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14. ABSTRACT

Today, in the Republic of the Philippines, the government is struggling to meet the growing energy demands of the nation, and has implemented energy policies that threaten the future well-being of the country. To become a more stable and prosperous nation, the Republic of the Philippines must increase energy security and sustainability through the use of renewable and nuclear energy to limit dependence on foreign fossil fuels, and improve their domestic power distribution systems to more efficiently and effectively reach their citizens.

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Hooked on Coal: Meeting Energy Demands in the Philippines

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A paper submitted to the Faculty of the Naval War College in partial satisfaction of the requirements of the Department of Joint Military Operations.

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Signature:----------

27 October 2011

Introduction

In today's modern societies, we have become accustomed to routine and uninterrupted access to electricity in our daily lives. We rely on it to heat and cool our homes, refrigerate food, power factories, charge mobile devices, keep medical and educational facilities running, and ensure our daily comfort. Our access is so predictable that many of us never consider where our electricity comes from, how we produce it, or how we would be affected if one day our lights went out.

While we are accustomed to this easy access to reliable electricity, such is not the case globally. Today, in the Republic of the Philippines, the government is struggling to meet the growing energy demands of the nation, and has implemented energy policies that threaten the future well-being of the country. To become a more stable and prosperous nation, the Republic of the Philippines must increase energy security and sustainability through the use of renewable and nuclear energy to limit dependence on foreign fossil fuels, and improve their domestic power distribution systems to more efficiently and effectively reach their citizens.

Current Energy Situation in the Philippines

The Republic of the Philippines is an archipelago consisting of over 7,600 individual islands spread across 300,000 square kilometers in Southeast Asia. The country is generally divided into three districts consisting of Luzon, Visayas, and Mindanao. The Philippines is the 13th largest nation on earth, with its approximately 100 million people distributed over more than 2,000 habitable islands throughout the country.[1] The Philippines is one of the fastest growing economies in the Southeast Asia and Pacific region, and has experienced an

annual growth rate of over 6 percent between 2006 and 2016.[2] With accompanying improvements in citizen standards of living and a growing population, the demand for reliable energy within the country is expected to increase by 5.3 percent annually for the foreseeable future.[3] This growing demand is not a new phenomenon in the country; data from the Philippine Department of Energy show a 65 percent increase in domestic consumption rates between 2005-2016.[4]

The availability of reliable electricity is critical to national prosperity by providing the power to fuel sustained economic growth, develop new markets, grow business, and expand the workforce. Dependable access to electricity also enhances stability by supporting the operation of critical service providers such as schools and hospitals across the country.[5] There is a strong and growing demand for additional electrical power to fuel the Philippine economy; power consumption in commercial and industrial sectors has increased by 78 percent and 54 percent respectively from 2005-2016. During the same time period, residential sector consumption grew 60 percent, indicating an increased demand for electricity to power appliances, electronic devices, and other household items.[6]

The Philippine government struggles to provide enough electricity to meet these burgeoning requirements. In 2016 the highest annual peak demand on the electrical grids servicing Luzon, Visayas, and Mindanao each exceeded the highest requirements of 2015 by 7-9 percent, resulting in rolling blackouts and electrical outages. Throughout the remainder of 2016, the Philippine Department of Energy declared several yellow and red alerts to announce shortfalls in power generation, and also frequently experienced power interruptions due to major grid disturbances and load dropping incidents.[7] It is worthwhile to note that the Philippine national grid (a loose term used to describe the collective power grids in Luzon,

Visayas, and Mindanao) habitually runs on a very low power reserve margin, and experiences routine blackouts due to line disruptions and mechanical failures requiring unplanned maintenance operations.[8] While the Visayas and Luzon grids are connected, the Mindanao grid remains separate from the national grid, preventing it from drawing on outside power when demand surpasses generation capabilities.[9]

To meet forecasted energy requirements through 2030, government estimates indicate the national grid will need significant capacity improvements. The Visayas grid will require at least an additional 1,300 megawatts (MW) in generating, transmission, and distribution capability, Mindanao will require 900 MW, and Luzon will need a staggering 5,000 MWs to meet projected demand.[10]

In an attempt to meet these increasing demands, the government of the Philippines has chosen to employ a variety of methods to generate power. In 2016 the country's electrical generation mix included coal, natural gas, oil-based, and renewable energy production facilities. Fossil fuels provided the vast majority of Philippine power generation at 76 percent of the total, with renewable energy resources comprising the remaining 24 percent. Coal-based production is the main source of power generation in the Philippines, accounting for 48 percent of all electricity produced. In descending order of production methods, natural gas provides 22 percent of power, geothermal 12 percent, hydroelectric 9 percent, oil-based 6 percent, and biomass, solar, and wind-based generation methods each account for 1 percent of the residual total.[11]

At 48 percent of all electrical power generated within the Philippines, coal is clearly the government's preferred solution to provide baseline reliable power to the nation. This policy to increase coal-based power generation can best be illustrated by examining the

country's power generation mix over time. Between 2005 and 2016 renewable energy-based generation increased by 16 percent, natural gas generation increased by 17 percent, and oil-based generation has decreased by 8 percent. During that same period, however, coal-based generation has increased by a stunning 184 percent.[12] Looking forward, and including coal-based facilities that are either under construction or in the planning phase, estimates predict that as much as 80 percent of electrical power generation in the Philippines could come from coal-based sources.[13] Coal-based plants are relatively quick and inexpensive to build, can be constructed almost anywhere to meet local demand, and will provide the government with a convenient means of power generation to meet electrical demand.[14]

This solution may be convenient, but it is important to note that the Philippines is a net energy importer. The most recent statistics released by the Philippine Department of Energy indicate that 2015 domestic coal production was near record highs at 8.1 million metric tons, and that the production rate has increased 523 percent since 1990. However, in 2015 the government of the Philippines also imported 17.8 million metric tons of coal, a 1,383 percent increase in imports over the same period. While the Philippines does export a small portion of its limited domestic coal production, 80 percent of retained domestic coal and the vast majority of imported coal serve to fuel power generation efforts. The Philippines has imported coal from Australia, China, Indonesia, Russia, South Africa, and Vietnam in the past, but since 2013, greater than 95 percent of its coal imports are sourced exclusively from Indonesia.[15]

Domestic production shortfalls, coupled with a heavy reliance on imported coal, present a potentially dangerous combination of threats to the government, people, and economy of the Philippines. As a net importer of coal, the country has created a situation in

which it is vulnerable to price fluctuations, supply disruptions, and both regional and global political dynamics.[16] This situation is clearly detrimental to the nation's energy security and jeopardizes the long-term energy sustainability of the Philippines.

Renewables

Increasing the use of renewable energy in the Philippines is a logical first step to reduce or eliminate imported coal as a primary source of electrical generation. Renewable energy fuels are often inexpensive or free, and are typically sustainable from year to year using reasonable conservation methods to protect or preserve the fuel sources. The Philippines is no stranger to renewable energy sources, which currently comprise 24 percent of its total energy generation.[17] While it is unlikely that leveraging renewables will quickly replace large capacity electrical generation in the near term, additional investments in the sector could allow the government to wean itself from its dependence on coal over time.

Most people regard renewable energy in a positive light; however, like fossil fuels, renewables have a few shortcomings. The primary argument against renewables is that they have a relatively high initial cost when compared to fossil fuel generation plants. While this is generally true, over the lifetime of a renewable energy facility, the negligible fuel costs of sunlight, running water, or agricultural residue are an important consideration. Renewables offer stable energy prices, and the cost of providing that energy lies primarily in upfront infrastructure rather than the sustainment cost of fossil fuels.[18]

Other considerations regarding the use of renewable energy are that they are typically unable to produce electricity in large quantities when compared to fossil fuel stations, and they can require large amounts of space to produce equivalent amounts of power.[19] For

example, by far one of the largest coal generation plants in the Philippines is the GNPower Mariveles facility, capable of producing over 650 MW of baseload energy. In comparison to this relatively powerful facility with a small footprint, a sprawling new 54 MW wind farm was recently added in Visayas.[20] Energy production density (generation capacity divided by space requirements to operate the facility) can be an important consideration to locating new construction. Clearly, the coal generation facility provides far more power in a smaller footprint than that produced by an entire wind farm. While large scale power generation facilities are almost certainly important in the provision of electricity to large urban areas, the population of the Philippines is spread across over 2,000 islands on the archipelago.[21] Many of the small islands cannot access the power grids associated with these large generation plants, and instead rely on inefficient mini-grids powered by imported fossil fuels.[22] It may be that renewables are ideally suited to providing energy to the smaller concentrations of the population.

Despite almost a quarter of its total energy supply being derived from renewable sources, great potential still exists within the nation for expansion.[23] Each renewable sector (biomass, geothermal, solar, hydroelectric, and wind) can be further exploited to produce additional energy and therefore reduce coal dependence.

There is considerable potential for further development of biomass-based power in the Philippines as it currently provides only 1 percent of the total energy production within the country. Biomass is organic material that comes from plants or animals and can be burned outright to produce heat or converted to other useable fuel such as methane, ethanol, or biodiesel.[24] With over 40 percent of its almost 300,000 square kilometers of land mass devoted to farmland, the Philippines has vast amounts of potential biomass fuel residue to

contribute to energy generation.[25] Rice is a staple food in the Philippines, and over 12,000 square kilometers of land is dedicated to rice production. In 2007 the country produced around 16 million tons of rice, with more than 2 million tons of residual rice hull waste. That two million tons of rice hulls equate to approximately 5 million barrels of oil in terms of potential biomass energy production. Almost 4,000 square kilometers of farmland is dedicated to sugarcane production, with an estimated 7.2 million tons of sugarcane waste recovered each year.[26] This sugarcane waste equates to over 7 million barrels of oil annually that could be converted to energy through biomass-based electrical production.[27] The Philippines is one of the largest coconut producers in the world, and approximately 500 million trees grow throughout the country. Conservative assessments of the various coconut residual wastes are estimated at over 10 million tons.[28] The combined total amounts of these agricultural wastes represent tremendous biomass potential for energy production. Some experts suggest that the agricultural waste from sugar and coconut production alone could account for at least 12 percent of the total national energy supply.[29]

While biomass sources of energy are clearly underused, geothermal power production is well established within the Philippines and comprises 12 percent of the total national energy supply.[30] In fact, the Philippines is second only to the United States as the largest producer of geothermal energy in the world.[31] Due to the Philippines' geographic location along the Pacific "Ring of Fire", the nation has tremendous geothermal energy production potential.[32] Geothermal energy works by drilling a well into the earth to tap geothermal hot fluids, which then flow through pipes to a surface generator where the expanding fluids are used to provide mechanical energy to turn turbine blades on a shaft to produce electricity.[33] Because geothermal power taps into this source of naturally occurring heat, energy produced

in this manner can be considered a base-load energy source because it does not suffer from intermittency problems.[34] Recent Department of Energy studies indicate that the Philippines contains more than double the amount of geothermal capacity than is currently being used.[35] If those resources could be tapped for energy production, it could account for well over 20 percent of the total national energy supply.

In comparison to geothermal power production rates, solar energy in the Philippines contributes a paltry 1 percent of the total national energy supply annually.[36] Solar energy is the most abundant renewable energy resource on Earth, with over 173,000 terawatts (one terawatt equals one million MW) striking the Earth's surface at any given time.[37] To put that into perspective, the amount of energy that strikes the Earth's surface over a 90 minute period is enough to satisfy the world's energy consumption for a year.[38] Solar-powered electrical generation works by capturing photons on panels to produce electricity, or by concentrating sunlight to create heat which is later used to produce electrical power.[39] Like most forms of renewable energy, solar has been traditionally criticized for having high startup costs, intermittency during times of darkness, and for requiring large amounts of space to generate significant amounts of power.[40] However, up-front costs for solar energy production have gradually declined since 2009 by over 90 percent.[41] In August 2017 the first photovoltaic panel factory opened in the Philippines, with the capacity to produce 2.5 million panels a year, which is the equivalent of 800 MW of electricity if all the panels were immediately put into use.[42] During the grand opening of the factory, Philippine President Rodrigo Duterte also announced an ambitious plan to install 5,000 MW of solar generating capacity, which if implemented, would overtake natural gas in terms of national energy production.[43]

As with solar, hydroelectric production holds vast potential reserves of renewable energy for the Philippines. Currently, hydroelectric provides 9 percent of the total national energy supply.[44] Hydroelectric power generation can take many forms, the most common of which is the hydroelectric dam. The hydroelectric dam works by harnessing the mechanical energy of moving water to turn a shaft connected to a generator which produces electricity.[45] The Philippine Department of Energy estimates that there are 13,000 MW of untapped hydropower resource potential yet to be harnessed by hydroelectric dams within the nation. The possible sites to harness this energy are evenly distributed throughout the country, and can be tailored to provide energy to the most remote of small populations or to urban consumers.[46] If only half of this untapped potential is harvested for energy production, hydroelectric generation could rival coal as the top energy source in the Philippines.

Hydroelectric power isn't simply limited to the use of dams, but can also produce energy from the ocean. Recently, the Philippine Renewable Energy Management Bureau published estimates that its territorial waters hold a staggering 170,000 MW of untapped hydroelectric power potential - more than enough energy to completely meet the nation's current and future electrical demands if it could be efficiently harvested.[47] Obtaining hydroelectric power from the ocean involves harnessing thermal energy from the sun's heat or taking advantage of the mechanical energy produced by tides and waves.[48] While the Philippine government does not currently take advantage of this resource, they recently awarded seven ocean-based hydroelectric projects with the goal of producing 75 MW of power by 2030.[49]

The final renewable energy source that the Philippines should invest in more heavily to achieve energy security and greater sustainability is wind power. Currently comprising

only 1 percent of the nation's total energy production, the Philippines is only tapping into a small fraction of the energy that wind power could provide.[50] The Philippine Renewable Energy Management Bureau published estimates that harnessing wind power could provide another 76,600 MW of sustainable electricity to meet the growing demand for power.[51] Like hydroelectric dams, wind turbines operate by harvesting the mechanical energy potential from the wind to turn blades around a shaft connected to a generator to create electricity. As with most renewable energy sources, challenges include high upfront costs, and it is considered an intermittent power source because turbines only produce energy while the wind is blowing. Other considerations for using wind power include noise pollution and the aesthetic impact of large wind turbines on the natural landscape.[52] The Philippines has recently set an aggressive agenda to increase wind power production to achieve over 2,300 MW of power by 2022, with the hope of gaining "wind grid parity" (the point at which wind generated electricity is equal to or less expensive than electricity purchased off the traditional grid) by 2025.[53] If those goals are achieved, wind will exceed the current energy production gained from diesel fuel and oil burning generators throughout the country combined.[54]

Nuclear

Renewable energy shows tremendous potential to provide electricity without the need to import coal. However, many argue that when fossil fuel supplemental generation is not possible, nuclear energy is required to provide foundational and uninterrupted power to electrical grids. Proponents of nuclear power believe it can be cost effective, use fuel that is readily available on the international market, and that advanced technology nuclear power plants are far safer than plants designed in the 1960s.[55] The capability of nuclear power to

meet energy demands is tremendous, with one gram of uranium-235 providing 2-3 million times the energy of an equivalent amount of coal or oil.[56]

While building a nuclear plant may appear at first glance to be a daunting and long-term undertaking, the Philippines already has one. The Philippine government, under then President Ferdinand Marcos, commissioned the plant in response to the 1973 oil crisis when OPEC proclaimed an oil embargo.[57] Construction began on the Bataan nuclear power plant in 1976, and it was completed in 1984 after nuclear fuel was delivered, with a total construction cost of $460 million. It is a Westinghouse light water reactor, designed to use pressurized water for heat exchange between the reactor and the steam generators. The plant was designed to produce 621 MW of electricity.[58] The Bataan nuclear plant was to be the first of two plants to be built on the island, and was the first nuclear power plant built in Southeast Asia.[59] Before being brought online, the facility was mothballed following the Chernobyl nuclear plant explosion in 1986.[60] Mindful of safety following the Chernobyl explosion, the Philippine government considered converting the reactor to a natural gas fueled plant, but the concept was rejected as impractical, and the site was simply maintained.[61] In 2007 in response to elevated oil prices, the government again considered placing the plant online, and the Department of Energy initiated a study to determine the detailed requirements to make the plant fully compliant with international regulations regarding the operation of nuclear power plants. The International Atomic Energy Agency (IAEA) assisted with the study, but the effort was later canceled following the Japanese Fukushima nuclear plant explosion in 2011.[62] In 2016 the Philippine Department of Energy renewed talks with the IAEA regarding the Bataan plant. Although a formal study has not yet occurred, the IAEA believes that nuclear power in the Philippines is a good option for the

nation, but estimated that placing the Bataan plant into commercial operation would take approximately $1 billion.[63] Since 2011 the plant has sat dormant, but maintained in anticipation of being placed into operation in the future.

When the Bataan plant was first conceived it was intended to be the first nuclear power plant in Southeast Asia. Today, Indonesia, Vietnam, and Thailand all have plans to construct nuclear power plants, and Malaysia is also considering nuclear power as an option to meet domestic demands. Throughout the broader Asian region, nuclear power is already well established with Japan, South Korea, Taiwan, and China deeply invested. China plans to add up to 100,000 MW of nuclear power to their domestic electricity production over the next 20 years.[64] It is clear that nuclear power has become a staple generation method among advanced Asian nations, and the government of the Philippines is falling behind other leaders in the region. With the tremendous base load capabilities of nuclear energy, the Philippines must take steps to renovate the Bataan plant to bring it online for commercial operation, or take deliberate action to construct a more modern facility if it hopes to supplant coal as a reliable core source of power in the nation.

Power Distribution Systems

Regardless of future energy production methods, the Philippine government must also prioritize the improvement and expansion of the national energy grid. With a population of approximately 100 million people spread over 2,000 individual islands, the country faces many electrical distribution and infrastructure problems.[65] Clearly, connecting these islands through transmission lines to generating plants is a significant undertaking. The Luzon and Visayas grids are already connected via undersea cables; however, Mindanao remains

isolated from the national grid. Interconnectivity, especially during the peak use summer months, would greatly contribute to a more well-balanced and well-supplied national electrical grid by allowing power to flow from external generating facilities to local facilities that cannot keep up with peak demands.[66]

In addition to the interconnectivity of the national grid, system reliability and generation entry are other areas of immediate concern due to the nation-wide frequency of electrical interruptions, power outages, and load dropping incidents.[67] System reliability upgrades are required to fix aging and defective power transmission and distribution lines and equipment. Generation entry upgrades are simply efforts to accommodate new power generation facilities into the larger grid system. As the Philippines continue to introduce new generation facilities (regardless of fuel source) to an already problematic national grid, the frequency of interruptions will inevitably increase as more power flows through insufficient electrical lines.[68]

While existing systems require significant investment as more power is added to the national grid to meet growing demand, it is important to also address the problem of electrical accessibility to the Philippine population. Ninety-four percent of urban dwelling Philippine people have access to electricity while 12 percent of those living in rural areas do not, leaving almost 12 million Philippines without access to power.[69] Clearly the challenges of grid development on an archipelago are difficult, but this challenge must be overcome for the government of the Philippines to meaningfully provide for its citizens and continue economic and social improvements.

Conclusion

Sustained economic and population growth, coupled with improved standards of living across the country, have placed enormous demands on the Philippine government to provide reliable national access to electricity. With increasing energy demands, the government has embraced an electrical generation mix that is dominated by fossil fuels imported from foreign nations. Due to this situation, the government is potentially vulnerable to manipulation from exporting nations and the international market, which poses a direct challenge to the nation's energy security. The government's decision to use fossil fuel as the primary source of electricity production is also a direct threat to Philippine energy sustainability due to limited domestic fossil fuel reserves. Increasing dependence on imported coal, coupled with an aging and incomplete national transmission and distribution grid, paints a bleak picture for the future of the Philippines and its people unless the government develops new ways to meet the nation's energy requirements.

Fortunately, the Philippines has significant amounts of mostly untapped renewable energy to help break its dependence on imported fuel and achieve energy security and sustainability. The tremendous potential of biomass, geothermal, solar, hydroelectric, and wind resources offer a range of readily available domestic options to increase energy production within the country. While the government already garners significant electrical returns from hydroelectric and geothermal investments, further development of all renewable resource options is required to gain both energy security and sustainability.

In addition to increasing investments in renewable resources, the Philippines must join other Asian nations to leverage the significant potential of nuclear energy plants. Despite the reluctance of many to rely on nuclear power because of international nuclear

plant incidents over the past 40 years, it provides the dense generation capabilities that the country requires to provide stable, base load electricity to its increasingly growing urban populations. To break away from foreign exports, the government must overhaul the Bataan plant to meet modern safety standards, then bring it online for commercial power generation. Additionally, the government must plan for and pursue more modern plants to meet the emerging energy demands of the growing nation.

Finally, an aging and incomplete electrical transmission and distribution system must simultaneously be addressed. Regardless of power generation source, the existing network is insufficient to meet today's power needs, and will only degrade in the future as more power is added to the network to meet increasing demands. The Philippine government should also immediately begin work to expand its network and provide electricity to the over 12 million Philippine citizens without access to electrical power.

The Philippines must break its growing dependence on foreign fuels to gain energy security and sustainability. By investing now in renewable and nuclear energy sources, as well as electric grid improvements, the government of the Philippines will ensure the stability and prosperity of its nation for years to come.

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