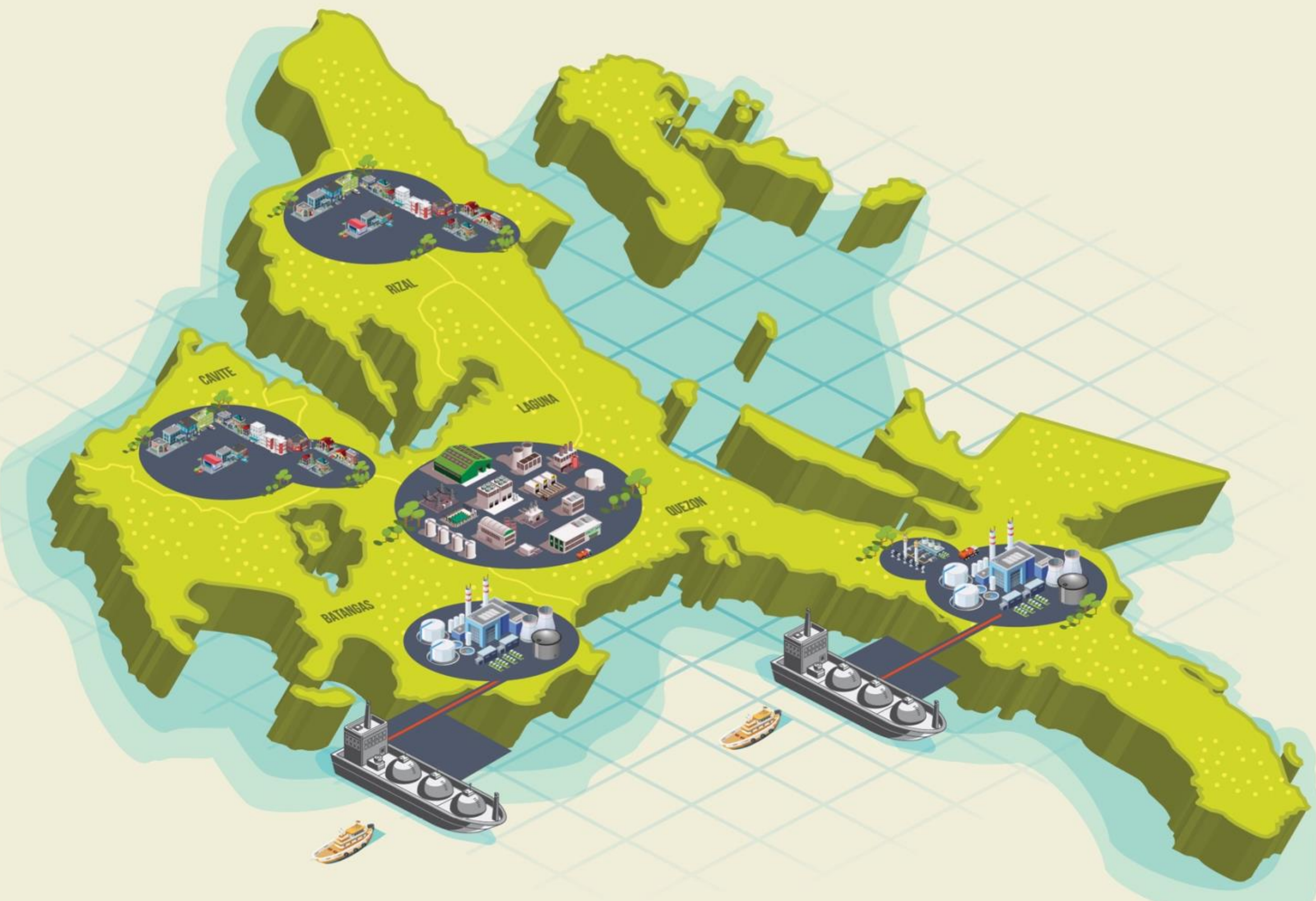
GAS POLICY DEVELOPMENT PROJECT

ASIA EDGE
Enhancing Development and Growth through Energy
The U.S. Government's Indo-Pacific Energy Initiative

UPSCRFI
University of the Philippines Statistical Center Research Foundation, Inc.

Market Profiling of Potential Natural Gas Users in Economic Zones



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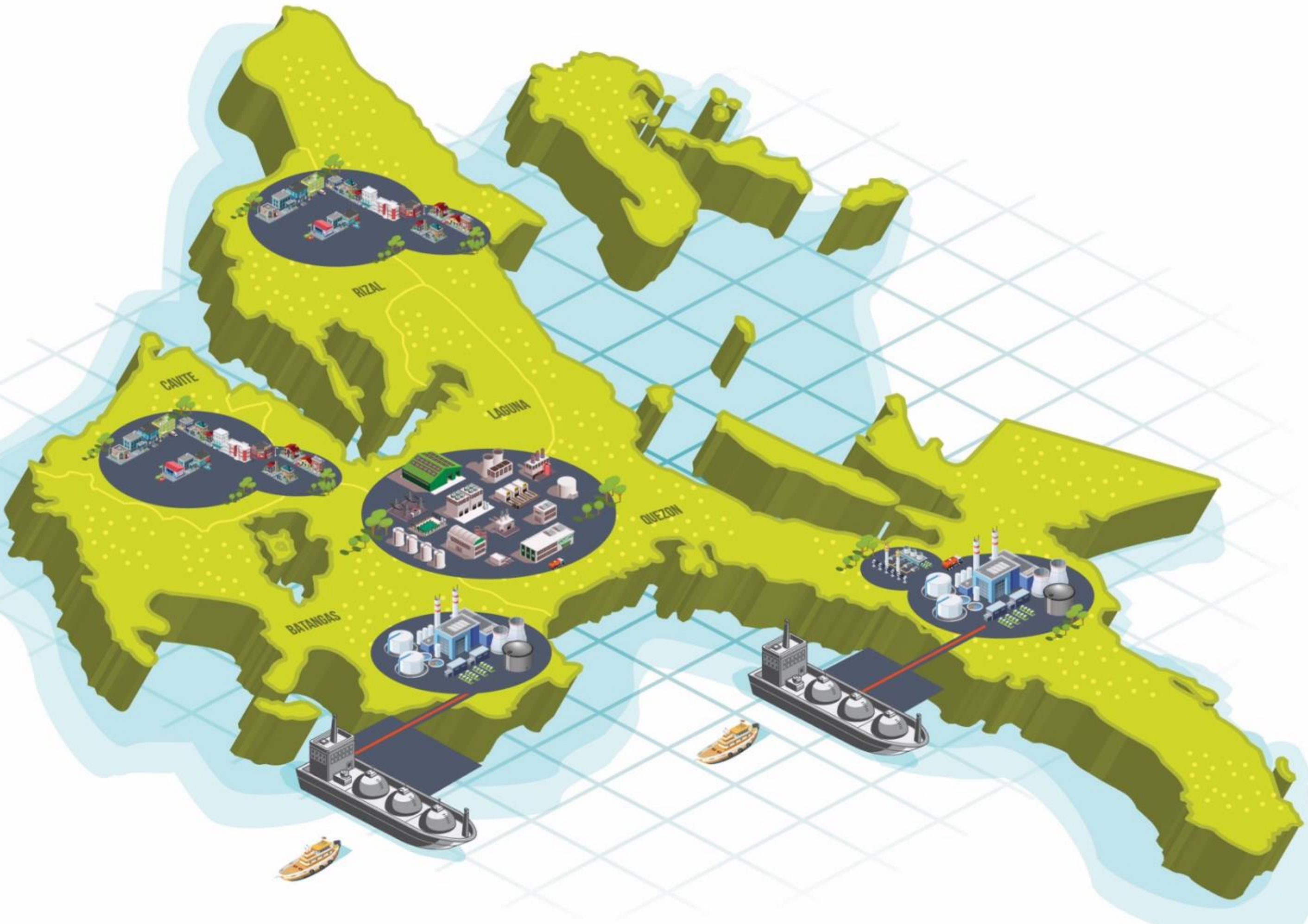

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Market Profiling on Potential Natural Gas Users in Economic Zones

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1. Introduction

Special economic zones (SEZs) are characterized as distinct areas where firms can benefit from lower export fees, taxes, import tariffs, less bureaucracy, inspections and paperwork (Farole, 2011 and Zeng, 2015 as cited in Davies et al., 2018). By providing such preferential policies, SEZs are able to provide an attractive environment for foreign direct investments and local exporting firms. It also paves the way for the adoption of new technologies and upgrading of skills. These are very important factors particularly to developing economies which aim to diversify their production base into manufacturing.

In 1995, the Special Economic Zone Act (Republic Act No. 7916) was passed by the Philippine Congress. The Act aims to promote investments, extend assistance, grant incentives, and facilitate the business operations of investors in export-oriented manufacturing and service facilities inside areas identified as Special Economic Zones (Philippine Economic Zone Authority (PEZA), n.d.). As of May 2020, there are 74 manufacturing economic zones, 291 I.T. centers and parks, 19 tourism ecozones, 3 medical tourism centers and parks, and 21 agro-industrial economic zones in the country. The manufacturing and agro-industrial economic zones are particularly important given the role of these industries in the structural transformation of an economy (Daway-Ducanes & Fabella, 2015; Ravago et al., 2019). Thus, it is necessary to determine systems and procedures that will improve their productivity and efficiency.

Due to their specialized facilities and technology, SEZ locators' energy demand and intensity are recognizably much greater than those of their non-SEZ counterparts. SEZ locators, those using specialized energy-intensive production technology processes, make them good candidates for direct users of liquefied natural gas (LNG). These ecozone locators currently use the more expensive and less environment-friendly diesel fuel in their heating production process. LNG offers a cleaner alternative to these SEZ locators.

Given the existing technologies among SEZ locators, an investigation on how they can adapt and switch to LNG is critical as the LNG industry is emerging. Previous studies (Japan International Cooperation Agency, 2011; Oil Industry Management Bureau, 2012; Ravago et al., 2021a) have acknowledged the potential of LNG in SEZs, noting however the need for information campaigns amongst SEZs regarding LNG (e.g., actual switch investment capitalization, price trajectory of LNG in tandem with available supply of LNG), technology transition programs, and assessment of strategic geographical locations for LNG distribution centers.

With the foregoing, the objective of this study is to update the profile and activities of the existing economic zones, identifying locators with energy-intensive operations in the CALABARZON, Clark, Subic, and Bataan areas and to determine the interest of locators in SEZs to convert to natural gas. We also aim to identify the economic, technical, and technological requirements for doing the conversion (e.g., savings that can be derived from the switching; costs that will be incurred for the required technology, etc.).

The rest of the paper is structured as follows: Section 2 details the design, materials, and methods used in the data collection. Section 3 presents and discusses the preliminary results. Finally, Section 4 provides the concluding remarks.

2. Design, Materials, and Methods

Figure 1 presents the flow chart of our study from data collection to analysis. To achieve our first objective of profiling the energy-intensive locators, we conducted a survey that aims to characterize the profile of SEZ locators and identify those with energy-intensive operations that are likely to adopt natural gas in their existing production processes. Our second objective is to identify the economic, technical, and technological requirements for doing the conversion. To this end, we conducted a consultative meeting with representatives from Tokyo Gas Co., Ltd., Japan's largest natural gas utility to gather insights from their experience in Japan and other countries.

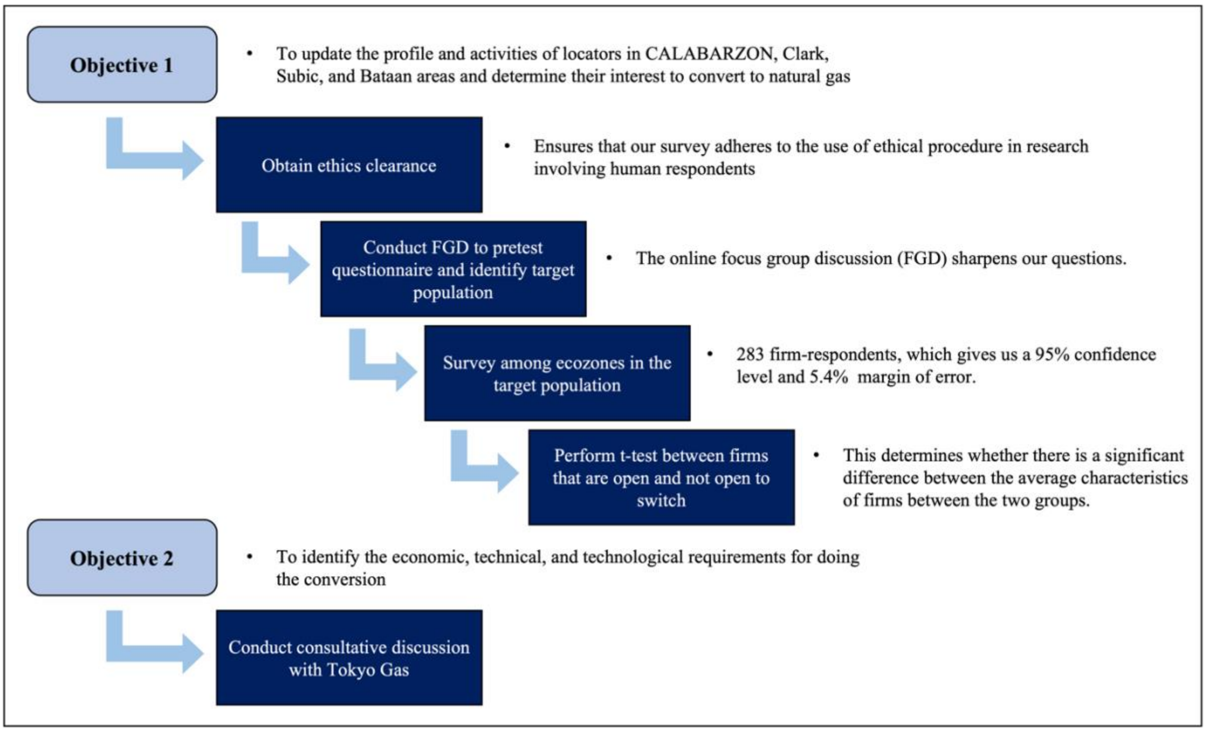


Fig. 1. Flow chart of the study.

Prior to implementing our survey, we obtained clearance from the Ateneo de Manila University Research Ethics Office (AdMUREO) to ensure that our survey followed the protocols and ethical procedures in conducting research involving individual participants and that it adheres to the data privacy act of the Philippines. The survey was implemented online from September 3 to October 19, 2021, among locators registered with PEZA in priority areas identified by the Department of Energy (DOE). The areas covered are CALABARZON, which includes the provinces of Cavite, Laguna, Batangas, Rizal, and Quezon, and the other contiguous area of the province of Zambales (Subic), Pampanga (Clark), and Bataan. The ecozones in these areas are classified as either manufacturing, information technology, tourism, agro-industrial, medical tourism, and logistics services ecozone. This survey also expands the survey conducted in 2019 on energy and fuel use of firms in economic zones in the Philippines, which covered only Laguna, Batangas, Cavite, Cebu, Pampanga, Benguet, Bulacan, and Metro Manila (Ravago et al., 2021a, 2021b). Hereafter, we refer to the survey in 2019 as the first survey.

2.1. Survey

We first organized a focus group discussion (FGD) among locators to pretest the survey instrument for clarity and ease of understanding. The FGD was conducted on July 9, 2021, via Zoom meeting owing to the Coronavirus Disease (COVID-19) pandemic. We had three representatives from the Laguna Technopark as participants, who are knowledgeable on the production and environmental aspect of their respective business operation. Laguna Technopark was chosen as the participating ecozone since it registered the greatest number of participants in the first survey. These three locators were also among the respondents of the first-round survey.

The FGD revealed that the current facilities of the locators are not designed for natural gas use. One participant uses fuels such as kerosene and LPG in its production processes. They are also not familiar with high-efficiency equipment such as regenerative and once-through burners that are compatible with natural gas. The FGD also revealed that locators are concerned with the safety, efficiency, price, and storage of natural gas. The locators would consider switching more seriously if there was an available fueling or regasification facility inside the ecozone. In addition, they also mentioned that partial or total replacement of some equipment will be needed before natural gas can be used in their production. These include melting furnaces, chillers, and compressors. When asked about their natural gas requirements in case of switching, the participating locators were not confident in their estimates, indicating limited knowledge on the use of natural gas in their production processes.

The survey instrument is a self-administered online questionnaire. Table 1 presents the coverage of the questionnaire. The questionnaire has 11 sections about general and company information, production schedule and operation, power generation, production, utilities, and aptitude on alternative fuels and primary energies, energy efficiency and conservation, environmental issues and perceptions, business operation during the COVID-19 pandemic, among others. A copy of the questionnaire is in Appendix A. The survey was implemented using SurveyMonkey, a subscription-based survey platform.[1] PEZA endorsed a memorandum to the target ecozones, which was then cascaded by the respective zone managers with the URL link of the survey to the locator-respondents.

[1] See more at https://www.surveymonkey.com.

Table 1. Coverage of survey questionnaire.

Section no.	Section title	Content
—	—	About the survey, administrator contact information, informed consent notice, general instructions
I.	General and company information	Ecozone, company, and geographical information, industrial classification, personnel book value
II.	Production schedule and operation	Production sales, peak and low month schedule and operation
III.	Power generation	Electricity sources, requirements, usage, considerations, and productions processes and equipment that use electricity
IV.	Fuels used in production	Importance, uses, procurement, consumption, and expenditure on different types of fuel in main production processes
V.	Utilities	Electricity and water consumption and expenditure
VI.	Aptitude on alternative fuels and primary energies	Knowledge, considerations, and opinions on alternative fuels and primary energies, and experiences in using them
VII.	Energy efficiency and conservation	Energy efficiency and conservation measures
VIII.	Environmental issues and perceptions	Awareness and opinions on environmental issues
IX.	Business during Covid	Impacts of Covid-19 pandemic on operations and personnel
X.	Other questions	Business expansion considerations
XI.	Respondent information	

We employed a simple random sampling procedure for our 63 target ecozones with 1,864 total number of operating locators as our target population (Table 2). This number excludes locators that are under construction, still in inception phase, not yet producing, temporarily closed, power generation companies, or retail electricity suppliers (RES). The complete list of ecozones is provided in Appendix B.

Given the target population size, the ideal sample size is 234 locators with a 6% error margin and at a 95% confidence level. We received a total of 283 unique and complete responses, allowing us to interpret results with 95% confidence level and a 5.4% margin of error. A response is unique if it has no duplicate in terms of both the enterprise name and ecozone location. There exist enterprises that are under the same name but located in multiple ecozones. These have been excluded. A response is complete if the respondent answered all required questions and successfully clicked the 'Submit' button on the last page of the survey. Respondents representing the firms are directors, supervisors, managers, or officers for production, finance, human resource, pollution control, environment, safety, and health, facilities, and equipment. If there were ambiguous responses to any of the questions, we conducted follow-up inquiries to the locators to clarify.

Table 2. Number of ecozones and locators in priority areas and sample size.

Priority area	No. of ecozones	No. of operating locators
CALABARZON	56	1,839
Subic, Clark, and rest of Bataan	7	25
Target population	63	1,864
Target sample size, 95% confidence and 6% margin of error		234
Actual sample size, 95% confidence and 5.4% margin of error		283

Note: The number of ecozones is based on latest available data as of July 2021.

2.2. Consultative meeting with Tokyo Gas Co., Ltd.

To complement the information from the survey, we conducted a consultative meeting with representatives from the Tokyo Gas Co., Ltd. on May 21, 2021 and March 30, 2022. We obtained insights and information on the technical requirements and limitations of switching to natural gas based on their years of experience in the industry. We asked information on the potential savings that can be derived from the switching; the costs that will be incurred for the required technology, among others.

2.3. Statistical analysis

Using the data obtained from the survey, we performed a simple t-test between the two groups of firm locators, those that are open and not open to switch to natural gas. This simple statistical analysis allowed us to determine whether there is a significant difference between the average characteristics of firms between the two groups.

3. Results and Discussion

We present results of our survey focusing on the firms' openness to switch to natural gas and their knowledge of natural gas. We then complement the results of the survey with the information we gather from our consultative discussion with Tokyo Gas, identifying the economic, technical, and technological requirements for doing the conversion. We also explore the role of natural gas as replacement for less clean fuels and its feasibility as a "bridge fuel" to facilitate efficient transition to even cleaner energy by examining respondents' awareness to environmental issues.

3.1. Openness to switch to natural gas

Table 3 shows that most of the locator respondents are concentrated in Laguna (48%), Cavite (30%), and Batangas (19%) provinces. Figure 2 presents the openness to switching of locators in each province. For the provinces that registered a significant number of respondents, there is some hesitancy in adopting natural gas in production. In Laguna, only 53 firms (39%) are open to switching to natural gas, while the remaining 61% are not open. Likewise, only 35 firms (41%) and 20 firms (36%) are open in Cavite and Batangas, respectively.

Table 3. Number of respondents per province.

Province	N	%
Laguna	137	48.4
Cavite	85	30.0
Batangas	55	19.4
Bataan	2	0.7
Zambales	2	0.7
Pampanga	1	0.4
Quezon	1	0.4
Total	283	100.0

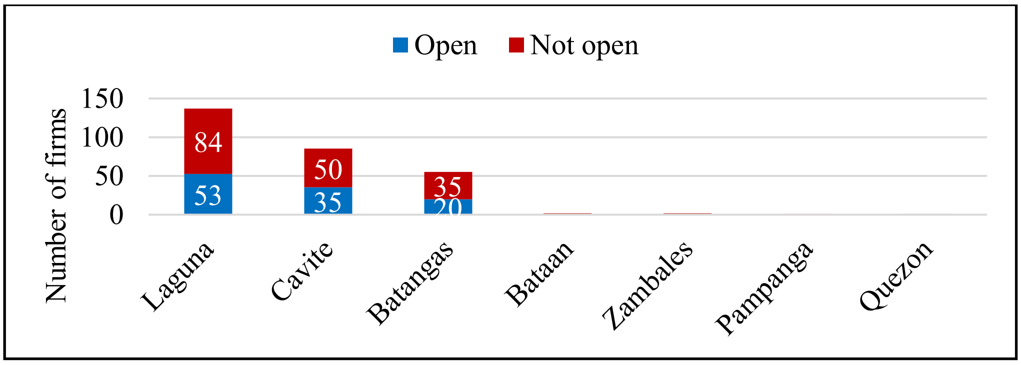


Fig. 2. Openness to switch to natural gas by province.

Across ecozones, the results show that there are fewer firms that are open to switch to natural gas (Table 4). Majority of the firms in ecozones with ten or more respondents are not open to switch. Overall, only 39% of the locators in our sample are open to switching to natural gas.

Table 4. Openness to switch to natural gas by ecozone.

Ecozone	Open		Not open		Total	
	N	%	N	%	N	%
Cavite Economic Zone	19	43.2	25	56.8	44	100.0
Laguna Technopark	11	26.8	30	73.2	41	100.0
Carmelray Industrial Park II	13	46.4	15	53.6	28	100.0
First Philippine Industrial Park	12	46.2	14	53.8	26	100.0
Calamba Premiere International Park	11	50.0	11	50.0	22	100.0
Lima Technology Center	6	42.9	8	57.1	14	100.0
Light Industry & Science Park I	5	38.5	8	61.5	13	100.0
First Cavite Industrial Estate	5	45.5	6	54.5	11	100.0
Greenfield Automotive Park	4	40.0	6	60.0	10	100.0
Laguna International Industrial Park	5	55.6	4	44.4	9	100.0
Golden Mile Business Park	3	33.3	6	66.7	9	100.0
People's Technology Complex	2	22.2	7	77.8	9	100.0
First Philippine Industrial Park II	1	11.1	8	88.9	9	100.0
Suntrust Ecotown Tanza	2	40.0	3	60.0	5	100.0
Golden Gate Business Park-Cavite Export Processing Zone	2	50.0	2	50.0	4	100.0
Carmelray Industrial Park	2	50.0	2	50.0	4	100.0
Light Industry & Science Park II	1	25.0	3	75.0	4	100.0
Light Industry & Science Park III	0	-	3	100.0	3	100.0
First Industrial Township - SEZ	1	50.0	1	50.0	2	100.0
Keppel Philippines Marine Special Economic Zone	1	50.0	1	50.0	2	100.0
Daiichi Industrial Park	1	50.0	1	50.0	2	100.0
Hermosa Ecozone Industrial Park	1	50.0	1	50.0	2	100.0
Filinvest Technology Park - Calamba	0	-	2	100.0	2	100.0
Gateway Business Park	1	100.0	0	-	1	100.0
Laguna Technopark Annex	1	100.0	0	-	1	100.0
Candelaria Agri Special Economic Zone	1	100.0	0	-	1	100.0
NYK-TDG I.T. Park	0	-	1	100.0	1	100.0
Toyota Sta. Rosa (Laguna) Special Economic Zone	0	-	1	100.0	1	100.0
YTMI Realty Special Economic Zone	0	-	1	100.0	1	100.0
SM City Clark IT Park	0	-	1	100.0	1	100.0
Subic Shipyard Special Economic Zone	0	-	1	100.0	1	100.0
Total	111	39.2	172	60.8	283	100.0

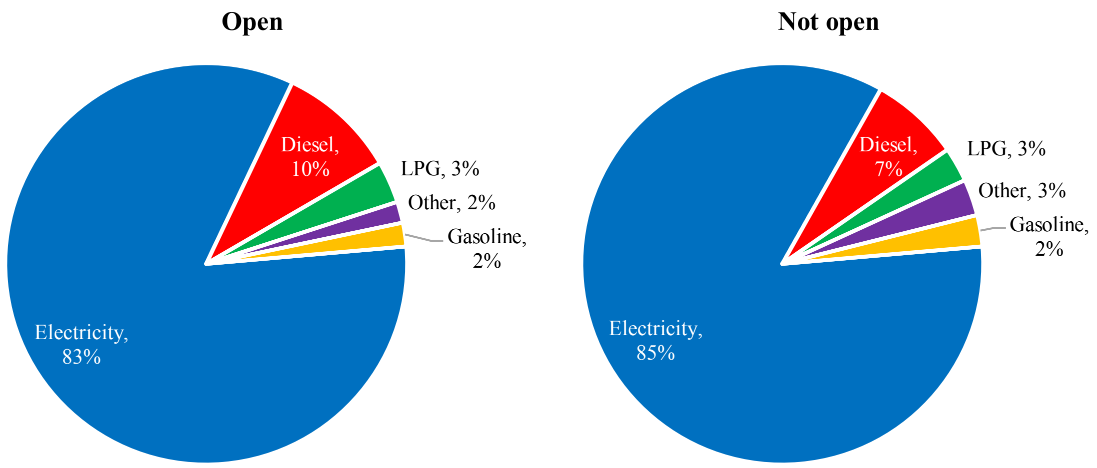
We grouped locators according to the 2009 Philippine Standard Industrial Classification (PSIC). This allows for clustering locators that are likely to have similar production processes. Table 5 shows the number and percentage of locators who are open and not open to switch by industry class. Except for firm-locators engaged in warehousing and transportation support (H52), and manufacturing of motor vehicles and basic metals (C29), all others are not open to switch. The results show reluctance towards natural gas use for most firm-locators engaged in manufacturing including manufacturers of paper and products, computer, electronic, and optical products, food products. It is worth noting that these industries in the not open group are the heavy users of fuel for their production.

Table 5. Openness to switch to natural gas by industry class.

Industry class	Open		Not open		Total	
	N	%	N	%	N	%
C10 - Food products	1	33.3	2	66.7	3	100.0
C12 - Tobacco products	1	100.0	0	-	1	100.0
C14 - Wearing apparel	4	44.4	5	55.6	9	100.0
C15 - Leather and related products	0	-	1	100.0	1	100.0
C17 - Paper and paper products	1	12.5	7	87.5	8	100.0
C20 - Chemicals and chemical products	0	-	2	100.0	2	100.0
C22 - Rubber and plastic products	16	45.7	19	54.3	35	100.0
C24 - Basic metals	3	60.0	2	40.0	5	100.0
C25 - Fabricated metal products, except machinery and equipment	13	50.0	13	50.0	26	100.0
C26 - Computer, electronic and optical products	7	25.9	20	74.1	27	100.0
C27 - Electrical equipment	3	50.0	3	50.0	6	100.0
C28 - Machinery and equipment, n.e.c.	3	37.5	5	62.5	8	100.0
C29 - Motor vehicles, trailers and semi-trailers	4	66.7	2	33.3	6	100.0
C32 - Other manufacturing*	34	33.7	67	66.3	101	100.0
C33 - Repair and installation of machinery and equipment	2	40.0	3	60.0	5	100.0
E38 - Waste collection, treatment and disposal activities; materials recovery	0	-	2	100.0	2	100.0
H52 - Warehousing and support activities for transportation	17	58.6	12	41.4	29	100.0
I56 - Food and beverage service activities	1	100.0	0	-	1	100.0
J62 - Other information technology and computer service activities	0	-	1	100.0	1	100.0
J63 - Information service activities	0	-	1	100.0	1	100.0
L68 - Real estate activities	0	-	2	100.0	2	100.0
N77 - Rental and leasing activities	1	50.0	1	50.0	2	100.0
N82 - Call centers activities (voice)	0	-	1	100.0	1	100.0
P85 – Education	0	-	1	100.0	1	100.0
Total	111	39.2	172	60.8	283	100.0

Note: *Includes manufacturing of dental products and other products not specified by respondents.

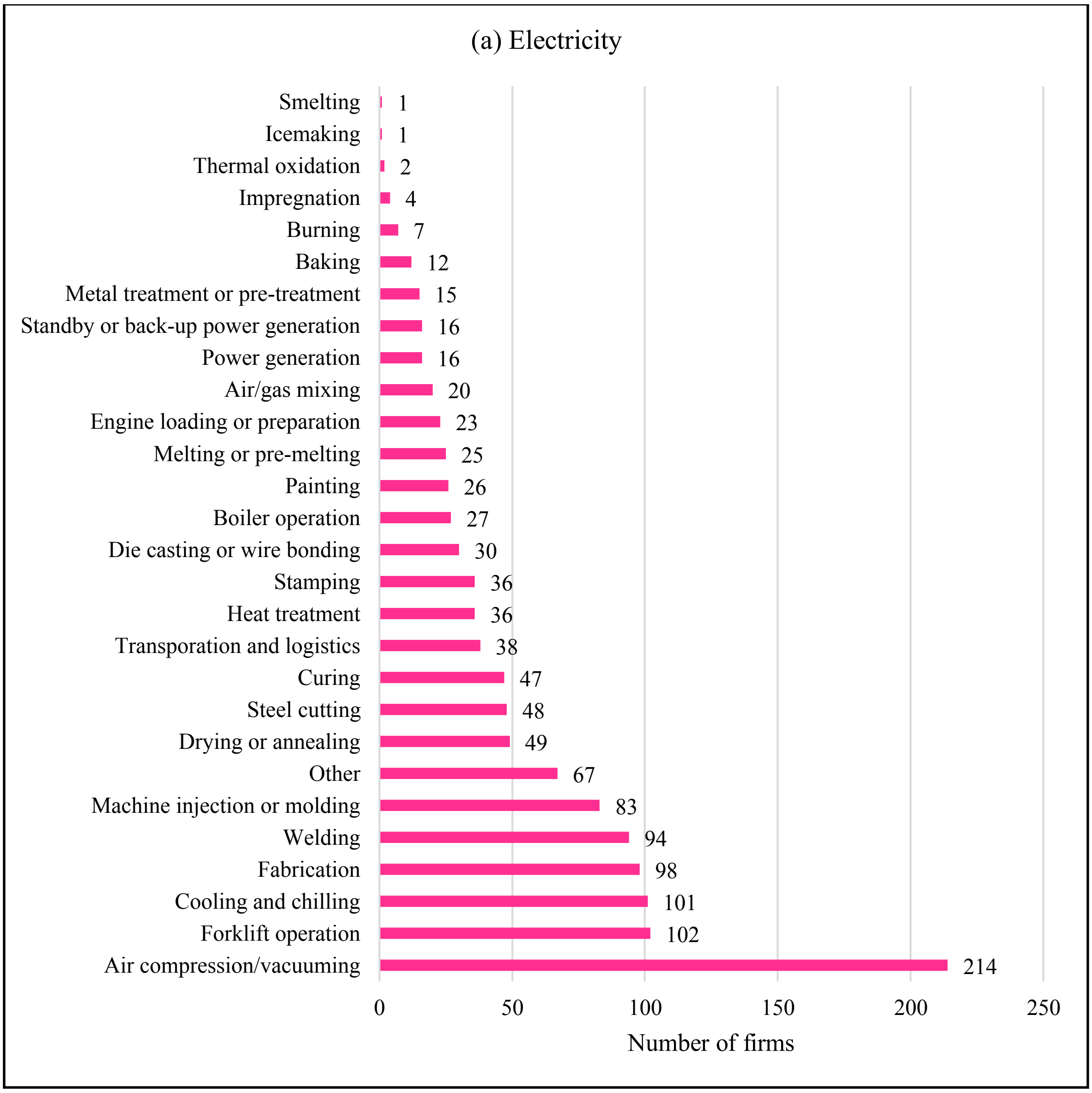
Currently, purchased electricity is the main fuel used by the locator-firms in their production. Figure 3 shows that among the those that are open to switch and not open to switch, 83% and 85% use electricity, respectively. Diesel and liquefied petroleum gas (LPG) come second and third.



Notes: Bunker, coal, natural gas, and propane were also included as options. "Other" category includes kerosene and biodiesel.

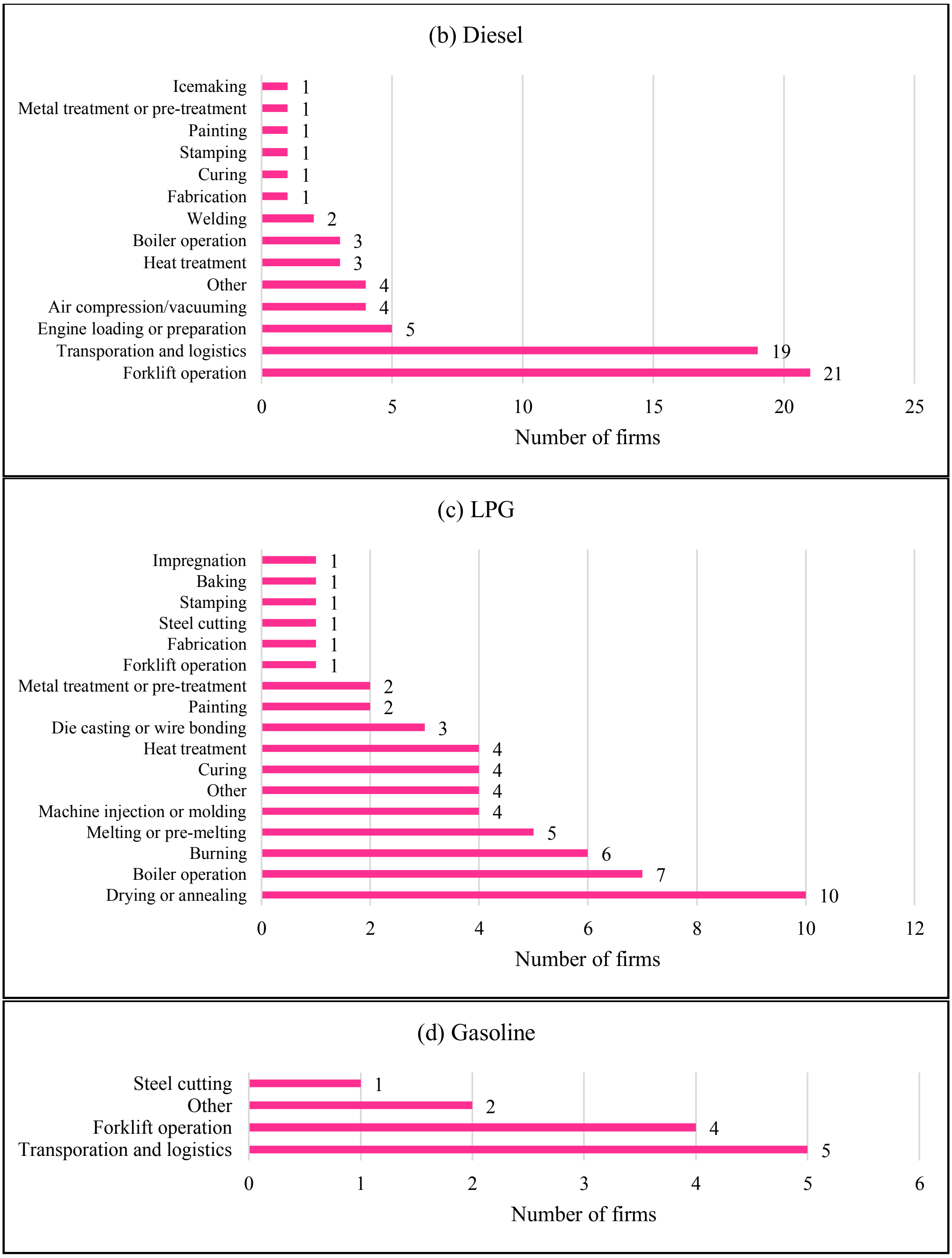
Fig. 3. Fuel mix used in production, by openness to switch.

Exploring further the locators' fuel use, we see in Figure 4a that electricity is intensively used to power equipment for air compression or vacuuming, forklift operation, cooling and chilling, fabrication, and welding. Diesel, on the other hand, is mainly used as fuel in forklift operation, transportation and logistics, and engine loading or preparation (Figure 4b). However, based on Figures 4c and 4d, LPG is used mostly as feedstock for production processes that involve drying or annealing, burning, machine injection or molding, curing, and dies casting or wire bonding, while gasoline is for processes that involve transportation and logistics and forklift operation.



Notes: Cooling or chilling, power generation, and standby or back-up power generation are response options only available in the question on electricity use in production. All other production processes that are not presented in the figures were available as response options but were not chosen at least once during the survey.

Fig. 4. Production process by fuel used.

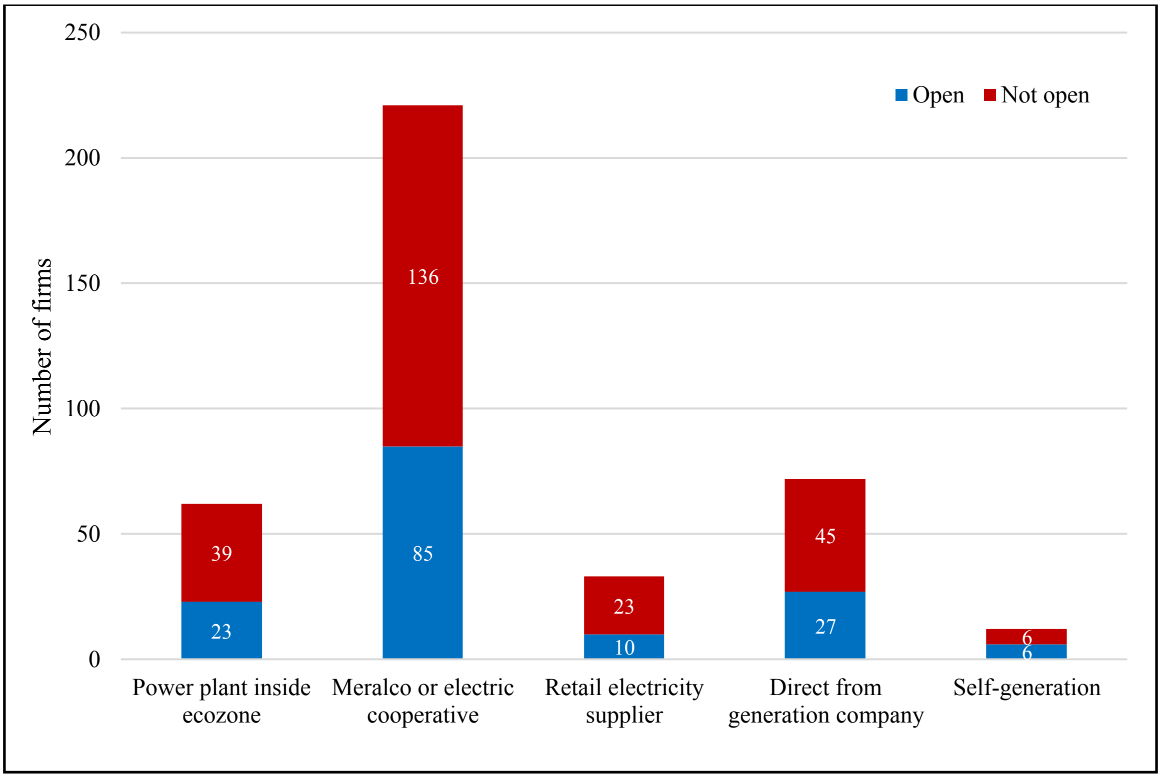


Notes: Cooling or chilling, power generation, and standby or back-up power generation are response options only available in the question on electricity use in production. All other production processes that are not presented in the figures were available as response options but were not chosen at least once during the survey.

Fig. 4. Production process by fuel used (cont.).

As shown above, production processes of many locator-firms are mainly powered by electricity. Where do they source their electricity? Figure 5 shows that 221 (out of the

242) or 91% of the locators are being supplied by Meralco (wherever available) or electric cooperatives. Furthermore, 72 (or 30%) locators source electricity directly from the generation companies, 62 (or 26%) from power plants inside the state-operated ecozone, 33 (or 14%) from retail electricity suppliers, and 12 (or 5%) from self-generation. Note that a locator can have multiple sources of electricity.



Notes: The data above exclude the information from 41 respondents who answered the same question in the first survey but with different reference period.

Fig. 5. Locators' sources of electricity.

Table 6 characterizes the locators by their book value[2] and annual production sales in 2020. Relatively more firm locators have book value and production sales of one billion and below. Across these sizes, there are fewer locators who are more open to switching to natural gas. Out of those with book value of one billion and below, only 40% of them are open to switch. From those with production sales of also less than a billion, only 39% are open to switch.

[2] Book value refers to the initial or acquisition cost of tangible fixed assets less accumulated depreciation charges. Tangible fixed assets refer to physical assets required and for use of the company and is expected to have a productive life of more than one year. They include land, buildings, other structure and land improvements, transport equipment such as cars, trucks, aircrafts, and ships, machinery and equipment, valuables such as paintings and sculptures, and other tangible fixed assets such as fixtures and furniture.

Table 6. Openness to switch by book value size and production sales.

Value	Openness to switch by book value			Openness to switch by production sales		
	Open	Not open	Total	Open	Not Open	Total
1 billion and below	88	134	222	99	154	253
	(39.6)	(60.4)	(100.0)	(39.1)	(60.9)	(100.0)
Above 1 billion	7	13	20	12	18	30
	(35.0)	(65.0)	(100.0)	(40.0)	(60.0)	(100.0)
Total	95	147	242	111	172	283
	(39.3)	(60.7)	(100.0)	(39.2)	(60.8)	(100.0)

Notes: The data above exclude the information from 41 respondents who answered the same question in the first survey but with different reference period. Numbers in parentheses are percentages.

Same patterns emerge when firm-locators are grouped by product destination (Table 7). Among the locators who sell their products domestically, only 35% are open to switching. The same is true for those who exclusively export and those who cater to both export and domestic markets – fewer firms are open to switching. Across firms that are open to switch, those that exclusively export are relatively more receptive to natural gas adoption. This reflects the characteristics of locators inside the ecozone, i.e., exporters receive more incentives than those whose products are sold only domestically.

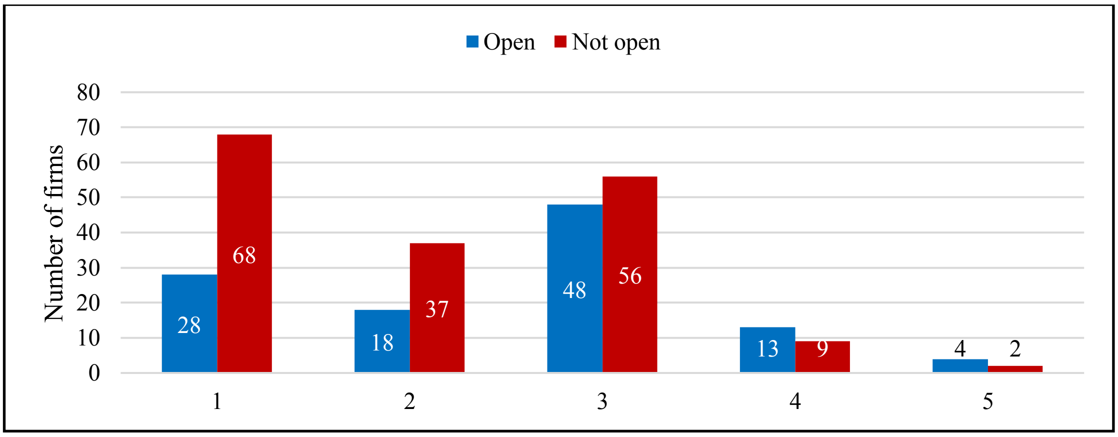
Table 7. Openness to switch by product destination.

Product destination	Open	Not open	Total
Sold domestically	16	30	46
	(34.8)	(65.2)	(100.0)
Exported	45	56	101
	(44.6)	(55.4)	(100.0)
Both	34	61	95
	(35.8)	(64.2)	(100.0)
Total	95	147	242
	(39.3)	(60.7)	(100.0)

Notes: The data above exclude the information from 41 respondents who answered the same question in the first survey but with different reference period. Numbers in parentheses are percentages.

3.2. Respondents' knowledge and perception of natural gas

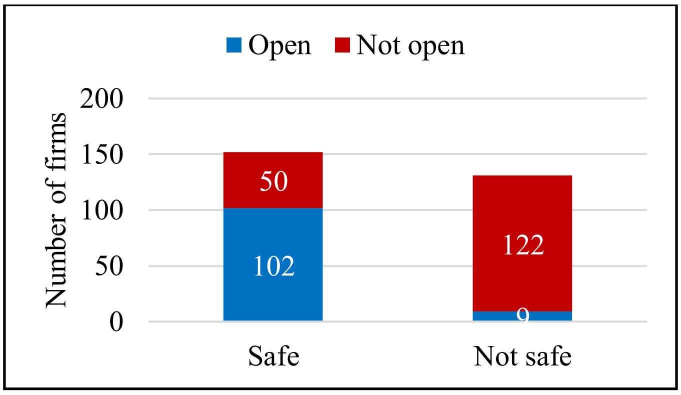
We investigate the respondents' extent of knowledge of natural gas, considerations before switching, perception on safety and cost competitiveness relative to their existing fuels, openness with the presence of regasification stations, among others. Figure 6 shows a greater number of firm-locators have limited to average knowledge (1 to 3) versus firm-locators with more advanced knowledge (4 to 5) of natural gas. It is also clear that the former tends to be more hesitant in adopting it as a fuel, while the latter tends to be more receptive to switching.



Note: Response to question "with 1 being limited, and 5 being advanced, what is the extent of your knowledge on natural gas as fuel?"

Fig. 6. Respondents' extent of knowledge.

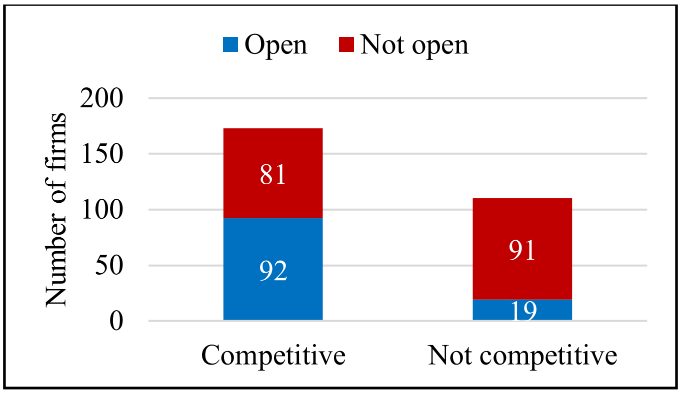
Based on perceived safety, 152 or 58% of the respondents think that natural gas is safe to use as a fuel in their existing production processes (Figure 7). Out of the 152 respondents, 67% are open to switching, while the remaining 33% are not open.



Note: Response to question "do you think natural gas is safe to utilize as fuel in your production process?"

Fig. 7. Respondents' perception on the safety of natural gas.

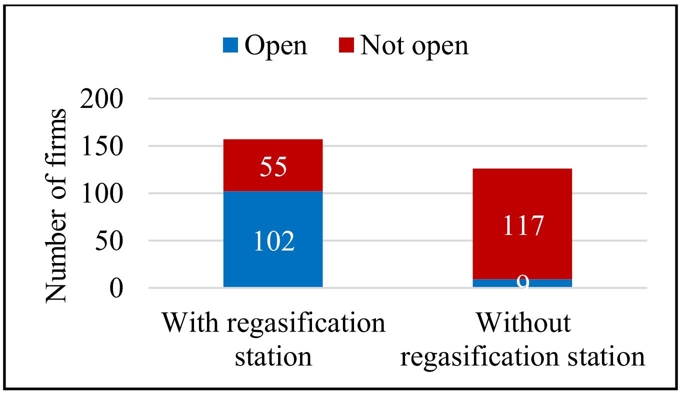
Figure 8 shows that 173 or 61% of the locators consider natural gas as a competitive fuel in terms of cost relative to their existing fuels and energy sources. Out of this number, more locators are open to adopting natural gas (at 53%) than those who are not.



Note: Response to question “do you think natural gas is cost-competitive relative to the fuels and primary energies you are currently using?”

Fig. 8. Respondents’ perception on cost-competitiveness of gas.

If and when natural gas becomes widely available, a number of locators (N = 157) signified interest in switching if there is an accessible fueling or regasification station inside their respective ecozones (Figure 9). The majority firm locators (65%) are open to switching which implies that more locators are open to switching if access is easier.



Note: Response to question “would you consider switching to natural gas if there is a fuelling/ regasification station inside your ecozone?”

Fig. 9. Respondents’ consideration to switching to natural gas if there is a fuelling/ regasification station inside your ecozone.

When asked about their preferred mode of delivery in case natural gas becomes available, there is strong preference for natural gas to be supplied via conventional pipelines among both open and non-open groups (Table 8). In addition, land (e.g., trailers, lorries, railroad trains) and water (e.g., LNG carriers, ships, barges) virtual pipelines are not preferred modes of delivery. More specifically for the open-to-switch group, only 34% are in favor of land virtual pipelines, and only 30% for the water virtual pipelines.

Table 8. Preferred mode of natural gas delivery.

Response	Open			Not open		
	Land virtual pipeline	Water virtual pipeline	Conventional pipeline	Land virtual pipeline	Water virtual pipeline	Conventional pipeline
Yes	38 (34.2)	15 (13.5)	74 (66.7)	52 (30.2)	14 (8.1)	101 (58.7)
No	73 (65.8)	96 (86.5)	37 (33.3)	120 (69.8)	158 (91.9)	71 (41.3)
Total	111 (100.0)	111 (100.0)	111 (100.0)	172 (100.0)	172 (100.0)	172 (100.0)

Note: Numbers in parentheses are percentages.

For locators that are considering the adoption of natural gas, diesel is the fuel that will most likely be replaced by natural gas in the main production processes, self- and back-up power generation (see Figure 10). In the production processes, diesel is followed by biodiesel, gasoline, and LPG as fuel to be replaced by natural gas. Moreover, natural gas is a likely replacement for gasoline, and LPG in self- and back-up power generation.

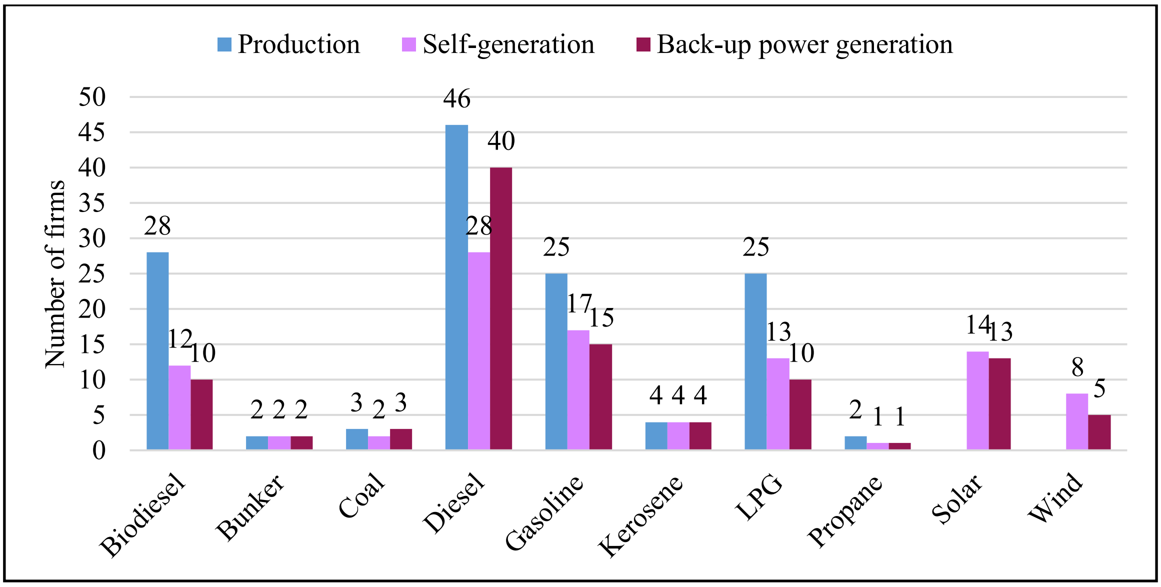


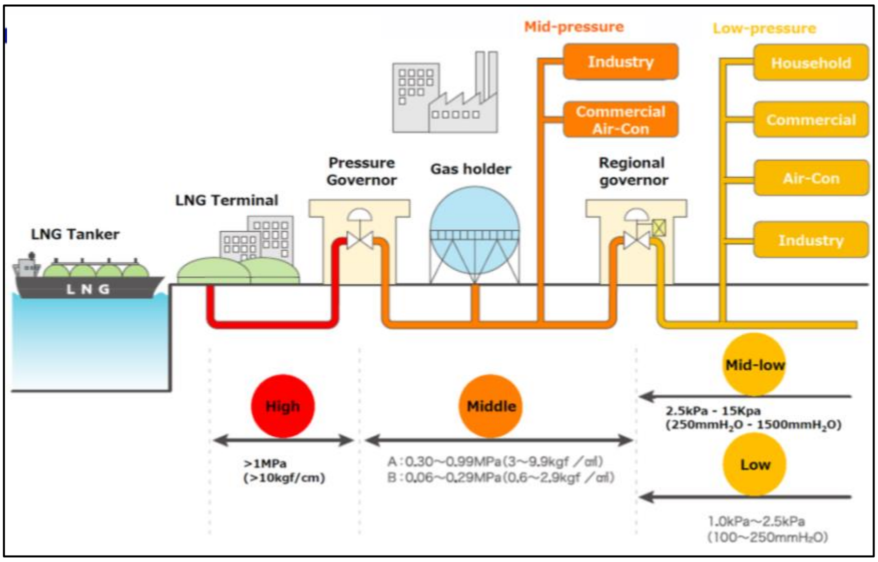
Fig. 10. Fuels likely to be replaced by natural gas in processes.

3.3. Requirements and limitations for switching

From our consultative meeting with Tokyo Gas Co., Ltd., we obtained insights on what technical requirements and limitations should be considered when locator firms switch to using natural gas. Based on their experience, a series of on-site inspections must be conducted before recommendations can be provided by the conversion service company. Payback period for switching is subject to the current conditions of facilities and is computed on a case-to-case basis.

The type of natural gas distribution system also affects the technological requirements. For a country that is building and expanding its natural gas industry, it must consider whether to replace existing pipelines and storage facilities or build new ones. There are two types of distribution system that are widely used: (1) direct connection via pipelines, and (2) delivery via lorries. For direct connection via pipelines, constructing an onsite storage facility may not be necessary. Pipelines for liquefied petroleum gas (LPG) cannot be used to deliver natural gas since their capacities are insufficient to transport natural gas. Natural gas has a lower caloric value per volume than LPG, so customized pipelines must be used.

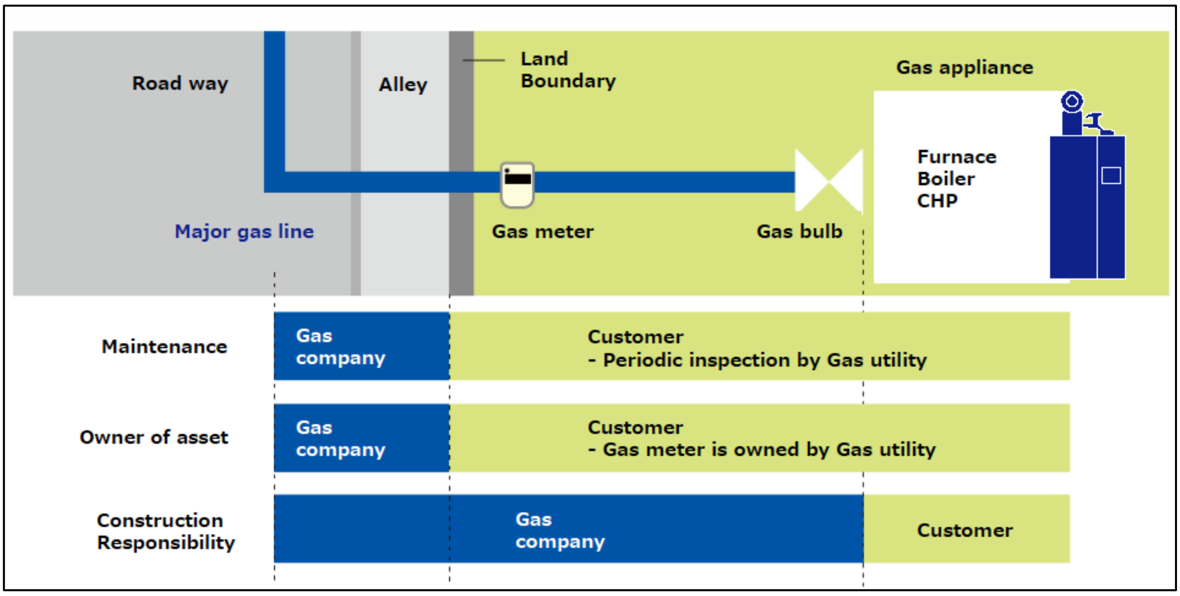
To lay a kilometer of pipeline system, the required investment is estimated to be around USD 1 million. Japan also has a strict regulation on the operating pressure in LNG pipelines. Depending on the location in the distribution line and type of customer, the allowable pipeline pressure can be classified into either high, middle, mid-low, or low. Figure 11 below shows the allowable pipeline pressure for various types of customers in a city gas distribution (Tokyo Gas, 2022).



Source: Tokyo Gas (2022)

Fig. 11. Pipeline pressure for city gas distribution.

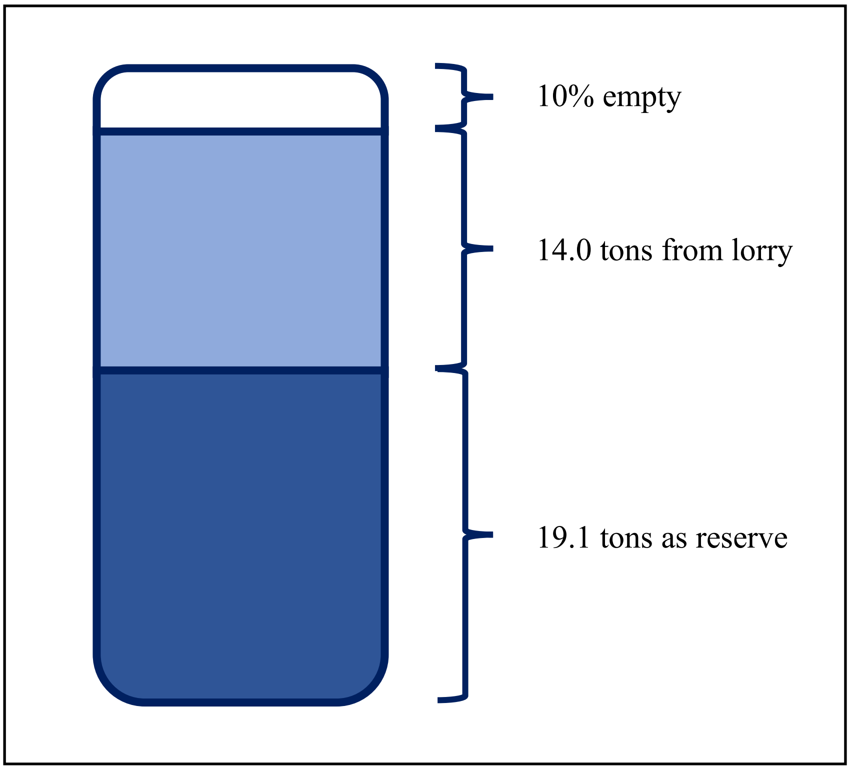
Typically, the customer owned the LNG pipelines and all other facilities (except for the gas meter) laid and constructed within the premises of the customer's property (see Figure 12). If there are many users from different companies, the capital investment may be split (Tokyo Gas, 2022).



Source: Tokyo Gas (2022)

Fig. 12. Construction, ownership, and maintenance of directly connected LNG facilities.

Tokyo Gas' industrial customers in Japan located within a 200-km radius from the source storage tank are serviced via lorry. Beyond this distance, delivery via pipeline is recommended considering the risks and complications associated with transporting LNG on land, the load that the isotanks are adding onto the roads, and the amount of time it takes to travel to the location and transfer the gas. For delivery via lorry, constructing one or more storage tanks is necessary. Existing LPG tanks cannot be used and must be replaced to accommodate storage requirements of LNG (e.g., -162 °C temperature, ventilation). Tokyo Gas recommends installing an LNG storage tank that has the capacity to store at least one full lorry, 3 days' worth of stockpile, with an additional 10% safety margin. For instance, the recommended volume allocation for an 80-kL storage tank that can accommodate 33.1 tons of LNG is shown and is serviced by a 14-ton capacity lorry in Figure 13 (Tokyo Gas, 2022).



Source: Tokyo Gas (2022)

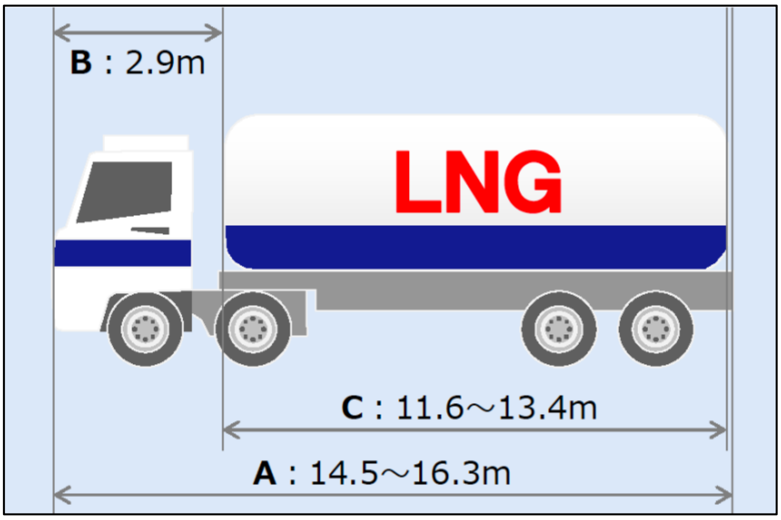
Fig. 13. Volume allocation for an 80-kL storage tank

The technical specifications including the load capacity and dimensions of tank and trailer and the required road width for the mid and large-sized lorries are presented in Table 9 and Figure 14. Small-sized lorries are inefficient so they are not typically recommended (Tokyo Gas, 2022).

Table 9. Lorry specification.

Specification	Lorry type	
	Mid	Large
Loading (in ton)	10.5	14.0
Length (in m) **[A]**	14.5	16.3
Width (in m)	2.5	2.5
Trailer (in m) **[B]**	2.9	2.9
Tank (in m) **[C]**	11.6	13.4
Height (in m)	3.5	3.5
Road width (in m)	6.9	7.5

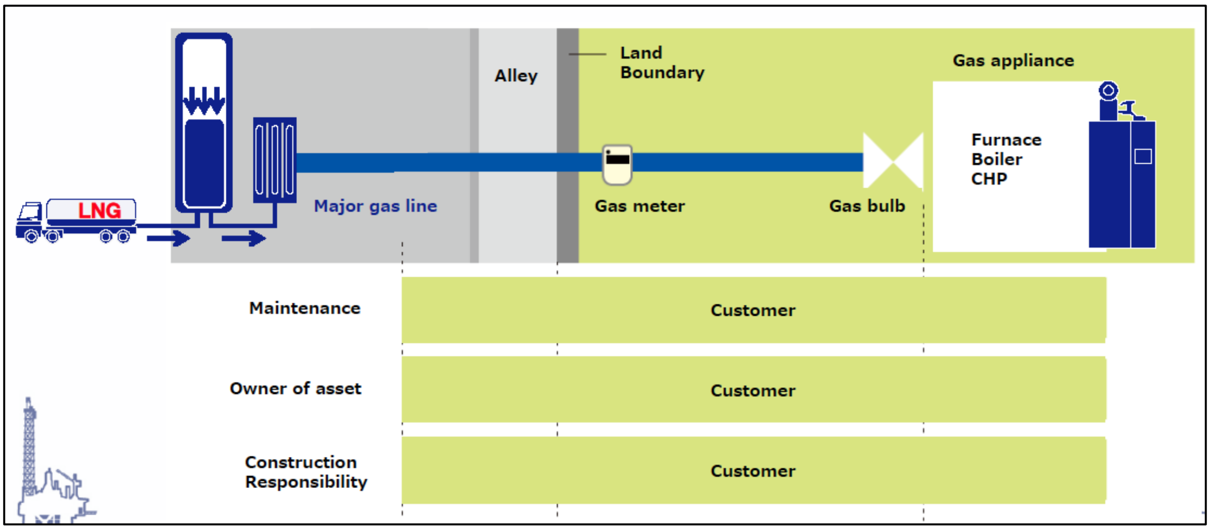
Source: Tokyo Gas (2022)



Source: Tokyo Gas (2022)

Fig. 14. Lorry specification.

Customers have the option to buy their own lorries or isotanks or lease from another company for the distribution. It is suggested to purchase an isotank only if the annual LNG consumption is 1 million cubic meters. It is advisable that a 1-to-1 user-isotank ratio is followed to avoid shortage. In addition to the lorry, as shown in Figure 15, the customer shoulders the cost of the construction and maintenance of all the assets within its premises such as LNG tanks, vaporizers, and gas pipes (Tokyo Gas, 2022).



Source: Tokyo Gas (2022)

Fig. 15. Construction, ownership, and maintenance of LNG facilities with lorry.

Switching to natural gas as fuels in production processes entails retrofitting equipment in the locators' facility. The common high-efficiency equipment[3] that are

[3] We thank Tokyo Gas Co. Ltd. for helping us identify these high-efficiency equipment.

compatible with natural gas are listed in Figure 16. The figure shows that majority of the locators are not familiar with all the high-efficiency equipment described.

Reluctance and hesitancy to switch to natural gas is a valid response. There are practical reasons for non-switching from oil or LPG to natural gas. There may be a negative impact on the product quality due to the change in flame shape or brightness. Most facilities utilizing glass melting and heat treatment furnaces may experience this. The economic benefits flow (e.g., lower fuel cost, lower labor cost) may not compensate for total cost of fuel conversion (e.g., pipeline expansion and replacement costs, combustion system replacement cost). Customers who operate 24/7 may not have enough time to convert their distribution and combustion systems since the conversion can only take place during inventory adjustments and production downtimes.

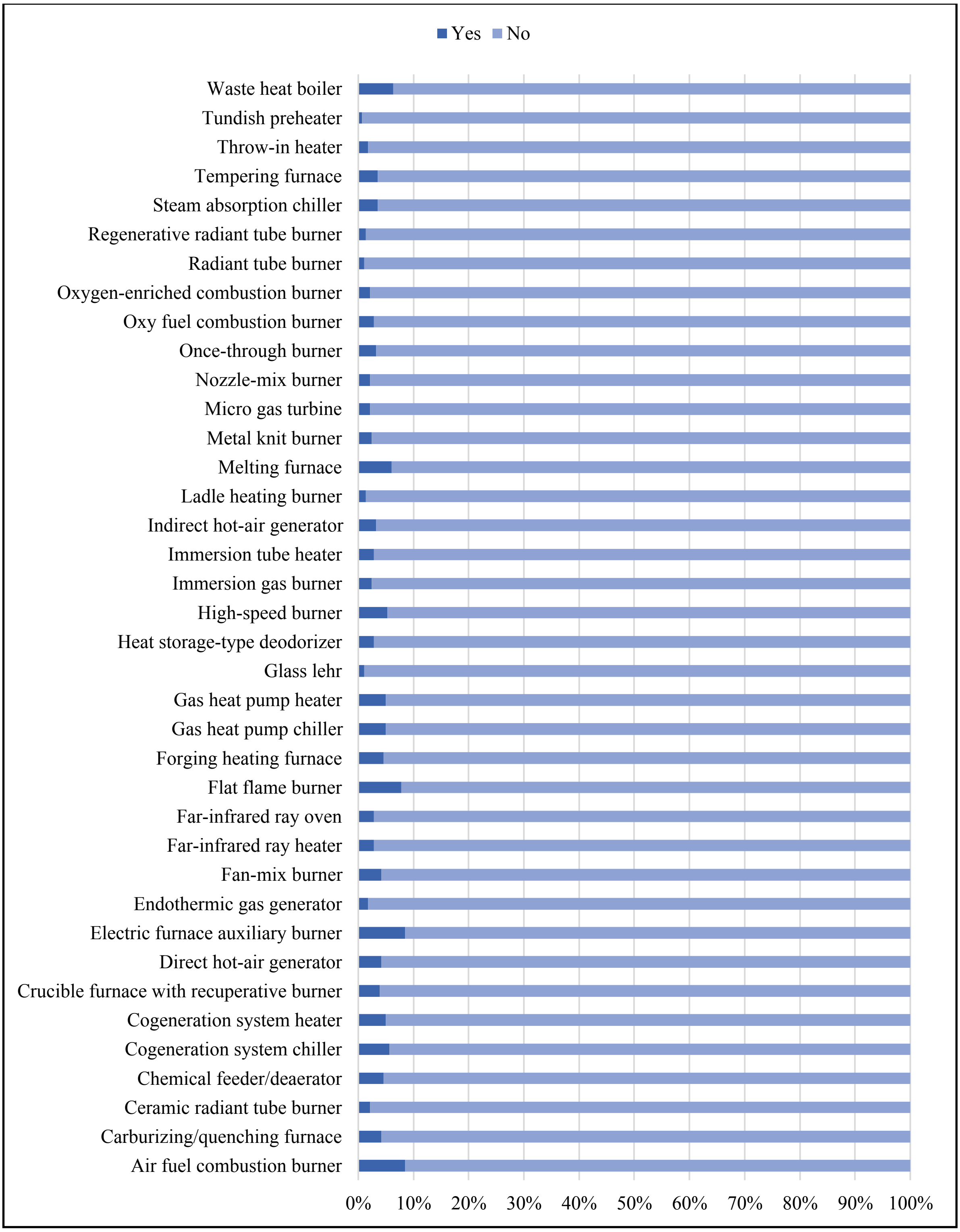
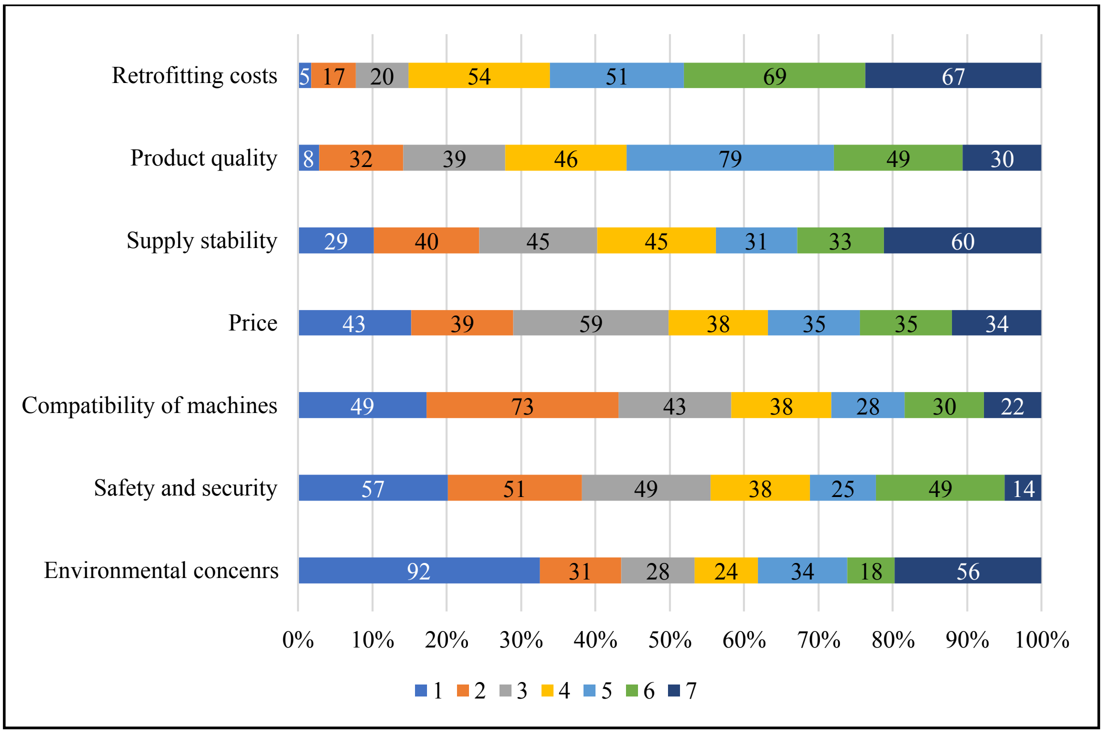


Fig. 16. Have you come across any of the following equipment?

3.4. Respondents' awareness to environmental issues

Natural gas has been referred to as "bridge fuel" (Delborne et al., 2020). This means it is deemed as substitute for fuel deemed environmentally unfavorable or unsustainable. Natural gas emits less carbon than coal for the same amount of energy produced. We explore this potential role of natural gas by examining respondents' awareness to environmental issues.

When asked about their interest in using natural gas, many of the locators noted environmental concerns as the most important, followed by safety and security, fuel compatibility with their equipment, and price (Figure 17). Conversely, retrofitting costs, product quality, and supply stability are the least important considerations according to the respondents.

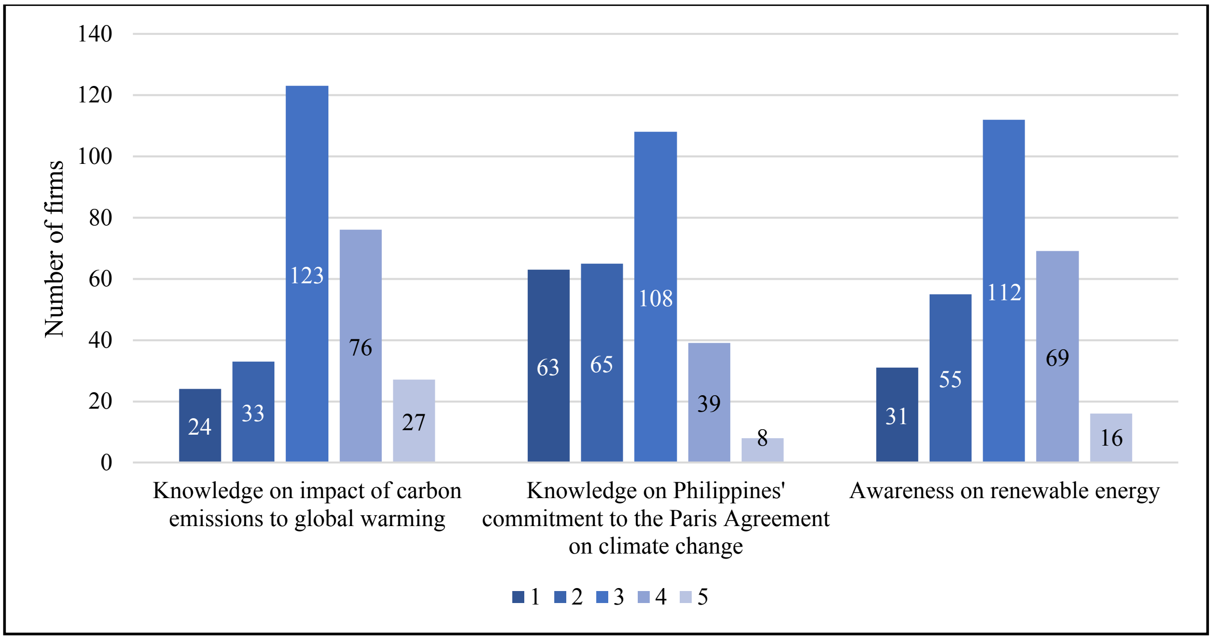


Note: Response to question "in case natural gas would be made available to you, what would be your considerations in using it in your production processes? Ranking is from 1 to 7, with 1 being the most and 7 being the least important."

Fig. 17. Respondents' considerations in using natural in production processes.

When further queried on the extent of their knowledge of significant environmental issues, Figure 18 shows that respondents have an average knowledge on the relation and impact of carbon emissions to global warming, the Philippines' commitment to the Paris Agreement on climate change, and renewable energies. Moreover, comparing the extremes, the figures convey that there are more locators at the favorable end of the scale for the assessment of knowledge on carbon emissions (i.e., sum of 27 and 76 > sum of 24 and 33). However, the opposite is true for the topics on Paris

Agreement commitment and renewable energy as there are more locators gathering at the unfavorable end of the scale.



Note: Scale is from 1 to 5, with 1 being limited and 5 being advanced.

Fig. 18. Respondents' extent of knowledge on key environmental issues.

Putting the spotlight on the specific environmental problems faced by the Philippines and the local communities, Figure 19 shows that regardless of the openness to switch, locators are generally aware of air pollution including the respiratory illness-causing type, poor waste management, flooding, and pollution and siltation of bodies of water. Aside from these, they are also aware of where the country is situated in terms of climate change, traffic congestion, deforestation, and carbon emission from fuel use.

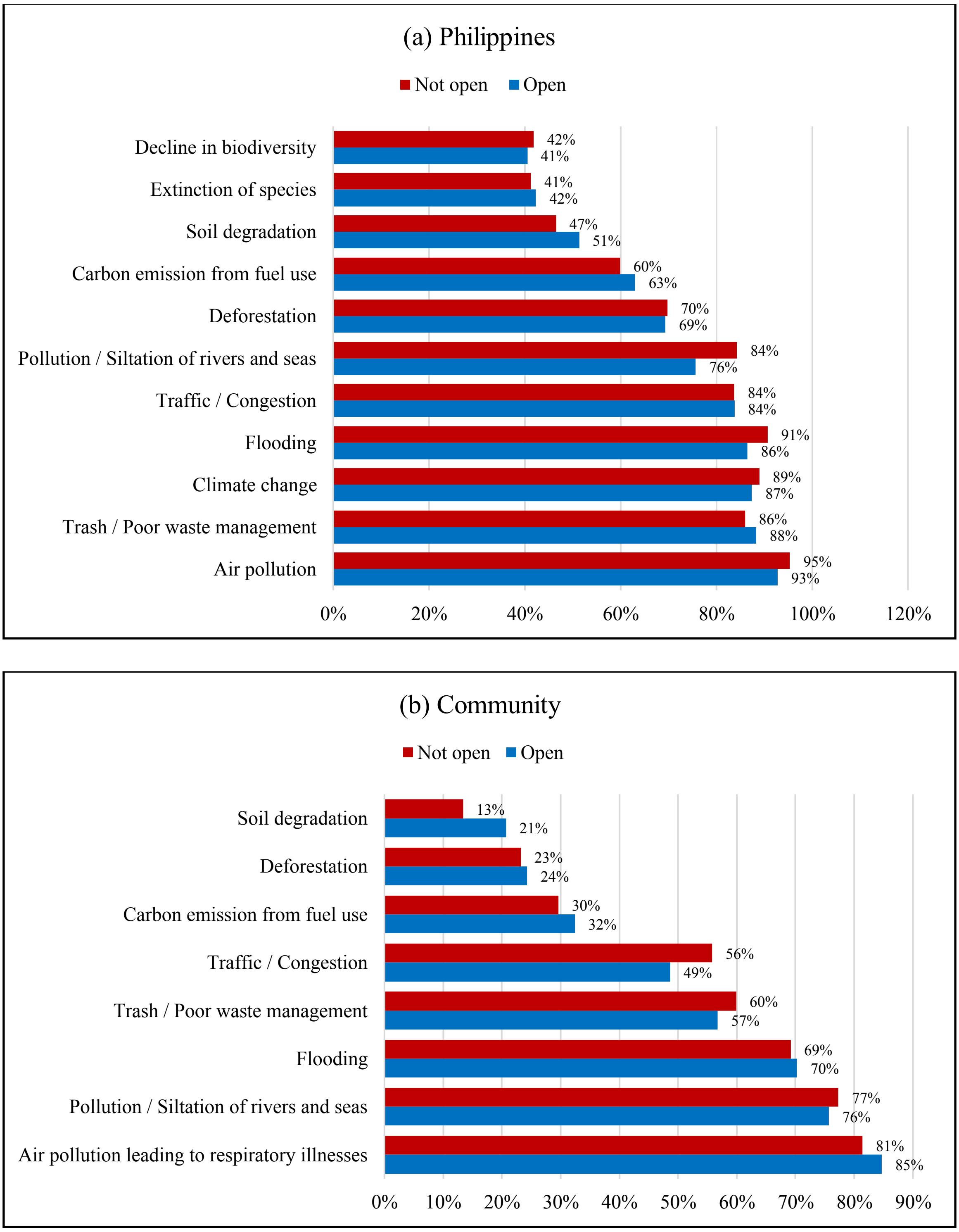


Fig. 19. Respondents' awareness on environmental problems.

3.5. Two-sample t-test

With the foregoing, we compare the two groups of locators, those that are open and those that are not open to switching, using two-sample t-test. The t-test measures the significant difference between the means of the two groups of locators. Table 10 shows that the means of the two groups are statistically different from each other for variables on knowledge, perceived safety, cost competitiveness, and regasification station. However, for all the environmental issues identified and the presence of heating in production process, we also find that the means of the two groups are not statistically different from each other (Table 10).

Table 10. Two-sample t-test by openness to switch.

Variable	T-statistic	Degrees of freedom	P-value	Open		Not open	
				N	Mean	N	Mean
Knowledge on natural gas[a]	3.54	281	0.00	111	2.52	172	2.07
Safety of natural gas[b]	−13.08	281	0.00	111	1.08	172	1.71
Relative cost-competitiveness of natural gas[b]	−6.44	281	0.00	111	1.17	172	1.53
Presence of regasification station[b]	−12.21	281	0.00	111	1.08	172	1.68
Presence of heating in production process[c]	−0.12	110	0.91	50	1.36	62	1.37
Knowledge on carbon emission and global warming[a]	−0.26	281	0.80	111	3.15	172	3.19
Knowledge on Paris Agreement[a]	0.27	281	0.79	111	2.54	172	2.51
Awareness on renewable energy[a]	−1.60	281	0.11	111	2.82	172	3.02

Notes: Test assumes that the two groups have equal variances.

[a] Scale is from 1 to 5, with 1 being limited and 5 being advanced.

[b] Assumed value of variable is 1 if answer to corresponding question is "yes"; 2 if "no".

[c] A locator has heating process if its production includes any one of these processes: baking, boiler operation, burning, curing, die casting or wire bonding, drying or annealing, fabrication, heat treatment, impregnation, machine injection or molding, melting or pre-melting, metal treatment or pre-treatment, smelting, thermal oxidation, and welding. Assumed value of variable is 1 if with heating; 2 otherwise.

The results imply that knowledge on, perceived safety of, cost-competitiveness of natural gas, and the presence of regasification are important factors for firm locators to consider switching to natural gas. These results are consistent with our earlier study

(Ravago et. al., 2021) on gauging the market potential for natural gas, albeit covering a smaller number of ecozones.

4. Concluding Remarks

Our objective in this study is to update the profile and activities of locators with energy-intensive operations in the CALABARZON, Clark, Subic, and Bataan areas. We also gauge their interest to convert to natural gas and identify the potential hurdle that likely to restrain their conversion. We examine the economic, technical, and technological requirements for doing the conversion (e.g., savings that can be derived from the switching; costs that will be incurred for the required technology, etc.).

We find that more locators are not open to switch, where we covered manufacturing, information technology, tourism, agro-industrial, medical tourism, and logistics services ecozones. This confirms our findings in the earlier study (Ravago et. al., 2021) that that the potential is greatest among firms that require intense heat for their production such as boilers, which is generated by burning less environmentally friendly fuels (e.g., diesel or coal, other than natural gas).

A substantial portion of surveyed locators who export are more open to switch to natural gas relative to those who cater to domestic markets only. This shows the exporters' willingness to enhance competitiveness by replacing more expensive fuels (e.g., diesel) in their production processes.

Hesitancy to switch heavily depends on the intimate knowledge on the properties of natural gas, and how natural gas can be integrated with the locator's present production processes. There are also gaps in knowledge about high-efficiency equipment that can be retrofitted to optimize natural gas use in firm's specific production processes. Establishing the market for these types of equipment is necessary for increasing the pace of adoption of natural gas.

Another major consideration for switching is the presence of needed infrastructure on site (e.g., regasification facilities inside the ecozones). This points out to the critical nature of logistical and infrastructure improvements before natural gas can be widely utilized.

Most firm locators are aware about pressing environmental concerns, especially those that are being affected by their production process. It is no surprise, then, that environmental issues are foremost in these locators' openness to switch to a natural gas as a cleaner alternative to more polluting fuels.

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.[4] As such, the conduct of the survey fulfilled the technical requirements necessary to demonstrate the use of the 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 personal information is treated with the utmost confidentiality. No identifiable information appears in the data gathered from the survey.

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[4] See more here: https://www.ateneo.edu/research/university-research- ethics- office.

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