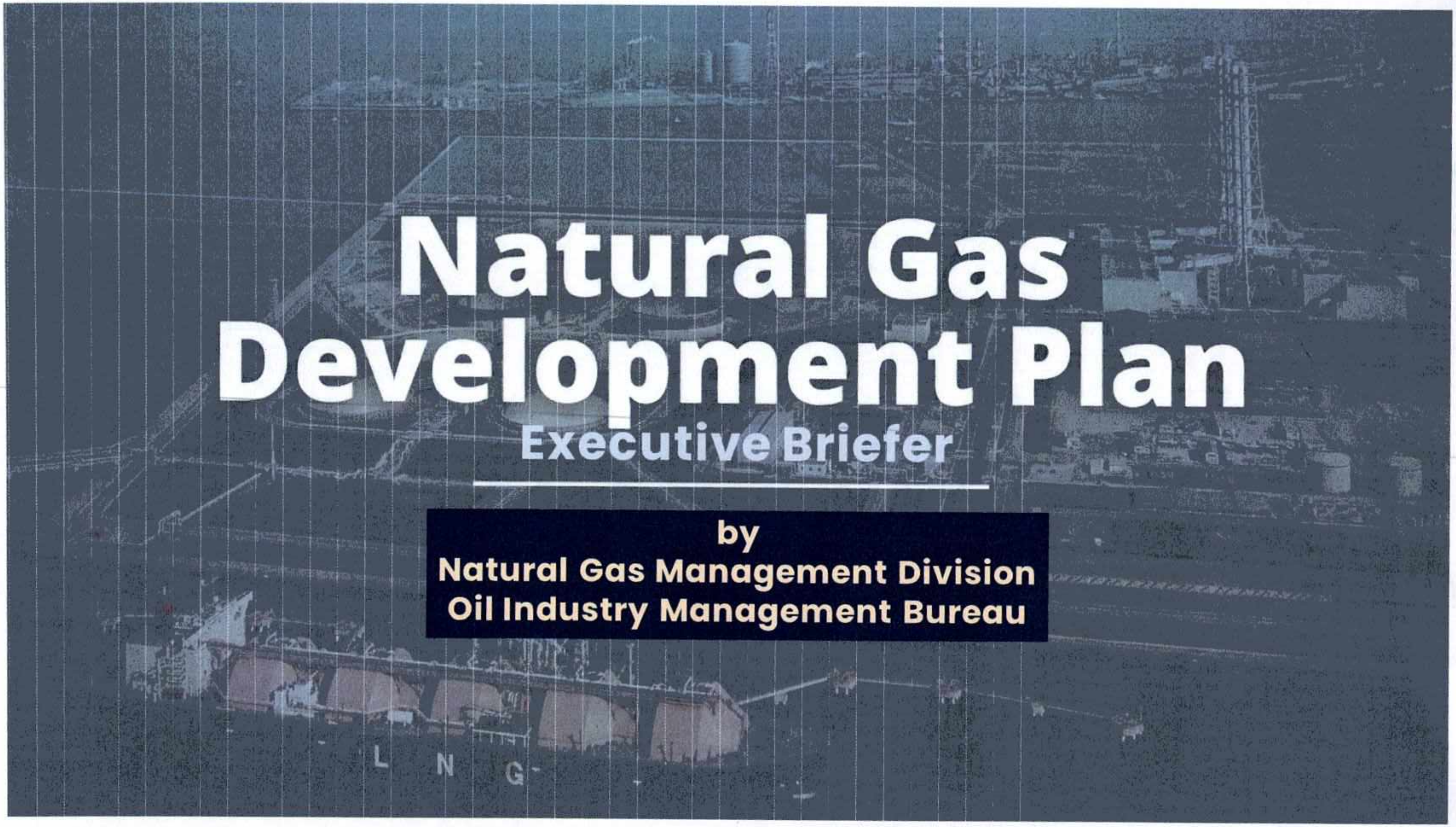


Natural Gas Development Plan

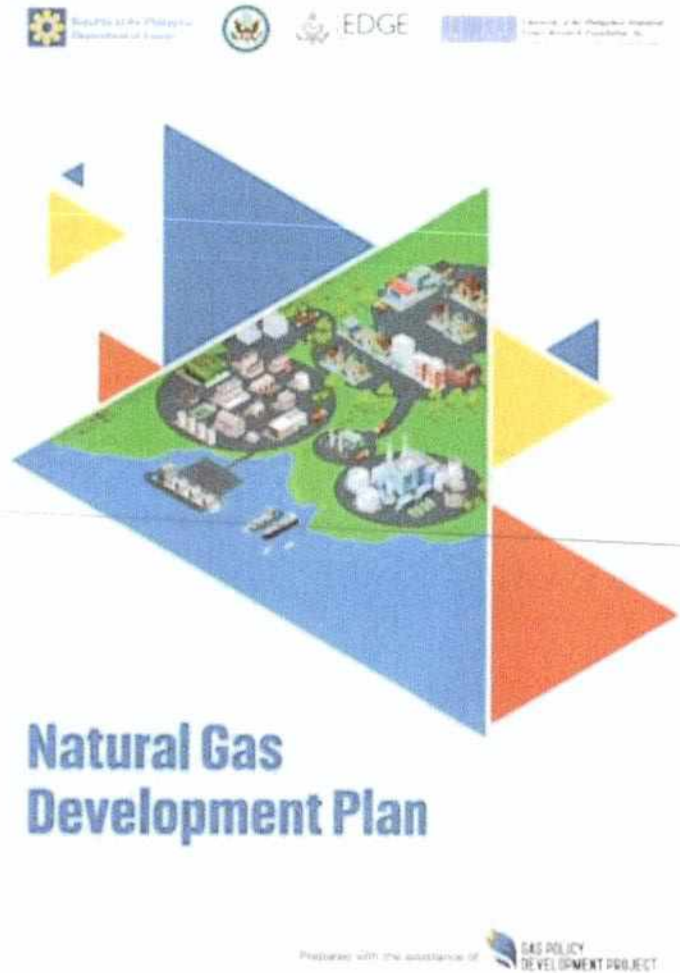
Executive Briefer

by
Natural Gas Management Division
Oil Industry Management Bureau

Natural Gas Development Plan (NGDP)

- Developed by the **Department of Energy-Oil Industry Management Bureau-Natural Gas Management Division** (DOE-OIMB-NGMD), in partnership with the **Gas Policy Development Project 2** (GPDP 2) of the **UP Statistical Center Research Foundation, Inc.** (UPSCRFI)

- **NGDP** is a comprehensive report on the Philippine natural gas sector which contains the **role of natural gas; legal and regulatory framework of the sector; ongoing projects; potential areas for development; and way forward plans for the sector.**



Overview

The NGDP is divided into four (4) main sections.

Section 1 provides an overview on the role of natural gas in the Philippine energy sector while

Section 2 provides details on natural gas demand and outlook.

Section 3 focuses on the existing legal framework on natural gas, highlighting the DOE's Department Circular (DC) No. 2017-11-0012 or the Philippine Downstream Natural Gas Regulation (PDNGR).

Section 4 discuss the ongoing projects, potential areas for development, and way forward plans for the sector.

I Philippine Energy Sector and the Role of Natural Gas

II Natural Gas Demand and Outlook

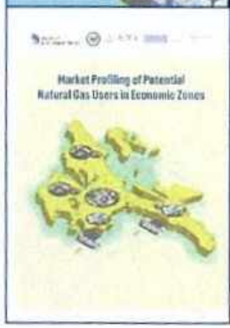
III Existing Legal Framework on Natural Gas

IV Development Plans and Programs

Research Studies

Research Studies Conducted under GPDP

LNG Investors' Guide, *Feb 2020* – This provides information on potential LNG investments in the country as well as the procedures and requirements in the pre-construction and operation of the facilities including permit and clearance requirements from other government agencies.

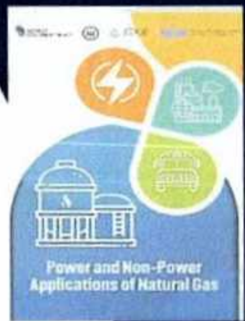


Market Profiling with Emphasis on the Use of Liquefied Natural Gas to Power Economic Zones, *Feb 2020* - The research analyzed the willingness of the company locators within these SEZs to shift from their current energy source to LNG.

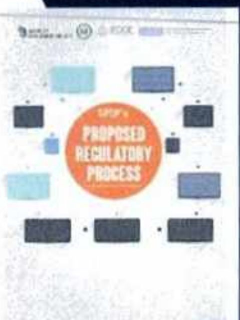
Market Profiling on Potential Natural Gas Users in Economic Zones, *May 2022* - expanded the results of the GPDP 1 study, gauging the extent of the potential demand for natural gas among firms in the Special Economic Zones (SEZs) covering CALABARZON, Clark, Subic, and Bataan areas

GPDP website: www.gpdp.online

Research Studies Conducted under GPDP



Power and Non-Power Applications of Natural Gas, *Jun 2022* presents findings on four major areas: inventory of existing power applications and technical discussions on power, industrial, and transport applications of natural gas



Proposed Regulatory Process (PRP), *Nov 2021*
Contains regulatory recommendations to government agencies and local government units involved in the PDNGI with the aim of bringing about a thorough yet efficient and coordinated regulatory system that incorporates globally accepted codes, standards, and best practices.

Investors' Guide

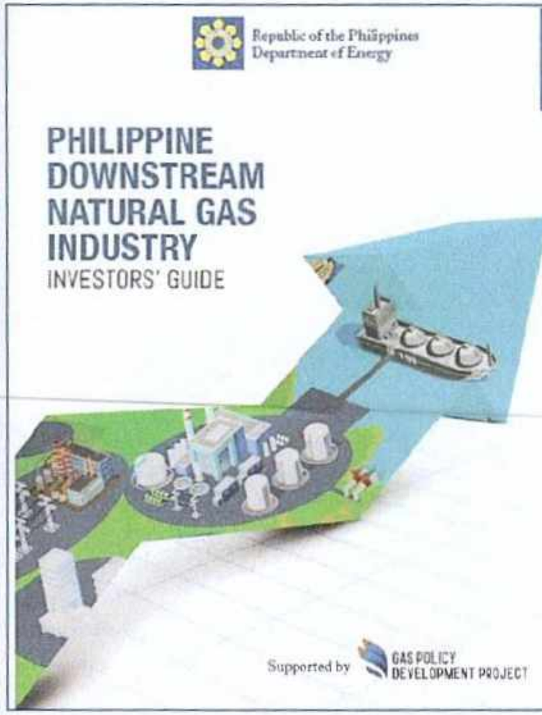
Feb 2022

I. Background

Provides guidance to investors on the policies put in place to facilitate investments and incentives that are made available to them.

II. Objective

GPDP 1's output that provides information on the procedures and requirements in the pre-construction and operation of the facilities including permit and clearance requirements from all concerned government agencies



Mechanism To Guide Investors in LNG Facilities

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Investors' Guide

Feb 2022

Mechanism To Guide Investors in LNG Facilities

Table of Contents

This section of the Guide provides the Philippine Downstream Natural Gas Industry (PDNGI) outlook for Power as anchor investments for LNG and potential non-power businesses.

• Natural Gas Industry Outlook in the Philippines

A. Anchor Investments for LNG: Power

Notice to Proceed Issued to four (4) companies with 1 PCERM Application

1) Tanglawan (expired)
2) First Gen
3) Excelerate
4) Batangas Clean Energy

Additional power capacities, 2017-2040 (in MW)

Capacity Addition in MW	Luzon	Visayas	Mindanao	Total by type
Baseload (coal, geothermal, natural gas*, nuclear*, biomass*, & hydro*)	13,635	5,330	6,300	25,265
Mid-merit (natural gas & all others)	8,300	3,000	3,200	14,500
Peaking (oil, wind** and solar PV**)	2,450	850	700	4,000
Total per grid	**24,385**	**9,180**	**10,200**	**43,765**

Notes: At 70, 20 10: Baseload, Mid-merit and peaking. *Natural gas is currently considered as baseload but belongs to mid-merit category; hydro is baseload only in rainy season; biomass is baseload only during availability of feedstock. **Wind and solar PV subject to availability

Source: DOE 2016

Natural Gas Industry Outlook in the Philippines

Potential Non-Power Businesses

1) Small power plants for island provinces and remote areas
2) Inter-island shipping
3) Trucking
4) Industrial and commercial use
5) Residential and other restaurants
6) Land-based public transport

Investors' Guide

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Mechanism to guide investors for LNG facilities

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The **Primer** contains information on the process and requirements for the application of the following:

1. Notice to Process (NTP)
2. Permit to Construct, Expand, Rehabilitate, and Modify (PCERM)
3. Permit to Operate and Maintain (POM)

Over-all Permitting Process

Overall Process Application of Permits from setting up to operations of LNG facilities

Taken from Dr. Ramon Clarete PPT_ Sep 3 2020 Investor's Guide

Investors' Guide

Feb 2022

Mechanism to guide investors for LNG facilities

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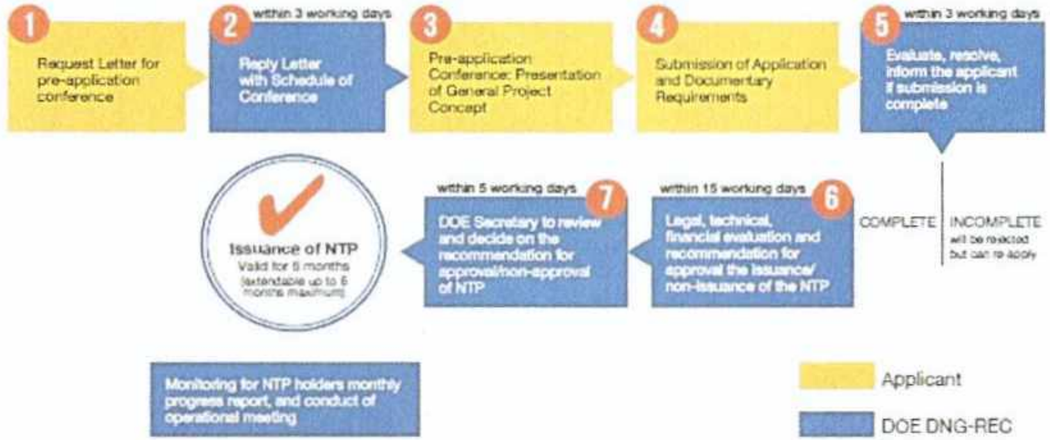
- The Figure outlines the process for the application of **NTP**. The NTP is valid for six (6) months and may be extended once for another six (6) months.
- The issuance of NTP authorizes the applicant to secure permits from other agencies.



Required Documentation

LEGAL	TECHNICAL	FINANCIAL
1. Information Sheet 2. SEC Registration 3. Certified true copy of the General Information Sheet (GIS) 4. Secretary's certificate	1. Applicant profile 2. Construction plans and design 3. Health, safety, environment (HSSE) Assessment and Management Plan (Construction and Equipment Installation Phase)	1. Economic/Financial Feasibility Report 2. Financial Closing Methodology 3. Supporting Documents • Certified executed copies of key binding agreements (e.g.EPG agreements, LNG supply agreement, Gas sales agreement • Certified true copy of Applicant's tax clearance certificate • Specific requirements for corporations existing › 2 years • Specific requirements for newly-organized corporation existing ‹ 2 year • Requirements for earmarked fund guarantee from chosen member/s of Applicant Group (for applicants with insufficient ability to raise equity share)

Notice to Proceed (NTP) Application Process and Requirements

Investors' Guide

Feb 2022

Mechanism to guide investors for LNG facilities

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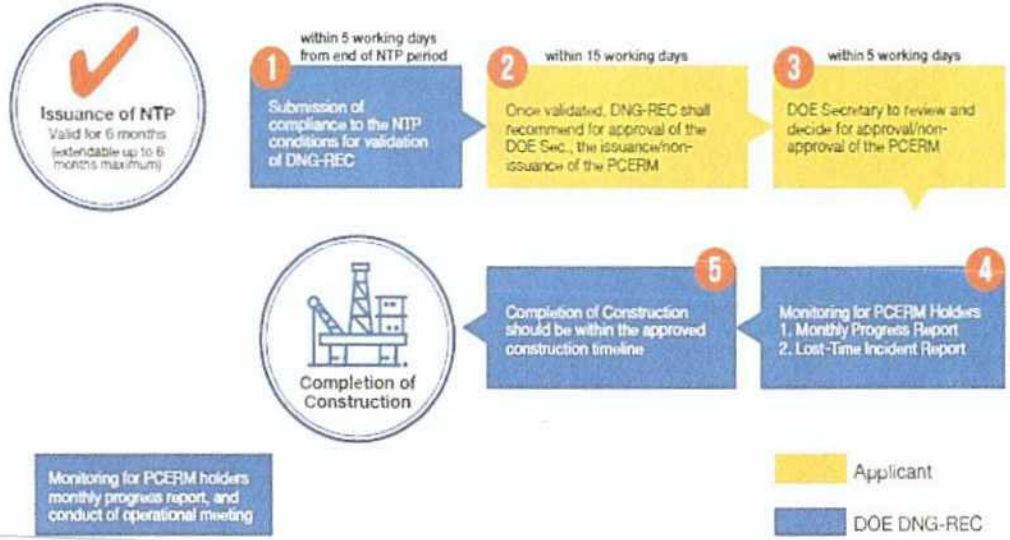
- The issuance of **PCERM** signals the construction of the proposed project



Required Documentation

PERMITS	FINANCIAL
1. DENR - Applicable regulatory permits and requirements to satify the Environmental Compliance Certificate 2. LGU - Endorsement and Permits for Operation 3. NCIP - Certificate of Pre-Condition (if applicable) 4. DOLE - Registration and Permit to Operate 5. BIR, Philhealth, HDMF-Pag-ibig, and SSS registrations 6. Fire Safety Inspection Certificate (Fire Code) 7. Sanitary Permits (Sanitary Code) 8. Other permits as may be required by law and rules	1. Submission of Proof of Financial Closing

PCERM Application Process and Requirements

Investors' Guide

Feb 2022

Mechanism to guide investors for LNG facilities

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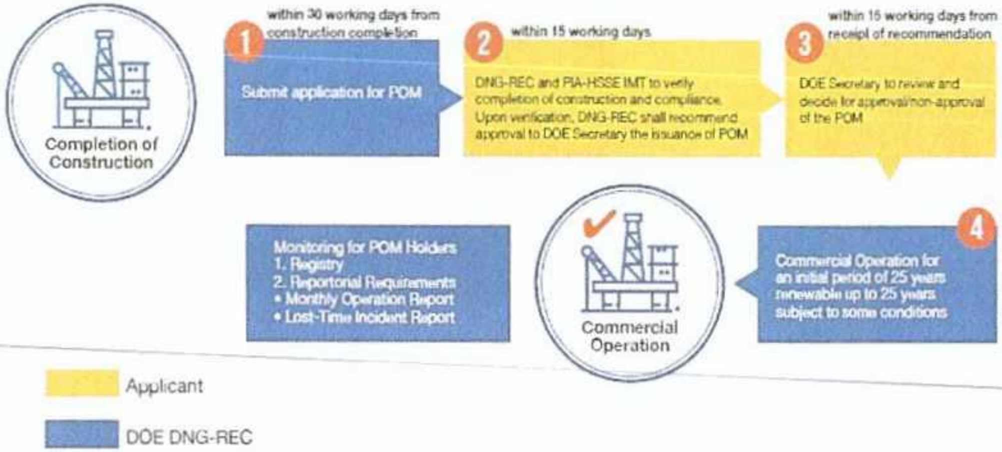
- Within 30 days of the completion of construction, the LNG investor will need to apply for a **POM.**

Permit to Operate and Maintain (POM)

Within 30 days of the completion of construction, the LNG investor will need to apply for a POM following the process included in **Figure 12** below.

Figure 12. POM application process and procedures



Required Documentation

PERMITS
1. Certificate of Completion
2. Summary List of Buildings, Facilities, and Equipment
3. Operational Process with Flow Diagram
4. Health, Safety, Security and Environment (HSSE) Assessment and Management Plan (Operational Phase)
5. Permitting Requirement of Other Government Agencies for the Operation of the Facility

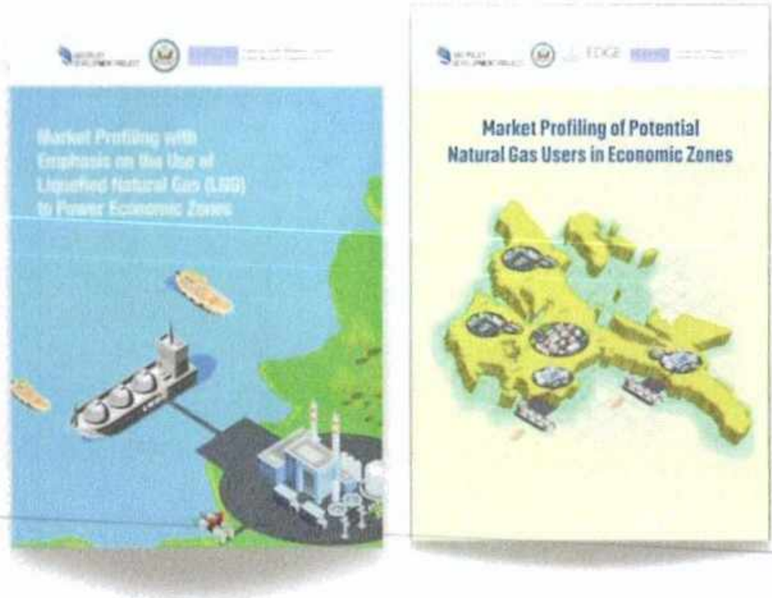
Permit to Operate and Maintain (POM) Application Process and Requirements

Market Profiling of Potential Natural Gas Users in Economic Zones

May 2022

I. Background

Consolidates the findings of GPDP 1 and 2's research on the potential use of natural gas in special economic zones, specifically looking into the likelihood of fuel switching by locator firms and their considerations for switching to natural gas.



The **first study determined the profile of power and fuel use among locators in manufacturing and agro-industrial SEZs** in Laguna, Batangas, Cavite, Cebu, Pampanga, Benguet, Bulacan, and Metro Manila.

The **second research augmented the initial study, widening the scope to all types of SEZs,** particularly identifying locators with energy-intensive operations in the Cavite, Laguna, Batangas, Rizal, Quezon (CALABARZON), Clark, Subic, and Bataan areas.

Market Profiling of Potential Natural Gas Users in Economic Zones

May 2022

II. Objectives

- Update the profile and activities of existing economic zones, identifying locators with energy-intensive operations in the CALABARZON, Clark, Subic, and Bataan areas
- Determine the interest of locators in SEZs to convert to natural gas
- Identify the economic, technical, and technological requirements for doing the conversion

III. Activities Done

Flow of the Study

Obtain ethics clearance
- Ensures that our survey adheres to the use of ethical procedure in research involving human respondents.

Conduct FGD to pretest questionnaire and identify target population
- The online focus group discussion (FGD) sharpens our questions.

Survey among ecozones in the target population
- 283 firm-respondents, which gives us a 95% confidence level and 5.4% margin of error.

Perform a *t*-test between firms who are open and not open to switch

This determines whether there is a significant difference between the average characteristics of firms between the two groups.

Presentation of GPDP 2 Researches on Market Profile, Jul 2022

Market Profiling of Potential Natural Gas Users in Economic Zones

May 2022

IV. Findings and Recommendations

A. Sampling and Respondents

283 locators in the sample were interviewed, which is above the target of 234 firms. The respondents were a combination of directors, managers or officers in departments responsible for production, finance, human resource, facilities and equipment.

B. Openness to Switch to Natural Gas by Ecozone

Most of the firms surveyed were not open to switch—which is about 61 percent of the total sample. When we look inside ecozones, we see that this pattern holds in general—that is, most locators reported that they were not willing to switch to natural gas.

A. Sampling and Respondents

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.

B. 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
Total	**111**	**39.2**	**172**	**60.8**	**283**	**100.0**

Note: Ecozones with less than 5 responses were not included in this table.

Market Profiling of Potential Natural Gas Users in Economic Zones

May 2022

IV. Findings and Recommendations

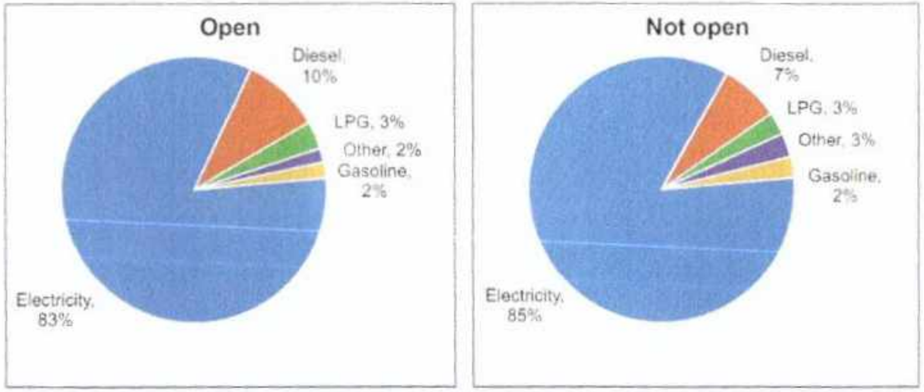
C. Fuel Mix Used in Production

Of those who were open to switch, 10 percent of these firms used diesel—which is relatively dirtier and more expensive. Diesel is the likely fuel that will be displaced by natural gas when it becomes available. Those who are predisposed to switch also heavily use electricity in production.

D. Locators' Sources of Electricity

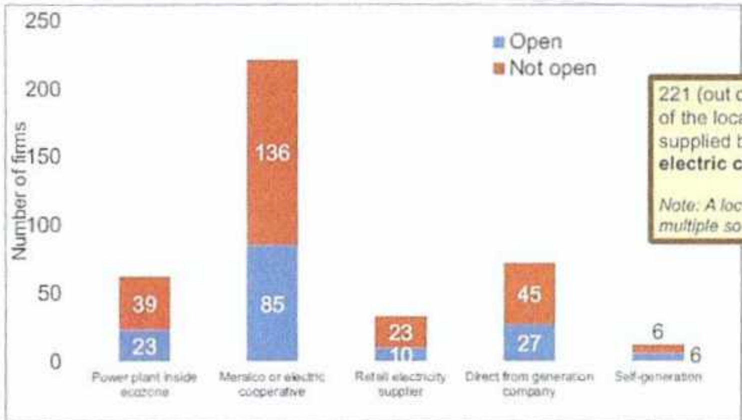
In our sample, 91 percent of firms reported that their electricity are supplied by Meralco or an electric cooperative. 39 percent of these firms reported that they are open to switching to natural gas.

C. Fuel Mix Used in Production



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

D. Locators' Sources of Electricity



221 (out of the 242) or 91% of the locators are being supplied by **Meralco or electric cooperatives**.

Note: A locator can have multiple sources of electricity.

Market Profiling of Potential Natural Gas Users in Economic Zones

May 2022

IV. Findings and Recommendations

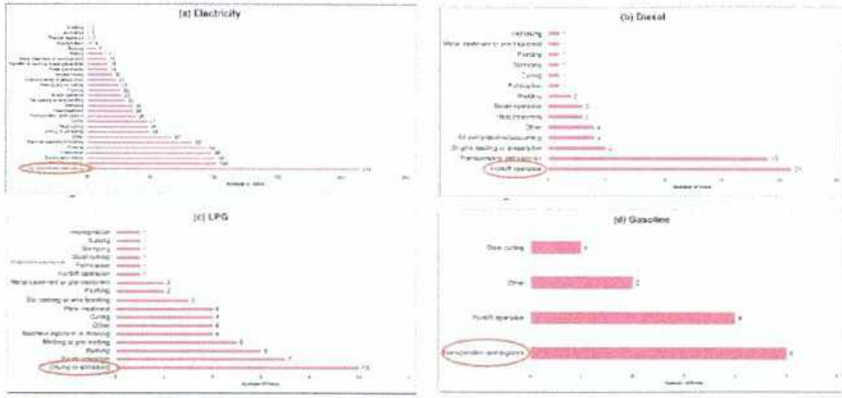
E. Production Process by Fuel

The production activity that heavily uses diesel and electricity are air compression/vacuuming, cooking and chilling, fabrication, transportation, forklift operation and boiler operation. Some of these processes are amenable for using natural gas.

F. Openness to Switch to Natural Gas

When looking at the size of the firm, a slightly higher proportion of firms with assets or sales 1 billion and below are more likely to be open to switching—but not overwhelmingly. However, exporters have a higher proportion than average in reporting openness to switching—44 percent of them report that they are open to switch. This reflects different incentives or even competitive pressures to lower costs among exporters compared to firms who purely sell domestically.

E. Production Process by Fuel



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. Other production processes that were available as response options but were not chosen at least once during the survey are not presented in these figures.

F. Openness to Switch to Natural Gas

- By book value size and production sales

Value	By book value		By production sales	
	Open	Not open	Open	Not Open
1 billion and below	88	134	99	154
	(92.6)	(91.2)	(89.2)	(89.5)
Above 1 billion	7	13	12	18
	(7.4)	(8.8)	(10.8)	(10.5)
Total	**95**	**147**	**111**	**172**
	(100.0)	**(100.0)**	**(100.0)**	**(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.

- By product destination
  - Comparing exclusive exporters and exclusive domestic sellers that are open to switching, **exporters are relatively more receptive** to natural gas adoption. Reflects the characteristics of locators inside the ecozone, i.e., exporters receive more incentives than those whose products are sold only domestically.

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)**

Market Profiling of Potential Natural Gas Users in Economic Zones

May 2022

IV. Findings and Recommendations

G. Extent of Knowledge of Natural Gas

Most of the respondents tend to report limited knowledge. And those who report limited knowledge are more likely NOT OPEN to switch to natural gas. Hence, there seems to be an intimate correlation between knowledge and the likelihood of switching.

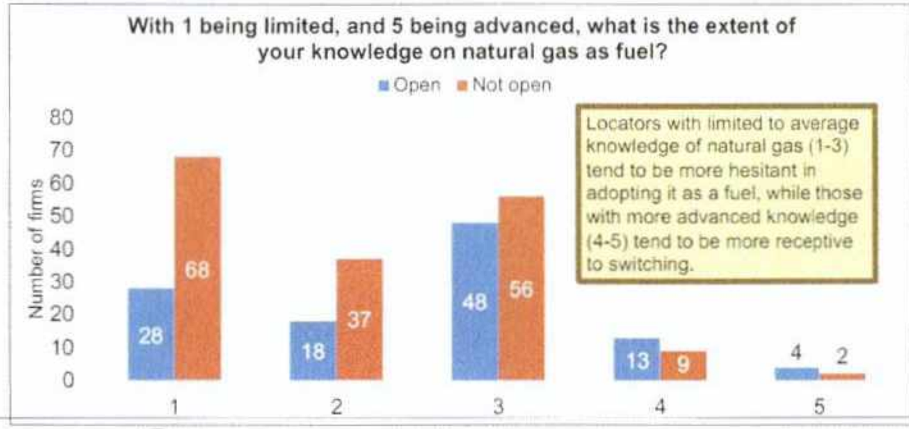
This points out the importance of information dissemination activities on natural gas to evaluate the pros and cons of shifting.

H. Safety of Natural Gas

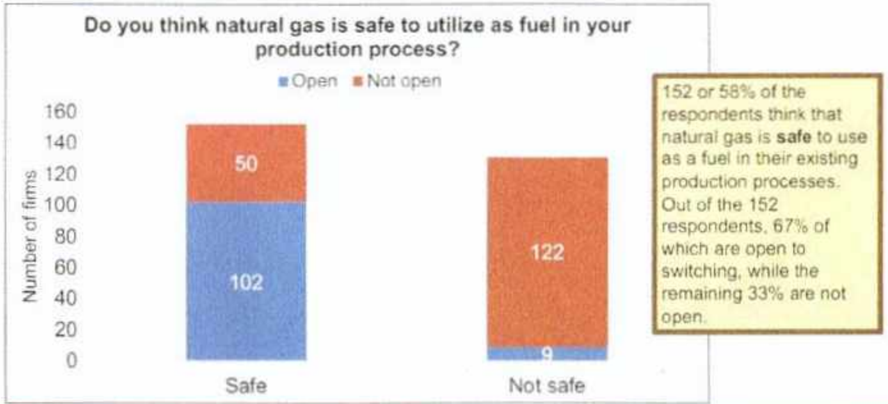
More than half of respondents believe that natural gas is safe to use. In addition, of those who think natural gas is safe, 67 percent are open to switching.

This is in stark contrast when we look at locators who believe natural gas is unsafe: 93 percent of them are not open to switching. Hence, the correlation of switching to natural gas is even stronger to the perception of safety.

G. Extent of Knowledge of Natural Gas



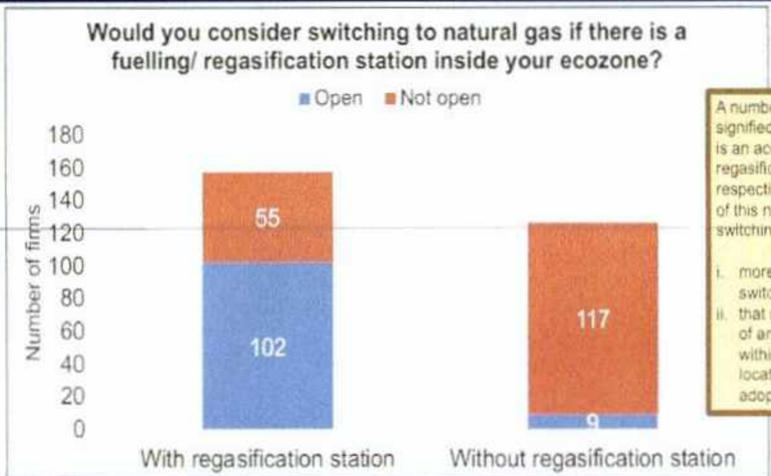
H. Safety of Natural Gas



Market Profiling of Potential Natural Gas Users in Economic Zones

May 2022

I. Fueling / Regasification Station

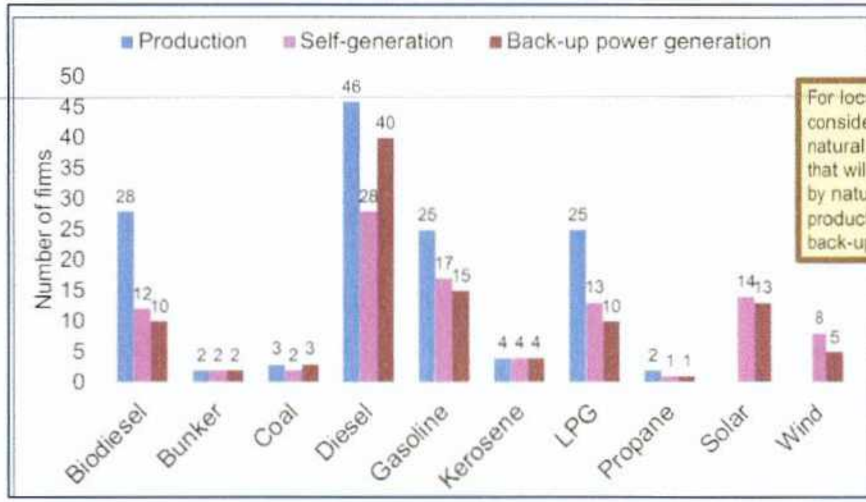


A number of locators (N = 157) signified interest in switching if there is an accessible fueling or regasification station inside their respective ecozones. The majority of this number (65%) is open to switching which implies that:

i. more locators will be open to switching if access is easier
ii. that regardless of the presence of an available regas station within their ecozone, many locators are open to natural gas adoption.

Without such facilities, an overwhelming 93 percent said they were not open to switching.

J. Fuels Likely to be Replaced by Natural Gas



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.

Market Profiling of Potential Natural Gas Users in Economic Zones

May 2022

IV. Findings and Recommendations

The study covers more locators including manufacturing, information technology, tourism, agro-industrial, medical tourism, and logistics services ecozones.

- Given the wider coverage, more locators are not open to switch.
- This confirms the findings in the first study 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).
- 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.
- 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.
- A 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.

Market Profiling of Potential Natural Gas Users in Economic Zones

May 2022

IV. Findings and Recommendations

- 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.

- Firms, whether open or not open to switch, 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.

Market Profiling of Potential Natural Gas Users in Economic Zones

May 2022

MARKET PROFILING ON NATURAL GAS POTENTIAL USERS IN ECONOMIC ZONES

The Study in a Nutshell

1 PROFILE OF LOCATORS OPEN TO NATURAL GAS USE

- Locators with boilers and other intensive heating equipment in their production process showed most potential in using to natural gas.
- Export-oriented locators are more willing to switch to natural gas versus domestic market-oriented locators.
- Natural gas can most likely replace diesel in the main production processes, self- and back-up power generation.

2 TOP CONSIDERATIONS FOR SWITCHING TO NATURAL GAS

- Switching to natural gas depends on the existence of needed infrastructure onsite.
- Environmental concerns, price, and safety and security also emerged as top considerations.
- Compatibility of machines and equipment is an important factor among manufacturing and agro-industrial locators.

3 KNOWLEDGE AND PERCEPTION OF NATURAL GAS

- Locators with more advanced knowledge tend to be more receptive to switching.
- Majority of locators deemed that natural gas is safe to use and is a competitive fuel in terms of cost relative to their existing fuels and energy sources.

4 KNOWLEDGE ON ENVIRONMENTAL ISSUES

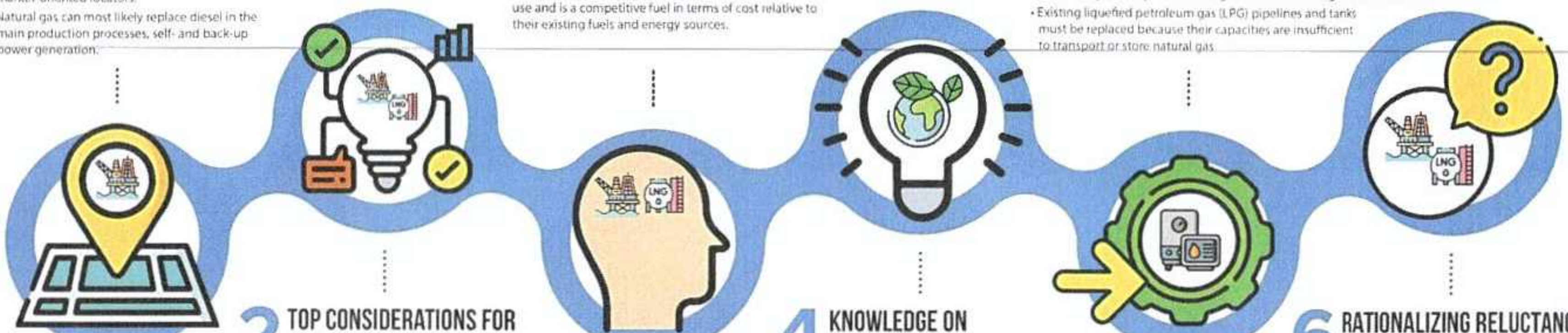
- Locators displayed average knowledge on the relation and impact of carbon emissions to global warming, the Philippines' commitment to the Paris Agreement on climate change, and renewable energies.
- Locators showed openness to switch to natural gas being a cleaner alternative to more polluting fuels.

5 TECHNICAL REQUIREMENTS FOR SWITCHING

- Requirements for switching to natural gas is assessed on a case-to-case basis.
- Majority of the locators are not familiar with the high-efficiency equipment that can be retrofitted to optimize natural gas use in the production processes.
- For direct connection via pipelines: constructing an onsite storage facility may not be necessary.
- For delivery via lorry: constructing one or more storage tanks is needed.
- Existing liquefied petroleum gas (LPG) pipelines and tanks must be replaced because their capacities are insufficient to transport or store natural gas.

6 RATIONALIZING RELUCTANCE TO NATURAL GAS

- Economic benefits may be smaller than total cost of fuel conversion.
- Locators with 24/7 operations may not have enough time to convert their distribution and combustion systems.



Power and Non-Power Applications of Natural Gas
June 2022

Background

Objectives:

1. Perform technical research on the utilization of natural gas for power applications;
2. Develop an inventory on the existing and emerging technologies for power applications of natural gas;
3. Assess the technical feasibility of using natural gas over the current fuel sources for non-power applications in the Philippines;
4. Identify capital and other economic requirements for the potential adoption of natural gas technologies for non-power applications; and
5. Estimate the carbon emission reduction because of the switch to natural gas.

Scope:

1. Inventory of existing and emerging technologies of power applications
2. Technical and economic analysis of natural gas applications:
   a) Thermodynamic analysis of a gas-fired power plant
   b) Technical research of the industrial and transport applications of natural gas
3. The role of natural gas in the decarbonization of the power, industrial, and transport sector

Power and Non-Power Applications of Natural Gas
June 2022

Scope

1. Inventory of existing and emerging technologies of power applications

Objectives

- Identify common power applications of natural gas and compare them with local available applications
- Identify equipment units in each power application and list available technologies for each unit

Types of power generation	Key Processes	Key Technologies
Simple Cycle Combined Cycle Reciprocating Engine	Compression Combustion Expansion (gas and steam) Heat Recovery Fluid Transport	Gas turbine Steam turbine HRSG

Comparison of Power Generation Types

Power Application	Key Characteristics	Capacity Requirement	Working Fluid	Efficiency	Start-up	Thermodynamic Cycle	Type of Moving Equipment	Operating Conditions	Local Power Plant
Simple Cycle	Pressurized hot gases are used to drive the turbine to produce electricity Waste heat is not utilized Robust, easy to operate, and reach efficiencies up to 40% at large power levels	Peaking power	Air + fuel (natural gas)	Reach efficiencies up to 40% at large power levels Limited efficiency	Quick start-up	Brayton cycle (gas turbine)	Gas turbine	Firing temperatures of 2400°F (1315°C) Inlet temp: 1200K to 1700K	Avion
Combined Cycle	Pressurized hot gas is used to drive gas turbine to produce electricity Hot exhaust gases are captured in a steam generator to raise steam Steam turbine produces additional electricity High efficiency and low environmental emission	Mid-merit/ intermediate	Gas turbine: air + fuel (natural gas) Steam turbine: water (waste heat)	High efficiency Between 50% and 60%	Slower start-up than simple cycle	Brayton cycle (gas turbine) Rankine cycle (steam turbine)	Gas turbine (topping cycle) Steam turbine (bottoming cycle)	Inlet temp: 1200K to 1700K Gas turbine exit conditions: between 900°F (482°C) and 1100°F (593°C)	Ilijan San Lorenzo Santa Rita San Gabriel

Power and Non-Power Applications of Natural Gas
June 2022

Types of LNG Receiving Facility

Receiving Terminal	Key Characteristics	Capacity Requirement	Typical Dimensions	Installation	Economic Costs	Import and Export Limits
FSRU	LNG is regasified topside and high-pressure gas is sent directly into the pipeline Good flexible option if distance from shore is too long, marine environment too hostile, but with good gas pipeline availability Moored at shore Solution for transfer of high-pressure gas, eliminates fixed infrastructure and is a cheaper alternative should FSRU be re-deployed Regasification modules are installed on the deck and gas is sent out via a riser and a subsea pipeline to the customer Receive LNG via an LNG Carrier that will moor to the seaward side of the FSRU or FSU in a ship-to-ship configuration	267,335 m^3 (typical for large FSRU vessels) 145,000 m^3 LNG carrier with an average unloading rate of 12,000 m^3/hr. Storage capacity of FSRUs is typically in the 145,000 m^3 to 350,000 m^3 range	Vessel Length Overall (LOA): 345 m Vessel Fully Loaded / Design Draft: ~12.5 m Beam: 54 m Berthing pocket & maneuvering area - Length: 500 m - Width: 475m Diameter of marine access area for FSRU Vessel / LNGC: 690-700 m Width of marine access channel: 250-260 m	Can be implemented in one to three years		Less flexibility than onshore terminals which can deliver import and export services
Onshore	LNG is unloaded by means of the ship pumps to the unloading arms on the Jetty and then to the storage tank through the unloading lines. It is then pumped to high pressure through various terminal components where it is warmed in a controlled environment. Most common terminal configuration Comprises berthing facilities, onshore storage tanks, regasification and gas distribution into the domestic network Mooring through LNG carriers	Terminal capacity is commonly defined by the storage and regasification capacity Actual capacity is often restricted by operational constraints such as restricted berth availability due to arrival slots 145,000 m^3 LNG carrier with an average unloading rate of 12,000 m^3/hr.		Typical critical path for an onshore re-gasification terminal is about 40 months of design construction after approval	Typically has higher CAPEX when compared to offshore marine terminals	Can accommodate large and small-scale LNG import and export

Power and Non-Power Applications of Natural Gas
June 2022

Scope

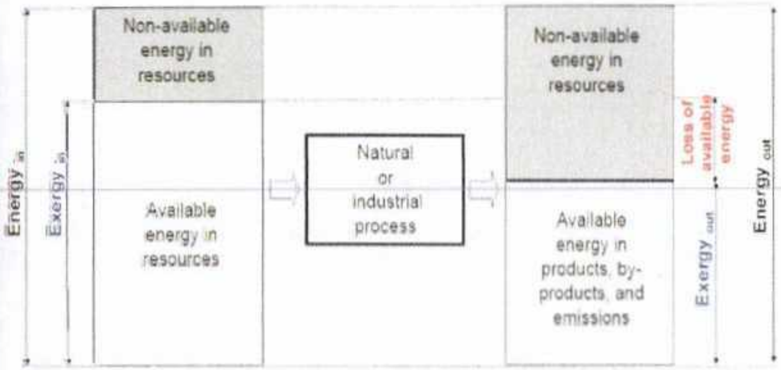
2. Technical Research on Power Applications

Two aspects of the Power Applications of Natural Gas:

- ➢Thermodynamic Analysis of Gas-Fired Power Plants
- ➢Decarbonization in the Power Generation Sector

Thermodynamic Analysis

Main objective: Use thermodynamics (energy and exergy balances) to identify fundamental changes in design, operation, maintenance, and economic evaluation of a process.



Mitra and Ghosh (2015)

Exergy is associated with the usefulness of energy.

Poor energy quality means that it cannot be transformed to generate useful work.

Key points:

1. Thermodynamic analysis could recommend strategies that can increase efficiency and reduce irreversibilities in gas-fired power plants.
2. Combustion chamber exhibited the highest irreversibility in the process. Reducing this irreversibility can result in higher plant efficiencies.
3. Optimizing process conditions can minimize cost and emissions and maximize plant efficiency.

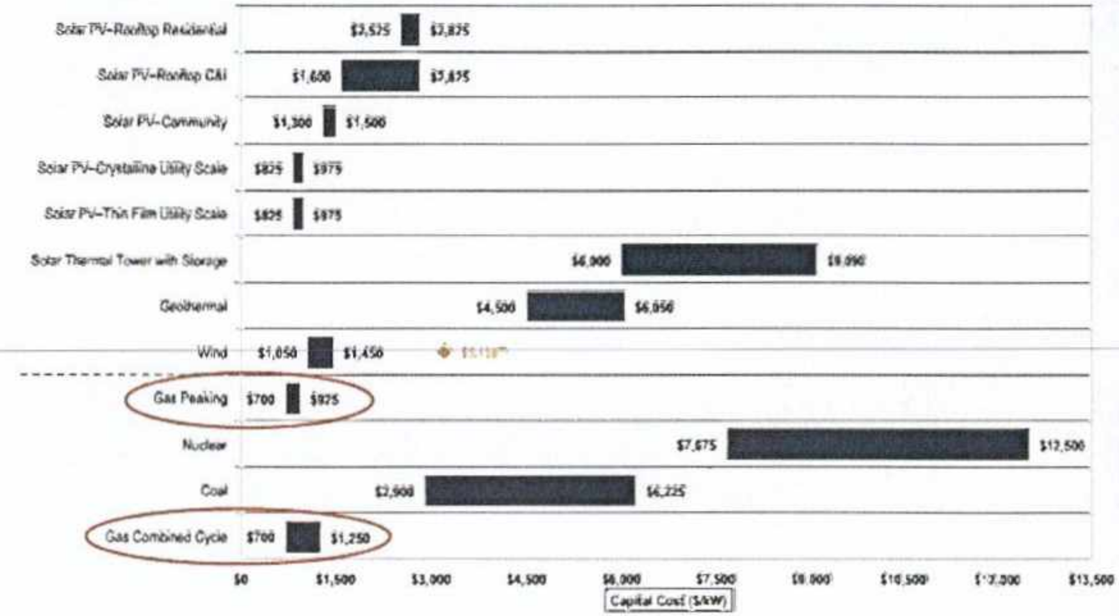
Power and Non-Power Applications of Natural Gas
June 2022

Scope

2. Technical Research on Power Applications

- ➢ Thermodynamic Analysis of Gas-Fired Power Plants

Capital Cost of Power Generating Technologies



Lazard (2020)

Gas technologies are also among the lowest in capital costs when compared to renewable energy alternatives.

Power and Non-Power Applications of Natural Gas
June 2022

Scope

2. Technical Research on Power Applications

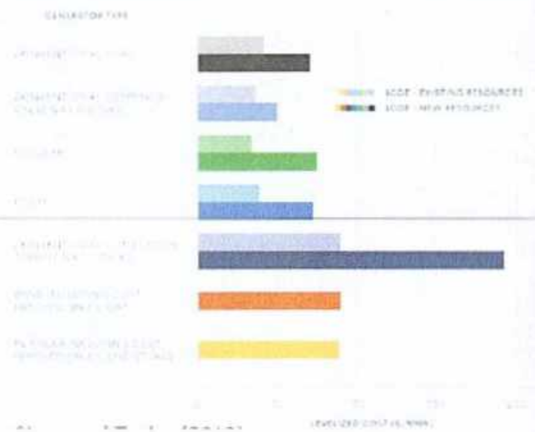
➢ Thermodynamic Analysis of Gas-Fired Power Plants

Levelized Cost of Electricity (LCOE)

LCOE: Cost per kilowatt-hour of electricity generation over the course of operation of the project (Fan et al., 2018)

Organization	Report	Year	LCOE for Single Cycle	LCOE for Combined Cycle
Institute for Energy Research	The Levelized Cost of Electricity from Existing Generation Resources	2019	\$89.9-\$192.9	\$35.9-\$50
Lazard	Lazard's Levelized Cost of Energy Analysis – Version 14.0	2020	\$151-198	\$44-73
International Energy Agency and OECD Nuclear Energy Agency	Projected Costs of Generating Electricity	2020	~\$80-\$115	~\$50-\$85

The combined cycle gas plant is a more cost-effective option and may be even at par with that of conventional coal.



In all cases, the LCOE of a combined cycle plant is lower than that of a single cycle. Combined cycle power generation offers a more cost-effective option, at par or even cheaper than that of conventional coal. Operating existing conventional fuel technologies are also still more economical than building new power plants

Power and Non-Power Applications of Natural Gas
June 2022

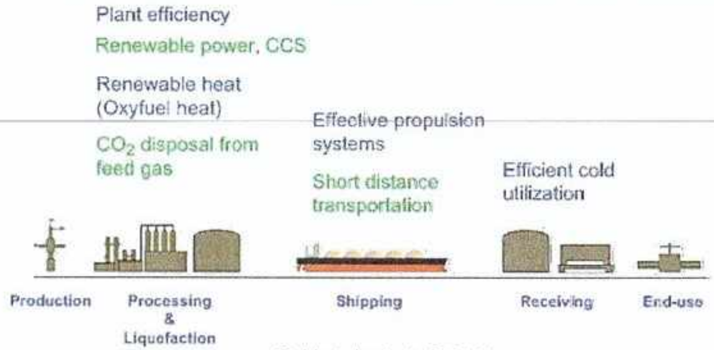
Scope

2. Technical Research on Power Applications

➢ Decarbonization in the Power Generation Sector

Challenges in Decarbonizing the Power Sector

- High fugitive emissions in upstream processes could outweigh lower carbon emissions during the use phase of natural gas.
- Carbon capture and storage technology remain at the R&D stage.



Mokhatab et al. (2014)

Power and Non-Power Applications of Natural Gas
June 2022

3. Technical Research on Industrial Applications

Background

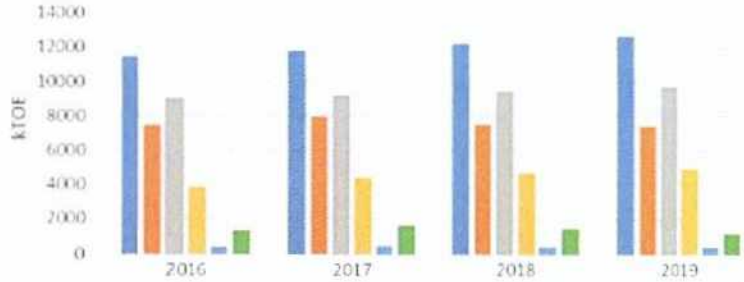
Provide a technical recommendation on a proposed LNG regasification infrastructure within the selected SEZ case.

Sections of the technical research

- Preliminary Market Study
- Industrial Decarbonization
- Process Description and Major Equipment

Energy Consumption of Local Sectors

Energy Consumption of each Sector, 2016 - 2019
Source: DOE, 2019



	2016	2017	2018	2019
Transport	11425	11823	12238	12689
Industry	7449	7925	7523	7389
Household	9035	9192	9431	9711
Services	3865	4404	4668	4915
Agriculture	450	516	440	472
Non-energy Use	1306	1613	1423	1137

Key points:

1. Transport, industry, and household are the top 3 sectors in the Philippines in terms of energy consumption.
2. Transport and industry sectors required the most attention in studying the possibility of switching to LNG-based energy sources.

Power and Non-Power Applications of Natural Gas
June 2022

4. Technical Research on Transport Applications

Background

Case studies in various countries have shown the feasibility of a CNG bus project.

- Argentina, Brazil, Pakistan, Iran and India leads in terms of bus deployment.
- Reduction of GHG emissions is the primary reason for switching to natural gas vehicles (NGV).

Decarbonization of the Transport Sector

CNG buses fared better than diesel buses in the reduction of GHG emissions.

- **Global Warming Potential (GWP) – 24% reduction**
  CNG bus: 1.67 kg CO2 eq per km
  Diesel bus: 2.14 kg CO2 eq per km
- **Lice Cycle Assessment (LCA) of Passenger Buses**
  - Switch from diesel to CNG or electric bus -> 37-41% reduction in resource depletion and overall damage to human health and the environment.

Power and Non-Power Applications of Natural Gas
June 2022

Challenges

- The supply of CNG and abundance of refueling stations are key determinant in the success of the project.
- The natural gas market for transport application is not developed yet.
    - › initially high capital cost due to installation of necessary CNG transport infrastructures
- The study utilized secondary data only.
    - › Further studies can be conducted using primary data.

Power and Non-Power Applications of Natural Gas
June 2022

Findings and Recommendations

- Efforts should be directed towards improving combustion efficiency and heat transfer in gas-fired power plants to increase plant efficiency.
- Natural gas use should be coupled with additional CO_2 mitigation strategies to ensure a streamlined transition to a zero-carbon future.
- For regions that are highly dependent on thermal sources, coal-to-gas (C2G) retrofits can be implemented to bring about significant CO_2 emission reductions.
- The adoption of CNG buses as an alternative means of public transport mitigates the effects of road transport pollution caused by diesel-powered vehicles. The market, however, would have to bear the burden of high initial capital costs on necessary transport infrastructures.

Proposed Regulatory Processed (PRP)

Nov 2021

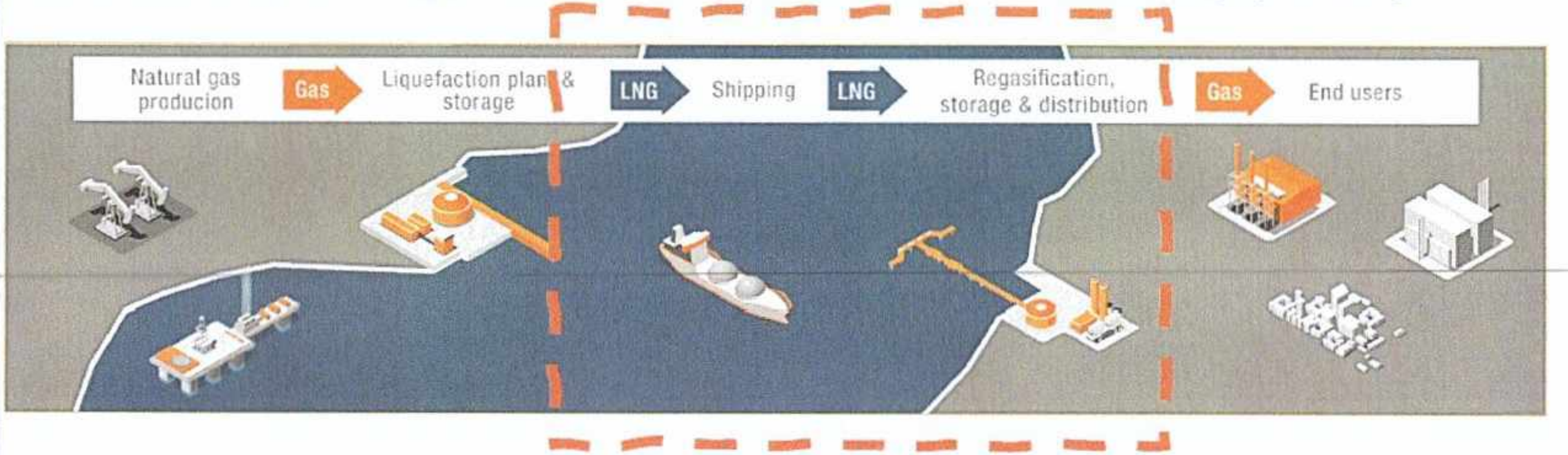
- Highlights GPDP 2's recommendations on the regulatory process per stage of operation, including the five (5) identified business types for each concerned agency as well as the list of current and proposed documentary requirements and checklist of codes and standards recommended for adoption.

The PRP is comprised of:

- Itemized technical, administrative, and regulatory recommendations for eleven agencies and two LGUs;
- Process flowcharts that show the recommended regulatory process for securing permits or clearances;
- List of current and proposed documentary requirements, and;
- Checklist of Codes and Standards to be adopted by each agency.

Proposed Regulatory Processed (PRP)
Nov 2021

Project Scope: Philippine Downstream Natural Gas Industry (PDNGI)

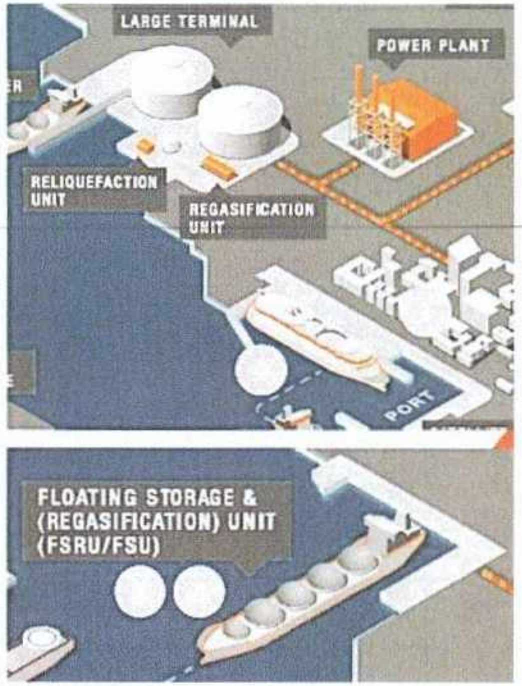


- **Importation**: Use of international LNG ships/carriers, delivered to ports connected to an on-shore import terminal or floating storage/regasification units
- **Distribution:** Use of international and domestic LNG ships/carriers
- **Processing:** At on-shore terminals connected to a port or at floating processing units

Proposed Regulatory Processed (PRP)
Nov 2021

Project Scope: Business Types

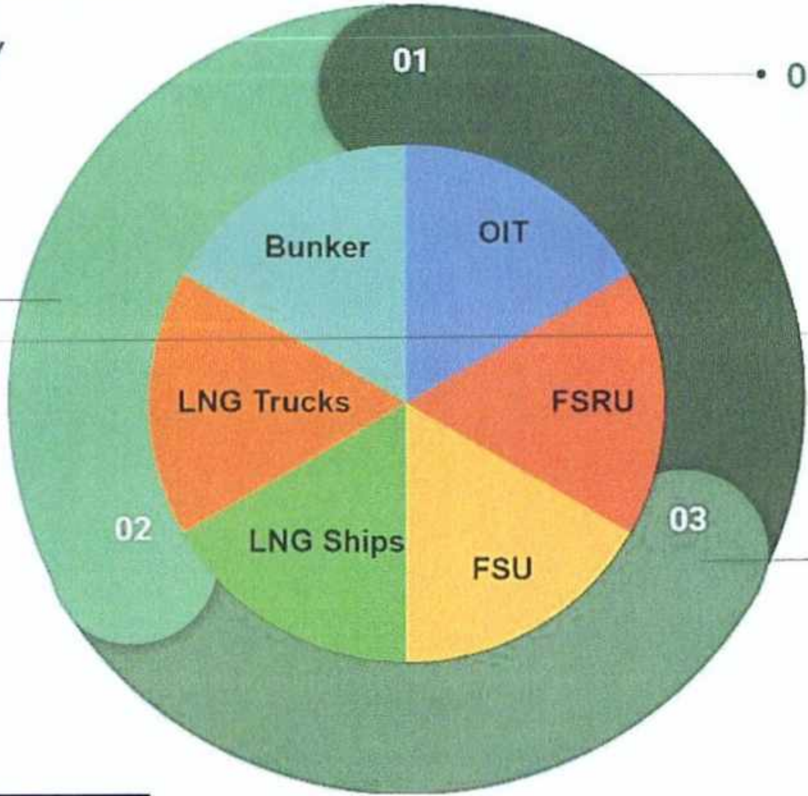
1. On-Shore Import Terminal – Ports (OIT)
2. Floating Storage and Regasification Units (FSRU)
3. Floating Storage Units (FSU)
4. Bunkers
5. LNG Ships/Carriers
6. LNG Trucks



Proposed Regulatory Processed (PRP)

Nov 2021

Scope of Study



01 Notice to Proceed (NTP)

02 Permit to Construct, Expand, Rehabilitate & Modify (PCERM)

03 Permit to Operate & Maintain (POM)

Proposed Regulatory Processed (PRP)
Nov 2021

Onshore Import Terminal	FSRU	FSU	LNG Ship	LNG Truck	Bunker
Jetty & Loading/ Unloading Arms & Hoses	Loading/ Unloading Arms or Hoses	Loading/ Unloading Arms or Hoses	Loading/ Unloading Arms or Hoses	Loading / Unloading Berth	Loading & Unloading Facilities
Cryogenic Pipelines	Cryogenic Pipelines	Cryogenic Pipelines	Cryogenic Pipelines	Piping & Controls	Manifolds & Cryogenic Pipelines
LNG Storage Tanks	LNG Storage Tanks	LNG Storage Tanks	LNG Storage Tanks	LNG Storage Tanks	LNG Storage Tanks
High- & Low-Pressure Pumps	High- & Low-Pressure Pumps	High- & Low-Pressure Pumps	High- & Low-Pressure Pumps	Pressure-building coils	High- & Low-Pressure Pumps
Boil-off Gas Recovery & Treatment	Boil-off Gas Recovery & Treatment	Boil-off Gas (BOG) Handling	Boil-off Gas (BOG) Handling		Boil-off Gas (BOG) Handling
LNG Vaporizer (Regasification Unit)	LNG Vaporizer (Regasification Unit)				
Vent & Flare System	Vent & Flare System	Vent & Flare System	Vent & Flare System	Relief Valve	Vent and Flare System
Send-Out & Metering System	Send-Out & Metering System	LNG Metering System	LNG Metering System	LNG Metering System	LNG Metering System

GAS POLICY DEVELOPMENT PROJECT

Source: R3DNGI PubCon Document, August 2020 (expanded)

Proposed Regulatory Processed (PRP)
Nov 2021

Covered eleven (11) regulatory agencies and two (2) local government units:

(1) Department of Environment and Natural Resources – Environment Management Board (DENR-EMB);
(2) Laguna Lake Development Authority (LLDA),
(3) Department of Labor and Employment – Bureau of Working Conditions (DOLE-BWC),
(4) Bureau of Customs (BoC),
(5)Philippine Ports Authority (PPA),
(6) Philippine Coast Guard (PCG),
(7) Maritime Industry Authority (MARINA),
(8) Department of Transportation - Civil Aviation Authority of the Philippines (CAAP),
(9) Department of Transportation - Land Transportation Office (LTO) and
(10) Bureau of Fire Protection (BFP)

Two LGUs:
(1) Batangas City, and (2) Pagbilao, Quezon

➢ **Recommendations per Agency** *page 12*

➢ **Inter-Agency Issues Identified** *page 56*

Proposed Regulatory Processed (PRP)
Nov 2021

Codes and Standards

These proposed standards are internationally accepted and recognized best practices, methods and procedures and its applicability to a tropical country like the Philippines.

The following standards were considered, and the complete and detailed list is in Annex I: Description of Recommended Codes and Standards for Local Adoption *(p.252)*, and Annex J: Codes, Standards, and Best Practices for Adoption Based on LNG Checklist (Per Agency) *(p.254)*:

1. American Petroleum Institute (API)
2. European Standard (EN)
3. European Standard/ International Organization for Standards (EN ISO)
4. International Organization for Standards / Technical Specifications (ISO/TS)
5. International Code of the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IGC Code)
6. National Fire Protection Association(NPFA)
7. International Standards on Audit (ISA)
8. Society of International Gas Tanker and Terminal Operators (SIGTTO)
9. LNG Bunkering Guide
10. British Standards (BS)
11. International Organization for Standards (ISO)

Development of Products, Facility, and Codes of Safety Practice Standards

DOE has entered into a **Memorandum of Agreement (MOA) with the Department of Trade and Industry (DTI) through its Bureau of Philippine Standards** on **14 May 2021** for closer coordination and collaboration in the development and promulgation of Philippine National Standards (PNS) on natural gas products, facilities, and code of practices of the downstream natural gas industry.

DEPARTMENT OF ENERGY • PHILIPPINES •

BUREAU OF PHILIPPINE STANDARDS

Way Forward

LEGAL / REGULATORY FRAMEWORK

01 Approval of a Midstream Downstream Natural Gas Law

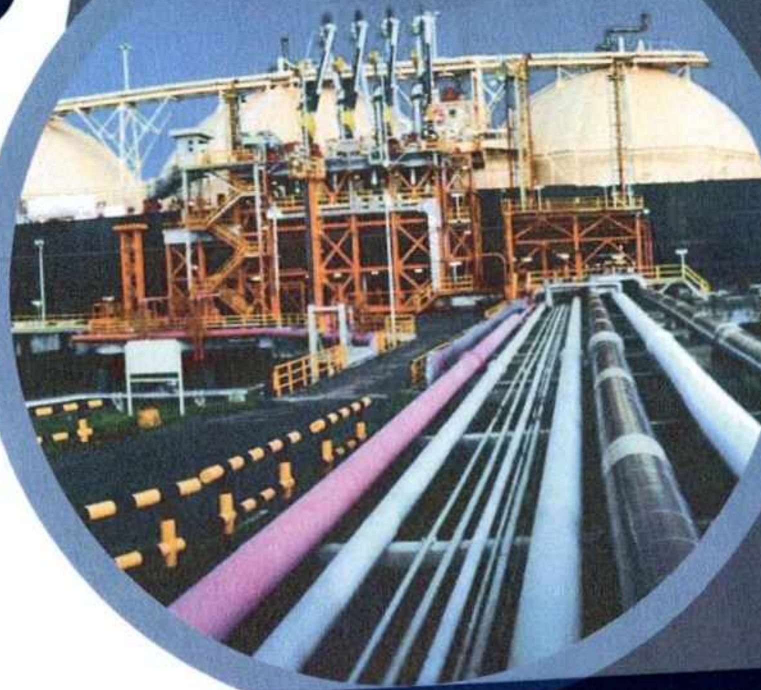
02 Development of Philippine National Standards on Natural Gas Product, Facility, and Code of HSSE Best Practices

03 Adoption and promulgation of Natural Gas specific regulation by concerned agencies using the PRP-based recommendations

RESEARCH

01 Potential Markets of Natural Gas in Visayas and Mindanao

02 Economic feasibility of small-scale LNG carriers for inter-island supply



THANK YOU!

Email: doe.oimb.ngmd@gmail.com

Direct Line: +632 8 840 0774