GAS POLICY DEVELOPMENT PROJECT

UPSCRFI

University of the Philippines Statistical Center Research Foundation, Inc.

Market Profiling with Emphasis on the Use of Liquefied Natural Gas (LNG) to Power Economic Zones

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Majah-Leah Ravago, Raul Fabella, Karl Robert Jandoc, Renzi Frias, and J. Kathleen Magadia*

UPSCRFI-USDS Gas Policy and Development Project (GPDP)

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Abstract

One group of sizable users of energy is the collection of locators in the Special Economic Zones (SEZs). The production process among many of the locators in the SEZs includes heating, which currently uses the more expensive and relatively “dirtier” diesel or liquefied petroleum gas (LPG) as fuel. Thus, LNG is a potential cost-competitive and cleaner substitute for the feedstock currently used in both heating process and electricity requirements of locators in SEZs. Our objective in this study is to determine the profile of power and fuel use among locators in manufacturing and agro-industrial SEZs with special emphasis on assessing the likelihood of switching to LNG.

The results of this study provide insights that are useful as the LNG industry in the country matures. We find that the locators’ extent of knowledge about natural gas and their production technology process are the primary determinants of the likelihood to switch. Critical to increasing the probability of switching by firms is the knowledge that natural gas is a cost-competitive alternative and that these firms use heating in their production process. Hence, energy-intensive manufacturing locators that use more expensive fuel sources such as diesel for heating are more likely to switch to natural gas.

1. Introduction

In the most recent decade, the Philippines has experienced a renewed economic dynamism, growing at an average of 6.34 percent from 2010-2018—a welcome deviation from boom-and-bust cycle that plagued the economy for several decades (World Bank 2019). Embodied in the Medium-Term Development Plan of 2017-2022 is the *Ambisyon Natin 2040*, a notional target to join the high-income group of countries by 2040 (Clarete et al. 2018). If the country is to realize this target, the country should grow at a sustained high-level of 7% or more. This economic growth will be accompanied by increasing energy and electricity consumption (Danao and Ducanes 2018). Energy demand is expected to continuously increase as the country's industrial, commercial, and other domestic sectors continue to grow. It is projected to reach 43,765 MW by 2040, almost four times the demand in 2018 (DOE Philippine Energy Plan 2018). The 100% electrification target across the Philippines by 2022 is also likely to contribute to additional demand (ADB 2018).

While economic growth is expected to remain robust, barring any unforeseen worldwide economic shocks, meeting the ever-growing energy demand becomes even more challenging as production levels from Malampaya gas field, the country's indigenous natural gas field, are expected to decline starting 2022. Without a replacement energy source, a looming energy crisis is foreseen as the Philippines stand to lose over 3,200 MW from existing gas plants, responsible for about one-third of Luzon's power generation (ADB 2018).

Importing liquefied natural gas (LNG) is seen as the immediate solution to prepare for the eventual depletion of Malampaya. As such, an LNG industry is emerging, and its development should be accompanied by appropriate regulation and some form of industrial policy. Presently, natural gas is being used for power and industrial sectors. These current uses may be further expanded while other uses of natural gas can also be explored and taken advantage of as the LNG industry expands.

One group of sizable users of energy is the collection of locators in in the Special Economic Zones (SEZs). Due to its specialized facilities and technology, energy demand and intensity of firms in SEZs are recognizably much greater than their counterpart firms in non-SEZs. Despite this, most SEZs rely on grid electricity. In a JICA study (2011), grid electricity accounted for almost 83% of total fuel used among 82 establishments surveyed along the Batangas-Manila (BatMan 1) gas pipeline. Majority of the establishments preferred sourcing their power from Meralco (distribution utility in greater Manila area) because it is reliable, and it provides special discounted rates. Furthermore, production process in many of the locators in the SEZs includes heating, which currently uses the more expensive and relatively "dirtier" diesel or liquefied petroleum gas (LPG) as fuel. Thus, LNG is a potential cost-competitive and cleaner substitute for energy sources used in both heating process and electricity requirements of locators in SEZs.

Since its inception, the Philippine Economic Zone Authority (PEZA) has been credited with attracting substantial foreign direct investments. In 2018, PEZA-approved foreign investments (FI) amounted to P68.3 trillion. In the first quarter of 2019, PEZA's approved FI reached P12.9 trillion, contributing the second largest FI approvals at 28.2% next to the Board of Investments (BOI). The said FI projects were anticipated to generate 72.4% of the total projected employment for the first quarter, providing 23,146 jobs (PSA 2019). PEZA's exports contribution makes up 63% of the total commodity export and 80% of the total service export of the Philippines. In 2018, PEZA exports constituted 16% of the country's gross domestic product (GDP) (House of Representatives 2019). Moreover, from 2014-2018, PEZA companies supported the domestic market by purchasing a total of P1.345 trillion of equipment and raw materials (PEZA presentation 2019).

With the foregoing, our objective is to determine the profile of power and fuel use among locators in manufacturing and agro-industrial SEZs with special emphasis on assessing the competitiveness of LNG. In order to achieve this, we conducted a primary survey among SEZ locators in Laguna, Batangas, Cavite, Cebu, Pampanga, Benguet, Bulacan, and Metro Manila. The choice of SEZs as sample for this study is dictated by the company size and engagement of locators in the manufacturing business. Given the importance of manufacturing in the structural transformation of an economy (see Daway and Fabella 2015; de Dios and Williamson 2015; and Ravago et. al 2019), it is vital to determine systems that will improve their productivity and efficiency.

The results of the survey provided insights that are useful as the LNG industry in the country progresses. We find that the locators' extent of knowledge about natural gas and their production technology process are the primary determinants of the likelihood to switch. Critical to increasing the probability of switching is the knowledge that natural gas is cost-competitive and that firms use heating in their production process. Hence, energy-intensive manufacturing locators that use more expensive fuel sources such as diesel are more likely to switch to natural gas.

The next section gives an overview on the use of natural gas in the Philippines. Section 3 discusses potential uses of natural gas including its current utilization and fuel switching abilities of firms in other countries. Section 4 presents our data and methodology. This section provides a description of our primary survey and selected results from the survey. Section 5 discusses the results of our econometric analysis. The last section offers recommendations and concluding remarks.

2. Natural Gas Use in the Philippines

The shift to natural gas is envisioned in the Department of Energy's (DOE) Philippine Energy Plan, wherein it is perceived to have the highest annual average growth rates in both capacity and generation at 6.1% and 6.6%, respectively in business-as-usual scenario and at 8% and 8.4%, respectively in clean energy scenario. In the clean energy scenario, natural gas will also take the largest share in the power generation mix at 35%.

Box 1. What is natural gas?

- It is a fossil fuel like oil & coal.
- It is formed when layers of decomposing plant and animal matter which lived on Earth many millions of years ago were buried under deposits of sedimentary rocks. They are subjected and exposed to intense heat and pressure under the surface of the earth over millions of years, where they underwent a transformation into fossil fuel. The gaseous form of these fossil fuel is natural gas.
- Raw natural gas or unprocessed natural gas is produced from the wells of natural gas fields. The raw natural gas still contains natural gas liquids (also called natural gas condensate, is a low-density mixture of hydrocarbon liquids), non-hydrocarbon components and impurities (such as water/ water vapor, nitrogen, carbon dioxide, hydrogen sulfide (H_2S), helium, and other compounds). Natural gas processing is designed to clean raw natural gas by separating non-hydrocarbon components and impurities and various non-methane hydrocarbons and fluids to produce what is known as pipeline quality dry natural gas.
- Dry natural gas composition can vary depending on the source of natural gas and the processing of the gas, a hydrocarbon gas mixture consisting primarily of methane with small quantities of other hydrocarbons such as Ethane, Propane, Butane, and non-hydrocarbon such as nitrogen. Typical sample composition in volume: methane 94.0%, ethane 4.7%, propane 0.8%, butane 0.2%, nitrogen 0.3%. It is odorless, colorless, non-toxic, and non-corrosive.
- Liquefied natural gas (LNG) is dry natural gas that has been cooled down to liquid form for ease and safety of non-pressurized storage or transport. It takes up about 1/600th the volume of natural gas in the gaseous state (at standard conditions for temperature and pressure). The natural gas is then condensed into a liquid at close to atmospheric pressure by cooling it to approximately −162 °C (−260 °F).
- Natural gas is used as fuel (in the power generation, industrial, commercial, transport, and residential sectors), as feedstock for the production of hydrogen, chemicals, fertilizer, animal and fish feed, and other products.

Source: Department of Energy

The Malampaya offshore gas field has been the Philippines' sole source of natural gas since 2001. Discovered in 1990, under Service Contract (SC) no. 38, Malampaya allowed the country to use natural gas as fuel for the power generation and industrial sectors and to produce electricity power for almost two decades. Power generation took the lion's share in gas usage with 98% and the remaining 2% was used for the industrial sector (DOE Natural Gas Situationer Report 2018).

Currently, the country has three operating baseload combined-cycle gas turbine (CCGT) power plants all located in Batangas City. These are the 1000-MW Sta. Rita and 500-MW San Lorenzo Power Stations owned and operated by First Gen Corporation and the 1200-MW Ilijan Power Station operated by KEPCO. Newer gas plants also use gas from Malampaya including the San Gabriel mid-merit and Avion peaking plant (ADB 2018). In 2018, natural gas contributed 29.3% of the Luzon generation mix alongside other energy sources such as coal, oil, and renewable energy sources wind, solar, and biomass hydro, geothermal (DOE 2018).

The Pilipinas Shell Petroleum Corporation, an oil refinery in Batangas City, is the sole user of natural gas to serve as fuel for its gas turbine generators as well as to provide supplement to its low-pressure fuel gas system (DOE n.d.-a).

The use of natural gas was also explored for the transport sector from 2008 to 2014 with the DOE's Natural Gas Vehicle Program for Public Transport. A total of 41 compressed natural gas (CNG) buses plied the Batangas - Laguna - Metro Manila routes. The pilot run displaced a total of 4 million liters of diesel fuel, equivalent to US$ 2 million forex savings and a corresponding reduction in carbon dioxide (CO_2) emission of around 4,400 metric tons (DOE n.d.-b).

With the anticipated depletion of the Malampaya offshore gas field and the expiration of SC 38 by 2022, the country is preparing to switch to imported LNG. Among the private sector, there is a race to construct an LNG terminal. The first one to operate has the potential to capture the benefits of a first-mover advantage by nature of the industry. As of October 2019, at least four LNG projects are in the pipeline: 1) First Gen Corporation's venture with Tokyo Gas Co Ltd; 2) Australia-listed Energy World Corporation's LNG hub project in Pagbilao, Quezon province; 3) Phoenix Petroleum Philippines LNG hub proposal; and 4) U.S. LNG company Excelerate Energy's floating LNG import terminal project (Reuters 2019). The Energy World Corporation has been given the permit to construct prior to the issuance of DOE Department Circular 2017-11-0012 or the Philippine Downstream Natural Gas Regulation or PDNGR.[3] In December 2019, Phoenix Petroleum Philippines' notice to proceed has already expired. The notice to proceed for the others are still valid as of February 2020.

3. Potential Uses of LNG

a. Power, industrial, transport, commercial, and residential sector

In the power sector, natural gas is used as fuel for gas turbines or for reciprocating engines that drive generators. Given its fast startup and shutdown nature, natural gas power plants can also serve as back-up for the intermittent operation of renewable energy power plants.

[3] https://www.doe.gov.ph/sites/default/files/pdf/issuances/dc2017-11-0012.pdf

Aside from its industrial use in an oil refinery, natural gas can also serve as a fuel for furnaces and heating equipment (e.g. for crude oil processing, glass making, steel production, among others) and for the gas turbine or reciprocating engine that drives compressors for refrigeration and air conditioning systems. It can also be used for ammonia refrigeration or absorption cooling. It also has heating purposes as it can be used to boil water inside boilers or heat recovery steam generators. Natural gas can likewise serve as a raw material (feedstock) to produce chemicals, fertilizer, and hydrogen (U.S. Energy Information Administration 2019). Given the aforementioned uses, petrochemical, agricultural/farm, food products, and metal-based durables industries can benefit from using natural gas as a primary energy source.

LNG technology entails higher upfront investment costs than CNG but offers higher efficiency and fuel cost savings potentials (World Energy Council 2016). In the U.S., commercial fleet owners who are more focused on life-cycle costs than upfront costs reap substantial economic benefits from converting their fleets from oil to natural gas. Prices of natural gas are often 30-50% cheaper than oil. Some countries have also used LNG as marine fuel while there are increasing plans for LNG bunkering infrastructure in Europe and Asia (World Energy Council 2016). There are a lot of potential uses of LNG in the Philippine transport system, particularly in public utility vehicles (e.g. buses, tricycles, and jeepneys), taxis, railways and subways, vessels, and tankers. As mentioned in Section 2, the Philippines has pilot tested the running of CNG buses.

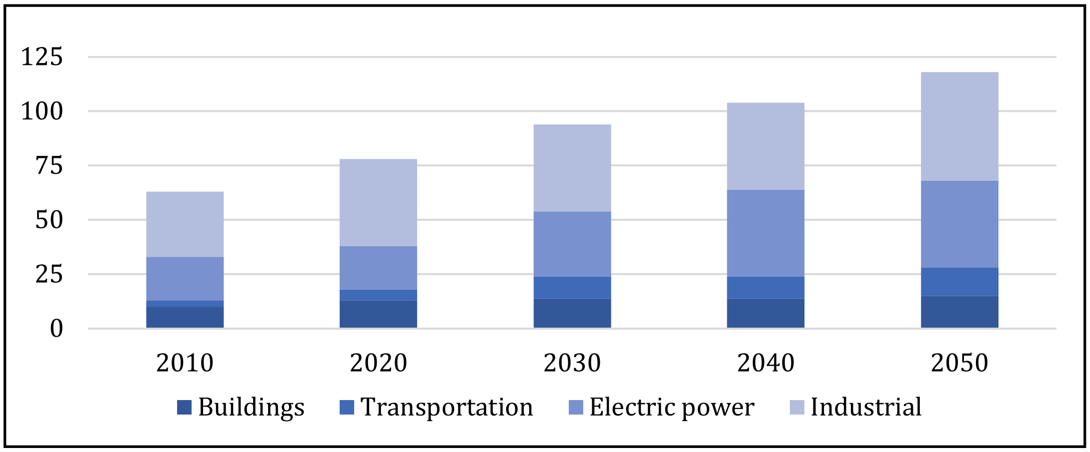
As for the commercial sector, natural gas can be used either to warm buildings in cold climates or operate cooling equipment in temperate locations. It may also be used to heat water, cook food, dry clothes, operate refrigeration, and provide outdoor lighting. It can likewise serve as a fuel in combined heat and power systems (U.S. EIA 2019). Given these, natural gas may be explored in the following commercial industries: pharmaceutics (e.g. laboratories or warehouses), hotels and resorts, shopping malls and groceries, restaurants, commercial buildings, and other small and medium enterprises

Much like its potential use in the commercial sector, natural gas can be used as fuel for cooking and heating in households. Other functions such as operating refrigeration and cooling equipment, drying clothes, and providing outdoor lighting can be also be explored in residential areas, such as subdivisions and condominiums.

b. Manufacturing sector

Natural gas consumption is projected to continuously increase worldwide with non-OECD countries in Asia accounting for the most growth. The increase in consumption is driven by an expanding industrial sector and the use of natural gas for electricity generation (Figure 1) (U.S. EIA, International Energy Outlook 2019). By 2050, non-OECD Asia’s natural gas consumption is expected to reach more than 45 quadrillion British thermal units (Btu) representing about 40% of all non-OECD consumption.

Figure 1. Non-OECD natural gas consumption by sector



Note: Values are in quadrillion Btu. Source: U.S. EIA, International Energy Outlook 2019

Table 1 presents the industrial sector energy consumption by region and energy source in 2012–2040. Non-OECD countries' industrial energy consumption is projected to grow by an average of 1.5% annually, higher than the 0.5% yearly growth among OECD countries. Compared to other energy sources, natural gas is predicted to have the highest average annual percentage change at 2.2.% in non-OECD countries closing in on the projected consumption growth of coal and liquid fuels. For the world total, however, natural gas comes second to liquid fuels from 2030 to 2040 (U.S. EIA, International Energy Outlook 2016).

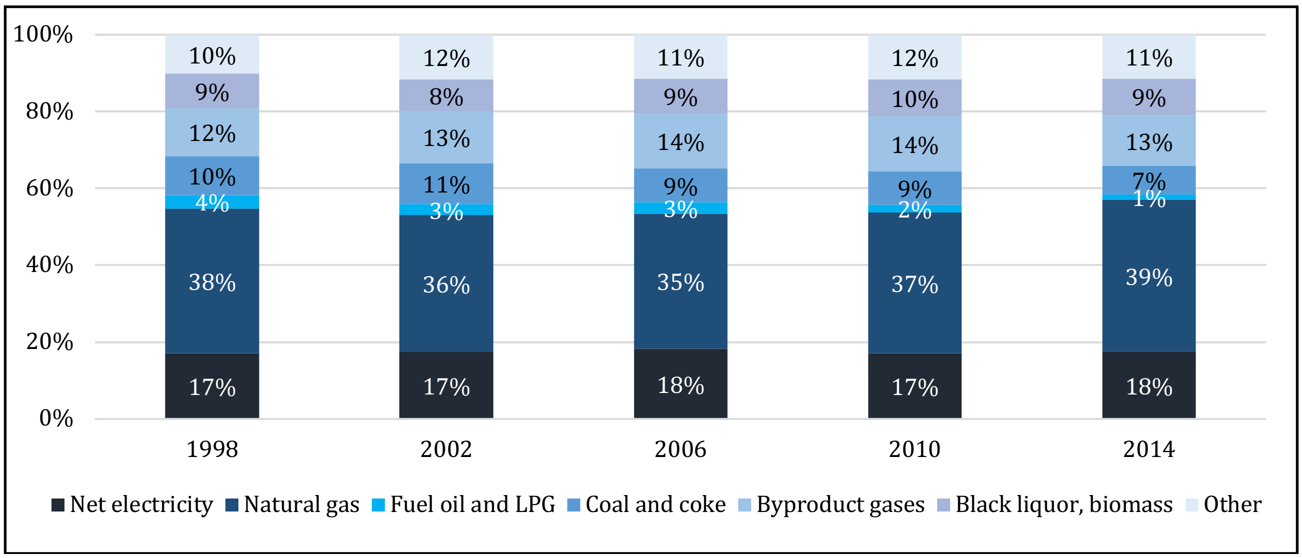
Table 1. Industrial sector energy consumption by region and energy source, 2012–40

Energy source by region	2012	2020	2025	2030	2035	2040	Ave. annual % change, 2012-2040
OECD	73.3	77.6	80.0	81.7	83.0	84.6	0.5
Liquid fuels	27.2	28.9	29.8	30.3	30.4	30.6	0.4
Natural gas	21.0	22.7	23.4	24.2	24.9	25.7	0.7
Coal	8.5	8.7	8.8	8.9	9.0	9.0	0.2
Electricity	10.9	11.6	12.1	12.5	12.8	13.2	0.7
Renewables	5.7	5.7	5.8	5.9	5.9	6.1	0.3
Non-OECD	149.0	168.3	182.6	196.3	21..0	224.5	1.5
Liquid fuels	39.3	43.3	46.7	50.3	54.2	57.9	1.4
Natural gas	29.7	33.6	38.6	43.8	49.6	54.7	2.2
Coal	47.3	53.4	55.5	57.1	58.6	59.7	0.8
Electricity	21.0	25.5	27.9	29.7	31.5	33.1	1.6
Renewables	11.8	12.5	13.9	15.4	17.1	19.0	1.7
Total World	222.3	245.8	262.6	278.0	294.0	309.1	1.2
Liquid fuels	66.5	72.2	76.5	80.6	84.6	88.6	1.0
Natural gas	50.7	56.2	62.0	68.0	74.5	80.4	1.7
Coal	55.7	62.0	64.3	66.0	67.2	68.7	0.8
Electricity	31.9	37.2	40.0	42.2	44.3	46.3	1.3
Renewables	17.4	18.2	19.7	21.3	23.0	25.1	1.3

Note: Values are in quadrillion Btu. Source: U.S. EIA, International Energy Outlook 2016

A similar trend can be observed in the U.S. wherein the share of natural gas in manufacturing energy consumption[4] increased between 1998 and 2014, while the shares of other fossil fuels, such as coal and petroleum products, decreased (U.S. EIA 2018). As of 2014, natural gas takes up the largest proportion of the total fuel consumption in U.S. manufacturing at 39.3% (Figure 2). It has been the preferred energy source for U.S. manufacturers as it is less expensive than fuel oil or LPG. Boilers that run on natural gas also emit fewer pollutants compared to those using coal and other fossil fuels, helping manufacturers avoid expenses related to pollutant mitigation and regulations such as the Environmental Protection Agency's boiler Maximum Achievable Control Technology (MACT) standards (U.S. EIA 2017). The increased availability, lower prices, and compliance with environmental regulations of natural gas led manufacturers to disregard "fuel switching"—which entails investments on equipment that could, among others, enable manufacturers to switch to less expensive fuels in their production processes. (U.S. EIA 2018).

Figure 2. Fuel consumption share in U.S. manufacturing



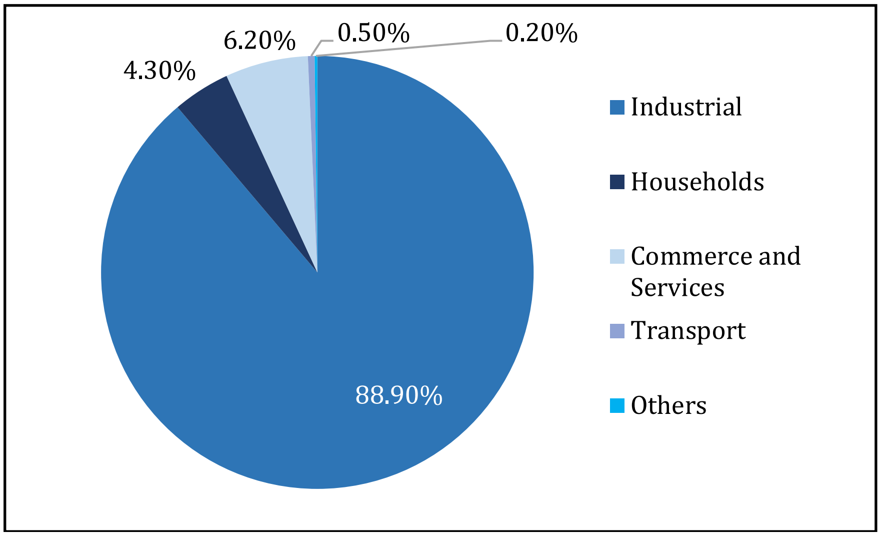
Note: Values are percentages of manufacturing fuel consumption in trillion Btu.
Source: EIA, Manufacturing Energy Consumption Survey, various years

Figures 3 and 4 show natural gas consumption of selected countries in Asia. Figure 3 shows that Singapore's industrial sector takes the bulk of the country's natural gas consumption (Energy Market Authority 2018). In Japan, the world's biggest LNG importer, uses natural gas mainly for electric power (Figure 4). This is mainly to offset the loss of nuclear generating capacity after the Fukushima Daiichi power reactors were severely damaged by the March 2011 earthquake and tsunami. Similar to Japan, South Korea uses

[4] The total U.S. manufacturing sector consumption of natural gas and all other fuels in any year depends on the level of production of manufacturing products, on energy efficiency, and on the relative prominence of high natural gas consuming industries in the manufacturing total.

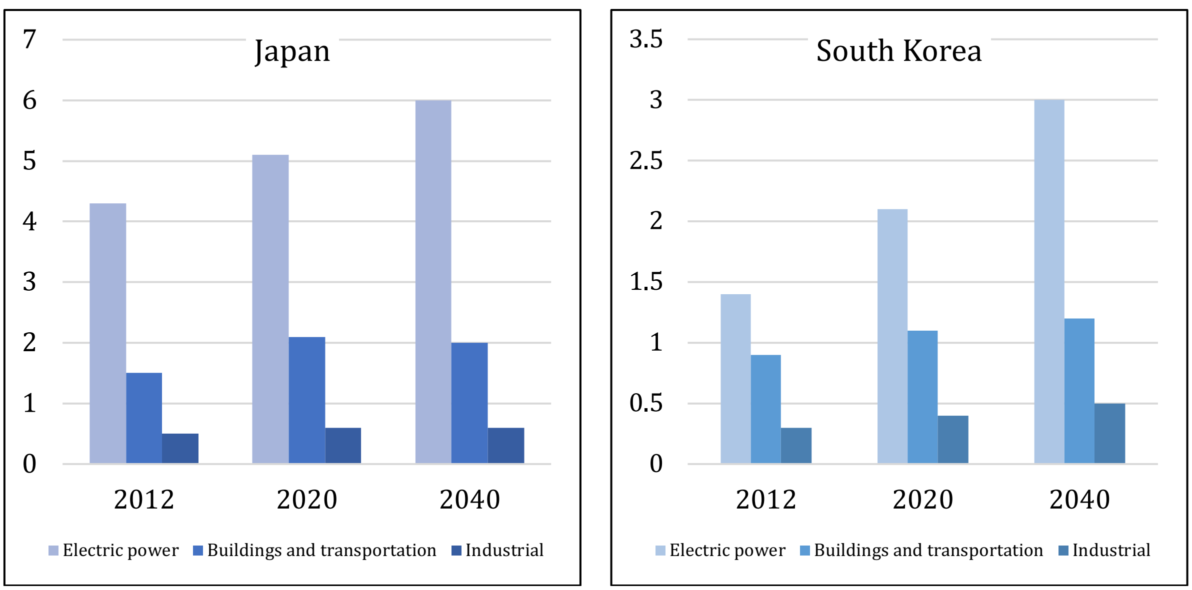
natural gas more for power, buildings, and transportation than for industrial purposes (EIA, International Energy Outlook 2016).

Figure 3. Singapore natural gas consumption by sector



Source: EMA 2018

Figure 4. Japan and South Korea natural gas consumption by end-use sector



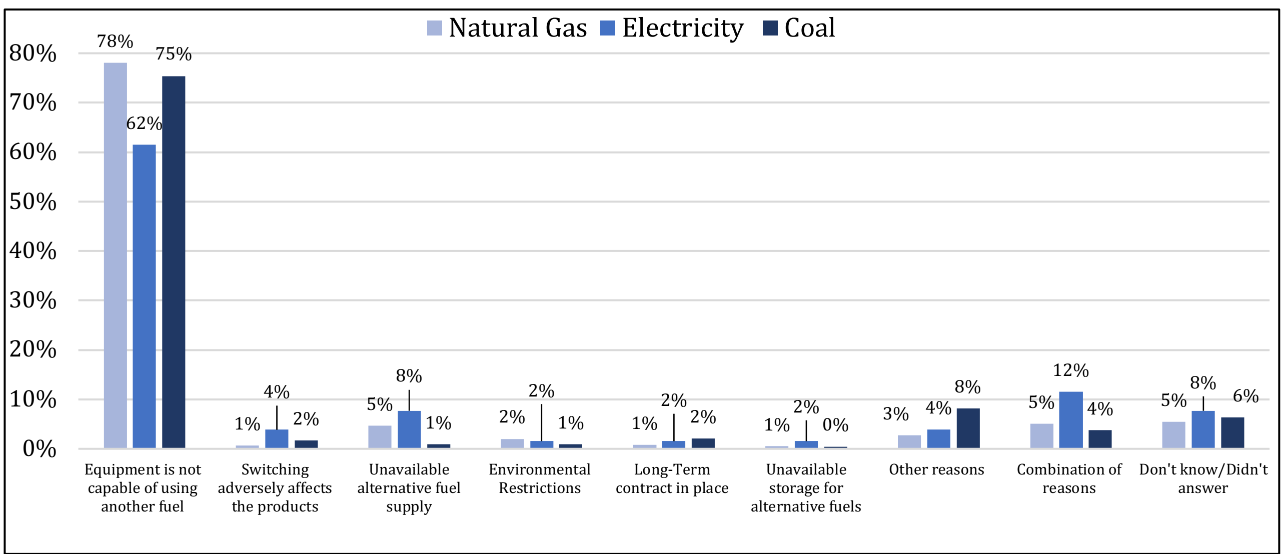
Note: Values are in trillion cubic feet. Source: EIA, International Energy Outlook 2016

c. Fuel switching

Fuel switching capability is defined by EIA as *"the short-term capability of a manufacturing establishment to have used substitute energy sources in place of those actually consumed. Capability to use substitute energy sources means that the establishment's combustors (for example, boilers, furnaces, ovens, and blast furnaces) had the machinery or equipment either in place or available for installation so that substitutions could actually have been introduced within 30 days without extensive modifications substitutable fuels used in manufacturing."* It can also be interpreted as manufacturing's ability to make choices to take advantage of relative price differences, to deal with supply shortages, or to handle other exigencies. (U.S. EIA 2018).

In 2014, the capability of the manufacturing sector to switch fuels declined continuously between 1994 and 2014. Figure 5 shows the reasons by the respondent manufacturers for not being able to switch fuels. The most cites was that the equipment onsite would not support it—78% of unswitchable natural gas, 75% of unswitchable coal, and 62% of unswitchable electricity receipts. Lack of availability of alternative fuels, environmental restrictions on alternative fuels, and restrictions of long-term contracts were also cited as reasons deterring fuel switch (U.S. EIA, 2018).

Figure 5. Reasons for non-switching of fuels in U.S. manufacturing

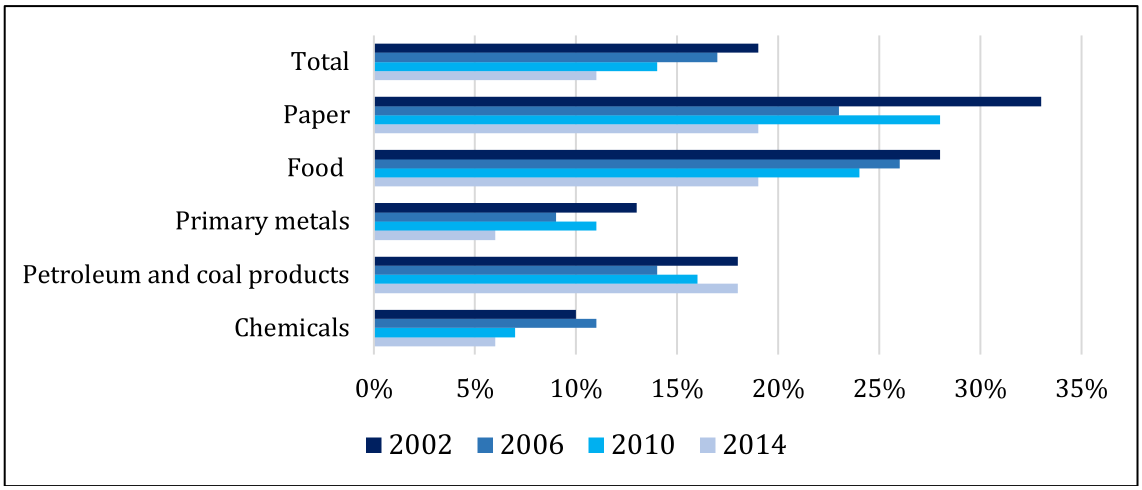


Source: 2014 U.S. Manufacturing Energy Consumption Survey (MECS). MECS is a survey that collects information from a national sample on the stock of manufacturing establishment, their energy-related building characteristics, and their energy consumption and expenditures. It is done every 4 years. MECS divides the capability for manufacturing fuel switching into three categories: 1) *unswitchable actual consumption* - amount of fuel that could not be switched into another fuel; 2) *switchable actual consumption* additional amount of fuel that could have been switched into another fuel but was not; 3) *potential additional consumption* amount - measure of all possible switching into the fuel from other sources that could be added to the actual consumption. Together, all three components represent the *maximum possible* consumption of any particular fuel.

The ability to switch fuels within the U.S manufacturing sector likewise varies according to industry type. Food, paper, petroleum and coal products, chemicals, and primary metals were the five largest natural gas-consuming industries in 2014 accounting for 81% of U.S. manufacturing fuel use. MECS data showed that chemical and primary metal industries showed less ability to switch from natural gas than the total manufacturing in each of the four survey years shown between 2002 and 2014 whereas paper and food showed substantially more ability to switch (Figure 6).

In some applications such as heating, many existing users of electricity could in principle switch to gas in the medium- to long-term with the normal substitution being onsite generation (OECD 2000; U.S. EIA 2018). The development of small-scale gas-fired electricity generation enhances the ability of large electricity consumers to switch to gas, enhancing the convergence of the gas and electricity markets (OECD 2000).

Figure 6. Ability of US manufacturing sector to switch from natural gas



Source: EIA, MECS, various years

4. Data and Methodology

a. Description of the survey

We conducted an online survey in August – September 2019 among SEZ locators classified as manufacturing and agro-industrial in the provinces of Laguna, Batangas, Cavite, Cebu, Pampanga, Benguet, Bulacan, and Metro Manila. For complete details of the survey, see Ravago et. al 2020, accompanying Technical Report to this paper. Our survey aims to characterize the profile of PEZA locators that are more likely to adopt alternative fuels and primary energies such as natural gas, solar, and wind in their existing production processes.

In 2019, there are a total of 396 operating SEZs nationwide ranging from manufacturing economic zones, information technology parks/centers, agro-industrial economic zones, tourism economics zones, and medical tourism parks and centers in the country. Adhering to the protocol of the Institutional Ethics Review[5] and keeping the survey optional, we employed a non-probability sampling procedure targeted to manufacturing and agro-industrial SEZs. The targeted sample of manufacturing and agro-industrial SEZs is a result of our pilot survey and focus group discussions (FGD) among selected locators. On the viability of LNG as a fuel used in the production process, the results from the FGDs highlighted that LNG is more feasible among locators that operate boilers. Boilers are used to apply heat in the production of manufactured goods. Manufacturing companies that intensively use power are those that use boilers, for instance, food manufacturers and agro-industrial companies.

Our survey was sent to 61 manufacturing and agro-industrial SEZs with a total of 1,613 operating locators.[6] We obtain a total of 115 locator-respondents, 100 from the online survey and 15 from the pilot survey. Published research on organization and workplace has typically 15-60 participants (Saunders and Townsend 2016). Our sample of 115 locators is considered a successful return given that the survey is voluntary. Our sample is larger than the 82 locators surveyed by JICA in 2011 (see JICA 2011), although the JICA study covers only locators in economic zones along the proposed Batangas-Manila (BatMan 1) natural gas pipeline (i.e., Batangas and Laguna areas only). Table 2 presents the profile of our locator-respondents. Out of the 115 locator-respondents, a considerable number are from SEZs located in Laguna at 64%, followed by locator-respondents in Batangas at 10%. The rest are from Cavite, Cebu, Pampanga, Benguet, Bulacan, and Metro Manila. Note that these provinces are all in the Luzon and Visayas islands.

[5] The proposal to conduct the survey has been examined and validated exempt from review of Ateneo de Manila University Research Ethics. As such, the team has fulfilled the technical requirements necessary to demonstrate the use of ethical procedures in the conduct of the survey.
[6] Total count is based on the February 2018 list of locators available online.

Table 2. Profile of locators by ecozone

Ecozone by province	No. of respondents		Company size		Annual production sales (in Philippine Pesos)		Annual per-capita production sales (in Philippine Pesos)	
	%	N	%	Mean	%	Mean	%	Mean
Laguna	**64.35**							
Laguna Technopark SEZ	19.13	22	4.98	548	7.68	6,473,000,000	23.08	65,021,600
Carmelray Ind. Park II	13.91	16	5.07	558	3.23	2,725,000,000	1.06	2,972,165
Calamba Prem. Int'l Park	13.04	15	2.42	266	0.25	206,700,000	1.43	4,025,332
Filinvest Tech. Park Cal.	4.35	5	0.21	23	0.12	100,000,000	2.74%	7,710,262
Laguna Int'l Industrial Park	4.35	5	2.54	280	4.82	4,060,000,000	2.89	8,135,588
Light Ind. & Science Park I	3.48	4	6.77	745	11.92	10,050,000,000	3.21	9,036,807
Greenfield Automotive Park	2.61	3	0.32	35	4.03	3,400,000,000	22.19	62,515,124
Laguna Technopark Annex	1.74	2	3.00	330	0.71	600,000,000	1.10	3,095,632
Light Ind. & Science Park II	0.87	1	0.63	69	0.12	100,000,000	0.51	1,449,275
Toyota Sta. Rosa SEZ	0.87	1	3.04	334	11.86	10,000,000,000	10.63	29,940,120
Batangas	**10.44**							
Lima Technology Center	6.09	7	6.93	762	10.29	8,671,000,000	2.71	7,633,361
First Phil. Industry Park	3.48	4	9.96	1,096	26.79	22,580,000,000	10.22	28,782,899
Keppel Phils. Marine SEZ	0.87	1	6.98	768	0.83	700,000,000	0.32	911,458
Cavite	**8.70**							
Golden Mile Business Park	6.09	7	3.67	404	0.12	100,000,000	0.98	2,761,036
People's Tech. Complex	1.74	2	1.12	124	0.59	500,000,000	1.44	4,061,762
Golden Gate Bus. Park-CEPZ	0.87	1	0.22	24	0.12	100,000,000	1.48	4,166,667
Cebu	**7.83**							
Mactan Economic Zone	3.48	4	14.87	1,637	3.11	2,625,000,000	3.09	8,701,762
West Cebu Industrial Park	2.61	3	0.50	55	0.44	366,700,000	2.85	8,015,873
Cebu Light Industrial Park	1.74	2	17.26	1,899	11.86	10,000,000,000	3.17	8,936,515
Pampanga	**6.09**							
Pampanga Economic Zone	4.35	5	1.47	162	0.17	140,000,000	0.76	2,140,653
TECO Industrial Park	1.74	2	3.70	408	0.36	300,000,000	1.29	3,645,833
Benguet	**0.87**							
Baguio City Economic Zone	0.87	1	3.17	349	0.12	100,000,000	0.10	286,533
Bulacan	**0.87**							
Victoria Wave SEZ	0.87	1	0.99	109	0.36	300,000,000	0.98	2,752,294
Metro Manila	**0.87**							
MacroAsia Ecozone	0.87	1	0.18	20	0.12	100,000,000	1.77	5,000,000
Total	100.00	115	100.00	494	100.00	3,987,000,000	100.00	18,980,590

Source: GPDP 2019

Our survey instrument collected information on the general profile of the locators, production and operation, utility consumption, fuels used in production, and aptitude on alternative fuels (Table 3). The questionnaire was created using the subscription-based survey platform SurveyMonkey (see https://www.surveymonkey.com).

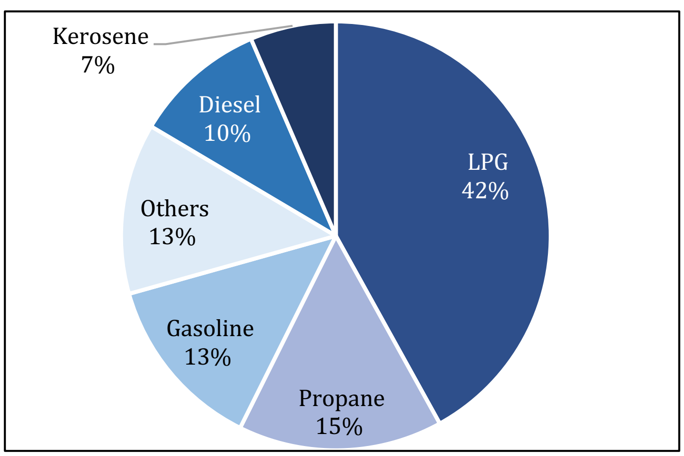
Table 3. Coverage of survey questionnaire

	Section	Coverage
I.	General information	Ecozone and company information, personnel, book value
II.	Production schedule and operation	Production sales, peak and low month schedule and operation
III.	Utilities	Electricity sources, requirements, uses, conservation measures. Water and electricity consumption and expenditure
IV.	Fuels used in production	Importance, uses, consumption, and expenditure on different types of fuel in main production processes
V.	Aptitude on alternative fuels and primary energies	Knowledge, considerations, and opinions on alternative fuels and primary energies, and experiences in using them
VI.	Other questions	Business expansion considerations

b. Results of the survey

We present here selected results of the survey focusing on respondents' aptitude and perception on natural gas. We first examine the fuels currently being used by locators (Figure 7). Of our sample locator, 42 percent uses LPG[7] as their fuel for heating in their production processes.

Figure 7. Expenditure share per fuel



Fuel	Mean expenditure
LPG	1,363,637.0
Propane	500,000.5
Gasoline	432,000.7
Others	418,624.1
Diesel	325,228.0
Kerosene	210,000.5

Notes: Biodiesel, bunker, and coal were not included in the figure. Other fuels include electricity, hydrogen, biomass, Thuban, nitrogen, oxygen, argon, helium, rice hull, hydraulic oil, engine oil.

[7] In the survey, LPG is defined as a combination of propane and butane.

Table 4 gives information on production processes of locators in PEZA, whether they have heating or no heating component. For those with heating component, electricity is the main power source of their equipment. Diesel and LPG come next as primary fuels to power the locators' heating equipment.

Table 4. Number of locators that have production processes that use electricity/fuel

Production process	Electricity	Diesel	Gasoline	Kerosene	LPG	Propane	Total
With heating component							
Fabrication	40	1	1	0	3	0	**45**
Welding	34	0	1	0	2	0	**37**
Machine injection or molding	33	0	0	0	0	0	**33**
Curing (e.g. oven curing, powder paint curing, etc.)	24	0	0	0	2	0	**26**
Drying or annealing (e.g. oven drying, mold drying, core drying, air handling, etc.)	24	0	0	0	2	0	**26**
Heat treatment	19	1	0	0	7	1	**28**
Standby or back-up power generation	12	0	0	0	0	0	**12**
Die casting or wire bonding	10	0	0	1	2	0	**13**
Boiler operation (e.g. for steam generation, etc.)	9	3	0	0	2	0	**14**
Melting or pre-melting	7	0	0	0	6	0	**13**
Burning	6	0	0	0	1	0	**7**
Power generation	6	0	0	0	0	0	**6**
Baking	2	0	0	0	0	0	**2**
Impregnation	2	0	0	0	1	0	**3**
Smelting	1	0	0	0	1	0	**2**
Thermal oxidation	0	0	0	0	0	0	**0**
Without heating component							
Air conditioning	94	0	0	0	0	0	**94**
Air compression/ vacuuming	72	1	2	1	1	1	**78**
Forklift operation	40	11	2	0	0	0	**53**
Other (cleaning of machine parts, threading)	38	4	1	3	3	0	**49**
Transportation and logistics (e.g. trucking, distribution, delivery, etc.)	25	10	4	0	0	0	**39**
Painting	15	0	1	0	0	0	**16**
Steel cutting	15	0	1	0	3	0	**19**
Stamping	12	1	0	0	0	0	**13**
Engine loading or preparation	8	1	0	0	0	0	**9**

Table 4. Number of locators that have production processes that use electricity/fuel (continued)

Production process	Electricity	Diesel	Gasoline	Kerosene	LPG	Propane	Total
Air/gas mixing (e.g. Selas mixing, etc.)	3	0	1	0	0	0	**4**
Ice making	1	0	0	0	0	0	**1**
Total^	115*	22	10	5	22	2	—

Note: All other options that were provided but were not chosen are baking, ice making, machine injection or molding, and thermal oxidation; ^Refers to the total number of locators that use fuel; *It is assumed that all locator-respondents use electricity in their production processes.

Table 5 gives a representative picture on the state of knowledge on natural gas. Less than half of the respondents (44%) have limited knowledge on natural gas. This is expected since natural gas is not widely commercially available.

Table 5. Extent of knowledge on natural gas

	Natural gas
1 (Limited)	44.35%
2	14.78%
3	29.57%
4	9.57%
5 (Advanced)	1.74%
Weighted Mean	2.10
N	115

Note: Responses vary from 1 (limited knowledge) to 5 (advanced knowledge).

The survey also asked the respondents regarding their perception on and openness to switching to natural gas. Despite respondents citing limited knowledge on natural gas, a greater number of them perceived natural gas to be safe and cost-competitive (Table 6). They are also open to switching to natural gas, with 63 percent responding positively to openness towards switching (Table 6).

Table 6. Perception on and openness to natural gas

	Safety (1)		Cost-competitiveness (2)		Openness to switching (3)	
	%	N	%	N	%	N
Yes	57.39	66	65.22	75	63.48	73
No	42.61	49	34.78	40	36.52	42
Total	100.00	115	100.00	115	100.00	115

Given their openness to switching to natural gas, compatibility of machines and equipment was the top consideration for economic zone locators to switch to natural gas (Figure 8). This gives us an indicator that the use of natural gas is more feasible among locators that operate boilers and other heating equipment in their production process. Locators which mainly depend on electricity for their operations are unlikely to shift to natural gas.

Figure 8. Top considerations for fuel switching

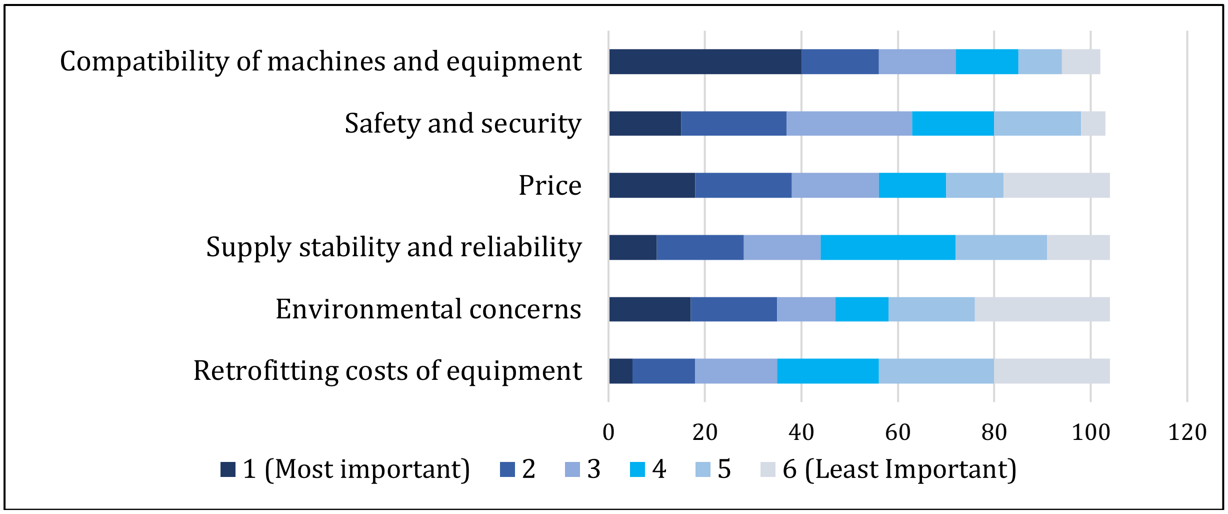


Table 7 provides information on what fuel will likely be replaced when natural gas becomes available. As expected in production process, the more expensive diesel and other fuels are the top candidates, followed by LPG and gasoline.

Table 7. Fuels to be replaced by natural gas in case of switching

	In production processes	In self-generation	In back-up power generation
Biodiesel	9	4	7
Bunker	2	1	1
Coal	2	3	3
Diesel	24	31	36
Gasoline	11	11	14
Kerosene	1	1	3
LPG	15	8	6
Natural gas	—	—	—
Propane	1	1	2
Solar	—	10	12
Wind	—	1	1
Other*	18	13	8
Total	73	73	73

Note: *Argon, electricity, biomass, not applicable, none.

In case of switching, most of the locators estimated the energy requirement for natural gas to be in the low range of 1-20 mmscfd (Table 8).

Table 8. Energy requirement for natural gas in case of switching

Units: mmscfd	%	N
1 to 20	69.86	51
21 to 40	10.96	8
41 to 60	9.59	7
61 to 80	5.48	4
81 to 100	4.11	3
101 and above	0.00	0
Total	100.00	73

Note: mmscfd - million standard cubic feet per day. Source: GPDP 2019

c. Methodology

We now investigate the factors that can determine locators' propensity to switch to natural gas as fuel in their production processes. Given that we have information on who are open and not open to switch, we employed a logistical regression or *logit* model to explain the probability of switching (switch=1) of locators. Equation (1) presents our model specification. The left-hand side takes on the value 1 when the locator-respondent is open to switch to natural gas, and 0 otherwise. The *logit* model is represented by:

$$\Pr(\mathrm{Y} = 1|\mathrm{X}, \mathrm{N}, \alpha, \beta) = \frac{\exp\,(\alpha N + \beta X + u)}{1 + \exp\,(\alpha N + \beta X + u)} \qquad (1)$$

where N represents locators' perceptions and knowledge about natural gas. We control for initial conditions of locators, denoted by X. This includes presence of heating in production process, perceived relative cost-competitiveness of natural gas, extent of knowledge on natural gas, electricity expenditure, company size, ecozone type, production sales, per-capita production sales, and whether locators source their electricity from Meralco or any electric cooperative. The error term is represented by u.

As secondary analysis, we also employ a linear probability model by conducting an ordinary least squares (OLS) specification. Table 9 below presents the variables used in the regression analyses, their descriptions, and units of measure. Mean, standard deviation, and minimum and maximum values are also tabulated.

Table 9. Summary statistics

Variable	Description	Unit	N	Mean	SD	Min	Max
Openness to Switch	1 if locator is open to switch to natural gas in its production processes, self-generation, and back-up generation of power; 0 otherwise		115	0.63	0.48	0.00	1.00
Heating	1 if locator has heating component in its production process; 0 otherwise		115	0.24	0.43	0.00	1.00
Cost-competitiveness	Perceived cost-competitiveness of natural gas relative to other fuels/ energies currently used		115	0.65	0.48	0.00	1.00
Knowledge	Extent of knowledge on natural gas; 1 if less knowledgeable; 2 if more knowledgeable		115	1.11	0.32	1.00	2.00
Electricity Expenditure	Average monthly electricity expenditure	Thou PHP	115	3,917	7,029	500	45,000
Ln (Electricity Expenditure)	Natural log of monthly electricity expenditure	% point	115	14.09	1.35	13.12	17.62
Company Size	Number of personnel	capita	115	494	964.	4	6,000
Ln (Company Size)	Natural log of company size	% point	115	4.76	1.79	1.39	8.70
Ecozone Type	0 if locator is in a private ecozone; 1 if in a public		115	0.09	0.28	0.00	1.00
Production Sales	Annual production sales in 2018	In Mn PHP	115	3,990	9,070	100	50,000
Per-capita Production Sales	2018 production sales divided by number of personnel	In Thou PHP	115	19,000	112,000	39	1,190,000
Ln (Per-capita Production Sales)	Natural log of per-capita production sales	% point	115	15.06	1.55	10.57	20.90
Meralco or Electric Cooperative	1 if locator sources electricity from Meralco or any electric cooperative; 0 otherwise		115	0.70	0.46	0.00	1.00

5. Results and Discussion

We performed a simple t-test to determine whether there is a significant difference between the average characteristics of locators who are open and not open to switch to natural gas across various categories (Table 10). In terms of the perception on cost-competitiveness of natural gas and extent of knowledge, there is a significant difference between the means of the two groups as evident by an almost zero p-value. Using the 1 – 5 scale with 5 being "advanced knowledge", the extent of knowledge about natural gas is likewise higher for companies who are willing to switch.

In terms of the presence of heating production component, ecozone type, whether locators source electricity from Meralco or any electric cooperative, and natural logs of electricity expenditure, company size, and per-capita production sales, there are little to no significant differences between the means of the companies who are willing to switch and those who are not.

Table 10. Openness to switch to natural gas, two-sample t-test

Variable	T-statistic	Degrees of freedom	P-value	Not open to switch		Open to switch	
				N	Mean	N	Mean
Heating	-0.10	113	0.92	42	0.24	73	0.25
Cost-competitiveness	-3.57	113	0.00	42	0.45	73	0.77
Knowledge	-2.47	113	0.01	42	0.26	73	0.49
Ln (Electricity Expenditure)	0.03	113	0.97	42	14.09	73	14.09
Ln (Company Size)	0.78	113	0.44	42	4.93	73	4.66
Ecozone Type	0.92	113	0.36	42	0.12	73	0.07
Ln (Per-capita Production Sales)	-0.81	113	0.42	42	14.90	73	15.15
Meralco or Electric Cooperative	0.18	113	0.86	42	0.71	73	0.70

In order to examine the factors that predispose a locator to switch to natural gas, we employ both a logistic regression (*logit*) model and a linear probability model using OLS. Regressors in this model include indicators whether heating was used in the locator's production process and whether they believe that natural gas is cost-competitive. We also include an indicator on the extent of knowledge on natural gas, whether the locator sources electricity from Meralco or any electric cooperative, as well as the type of ecozone, whether public or private. We also included variables on the size of the locator in terms of employment, sales, and electricity expenditure.

The results of the *logit* model and OLS estimates are presented in Table 11. The results show that cost-competitiveness (regardless of presence of heating component in the production process), extent of knowledge on natural gas, ecozone type, and whether electricity is sourced from Meralco or any electric cooperative significantly affect the locator's openness to switch.

Column [1] of Table 11 presents the estimates using logistic regression in odds ratio units. Column [2] presents the marginal effects at the means (MEM). The results of the MEM estimates show that locators have a higher predictive probability to switch when they have heating component in their production processes and perceived natural gas to be more cost-competitive relative to their existing fuels (*Heating* = 1; *Cost-competitiveness* = 1).

Table 11. What would influence locators to switch to natural gas?

Dependent variable: *Open to switch = 1;* Not open = 0	Logistic Regression		OLS Regression
	Odds Ratio	Margins	
	[1]	[2]	[3]
Heating = 0; *Cost-competitiveness* = 0	1.293	0.448**	0.450**
	(1.043)	(0.096)	(0.085)
Heating = 0; *Cost-competitiveness* = 1	4.730*	0.748**	0.733**
	(3.662)	(0.060)	(0.062)
Heating = 1; *Cost-competitiveness* = 0	—	0.385*	0.392*
		(0.166)	(0.153)
Heating = 1; *Cost-competitiveness* = 1	5.750	0.783**	0.768**
	(5.340)	(0.102)	(0.112)
Knowledge = 0	—	0.564**	0.559**
		(0.065)	(0.058)
Knowledge = 1	2.582*	0.770**	0.745**
	(1.175)	(0.065)	(0.068)
Ln (*Electricity Expenditure*)	1.251	0.051	0.044
	(0.307)	(0.055)	(0.050)
Ln (*Company Size*)	0.795	-0.052	-0.046
	(0.155)	(0.044)	(0.039)
Ecozone Type = 0 (Private)	—	0.666**	0.645**
		(0.050)	(0.045)
Ecozone Type = 1 (Public)	0.588	0.540**	0.531**
	(0.459)	(0.185)	(0.154)
Ln (*Per-capita Production Sales*)	0.971	-0.007	-0.006
	(0.153)	(0.036)	(0.031)
Meralco or Electric Cooperative = 0	—	0.713**	0.686**
		(0.095)	(0.091)
Meralco or Electric Cooperative = 1	0.688	0.631**	0.614**
	(0.396)	(0.063)	(0.055)
Constant	0.115	0.115	0.073
	(0.451)	(0.451)	(0.791)
R-squared / Pseudo R-squared	0.123	0.126	0.158
N	115	115	115

Note: * p<0.05; ** p<0.01. Margins are marginal effects at the means using the Stata command "margins, dydx(*) atmeans"

Specifically, the predictive probability for these locators to switch to natural gas are higher by 39.8 percentage points (= 78.3% – 38.5%) compared to a firm with heating but do not believe natural gas to be cost-competitive (*Heating* = 1; *Cost-competitiveness* = 0), holding all other variables at their average. For those with no heating component, the predictive probability of switching is 30 percentage points (= 74.8% – 44.8%) higher for those who think natural gas is more competitive than those who think otherwise, holding all other variables at their means.

In terms of knowledge extent, more knowledgeable locators have 20.6 percentage points (= 77% – 56.4%) higher predictive probability of switching than less knowledgeable locators, holding all other variables at their means. By type of ecozone, locators in private ecozones have 12.6 percentage points (= 66.6% – 54%) higher predictive probability of switching than locators in public ecozones, holding other variables at their means. In terms of sources of electricity, locators who get their electricity from other sources, such as direct from generation companies through retail competition and open access (RCOA) have 8.2 percentage points (= 71.3% – 63.1%) higher predictive probability of switching than those who get their electricity supply from Meralco or cooperatives, holding all other variables at their means. The other covariates, natural logarithm of electricity expenditure, company size, and per-capita production sales do not significantly affect the locator's openness to switch.

The results of our secondary analysis using OLS is presented in Column [3]. The results shows that a locator with heating component in their production processes and perceived natural gas to be more cost-competitive relative to their existing fuels (*Heating* = 1; *Cost-competitiveness* = 1), are 37.6 percentage points (= 76.8% – 39.2%) more likely to switch to natural gas compared to a firm with heating but do not believe natural gas to be cost-competitive (*Heating* = 1; *Cost-competitiveness* = 0). In addition, there is a strong correlation between cost-competitiveness and openness to switch among locators with no heating component in their production processes. For locators with no heating component, those who think natural gas is cost-competitive are 28.3 percentage points (= 73.3% – 45.0%) more likely to switch than those who think otherwise. Furthermore, locators who are relatively more knowledgeable on natural gas are more likely to switch to natural gas than those with limited knowledge. More knowledgeable locators are 18.6 percentage points (= 74.5% – 55.9%) more likely to switch than less knowledgeable locators. Moreover, locators within private ecozones are, on average, 11.4 percentage points (= 64.5% – 53.1%) more likely to switch than locators within public ecozones. In terms of electricity source, locators that do not source electricity from Meralco or any electric cooperative are 7.2 percentage points (= 68.6% – 61.4%) more likely to switch than locators that do.

In summary, switching to natural gas involves both knowledge and the technology employed in the production process. Crucial to increasing the probability of switching is the extent of knowledge about natural gas, that it is cost competitive, that firms use heating in their production process, type of ecozone locators are in, and electricity provider. Hence, energy intensive manufacturing locators with more expensive fuel sources are more likely to switch.

Given the results above, we can determine which among the SEZs are more likely to switch considering the type of locators operating in their area. We do this by computing the predicted likelihood of switching of each locator using the parameter estimates from Table 11. We then sum up the predicted value, weighted by the locators' size per ecozone. Table 12 presents the results of predicted likelihood of switching by ecozone. The estimates using *logit* and OLS resulted in almost the same ranking of SEZs. Keppel Philippines Marine SEZ ranks first in the likelihood to switch at 83.14% (Column 1), followed by Greenfield Automotive Park (81.02). SEZs that are least likely to switch are Victoria Wave Special Economic Zone at 24.73%, followed Mactan Economic Zone (33.38%) and Pampanga Economic Zone (35.65%).

Table 12. Likelihood to switch to natural gas, Ranking by SEZs

Ecozone	Municipality, Province	Logit		OLS	
		Weighted Mean (%)	Rank	Weighted Mean (%)	Rank
		[1]	[2]	[3]	[4]
Keppel Philippines Marine SEZ	Bauan, Batangas	83.14	1	83.04	1
Greenfield Automotive Park	Sta. Rosa, Laguna	81.02	2	80.80	2
Laguna Technopark Annex	Biñan, Laguna	78.91	3	77.87	3
MacroAsia Ecozone	Pasay	76.61	4	75.44	4
Laguna International Industrial Park	Biñan, Laguna	74.94	5	73.84	5
Cebu Light Industrial Park	Lapu-Lapu, Cebu	73.16	6	73.48	6
Lima Technology Center	Malvar and Lipa, Batangas	68.76	7	68.99	7
West Cebu Industrial Park	Balamban, Cebu	67.49	8	66.86	8
Golden Mile Business Park	Carmona, Cavite	66.28	9	64.79	9
TECO Industrial Park	Mabalacat, Pampanga	65.37	10	64.18	10
Calamba Premiere International Park	Calamba, Laguna	62.85	11	62.81	11
First Philippine Industry Park	Sto. Tomas, Batangas	58.80	14	60.42	12
People's Technology Complex	Carmona, Cavite	58.75	15	59.43	13
Filinvest Technology Park Calamba	Calamba, Laguna	59.26	13	58.57	14
Golden Gate Business Park – Cavite Export Processing Zone	Carmona, Cavite	60.53	12	57.81	15
Carmelray Industrial Park II	Calamba, Laguna	58.16	16	57.25	16
Baguio City Economic Zone	Baguio, Benguet	56.98	17	56.08	17
Light Industry & Science Park I	Cabuyao, Laguna	52.43	18	52.38	18
Laguna Technopark SEZ	Sta. Rosa and Biñan, Laguna	49.65	19	49.08	19
Light Industry & Science Park II	Calamba, Laguna	44.63	20	45.07	20
Toyota Sta. Rosa (Laguna) SEZ	Sta. Rosa, Laguna	42.47	21	42.15	21
Pampanga Economic Zone	Angeles, Pampanga	35.65	22	36.68	22
Mactan Economic Zone	Lapu-Lapu, Cebu	33.38	23	34.25	23
Victoria Wave SEZ	San Rafael, Bulacan	24.73	24	26.72	24

Figures 9a and 9b below provide a visual presentation of the probability of switching by city or municipality categorized by "very high," "high," "medium," and "low." In Luzon, Figure 9a shows that SEZs in Bauan, Batangas are very highly likely to consider natural gas as fuel followed by highly-likely-to-switch in Malvar and Lipa, Batangas. Pasay; Balamban, Cebu; Carmona, Cavite; and Mabalacat, Pampanga SEZs are also highly likely to switch to natural gas. SEZs in Angeles, Pampanga, and San Rafael, Bulacan on average, consider natural gas as a fuel but at a low likelihood.

Figure 9a. Likelihood to switch to natural gas, Luzon

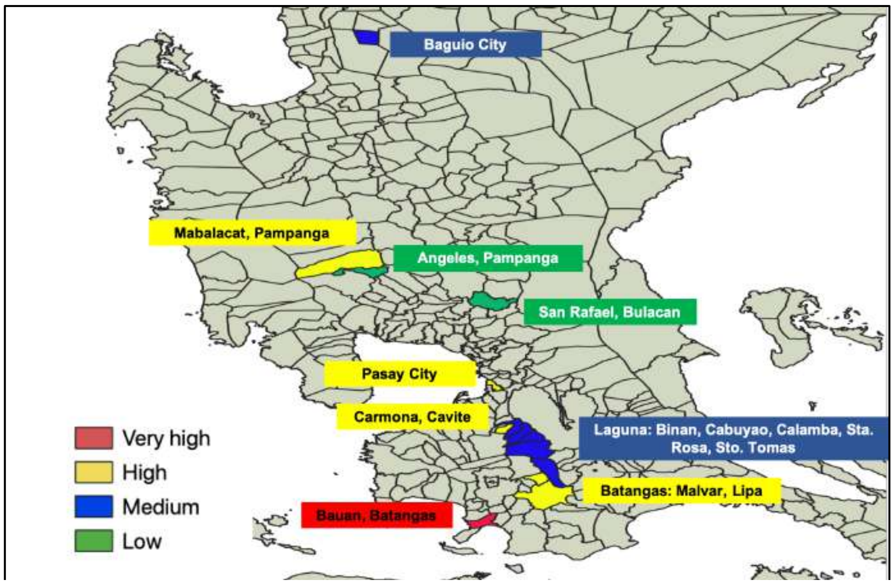
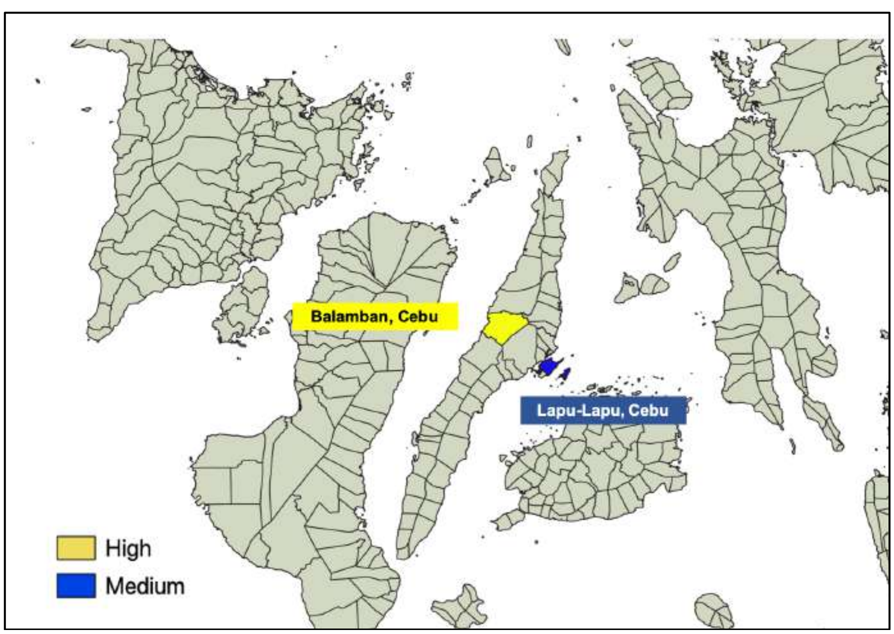


Figure 9b. Likelihood to switch to natural gas, Visayas



There are tangible benefits of switching to natural gas especially if it decreases the pollutants related with the use of "dirtier" fossil fuels. These pollutants not only harm the environment, but also cause serious respiratory health problems. The estimated monetary cost of all damages emanating from local pollutants can be substantial, insofar as these induces respiratory problems including coughing, wheezing, shortness of breath, or a tightness around the chest (Jandoc et al. 2018). There are several ways in which natural gas reduces damages: First, if the locator uses diesel in the production process and decides to switch to natural gas, then the reduction avoids the potential damages of diesel use. Second, if natural gas can be used as fuel in generating electricity inside the SEZs, damage cost associated with the use of diesel, oil, and coal in generating electricity could potentially be avoided. Switching to electricity generated using natural gas is possible, especially if the natural gas power plant is located inside the SEZ and is able to offer a lower rate than their current electricity distribution utility outside of the SEZs. We conducted a back-of the-envelope calculation of the avoided damage cost should diesel be replaced by natural gas in the heating process and should coal be replaced by natural gas in electricity generation. The results are presented in Table 13.

For those 73 locators that are open to switch and currently sourcing their electricity from a utility outside of SEZs, the total marginal avoided damage cost of SO2, NOx, and PM2.5 are USD 566, USD 40, and USD 69 per MWh, respectively. For those who are using diesel in their production processes and are open to switch, the total marginal avoided damage cost of SO2, NOx, and PM2.5 are USD 4, USD 12, and USD 0.37 per MWh, respectively.

Table 13. Marginal damage cost of local pollutants per MWh of electricity produced from fuel

Fuel	Fuel consumption (liter) [A]	Electricity produced per fuel (MWh/unit of fuel) [B]	Total electricity consumption from fuel (MWh) [A x B = C]	Marginal damage cost of local pollutant (in USD per MWh) [D]			Total marginal damage cost of local pollutant (in USD per MWh) [C x D = E]		
				SO2	NOx	PM2.5	SO2	NOx	PM2.5
Coal *	—	—	38.33 ***	14.76	1.05	1.79	565.77	40.25	68.61
Diesel **	287.43	0.01	3.06	1.16	4.06	0.12	3.55	12.41	0.37

Notes: Calculations are based only on locators willing to switch to natural gas (N = 73). *N_{coal} = 51; **N_{diesel} = 15; ***No locator uses coal as raw fuel. Value is computed from locators' Meralco electricity consumption. Authors use 31.05% as the percentage of coal used in producing Meralco electricity.

6. Concluding Remarks

The purpose of this research is to gauge the extent of the potential demand for natural gas among locators of the ecozones under the umbrella of PEZA. The first order of business is to identify those locators who are likeliest to switch to natural gas if this becomes available. At the moment locators' demand for power are met by electric distribution utilities and/or power generation units based on fuels other than natural gas. The second order of business is to gauge (a) their awareness of the natural gas potential for their respective firms and (b) their willingness to switch. We have dealt on these two issues in this paper. We confirm that the potential is greatest among firms that require for their production intense heat such as boilers, which at the moment is generated by burning less environmentally friendly fuels (say diesel or coal) other than natural gas. We confirm that switching is least likely among firms whose power needs are at the moment supplied by electric utilities.

Price, supply stability and reliability, and environmental concerns are among the top considerations for locators who show willingness to switch to natural gas. Price offered to the end-user would be influenced by several factors including the LNG virtual pipeline delivery system; the capital and operating expenditures of satellite or the small-scale LNG storage and regasification terminals to be located inside the SEZs, among others. Of course, locators also take into account the upfront capital cost of switching including the stranding cost of replaced equipment all of which may protract the decision to switch.

Natural gas as an alternate energy source would also allow for more competitive electricity costs owing to the current oversupply of natural gas in the world market and the relative ease of transport given the liquefaction technology. Furthermore, natural gas could play a crucial role in lowering the Philippines' carbon emissions given that natural gas emits 60% less carbon dioxide than coal. The use of natural gas is also an important step in the transition to a more renewable future as it can potentially ease the intermittency problem of solar and wind through its quick start-up and shutdown capacity (Anderson and Leach 2004; Lee et. al. 2012.). But the foci of these issues are outside the limited purview of this current study.

From a policy point of view, the results of our study suggest a potential growing market for LNG in the Philippines in addition to the requirement to fill the need due to the depletion of Malampaya gas field. The LNG industry is responding, and its development should be nurtured by appropriate regulation. There will also be a need for more intense information drive on the minutiae of switching if and when natural gas becomes available.

Adherence to Privacy and Ethical Requirements

The proposal to conduct the survey has been examined and validated exempt from review by the Ateneo de Manila University Research Ethics Committee.[8] As such, the conduct of the survey fulfilled the technical requirements necessary to demonstrate the use of ethical procedure in research involving human respondents. Implicit informed consent has been obtained from the participants because they have agreed to be interviewed. They have also been appropriately informed that answers are treated with utmost confidentiality. All data gathered from the survey are reported as an aggregate or average and do not refer to individual response.

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[8] See link for more information: https://www.ateneo.edu/research/university-research-ethics-office.

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