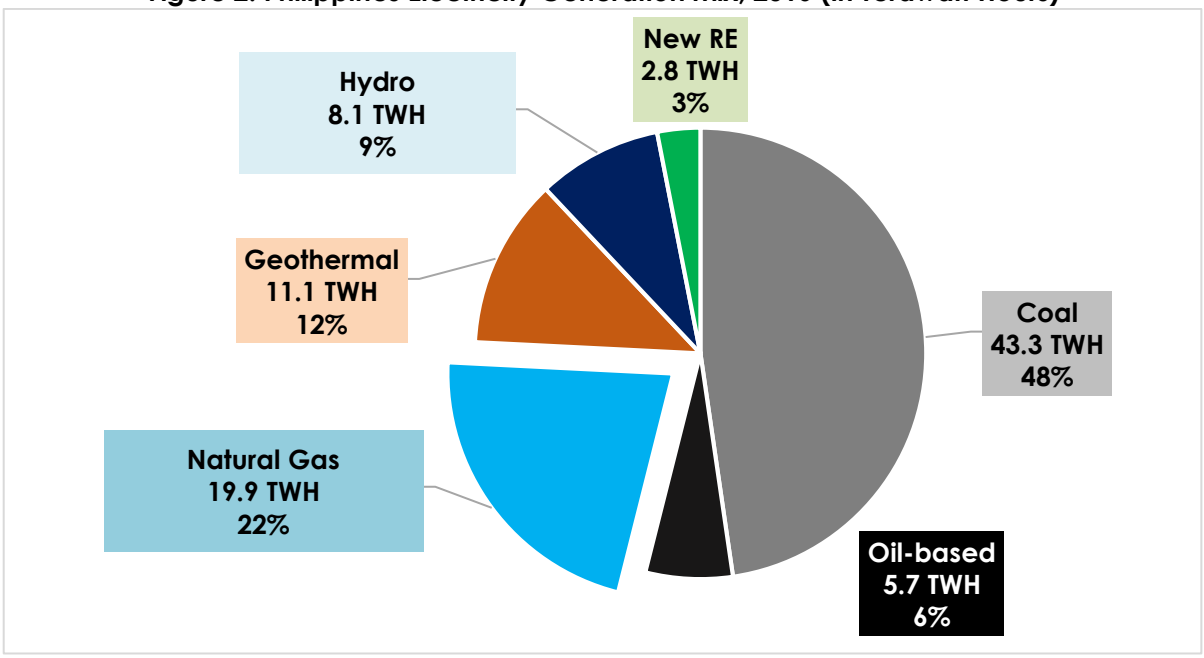
Figure 1: Historical Electricity Generation Mix in the Philippines (in Terawatt Hours and %)



Source: Department of Energy

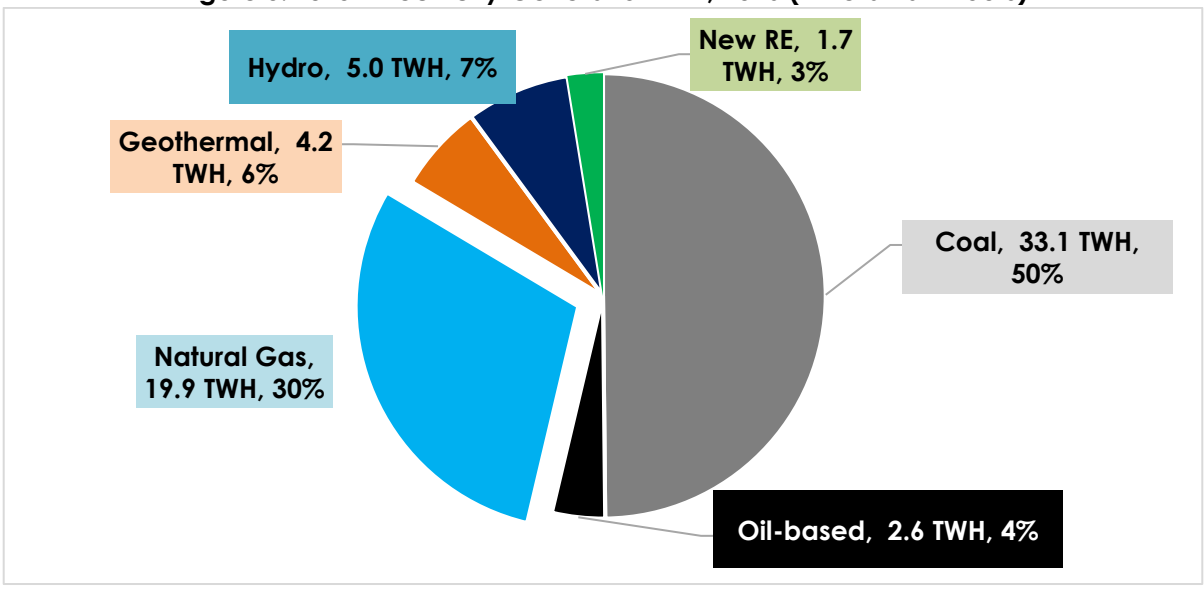
- Figure 1 suggests that the present energy mix was largely defined by two structural shifts within the Philippine energy generation industry:
  - The sustained expansion of coal power beginning in the late 90s
  - The introduction of natural gas power at the turn of the century
- The numbers suggest that natural gas energy (alongside coal energy) "crowded out" oil energy. Figure 1 clearly illustrates the manner in which the share of oil energy declined as natural gas energy increased.
- The numbers also indicate that natural gas played a key role in expanding the supply of energy despite the lack of growth in geothermal energy and hydro energy.

Figure 2: Philippines Electricity Generation Mix, 2016 (in Terawatt Hours)



Source: Department of Energy

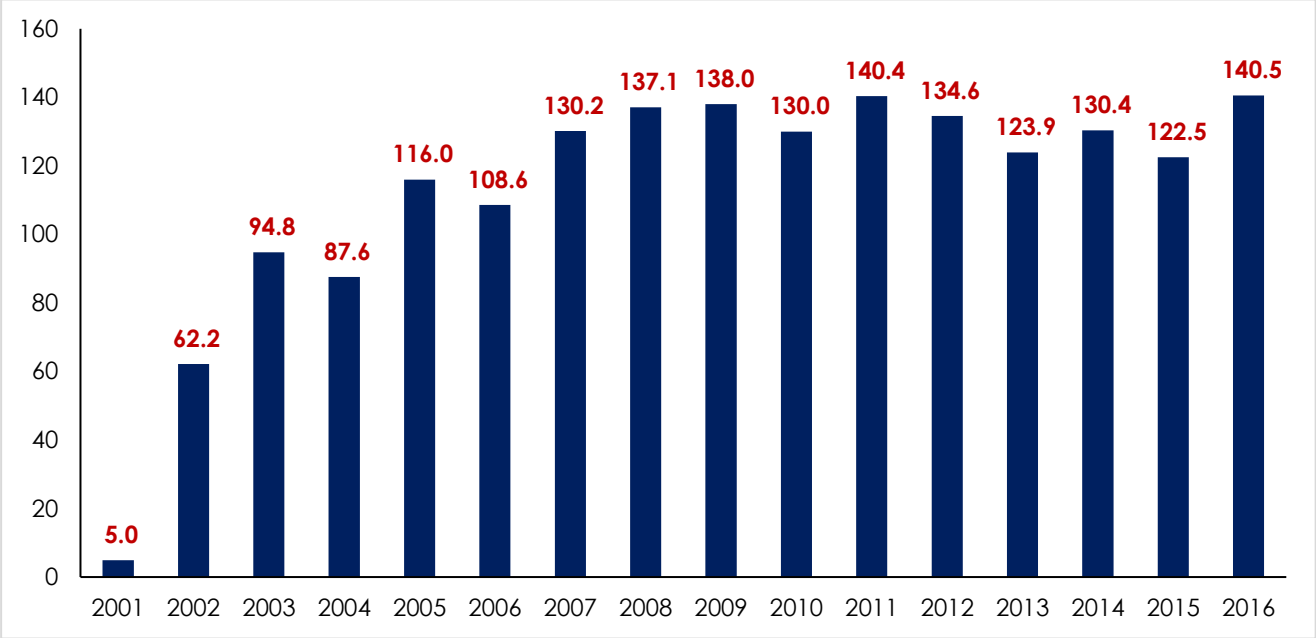
Figure 3: Luzon Electricity Generation Mix, 2016 (in Terawatt Hours)



Source: Department of Energy

- Figures 2 and 3 provide snapshots of the Philippine energy generation mix. The numbers indicate that natural gas is, at present an indispensable component of the Philippine energy generation mix.
- Natural gas energy is the second largest component of the Philippine energy mix and is responsible for close to a fourth of the generation of the entire Philippine archipelago.
- Figure 3 further underlines the importance of natural gas to the Luzon grid. Natural gas energy constitutes almost a third of the total energy generation of the Luzon grid.
- Another important consideration is that ALL natural gas electricity goes to Luzon. Given the centrality of Luzon to the Philippine economy, the phasing-out or replacement of natural gas in the energy mix is a key policy concern.

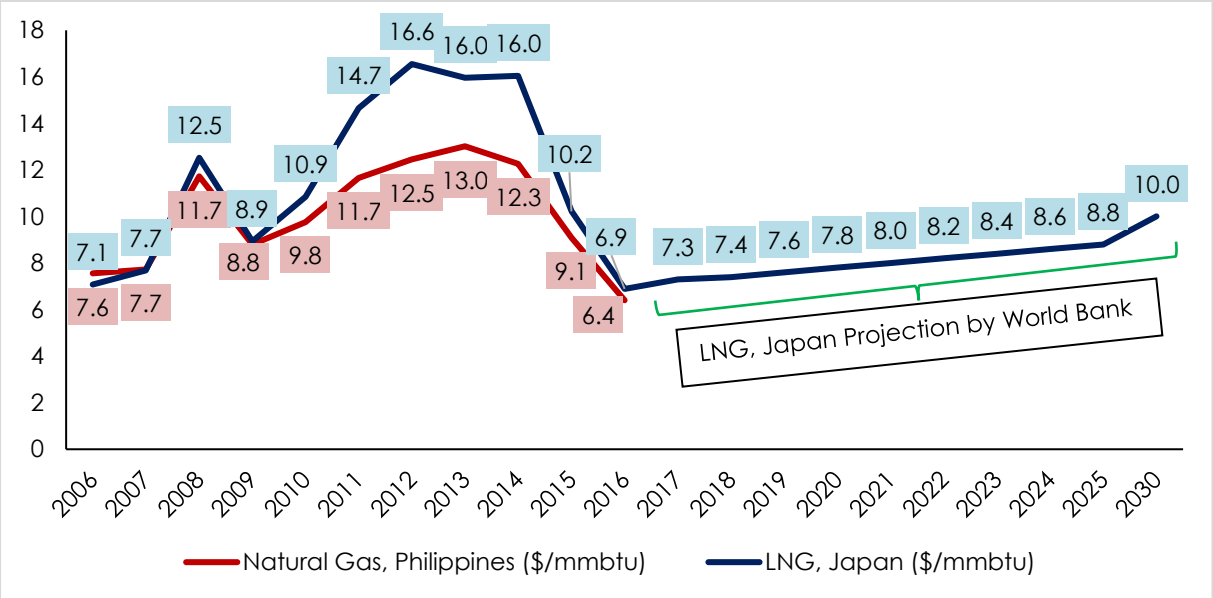
Figure 4: Natural Gas Production in the Philippines (in Billion Standard Cubic Feet)



Source: Department of Energy

- Figure 4 provides an overview of the production of natural gas in the Philippines in the past 15 years. The numbers indicate that the Philippines would need to import 140.5 billion standard cubic feet of natural gas when Malampaya reserves run out and if the Philippines is unable to find additional natural gas reserves.

Figure 5: Natural Gas Prices ($ per Million British Thermal Unit)



Source: Department of Energy, World Bank

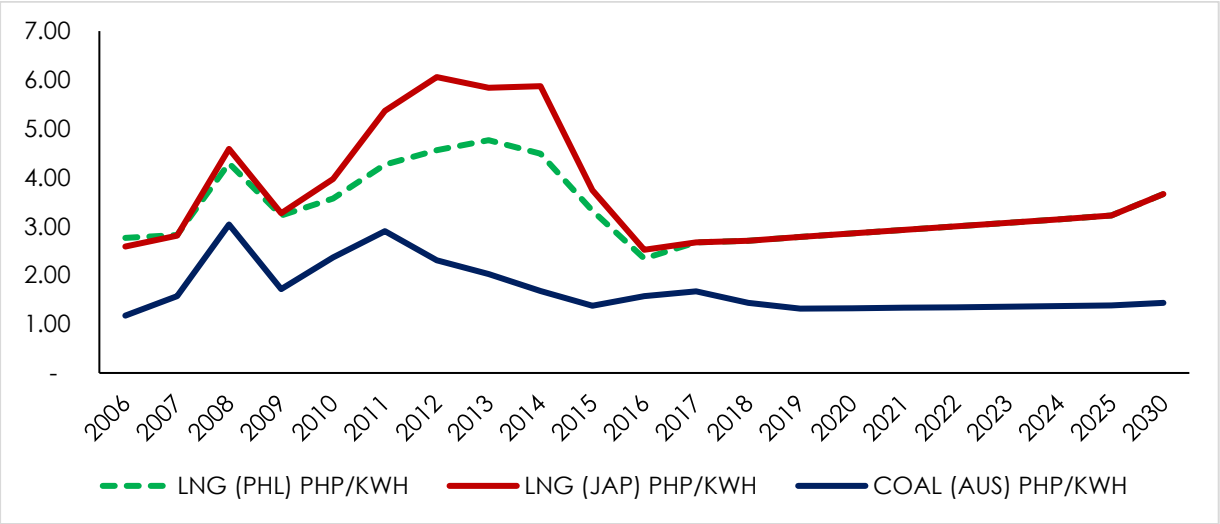
- Figure 5 contrasts the natural gas price in the Philippines with the natural gas price index in Japan. The numbers indicate that while both prices appear to follow the same general trends, Malampaya natural gas can be markedly cheaper than the Japan LNG price index. This, in turn, implies that the exhaustion of Malampaya reserves would result in noticeably more expensive natural gas.

Option #1: Business as Usual - Let the Market Decide

- The first option is to allow the market decide. The government does nothing in years leading up to the depletion of Malampaya and lets the market decide the energy mix.
- Historical price data and price projections suggest that if the market is left to its own devices, the bulk of the share of natural gas in the energy mix will be replaced by coal and the remainder will be replaced by variable renewables.
- It is important to note that a business as usual strategy will not necessarily result in the phasing out of natural gas. Natural gas can still compete in a market-driven energy industry if conditions are favorable.
- The competitiveness of natural gas within a free market setting would be determined chiefly by the following factors:
    1) The price of fuels: In particular, the price of coal and imported LNG.
    2) The cost of developing and maintaining natural gas plants
    3) The cost of developing and maintaining an onshore terminal or a floating storage and regasification unit (FSRU).

Issue #1: Fuel Costs

Figure 6: Coal and LNG Electricity Price Projections (FUEL COSTS ONLY)



Source: World Bank, Additional Computations by the Office of Senator Gatchalian
*PHL prices beyond 2016 were taken from the Japanese price projections

- Figure 6 provides the fuel price per kilowatt hour for Malampaya natural gas, Japanese natural gas imports, and Australian coal. The prices above can be viewed as the fuel costs for electricity generation for coal and natural gas.
- Figure 6 indicates that Malampaya natural gas reserves has provided domestic natural gas producers with cheaper fuel in the past several years. Moreover, it can be inferred that Malampaya has afforded domestic natural gas plants insulation from the volatility of natural gas in the international market.
    - From 2010 to 2016, Malampaya was, on average, 0.86 PHP/KWH cheaper.
- The numbers also indicate that the fuel for coal energy is projected to be cheaper than the fuel for natural gas energy in the coming years.
- The preceding discussion suggests that the depletion of Malampaya will (1) likely increase fuel prices for domestic natural gas energy producers and (2) remove the insulation presently enjoyed by these domestic natural gas energy producers. The depletion of Malampaya will likely increase the fuel cost of producing natural gas energy and diminish the competitiveness of natural gas energy vis-à-vis coal energy.

Issue #2: Overnight Capital Costs and O&M Costs

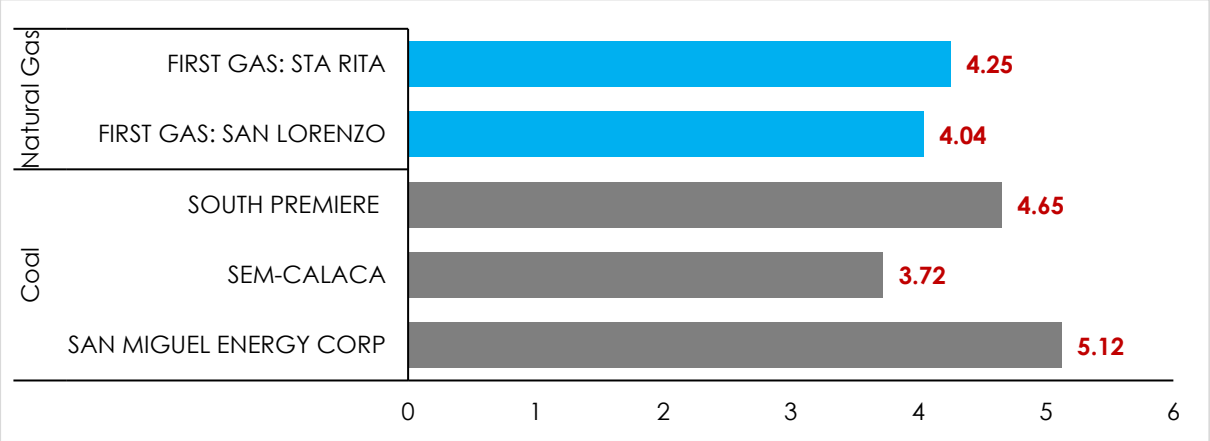
Table 1: Comparison of Capital Costs of Natural Gas and Coal

	Overnight Capital Cost ($/KW)	Fixed O&M ($/KW - year)
Natural Gas	676 to 2,095	7.04 to 31.79
Coal	2,934 to 6,599	31.18 to 80.53

Source: US-EIA

- Table 1 provides a comparison of the capital costs of natural gas and coal power plants. According to the United States Energy Information Administration (US-EIA), the overnight capital costs and the fixed O&M costs of natural gas plants are markedly lower than the costs for coal. These, in turn, suggest that natural gas non-fuel costs can compensate for part of the cost disadvantage it suffers from its fuel costs.

Figure 7: Natural Gas and Coal Retail Rates for MERALCO, August 2017



Source: MERALCO

- Table 2 provides a comparison of natural gas and coal retail rates. The numbers constitute additional evidence that (1) the capital cost advantage of natural gas and (2) access to Malampaya enable natural gas power producers to compete with coal power producers. Put simply, present conditions allow natural gas to compete with coal.

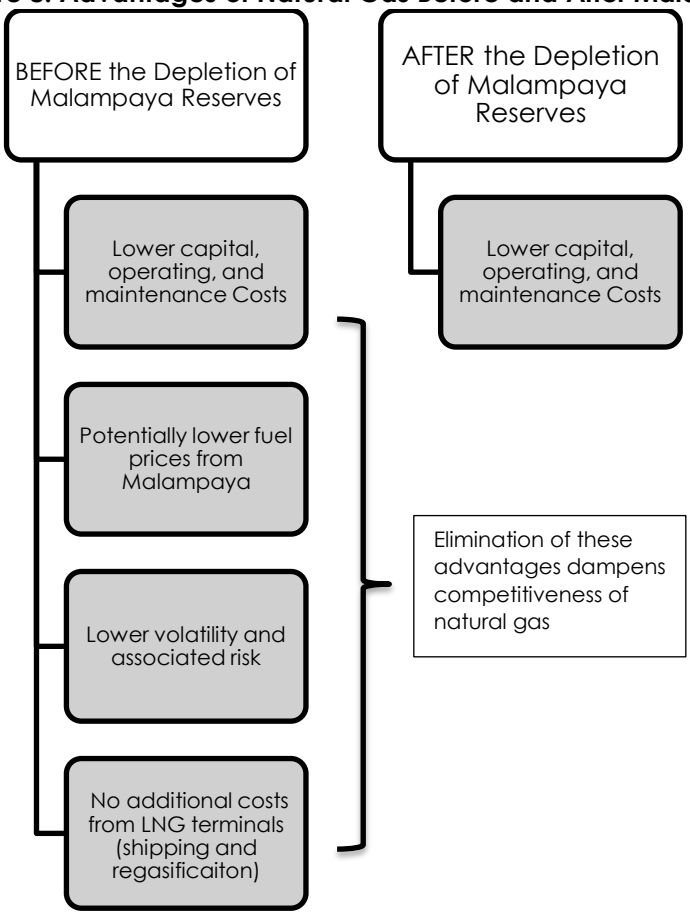
Issue #3: Developing an LNG Terminal

- Given that the Philippines presently has no LNG terminals, the cost of developing and maintaining an LNG terminal will be added to the cost of natural gas power.
- International literature on natural gas terminals indicate that the construction of an onshore LNG terminal will cost approximately 750 million USD (approximately 37.5 billion pesos) while the construction of a floating storage and regasification unit will cost 450 million USD (approximately 22.5 billion pesos).
- The costs of developing an LNG terminal is substantial and would thus translate to substantial increases in the price of natural gas energy. Given the present situation of natural gas energy in the Philippines, it can be inferred that natural gas would likely find it more difficult to compete with coal once the Malampaya reserves are depleted.

Synthesis of Issues

- The competitiveness of natural gas vs. coal is determined by (1) coal and natural gas fuel prices, (2) coal and natural gas capital costs, and (3) the presence/absence of domestic natural gas reserves.
- At present, natural gas energy can compete with coal energy in the Philippines for the following reasons:
    - Lower capital, operating, and maintenance costs
    - Implicit fuel discount from Malampaya reserves
    - Price stability via insulation from international market forces and shocks (lower risk)
- Once Malampaya runs out, natural gas energy in the Philippines will lose any advantages afforded by Malampaya. This would increase the price of coal and diminish the competitiveness of natural gas vis-à-vis coal energy.
- Once Malampaya runs out, natural gas energy producers in the Philippines would need to invest in the development and maintenance of an LNG terminal. This, in turn, further increases the price of natural gas energy and further diminishes the competitiveness of natural gas energy vis-à-vis coal energy.
- It is thus reasonable to expect coal energy to crowd out natural gas energy in the business as usual strategy.
- The resulting Philippine energy grid could still accommodate natural gas in the mid-merit space. The hypothesized price increases in natural gas, however, would likely outright prevent natural gas energy from competing with coal for baseload demand.

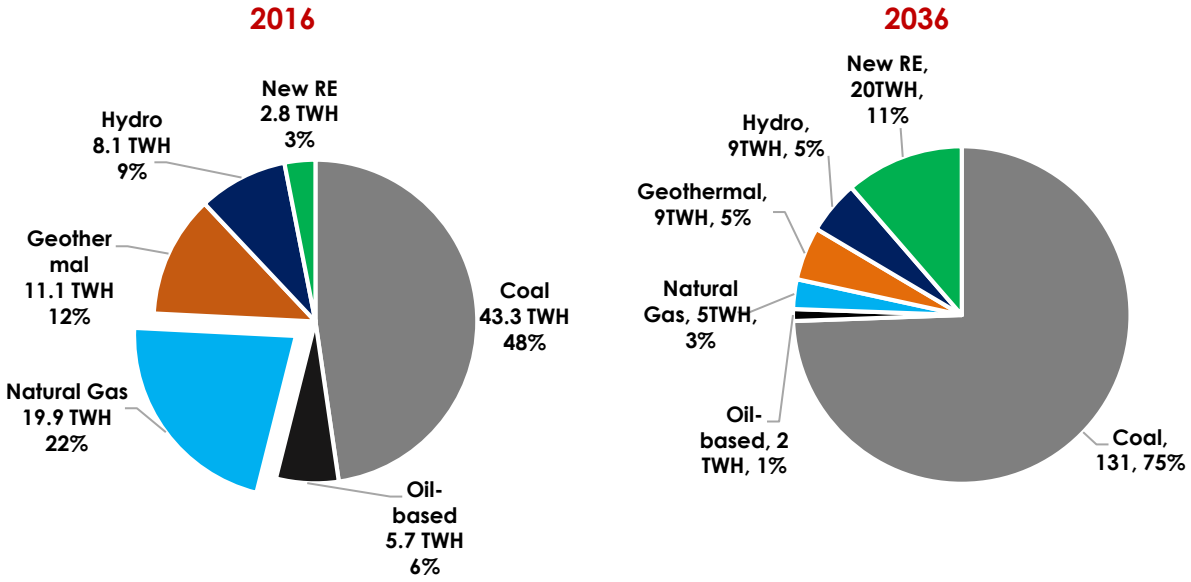
Figure 8: Advantages of Natural Gas Before and After Malampaya



- The hypothesis above is consistent with the forecasts put forward by MGEN in cooperation with the Lantau Group. MGEN expects coal energy to absorb the market share of natural gas in a business-as-usual or least-cost-energy scenario.

- Figures 8 and 9 provide the forecasts of MGEN. MGEN expect coal to constitute approximately 75% to 80% of the total energy mix of the Philippine energy grid.

Figure 9: Generation by Technology for the Overall Philippine Grid



Source: MGEN

- It can thus be inferred that if the market is left to its own devices, the likely scenario is that (1) natural gas energy will contract, (2) coal energy will expand, and (3) intermittent renewables will continue to expand.
- Natural gas, if not phased out, will likely compete in the mid-merit market. It will be crowded out of the baseload market.
- Provided that the load demand curve of the Philippines remains dominated by baseload demand ("blocky" as opposed to "pointed" or "jagged") baseload coal energy will likely possess a distinct advantage.

Option # 2: LNG Terminal Option Onshore Terminal or FSRU

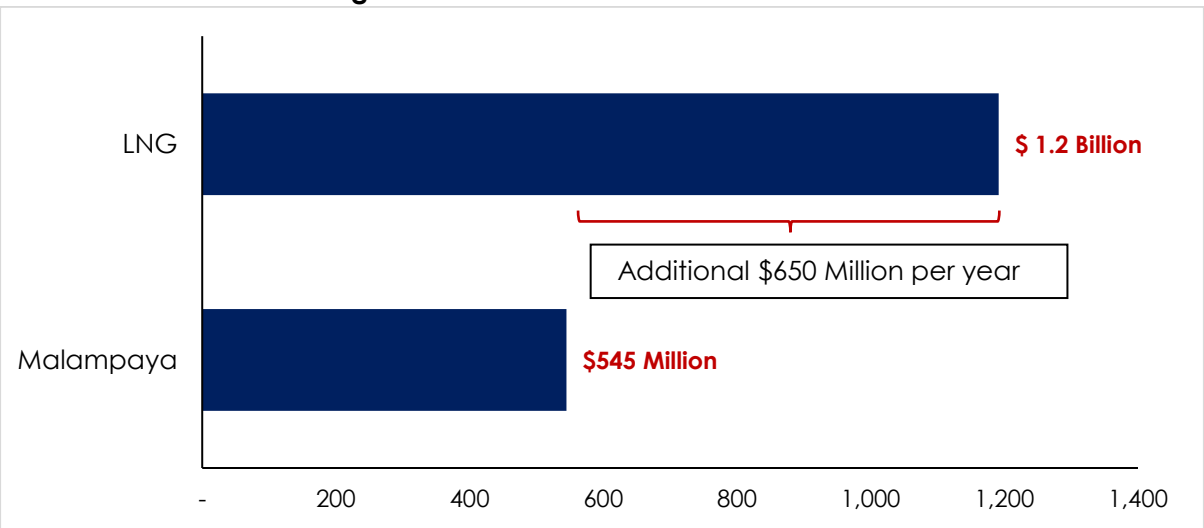
Table 2: Basic Information on LNG Terminals

	Onshore Terminal	Floating Storage Regasification Unit (FSRU)
LNG Terminal		
Investment Cost	$ 750 Million	$ 450 Million
Construction Time	36-40 Months	27-36 Months
Capacity	180,000m^3	180,000m^3
No. of LNG Deliveries Needed to Supply Current Capacity	30-40	30-40

Source: Oxford Energy

- According to Oxford Energy, the capital cost of an onshore LNG import terminal is around 750 million USD (approximately 37.5 billion PHP) while a new FSRU terminal will cost 450 million USD (approximately 22.5 billion PHP).
- Operating costs of a typical FSRU is estimated to be 2.5% of overall capital costs. Estimated daily operating costs would be approximately 24,000 USD (1.2 million pesos per day).

Figure 11. Annual Fuel Cost of Natural Gas



Source: Computations from O/S Gatchalian

- Importing LNG to supply our existing natural gas plants will result in higher dollar fuel expenses for the Philippines. Based on our computation, it will cost the country $1.2 billion compared to the current cost of purchasing Malampaya natural gas of $545 Million.
- The increase of $655 million in yearly fuel cost stems from the fact that the Philippine government gets a 60% share from Malampaya's revenues. If LNG is imported, all the revenues from importing LNG will go to private investors.

Issues Surrounding the Development of an LNG Terminal in the Philippines

- The numbers above indicate that an LNG terminal, whether onshore or offshore, will necessitate the mobilization of a massive amount of funding. Given the large magnitude of the funding, the implied risk to investors is expected to be massive as well.
- The risk can be viewed to be the primary deterrent preventing investors from committing to the development of an LNG terminal. This risk is also compounded on top of the risk that stems from the observed volatility of LNG in the global market.

The Role of the Government in Addressing LNG Terminal Issues

- The government can facilitate the development of an LNG terminal in two ways.
    1. Reduce the risks associated in engaging in the production of natural gas energy
    2. Offset the costs associated with the development of an LNG terminal
- The government can reduce the risks in natural gas energy by guaranteeing the competitiveness of natural gas in the domestic energy industry. This can be done in a number of ways.
    1. Diminish the competitiveness of coal via coal and/or carbon taxes
    2. Guarantee spaces for natural gas in the energy mix

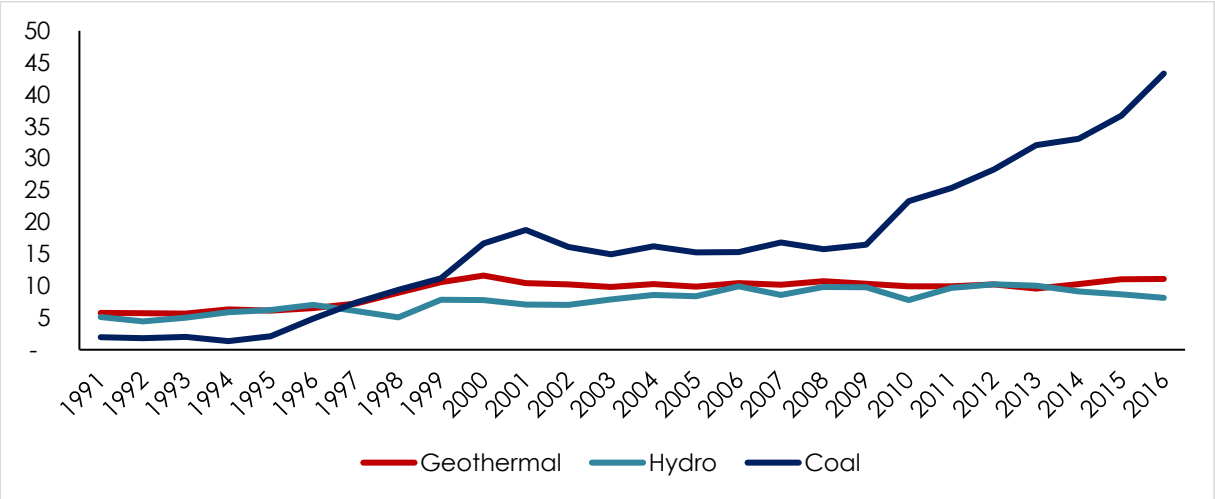
3. Expand intermittent renewables (given that fast-ramping natural gas energy can be viewed to complement intermittent renewables).

- The government can offset the costs associated with the development of an LNG terminal by providing tax breaks or financial support to the developer. In essence, the government absorbs part of the cost in order to keep natural gas energy economically viable.
- Either approach, however, will ultimately cost consumers more. Imposing coal/carbon taxes, carving out rigid spaces in the energy mix for natural gas, and aggressively rolling out intermittent renewable capacity will make electricity more expensive. Similarly, tax breaks and subsidies will be shouldered by the consumers.

Option # 3: Aggressive Promotion of Indigenous Resources

The Current State of Hydro and Geothermal Energy in the Philippines

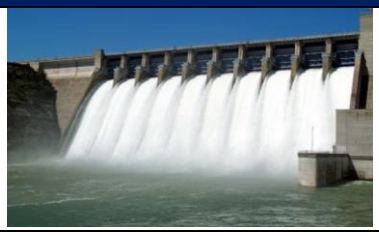
Figure 12: Growth of Generation in Geothermal, Hydro, and Coal Energy (in TWH)



Source: Department of Energy

- Figure 10 contrasts the growth trajectories of geothermal, hydro, and coal energy. The numbers indicate that geothermal and hydro energy have stalled. Geothermal energy has not registered generation figures that exceed its 2000 peak of 11.6 TWH. Hydro energy generation fell by over 2.1 TWH from 2012 to 2016. In contrast, coal has surged by leaps and bounds.
- The numbers indicate that neither geothermal energy nor hydro energy are struggling to compete in the emerging energy industry. The struggles of traditional renewables can be attributed to the following:
    1. The relative competitiveness of coal
    2. The limitations to the development of hydro and geothermal energy resources
- The relative cost competitiveness of coal is made evident in Table 3. The numbers indicate that coal energy is typically markedly cheaper than hydro and geothermal energy. The cost competitiveness of hydro energy as well as that of geothermal energy are dampened by the location of hydro resources. Hydro and geothermal resources are often found in remote locales and/or situated within lands claimed by indigenous people. Geothermal reservoir development and maintenance are also costly and risky.
- The limitations of geothermal and hydro energy stem from the finite nature of their base resources. Estimates indicate that neither energy source could be expected to grow significantly in the medium-term or even the long-term.

Table 3: Potential Additional Hydro and Geothermal Capacity

Technology	Geothermal	Hydropower
		
Target Additional Capacity 2016-2030	1,371 MW	1,554 MW
Investment Cost	$ 5.3 Billion	$ 3.9 Billion

Source: Department of Energy, Computation from O/S Gatchalian

1. The DOE estimates that geothermal energy can expand by 1,371 MW by 2030 (approximately 5.3B USD). It is of note, however, that only 93 MW are committed.
2. The DOE estimates that hydro energy can expand by 1,554 MW by 2030 (approximately 3.9B USD). It is of note, however, that only 210 MW are committed.

Table 4: Global LCOE Estimates for Hydro and Geothermal Energy

	Estimate Lower Limit (PHP/KWH)	Estimate Upper Limit (PHP/KWH)
Hydro	1	7.5
Geothermal	3.5	7.5

Source: IRENA

- International Renewable Energy Agency (IRENA) estimates indicate that hydro and geothermal energy LCOE estimates vary widely.

- Hydro energy can be cheap or expensive depending on the location of the hydro power plant (i.e. the characteristics of the body of water it is built upon), the amount of rainfall, and developments upstream. The economic viability of a hydro energy plant is thus hugely dependent on favorable conditions.
- Geothermal can compete with coal if (1) the number of attempts to identify viable wells is minimized (i.e. exploration and development costs are minimized) and (2) the maintenance costs of the wells are minimized.
- Given the stagnation of hydro and geothermal energy in the past 15 years, it can be inferred that the domestic hydro and geothermal energy prices are nearer their respective upper limits and would thus be hard-pressed to compete with coal energy.
- The numbers above indicate the following:
    - The combined potential of hydro and geothermal energy is most likely insufficient to replace natural gas given current levels of demand.
    - Even if the maximal amounts of capacity indicated by DOE are reached, the capacity would likely be unavailable when Malampaya reserves are exhausted.
    - Targeted subsidies are needed to empower hydro and geothermal energy to compete with coal energy and reverse the stagnation of hydro and geothermal energy in the past fifteen years.

Upstream Natural Gas Development

Table 5: Existing and Viable Natural Gas Reservoirs

Field	Estimated Reserves	Status
SC 38- Malampaya Field	3.08 to 3.29 Trillion Cubic Feet	OPERATIONAL
SC 72 (Reed Bank) - Sampaguita Field	2.6 Trillion Cubic Feet	FORCE MAJEURE

Source: SPEX, PXP Energy, Department of Energy

- According to the DOE and private firms (SPEX and PXP), the Sampaguita field located in the Reed Bank has the potential to replace Malampaya. Estimates indicate that the Sampaguita field has 2.6 trillion cubic feet of natural gas – approximately 80% to 90% of the size of the Malampaya field when it was first discovered.
- DOE also identified other potential natural gas sites located in SC 72. As such, it is possible that the combined natural gas reserves in SC 72 could exceed the Malampaya reserves.
- If the Malampaya development cost is used as a baseline, the development of the Sampaguita field and surrounding field could cost approximately 4.5 to 5 billion USD.
- Unfortunately, the ongoing territorial dispute with China effectively prevents private firms from more thoroughly exploring SC 72 and developing the wells supposedly located within its territories.

Options Matrix

	Business as Usual	Import Natural Gas	Promote Indigenous Energy
Description	The government does not intervene in the issue of natural	The government may need to correct the market	The government provides subsidies and other support to

	gas and allows the market to determine the energy mix.	failure that has thus far prevented the development of an LNG terminal.	promote geothermal and hydro to replace natural gas. It also encourages the exploration and development of natural gas reservoirs
Advantages	1. Consumers are given the least cost energy mix. 2. The government does not need to spend on subsidies. 3. There are no market distortions that could create externalities.	1. Lowers carbon footprint by negating need to expand coal. 2. Facilitates further development of new renewables 3. Lowers reliance on coal	1. Strengthens energy independence and security by lowering reliance on imported fossil fuels. 2. Lowers carbon footprint 3. Ensures more diversity in the energy mix.
Disadvantages	1. Increases carbon footprint 2. Increases dependence on imported coal 3. Promotes a homogeneous energy mix	1. Entails additional costs that would be saddled onto consumers. 2. Makes the Philippine grid more vulnerable to volatility of the price of natural gas in the global market.	1. Developing hydro and geothermal resources is accompanied by a lot of risk. 2. Developing hydro and geothermal resources will require subsidies and support 3. Reed bank is in the disputed area of the SCS/WPS 4. Hydro and geothermal energy have a hard cap.
Policy Tools	None needed although a competitive selection process and a functioning electricity market would be beneficial	1. Tax breaks and subsidies for natural gas players. 2. Carbon/coal taxes 3. Commitment on spaces for natural gas in the energy mix	1. Tax breaks and subsidies for developers. 2. Carbon/coal taxes 3. Renewable portfolio standards 4. Resolution of SCS/WPS dispute or bilateral exploration and development with China

Insights and Recommendations

- Option #1 is the least-cost option but it is the least environmentally-friendly option because coal is the simultaneously the cheapest and the dirtiest energy option. Projections indicate that if the market is left to decide the energy mix, coal will likely dominate and comprise 70% to 80% of the overall energy mix.
- Given present circumstances, natural gas can compete with coal but at a noticeable disadvantage. If natural gas energy producers are forced to import natural gas they would

have to sell their energy at higher prices – increasing the gap between natural gas prices and coal prices.
    - The exhaustion of Malampaya reserves and the need to import and process liquefied natural gas will increase the price of natural gas energy and further diminish the competitiveness of natural gas vis-à-vis coal. In other words, the fuel costs of natural gas would be expected to increase with the depletion of the Malampaya reserves.
    - The need to develop either an FSRU terminal or an onshore processing terminal further increases the cost of natural gas.
- Malampaya provides natural gas producers two key benefits: insulation from price volatility and slightly lower prices – especially during high price situations in the global market.
- While the fuel cost of coal is markedly lower than the fuel cost of natural gas, the nonfuel cost of natural gas is markedly cheaper than the nonfuel cost of coal. Once Malampaya is depleted and no replacement is found, this would be the only advantage of natural gas over coal.
- Prevailing trends suggest that geothermal energy and hydro energy are likely incapable of crowding out and replacing natural gas in the Philippine energy mix. The numbers indicate that they have not registered significant growth rates in the past several years. They would need targeted subsidies and support from the government to expand.
- Significant developments in the variable renewables sector and the continued cost-competitiveness of coal suggest that their shares in the Philippine energy mix will continue to grow in the coming decades.
- In the absence of structural reform that significantly affects the prices of coal and natural gas (e.g. taxes and subsidies), coal will likely be the replacement for natural gas when Malampaya reserves run out. If the market is left alone, the share of coal in the overall generation mix will continue to increase.
- If the medium-term to long-term goal is to ensure that the Philippines gets the cheapest energy, then the market can be left alone.
- If the medium-term to long-term goal is to improve the diversity of the Philippine energy mix or reduce overall dependence on coal, then it would be necessary to either (1) diminish the price competitiveness of coal via coal and/or carbon taxes or (2) provide subsidies to cover the increase in the price of natural gas.
- Variable renewables will continue to grow in the coming decades.
- Variable renewables, however, will not be able to fully replace natural gas energy.
- Similarly, traditional renewables will not be able to fully replace natural gas energy. DOE has adjusted its estimates and their latest projections suggest that geothermal and hydro would be hard-pressed to cover the 3,400 MW of natural gas. Their optimistic target is approximately 2,800 MW. Committed geothermal and hydro plants, however, only amount to approximately 300MW.