Factors Affecting Use of Natural Gas Vehicles (NGV) in Thailand

by

Ms. Tipkunchorn Paitoon

A Final Report of the Three-Credit Course
CE 6998 Project

Submitted in Partial Fulfillment
of the Requirements for the Degree of
Master of Science
in Computer and Engineering Management
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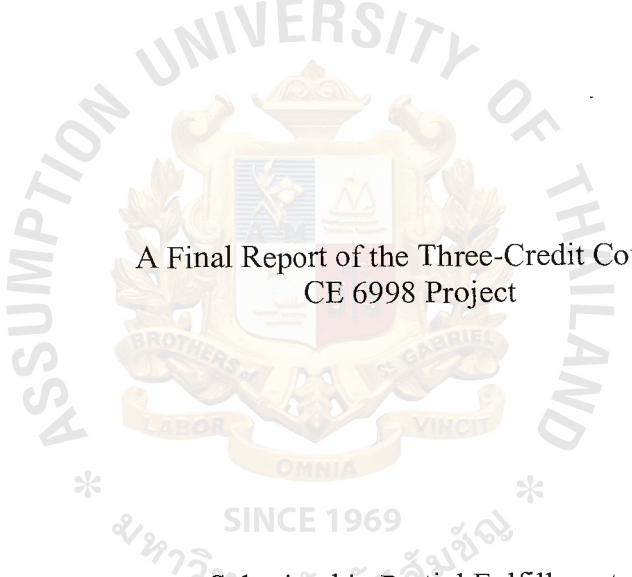

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Project Title	Factors Affecting Use of Natural Gas Vehicles (NGV) in Thailand
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The Graduate School of Assumption University has approved this final report of the three-credit course, CE 6998 PROJECT, submitted in partial fulfillment of the requirements for the degree of Master of Science in Computer and Engineering Management.

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ABSTRACT

Air pollution is one of the big problems worldwide, mainly caused by emissions from vehicles and industries which continues to grow each year along with economic growth. Cars is one of the major causes of air pollurion. NGV program has been launched in Thailand since 1984 but not widely used and the growth is significantly slow.

The purpose of this study is to identify satisfactory perception for natural gas vehicles (NGV) focusing on four factors which are its safety, environment, cost and economy, and refueling. The result of this study would be a guideline for government sectors or organizations concerned to promote NGV that would enhance the growth of NGV market and save the country's energy cost, such as importing oil.

The methodology is data collection from the population. The sampling unit is collected at random. The questionnaire is close-ended, and prepared in the Thai language. The data collection is done by mailing questionnaire method. The selected compnay is Unocal Thailand, Ltd., Operation Department.

The results of this study showed that people are in doubt about the safety of NGV but aware of its benefit on environment, cost and economy, and refueling factors.

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I am indebted to the following persons and organizations. Without them, this project would not have been possible.

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I. GENERALITIES OF THE STUDY

1.1 Introduction to the Study

The air pollution is one of the big problems worldwide, mainly caused by emission from vehicles and industries, which continues to grow each year along with the economic growth. Cars is one of the contributory causes of air pollution. For decades, natural gas vehicles (NGV) program has been launched in many countries of the world. Natural gas is the best choice because it is an environmentally clean, plentiful, low-cost, and domestically produced fuel in many countries including Thailand.

In Thailand, natural gas is produced in the Gulf of Thailand and flowed by gas pipelines to the Gas Separation Plant. Natural gas contributes more than about one-fifth of the total energy which Thailand needs and one-third of the energy is required for electricity generation. Moreover, it can be used as fuel for vehicles, which is cleaner, more economical, and cheaper than conventional diesel and gasoline.

NGV program has been launched in Thailand since 1984 with the promotion of Petroleum Authority of Thailand (PTT). They firstly commenced a pilot project for taxis and buses in Thailand. However, in 2002, there were only 82 NG buses and 1,100 NGV cars in Thailand. NGV is not widely used and the growth is significantly slow. People still consume conventional diesel and gasoline even though the price of gasoline has been increased considerably.

The selected company for this study is Unocal Thailand, Ltd. (UOT), which is one of the gas exploration and producers in Thailand. Unocal Thailand was founded in 1963, which is subsidiary of Unocal Cooperation in U.S.A. UOT is the company that explored and produced natural gas, condensed the oil from the Gulf of Thailand and

flowed it by pipelines to the gas separation plant. There are more than thousands of employees and contractors. The study area will be the employees in the Operation Department who work in natural gas operations both onshore and offshore area. Since they work closely in this area, their perception could better reflect the other people's perception that work in other kind of businesses.

UOT has 6 main locations and work places in Thailand. They are:

(1) Head Office, Bangkok

(2) Songkhla Logistics Base, Amphur Muang , Songkhla

(3) Settapat Center, the Institute of Rajmangala Southern Campus, Amphur Muang, Songkhla

(4) Air Center, the Songkhla Naval Base, Amphur Muang, Songkhla

(5) Songkhla Onshore Workshop, Amphur Muang, Songkhla

(6) Emergency Response Training Center, Amphur Muang, Songkhla

(7) Offshore Drilling and operations Base and platforms facilities, the Gulf of Thailand

Songkhla logistic base provided supporting logistics for UOT's offshore drilling, construction and production operations which involves the movement or transfers of equipment, materials and personnel either by sea or air to offshore facilities.

Settapat center and emergency response training center supports the learning environment which maximizes the value of organization, promotes innovative change process, and facilitates the growth and development of all employees and external stakeholders.

Air center is responsible for arranging air transportation from Songkhla base to offshore facilities.

Songkhla onshore workshop provides for supporting equipment modification and prefabrication for construction and production operations.

In addition, offshore facilities are responsible for producing and processing natural gas and delivery by the sub sea pipelines to the gas separation plant.

1.2 Purpose of the Study

The main objectives of this study are to identify satisfactory perception for each NGV factor of the respondents and to determine the factor that affects the use of NGV.

The area in this study could be a guideline for the government and organizations concerned to promote consumers' use of NGV, and the potential for the growth of the NGV market. The main concern of this study is to examine the respondents' demographic profile, and to identify the consumers' perception on NGV that the respondents have. The study would address the following specific questions for the study:

(1) What is the profile of respondents in terms of:

- (a) gender
- (b) age
- (c) marital status
- (d) education level
- (e) classification of employees
- (f) work position
- (g) years of service
- (h) income

(2) What are the respondents' perceptions on NGV in terms of:

- (a) safety
- (b) environment

(c) cost and economy

(d) refueling

(3) What are the perceptions of three different education levels and four different work positions of respondents on each factor of NGV in term of:

(a) safety

(b) environment

(c) cost and economy

(d) refueling

The methodology is data collection from the population. The sampling unit is collected at random. The questionnaire consists of close-ended and open-ended for any additional comments, and prepared in the Thai language. The data is collected by mailing questionnaire method.

1.3 Research Hypotheses

The proposed research hypotheses follow directly from the research questions. There are four hypotheses which are as follows:

H1 : There will be a significant interaction between education level and work position of the respondents towards the use of NGV in terms of safety.

H2 : There will be a significant interaction between education level and work position of the respondents towards the use of NGV in terms of environment.

H3 : There will be a significant interaction between education level and work position of the respondents towards the use of NGV in terms of cost and economy.

H4 : There will be a significant interaction between education level and work position of the respondents towards the use of NGV in terms of refueling.

1.4 Scope of the Study

This study will study the perception and factors of NGV consumed by the employees of Operations Department in Unocal Thailand, Ltd., by dividing the group of study into four groups as follows:

(1) Bangkok petroleum engineers

(2) Bangkok production engineers

(3) Offshore production staff and operators

(4) Offshore maintenance staff and operators

1.5 Limitation of the Study

The limitation of this study included the following factors:

(1) This study is limited to only the respondents that work at Operations Department.

(2) The accuracy of translation since the questionnaires will be prepared in Thai language.

(3) The respondents may not provide accurate answers, as they may be lack of knowledge in NGV.

1.6 Significance of the Study

This study is intended to let the respondents express their perceptions on NGV consuming factors. The result of this study would be a guideline for government sectors or organization concerned to promote consumers' use of NGV that would enhance the growth of NGV market and save the country's energy cost, such as importing oil.

1.7 Definitions of Terms

For clarity of the study, the following terms applied in the study are defined as follows:

Bangkok petroleum engineer - It refers to the employees that work in Bangkok Office in the position of Petroleum Engineer. Their responsibilities are to ensure consistency in reserve determination methodology by risk analysis, recovery factors, and reserve factors, to facilitate production/reserve enhancement, to focus on production of reserves to deliver the highest value while meeting gas demand, and to support the new ventures/exploration on exploration economics.

Bangkok production engineer - It refers to the employees that work in Bangkok office in the position of Production Engineer. Their responsibilities are to maintain and to solve problems regarding the operation equipment and facilities.

Air Quality Standards - It refers to the level set by law that may not be exceeded for restricted pollutants in the ambient air. Such standards are used to determine the amount of pollutants that may be emitted by industries and motor vehicles.

Alternative Fuel - It means a fuel that can be used instead of traditional fuels such as gasoline or diesel. Alternative fuels include natural gas (compressed and liquified), propane (LPG), hydrogen, biomass-derived fuels, alcohol (including ethanol and methanol), alcohol mixtures with gasoline or other fuels, electricity, or any other fuel determined to be substantially not petroleum and yielding substantial energy security and environmental benefits, sometimes referred to as "alternative transportation fuel".

Alternative Fuel Vehicles (AFVs) - Vehicles with engines that operate on a fuel other than gasoline or diesel. AFVs are designed and manufactured by an original equipment manufacturer (OEM), or are converted to operate on fuels other than gasoline or diesel on the "aftermarket". (see dedicated, bi-fuel and dual-fuel vehicles).

Barrel - refers to a volumetric unit of measure for crude oil and petroleum products, equivalent to 42 U.S. gallons.

Bi-fuel Vehicle - refers to a vehicle with two separate fuel systems designed to run on either an alternative fuel or a conventional fuel using only one fuel at a time. Typically, gasoline/natural gas bi-fuel vehicles are gasoline vehicles converted to bi-fuel operation by adding natural gas fuel storage, pressure regulation and control systems.

Carbon Dioxide (CO_2) - It is a colorless, odorless, nonpoisonous gas that is a normal constituent of the air. CO_2 is a product of fossil fuel combustion. Although it does not have direct adverse human health effects, it creates greenhouse gas that traps the earth's heat, contributing the potential for global climate change.

Carbon Monoxide (CO) - It is a colorless, tasteless, odorless gas slightly lighter than air. It is poisonous if inhaled since it combines with hemoglobin in the blood to prevent oxygen transfer. CO is emitted in incomplete combustion of fossil fuels (too little air, or oxygen) and is a major cause of urban air pollution.

Compressed Natural Gas (CNG) - It refers to a natural gas which is compressed so that it can be used as a portable fuel supply. CNG is stored in high-pressured containers.

Conservation - the act of preserving natural resources.

Conventional Fuel - traditional gasoline or diesel fuels.

Cost and Economy - It refers to expense related to vehicles such as cost of fuel, new engine, and maintenance cost. The economy is referred to maintenance intervals and also related to the investment in the conversion of an existing diesel engine to natural gas (NG) operation.

Dedicated Vehicle - a vehicle that operates only on natural gas and is therefore optimized to take full advantage of the high octane inherent in natural gas, thus using the fuel more efficiently. A dedicated vehicle only operates on one fuel.

Diesel Fuel - a complex mixture of hydrocarbons, composed primarily of paraffins and naphthenic compounds that auto-ignite from the heat of compression in a diesel engine. Diesel is used mainly in heavy-duty on-road vehicles, construction equipment, locomotives and stationary and marine engines.

Dual-Fuel Vehicle - a vehicle designed to operate on the combination of both an alternative fuel and conventional fuel at the same time. Though dual-fuel vehicles have two separate fuel systems, they can operate on one fuel or the other.

Emission - the release or discharge of a substance into the environment. Generally it refers to the release of gases or particulates into the air.

Environment - It refers to substances in water, soil, or air that degrade the natural quality of the environment and adversely affect sight, taste, or smell, and/or cause a health hazard.

Fast-fill Station - a vehicle fueling station designed to refuel NGVs quickly (5 to 10 minutes) depending on the size of the on-board vehicle storage

tanks. Expensive high-pressure storage is required for fast-fill refueling, therefore fast-fill stations are usually public stations co-funded by public and/or private entities.

Flammable - any material that can be ignited easily and will burn rapidly.

Fuel Cell - an advanced propulsion system that relies on the chemical interaction of natural gas (or other feedstock fuel) and certain other metals, such as platinum, gold and other electrolytes to produce electricity. The only by-product of fuel cell operation is water. Fuel cell technology is in the early development phase and therefore is very expensive.

Geenhouse Effect - a term used to describe the roles of water vapor, carbon dioxide, and other gases which make the Earth's surface warmer. These radiatively active gases are relatively transparent to incoming short-wave radiation, but are relatively opaque ("blocking") to outgoing long wave radiation. The "greenhouse" gases within the lower levels of the atmosphere trap the long wave radiation, which would otherwise escape to space, causing re-radiation of some of the energy back to the Earth. This maintains the surface at higher temperatures if the gases were absent.

Greenhouse Gases - include water vapor, carbon dioxide, tropospheric ozone, nitrous oxide, and methane. Greenhouse gases are transparent to solar radiation but opaque to long wave radiation.

Hydrocarbons (HC) - organic chemical compounds that consist only of carbon and hydrogen. Hydrocarbons are usually major components of petroleum products, natural gas, and coals. Hydrocarbons that are not burned completely during combustion contribute to air pollution, i.e., smog.

Hydrogen (H_2) - a colorless, odorless, highly flammable gas used in hydrogenation of petroleum and to produce ammonia. Hydrogen is also an important constituent of manufactured gas.

Liquefied Natural Gas (LNG) - natural gas (primarily methane) that has been liquefied by reducing its temperature to minus 260 degrees F at atmospheric pressure.

Methane (CH_4) - is the simplest of the various hydrocarbons and is the major hydrocarbon component of natural gas, and in fact is commonly known as natural gas. It is colorless, odorless, and burns efficiently without many by-products. Methane is a greenhouse gas.

Natural gas - a mixture of hydrocarbon compounds and small quantities of various other constituents existing in the gaseous phase or in solution with crude oil in natural underground reservoirs. Pipeline quality natural gas has most but not all natural gas liquids and other contaminants removed. On board a vehicle, natural gas is stored at high pressures of between 2,500 to 3,500 pounds per square inch (psi).

Natural Gas Vehicle (NGV) - a vehicle that operates on either CNG or LNG.

Offshore production staff and operator - It refers to the employees whose job descriptions and principal work places are based on the production platforms and other offshore facilities in the Gulf of Thailand or other offshore areas and who are required by the nature of their work to work for 14 consecutive days and not less than 12 consecutive hours per shift. The nature of the production staff work is petroleum operations and services relating production operations.

Offshore maintenance staff and operator - It refers to the employees whose job descriptions and principal work places are based on the production platforms and other offshore facilities in the Gulf of Thailand or other offshore areas and who are required by the nature of their work to work for 14 consecutive days and not less than 12 consecutive hours per shift. The nature of the maintenance staff's work is operations and services relating maintenance works and operations.

Oxides of Nitrogen (NOx) - the collective designation, or a general term for compounds of nitrogen oxide (NO), nitrogen dioxide (NO_2) and other nitrogen oxides. Oxides of nitrogen are typically created during combustion processes, and are major contributors to smog formation and acid deposition. NO_2 is one of the major air pollutants, and causes numerous adverse health effects.

Original Equipment Manufacturer (OEM) - the original vehicle or engine manufacturer that provides the original design and materials for assembly and manufacture of their products. OEMs are directly responsible for manufacturing and modifying vehicles, commercially viability and warranty for each product.

Petroleum Authority of Thailand (PTT) - a vertically-integrated state owner enterprise (SOE), is engaged in oil and gas exploration, production, gas transmission, and limited gas distribution activities. PTT was founded in 1978 as a state enterprise under the supervision of the Minister of Industry, and also has interests in refining and petrochemicals (through the operation of the Gas Separation Plant in Rayong). PTT has a number of international subsidiaries and

partnerships encompassing operations in China, Myanmar, The Philippines and Vietnam.

Pipeline - a continuous pipe conduit, equipped with valves, compressor stations, communications systems, and meters, etc. for transporting natural and/or supplemental gas from one point to another, usually from a point in or beyond the producing field or processing plant to another pipeline or to points of use.

Pollution - Substances in water, soil, or air that degrade the natural quality of the environment, adversely affect sight, taste, or smell, and/or cause a health hazard.

Refueling - Filling up the vehicle with fuel. In refueling NGV, gas is taken from the distribution mains and pumped to the vehicle storage cylinder.

Safety - It refers to the quality of being safe from potential danger such as danger of fire or explosion.

Slow-Fill Station - A method of fueling a vehicle with natural gas over an extended period of time, usually 6 to 8 hours (overnight) that is less expensive than high-pressure, fast-fill compressor stations.

Smog - It is evolved from both "smoke" and "fog", derived mainly from the exhaust of vehicles and industry, and usually meteorological conditions are required to enhance chemical reactions that create pollution that impairs visibility and/or causes adverse health effects.

Tailpipe Emissions - Emissions resulting from engine operations that exit through a vehicle's tailpipe system.

U.S. Environmental Protection Agency (EPA) - The United States agency which sets policies and guidelines for the protection of national interests with regard to environmental resources.

Volatile Organic Compound (VOC) - Any organic compound which easily evaporates into the atmosphere. VOCs contribute significantly to photochemical smog production and certain health problems.

II. LITERATURE REVIEW

This chapter presents a review of the literature and research related to NGV background and consuming.

2.1 Energy Evolution

It is seen in Figure 2.1 that the world relied almost exclusively on wood for heating hundred years ago. Water wheels, windmills, and steam engines were used for other energy requirements. A major source of energy was used in agriculture which includes horses, mules, and other animals, as well as human labor.

With the advent of coal-burning technology, the use of wood as fuel rapidly decreased, especially in urban areas and major cities. The availability of coal offered an economic advantage as the supply of wood diminished exponentially. Industrial energy demands were supplied with coal, and at the beginning of the 20th Century, most of the world's energy requirements were being supplied by coal (the exception: using wood-burning stoves in private residences for heating and hot water).

After World War I, oil and natural gas began replacing coal as a primary energy carrier. Both oil and natural gas were easier to transport and store. The following four decades was the transition period of energy (from coal to oil) because of being abundant.

In the field of transportation, during the post-World War II era, efficient oil-fired diesels replaced coal as the primary fuel. This was partially due to the evolution in transport, from public rails to private automobiles. In many countries, this change was followed by residential and commercial customers using pipeline natural gas for house heating. The gasoline era evolved in response to the growing demand of automobiles.

This growth in fossil fuel use led to the establishment of an energy infrastructure network not seen in previous attempts by human.

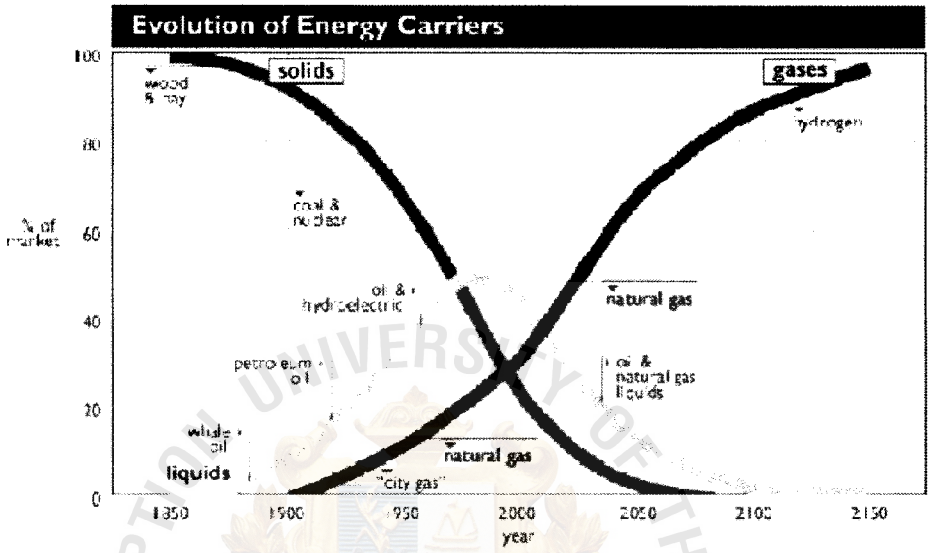


Figure 2.1. Evolution of Energy Carriers (http:\\www.greenercars.com 2003).

After World War II, nuclear fission was thought to be the next logical step in meeting the world's requirement for an inexpensive, inexhaustible source of energy. However, between the very limited and costly supply of nuclear fuel and the devastating radioactive disposal dilemma, nuclear energy was proven to be economically and environmentally risky. The growth of aerospace and nuclear technologies during the Cold War have resulted in a new generation of energy resources. Fuel cells based on new materials offer a pathway to the widespread use of alternative clean energy. Many industries are developing, testing, and demonstrating fuel cells for a variety of applications, both in transportation and stationary power. Fuel cells will be part of the evolving future of energy.

2.2 Natural Gas

Natural gas is one form of hydrocarbons, a series of molecules containing atoms of hydrogen and carbon originating from the accumulation of fossils and normally found at considerable depths beneath the earth's surface. When burnt, petroleum offers higher caloric value than woods. Natural gas normally comprises of several hydrocarbon components for example, methane, ethane, propane and butane, as well as carbon dioxide, nitrogen and liquid. About 70% of most natural gas is methane. Various compositions can be separated out and utilised for various purposes. As shown in Figure 2.2, Natural gas is usually used directly as a fuel for power plants, industries and vehicles, and when separated, can be used for a host of application.

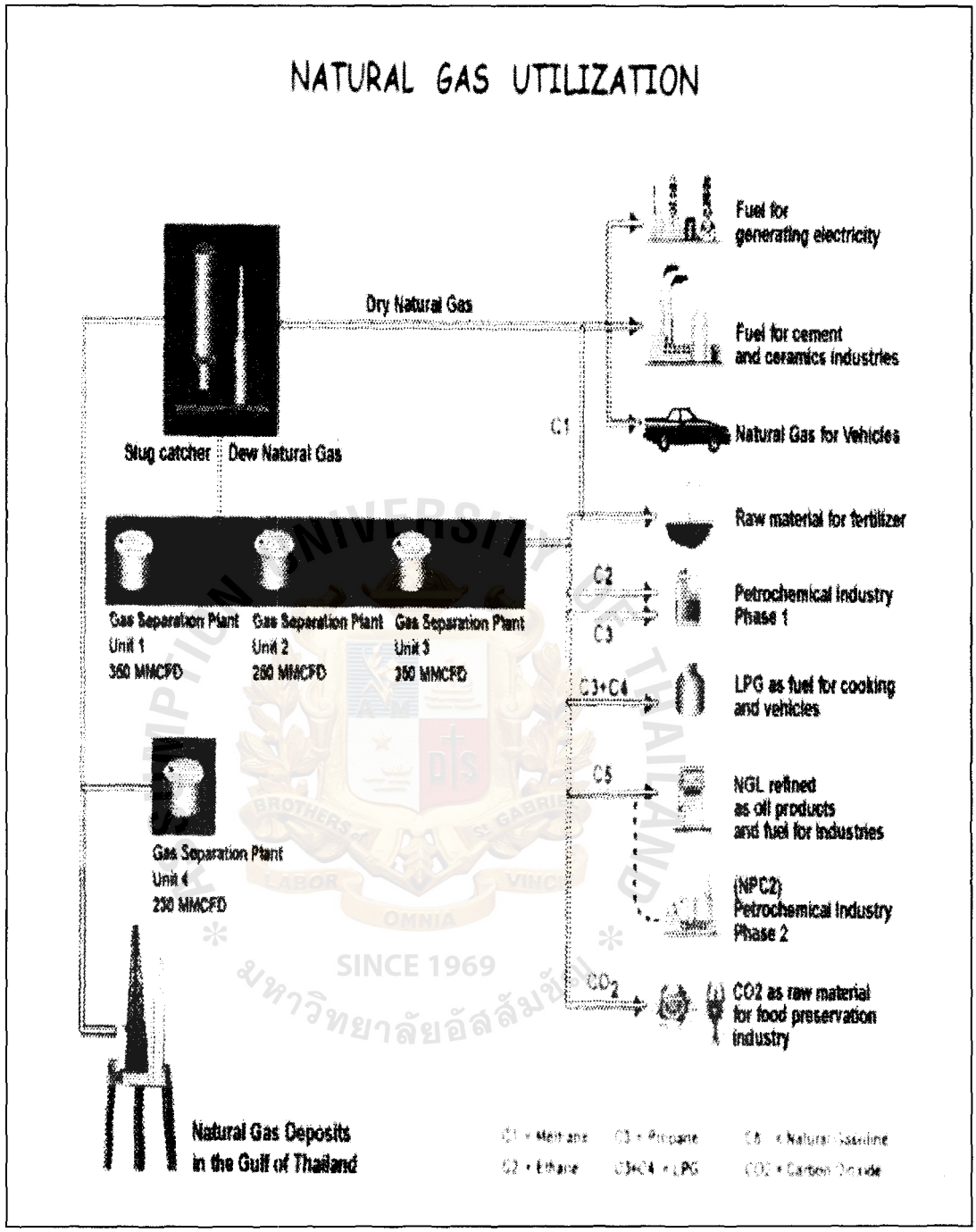


Figure 2.2. Natural Gas Utilization (http:\\www.pttplc.com 2003).

2.2.1 Product from Gas Separation Plants

Natural gas from the Gulf of Thailand is rich with several valuable hydrocarbon components and PTT has built separation plants in Rayong and Nakhon Si Thammarat to extract them.

Quality of natural gas is highly significant to the buying and selling of natural gas. PTT has thus set up a dedicated body specifically responsible for examining and controlling the quality of gas flow to comply with the contract. In addition, natural gas that PTT purchase from the Gulf of Thailand is transmitted through pipeline network through offshore platforms and sent directly to gas separation plants. The gas separation plant maximises benefits from the natural resources, giving rise to a host of industrial development. Products from gas separation plants are largely supplied as raw materials to the local petrochemical industries with some being delivered to other domestic industries and overseas buyers.

Pipeline natural gas is composed primarily of methane, ethane, propane, and heavier hydrocarbons. Small quantities of nitrogen, oxygen, carbon dioxide, sulfur compounds and water may also be found in pipeline natural gas. The following are the major components of natural gas:

(1) Methane : The bulk of natural gas is methane (C_1) , typically at least 85 percent. It is normally used as a fuel for power generating, and heating in industries, and a vehicular fuel, or NGV which is compressed into a cylinder. It is transported through a pipeline system for customers in Rayong, Chonburi, Samutprakan, Bangkok, Pathumthani, and Saraburi.

(2) Ethane : (C_2) has wide applications as raw materials for upstream petrochemical industries. It can be a raw material in polyethylene (PE) to produce plastic bags, toothpaste tubes, shampoo bottles and plastic fibers.

It is transported through a pipeline in Mab Ta Phut Industrial Estate, to be used in petrochemical industry, for example, National Petrochemical pc.,Ltd. , Thai Olefins Co., Ltd.

(3) Propane : (C_3) can also be used as a raw material for upstream petrochemical industries and used as a fuel in industry. When combined with Butane (C_4), it is turned into LPG (liquefied petroleum gas) which is widely used as household fuel or vehicular fuel. It can be a raw material for petrochemical industry to produce plastic, propylene (PP) such as battery, glue, and additive in lubricant. It is transported by trucks and product pipeline in Mab Ta Phut Industrial Estate.

(4) Liquefied petroleum gas (LPG) : LPG normally refers to either the mixture of propane and butane or the whole part of each of the two gaseous components. In Thailand, the LPG derived from the natural gas separation plants comprises 70% propane and 30% butane, and thus yielding a high caloric value. LPG can be used as a fuel, cooking gas and vehicle fuel. It is transported from Rayong Gas Separation Plant via the pipeline and delivered to customers in Mab Ta Phut Industrial Estate, and then through the pipeline to Khao Bo Ya LPG Terminal, Ban Rong Po LPG Terminal, then distributed to domestic and overseas customers. From Khanom Gas Separation Plant, it is shipped to Surat Thani LPG Terminal and Songkhla Petroleum Terminal to be distributed in the South of Thailand.

(5) Natural Gasoline : It is used as a raw material in solvent industry, mixed with benzene, and used as a raw material in petrochemical industry. It is transported from Rayong Gas Separation Plant through the 4-inch sized pipeline for customers in Mab Ta Phut Industrial Estate. And then

transported to Khao Bo Ya LPG Terminal through the 4-inch sized pipeline to be exported.

(6) Carbon Dioxide : Once separated, carbon dioxide is turned into a solid state, more commonly known as dry ice, which is widely used for refrigeration purposes, for artificial rain making, to mention just a few. CO_2 is used in metal industry, food preservation industry, soft drink industry, fire extinguishers, artificial rain etc. It is transported through Carbon Dioxide pipeline in Gas Separation Plant for CO_2 and dry ice producers.

2.2.2 Natural Gas Utilization in Thailand

For more than 20 years, Petroleum Authority of Thailand (PTT) has been the country's sole outfit involving in integrated natural gas businesses in the kingdom. It has been procuring natural gas supplies, both from local and overseas sources. The natural gas being supplied by PTT is in the range of 2,300 million standard cubic feet per day (MMscfd). Thailand's proved natural gas reserves are estimated at 12.7 trillion cubic feet.

In Thailand, natural gas procured by PTT comes from offshore and inland sources as well as from Myanmar. Indigenous gas represents about 75% of total gas supplies with the remaining 25% from Yadana and Yetagun fields in Myanmar's Gulf of Martaban (Howard 2002).

In 2002, more than 60% of Thailand's electricity is generated by natural gas. About 77% of some 2,000 MMscfd of gas is directed to the Electricity Generating Authority of Thailand (EGAT), independent power producers and small power producers. About 8% of the overall gas is delivered to factories and 15% to natural gas

separation plants as raw materials. The natural gas substitutes fuel oil that costs the country tens of billion Baht a year.

Natural gas is reasonably priced with no cost burdens involving storage keeping or transportation. It offers constant heating value with little operating and maintenance costs. It is a clean fuel, providing complete combustion, enhancing efficiency and extending life of parts or machinery such as boiler. Industries can rest assured about the consistent quality standard of PTT natural gas and supply security. The heating value of natural gas for the eastern pipeline network has been standardized.

In Thailand, natural gas is supplied as fuel to the following sectors:

(1) Power generation : Natural gas is supplied to the Electricity Generating authority of Thailand (EGAT), independent power producers (IPPs) and small power producers (SPPs).

Natural gas now generates about 69% of Thailand's electric power supplies. In 2002, PTT delivered an average of 1,935 million cubic feet per day of natural gas, or 335,940 barrels of oil equivalent per day, to the power plants operated by Electricity Generating Authority of Thailand (EGAT), Independent Power Producer (IPPs) and Small Power Producers (SPP).

(2) Industrial plants : Natural gas is used as industrial fuel. Natural gas offers a wide application for industrial plants, fuelling boilers, dryers, smelters, furnace, etc. to substitute other types of fuel like LPG and fuel oil.

A total of 140 manufacturing plants, ranging from ceramic, glass, iron, copper, metal sanitary ware and tyre, to computer parts, are now relying on natural gas from PTT. Among these plants, 12 plants use natural gas for power generation in their co-generation units. The average

combined gas delivery to this sector at the end of 2002 was at 198 MMscfd, 8% up from the previous year.

(3) Transportation fuel

Natural gas may be used as a transportation fuel in two forms which are compressed natural gas (CNG) and liquified natural gas (LNG). Fundamentally, the difference between these two forms is energy density which is a liquid fuel carrying more energy per pound than a gaseous fuel. However, in whichever form of fuel that stored in vehicle is, the important matter is how the fuel could reach the engine in the vapor phase.

Compressed natural gas (CNG) is pressurized natural gas that is stored in cylinder tanks at pressures of 3,000 up to 3,600 pounds per square inch (psi) for an internal combustion engine. CNG is usually pipeline gas that is dried by removing water and compressed at a refueling station. Many refueling stations have been constructed to compress natural gas to use in natural gas vehicles (NGVs). Currently, CNG is the most common form of natural gas used as a clean alternative fuel, though it is noteworthy that heavy-duty vehicle fuel markets are developing rapidly for liquified natural gas (LNG).

Liquefied Natural Gas (LNG) is pipeline natural gas refined through a process called liquefaction to make LNG, which removes oxygen, carbon dioxide, sulfur compounds, and water from the fuel. The process can also be designed to purify the LNG to almost 100 percent methane.

To facilitate the transportation of natural gas over a long distance, i.e. over 2,000 kms, natural gas is liquefied by cooling the gas to minus 162 Degree Celsius where it condenses to a liquid, thus reducing its volume by

600 times. The liquefied natural gas (LNG) is then transported by LNG carrier to its destinations. A gallon of LNG weighs less than one-half that of water and is odorless, colorless, non-corrosive, and non-toxic. When vaporized, it burns only in concentrations of 5 to 15 percent when mixed with air. Neither LNG, nor its vapor, can explode in an unconfined environment.

LNG tanks have double-walled construction with extremely efficient insulation between the walls. Large tanks are low aspect ratio (height to width) and cylindrical in design with a domed roof. Storage pressures in these tanks are very low which is less than 5 psig. Smaller quantities, 70,000 gallons and less, are stored in horizontal or vertical vacuum-jacketed, pressure vessels. These tanks may be at pressures anywhere from less than 5 psig to over 250 psig. To remain LNG as a liquid LNG, it must be maintained cold at least below -117°F with independent of pressure.

2.3 Natural Gas Vehicles (NGV)

Natural gas has been used as a vehicular fuel for more than 80 years. NGV was first introduced in Italy where more than 300,000 cars are now driven by natural gas. Many other countries, spanning from Americas to Asia and Australia, have adopted NGV as one of the fuels for cars. Today, more than one million cars around the globe are powered by NGV (see Figure 2.3).

Natural gas for vehicles (NGV) comprises mostly of methane. In its natural form, NGV is colorless, odorless, and lighter than air. It offers complete and clean burning in engines with lower level of emission than other fossil fuels and possessing 130 octane number. It is regarded as an economical, safe, environmentally friendly fuel for vehicles. For those reasons, NGV has become more popular throughout the world.

2.4 Natural Gas Vehicles in Thailand

NGV made its debut in Thailand in 1984 when a number of Bangkok buses and tuk-tuk taxis underwent the NGV experimental program. Technically speaking, the experiment was a success with satisfactory engine performance being noted. However, the lower cost of motor fuels and the high costs of modifying engines to NGV fuelling at that time made the program not economical.

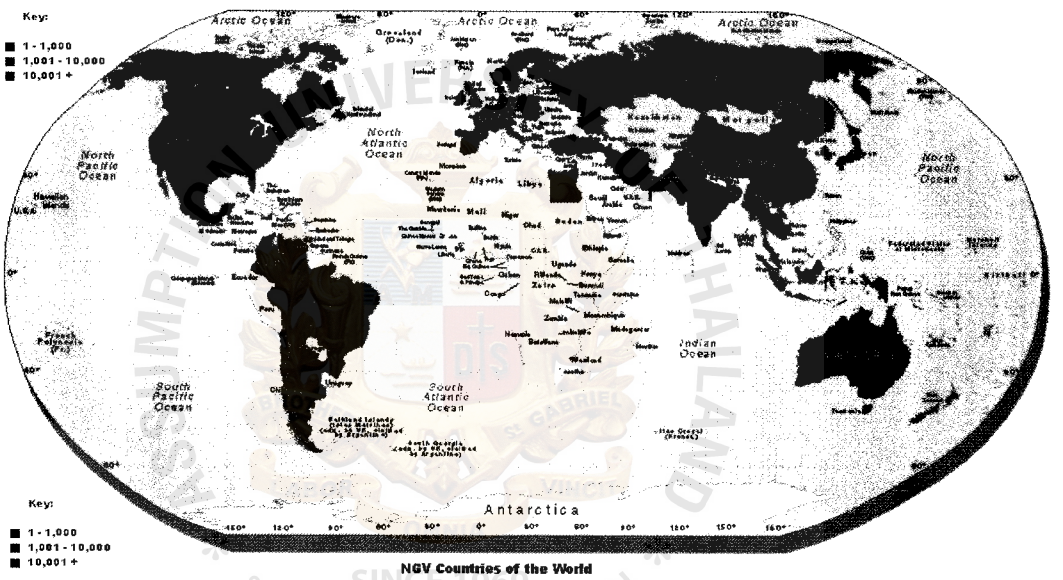


Figure 2.3. NGV Countries of the World (http:\\www.iangv.org 2003).

In 1993, the government's policy in addressing the air pollution problems revived the interest in NGV. Funding supports were granted to the Bangkok Mass Transit Authority (BMTA) to acquire 82 NGV buses and the country's first NGV filling station being built by PTT at BMTA's Rangsit depot in Bangkok's northern outskirts.

In 1999, PTT embarked on another trial, modifying 12 petrol engine cars and 16 diesel engine vehicles into oil/gas bi fuelling. The results were satisfactory. A larger

NGV test program was launched a year later when PTT sponsored the costs of turning 100 city taxis into oil/NGV burning vehicles.

The success led PTT to start a pilot project by PTT bearing the cost of changing 1,000 taxies into NGV powered cars. In parallel, PTT has started building NGV filling stations in Bangkok and its adjoining areas.

The Thai government has realized that utilizing NGV as an alternative fuel in the transportation sector helps Thailand in improving air quality and saving foreign currencies for importing crude oil since natural gas is an indigenous fuel while crude oil is mostly imported. In addition, to maximize the advantages and minimize the disadvantages of NGV, the government has not only announced and committed on NGV expansion in March 2000, it also provides the following supportive measures:

(1) Having National Energy and Policy Office (NEPO), a government agency, to co-operate with PTT in arranging financial support to vehicle owners, such as loans with special low interest rates and long term repayment for taxi conversion, and granting BMTA and BMA additional cost for purchasing NGV vehicles instead of diesel-powered vehicles.

(2) Obtaining price advantage of NGV by maintaining current pricing structure for refined crude oil products which they are imposed with excise tax, municipal tax, oil fund and energy conservation fund as well as VAT, while natural gas is exempted from any taxes, except VAT. This pricing regime facilitates NGV to be priced lower than any other fuels.

(3) Reducing import tax for the following NGV refueling facilities and conversion kits:

(a) NGV refueling facilities: Compressor 3 %, other equipment 1%

(b) Vehicular conversion kit: Equipment 1%, NGV cylinder 10% for all material types.

(4) Revising the existing natural gas powered vehicle regulations to accommodate the latest NGV technologies.

(5) Developing NGV refueling station regulation.

Table 2.1 shows the comparative characteristics of natural gas, gasoline, diesel, and LPG including the issues of physical status, safety, flammability limit, usage, combustion efficiency, environmental, fuel quality, and other expenses.

Table 2.1. Comparative Characteristics of Natural Gas, Gasoline / Diesel, and LPG (http:\\www.ngv.org 2002).

Issues	Natural Gas	Gasoline / Diesel	LPG
Physical Status	Gas	Liquid	Gas/Liquid at 7 bar
Safety	Safer as it is lighter than air and so disperses upwards when leaking.	Heavier than air and so flows on the ground when leaking.	Heavier than air and so remains on the ground when leaking.
Flammability limit (% by volume)	5-15%	Gasoline 1.4-7.6 %, Diesel 0.6-7.5 %	2.0-9.5 %
Usage	As a gas, it can directly mix with air.	It needs an atomizer to mix it with the air before combustion can take place.	It is a liquid that must be gasified before using.
Combustion Efficiency	Complete combustion, produces a better flame and leaves no residue.	It burns poorly and creates soot.	Better combustion than fuel oil and mixes with air better.
Environmental	Cleaner and less polluting.	It burns poorly and creates soot.	Complete combustion and no soot.
Fuel quality	Colorless, odorless; direct fired combustion by natural gas has no effect on products or processes.	Its color and odor may affect the manufacturing process or product quality.	Colorless, odorless; odorant is filled for safety and usage.
Other expenses	- Delivered by pipeline, it is always ready to be tapped. - Reduces the expense of barrels, storage, and repeated odoring.	- It must be stored in tanks. - Advance purchase order required. - Area for tanks needed.	It must be stored in tanks. Area for tanks required. Advance purchase order required.

2.5 Discussion of NGV in Terms of Safety

Natural gas has been used as a motor fuel since the 1930s or for more than 60 years. According to the US Gas Research Institute, there have been no fatalities, burn accidents or serious injuries related to the use of natural gas in more than 430 million vehicle-miles of use. Natural gas for vehicles has an unparalleled safety record.

In case of spill, natural gas is non-toxic, non-carcinogenic and non-corrosive, there is no threat to land or water in the event of a spill.

In its pure state, natural gas is tasteless, colorless and odorless. As a safety measure, an odorant called mercaptan is added so that any leak can be detected easily.

Any motor vehicle fuel can be dangerous if handled improperly. Fuels contain energy which must be released by burning. Gasoline is a potentially dangerous fuel, but we have learned to use it safely over the time. The same is true to natural gas. Natural gas is used in industries and by residents to generate electricity, heat homes, and cook meals. For safety, natural gas must be understood and respected like gasoline.

Natural gas vehicles have an excellent safety record for two primary reasons which are the properties of the fuel itself and the integrity of the natural gas vehicle and its fuel delivery system. Natural gas has a very limited range of flammability. It will not burn in concentrations below about 5% or above about 15% when mixed with air. Gasoline and diesel burn at much lower concentrations and ignite at lower temperatures. Although it takes very little energy to ignite a flammable mixture of air and natural gas, gasoline, or diesel, natural gas burn at a somewhat lower temperature.

From the gas field to the vehicle's engine, natural gas requires very little processing to make it suitable for use as a fuel. Gasoline and diesel must be processed from crude oil in large and complex oil refineries. After water vapor, sulfur and heavy

hydrocarbons are removed, natural gas flows by pipeline which is the safest way to transport energy directly to the fueling station where it is compressed for use. Alternatively it may be liquefied at cryogenic temperatures on site or at a central facility and delivered by truck. Gasoline and diesel are delivered to fueling stations by tank trucks over the highways.

At a compressed natural gas fueling station the gas is compressed before being provided to vehicles at 3,000 to 3,600 pounds per square inch (psi). Stations can deliver a fast fill to vehicles in minutes or, using a slow fill strategy, from a few hours to overnight.

Cylinder selection is critically important when designing a natural gas vehicle. The summary of cylinder technology and design theory from Gas Research Institute (GRI), the United States provides helpful information for the vehicle designer. The research bulletin from Gas Research Institute (GRI) provides background and guidance on natural gas vehicle (NGV) cylinder inspections. Another important GRI document identifies proper practices in the care and handling of NGV compressed gas cylinders.

Although the use of high storage pressures might appear dangerous, compression, storage and fueling of natural gas vehicles meet stringent industry and government safety standards. Remember that high-pressure gases are used safely every day in industrial and medical applications.

The NGV fuel storage system is made of forged steel or fiberglass wrapped aluminum that is one to two centimeters (0.4-0.8 inches) thick. The strength of the NGV fuel storage system allows it to withstand crashes and heat much better than a standard gasoline tank.

Although CNG is a flammable gas, it has a narrow flammability range, making it an inherently safe fuel. Strict safety standards make CNG vehicles as safe as gasoline-

powered vehicles. In the event of a spill or accidental release, CNG poses no threat to land or water; it is nontoxic. CNG also disperses rapidly, minimizing ignition risk. Natural gas is lighter than air and will not pool as a liquid or vapor on the ground. Nevertheless, leaks indoors may form a flammable mixture in the vicinity of an ignition source. CNG is primarily methane, however, which is a greenhouse gas that could contribute to global climate change if leaked. Methane is slightly soluble in water and under certain environmental conditions (anaerobic) does not biodegrade; if excess amounts accumulate, the gas can bubble from the water, possibly creating a risk of fire or explosion.

There is some different safety concerns with CNG buses than diesel fuel buses, such as greater breaking distance due to increased fuel storage system weight. This is a relatively small concern; however, because the fuel system is a small fraction of a bus' total weight. CNG buses also might accelerate because they are slower than their diesel counterparts.

Natural gas powered vehicles are designed and built to be safe both in normal operation and in crashes. New natural gas vehicles are subjected to the same crash tests as other vehicles. Natural gas vehicle fuel systems must meet Federal Motor Vehicle Safety Standards 303 and 304. Natural gas cylinders are much thicker and stronger than gasoline or diesel tanks. Industry standards require them to withstand 11,250 fill cycles, and endure far beyond normal environmental and service damage risks. Cylinders must even withstand a bonfire test and penetration by a 30-caliber bullet without rupture.

No matter what the fuel is, fueling stations, indoor parking structures and repair garages must be built to ensure high levels of safety. Requirements for facilities handling natural gas and natural gas vehicles may differ from those for gasoline or diesel vehicles. For example, leaking diesel and gasoline form puddles on the floor.

Natural gas normally rises toward the ceiling and disperses. Therefore the danger of fire would be greatest near the floor for liquid fuels and near the ceiling for natural gas.

Time has proven natural gas vehicles to be safe in actual operation. Based on a Natural Gas Vehicle Safety Survey by American Gas Association in March 1992, a survey of 8,331 natural gas utility, school, municipal and business fleet vehicles (NGVs) that traveled 178.3 million miles showed that:

(1) The NGV fleet vehicle injury rate was 37% lower than the gasoline fleet vehicle rate.

(2) There were no fatalities compared with 1.28 deaths per 100 million miles for gasoline fleet vehicles.

(3) The collision rate for NGV fleet vehicles was 31% lower than the rate of gasoline fleet vehicles.

(4) The fleet of 8,331 NGVs was involved in seven fire incidents, only one of which was directly attributable to failure of the natural gas fuel system.

International Gas Union and International Association of Natural Gas Vehicles, Task Force Report in Milan 1994, reported that although there are approximately 85,000 natural gas vehicles now operating in the United States, there has not been a fuel tank rupture in over two years. The report from Gas Research Institute by Mr. Bill Liss in 1999, regarding NGV Storage Update showed that with over 300,000 NGVs operation in Italy, there was only one fuel tank rupture during the last three years. In the U.S.A., not only transit agencies and police are using natural gas vehicles, more and more school buses are now powered by natural gas.

The strength of the natural gas cylinders and fuel system generally avoids any leakage or fire. The following examples showed how natural gas vehicles had behaved

in crashes. These are reported from the accidents involving a CNG-powered pick-up proved to be a testimonial to the safety of CNG tanks.

Automotive Fleet, Energas Pick-Up Accident Demonstrates Safety of CNG in May 1995 reported that in Midland, Texas, when the 1992 CNG pick-up was broadsided, the most vulnerable part of the fueling system bore the brunt of the hit. The CNG tanks did not rupture on the impact and the driver could walk away from it safely. In a tragic 1998 accident, a stopped bi-fueled Honda (a vehicle which could run on either natural gas or gasoline) was hit by another vehicle moving at nearly 100 mph and a fire fed by gasoline broke out. The 50-liter natural gas fuel tank was intact and remained secured in its support brackets.

In summary, technical data, appropriate safety regulations and years of experience show natural gas vehicles are as safe as, or safer than, conventionally fueled vehicles.

2.6 Discussion of NGV in Terms of Environment

There are three primary reasons that natural gas is an environmentally friendly fuel. First, natural gas typically consists of about 90 percent methane (CH_4). The emissions from natural gas vehicles also are primarily unburned methane. Methane is not a volatile organic compound (VOC). This is important because unburned and evaporative VOCs combine with oxides of nitrogen (NOx) in the presence of sunlight to form ground level ozone. Methane is a greenhouse gas (and, in fact, is a more intense greenhouse gas than carbon dioxide), natural gas vehicles on the whole contribute less to greenhouse gas formation because natural gas has less carbon than gasoline and other petroleum motor fuels.

Secondly, the fuel cycle emissions of natural gas are much less than other transportation fuels. Fuel cycle emissions include emissions that occur during energy

extraction, processing, conversion, transportation and distribution. Because it generally is not refined or transported by truck or barge, natural gas does not pose nearly the transportation related environmental and safety hazards associated with gasoline and diesel.

Thirdly, as a motor fuel, natural gas provides superior emission performance relative to gasoline and diesel. Among the reasons for this are that NGVs:

(1) have virtually no evaporative and running loss emissions due to their sealed fuel systems and negligible refueling emissions

(2) have inherently lower non-methane hydrocarbon (NMHC) emissions since the fuel is 85-99 percent methane which emits significantly less toxic air contaminants such as benzene and 1,3 butadiene since these chemicals and their precursors are not found in natural gas

(3) have lower " off cycle" emissions

(4) have lower cold-start emissions

(5) have better emission durability due to the reduced complexity of their emission control systems.

Furthermore, the benefits of NGVs in reducing real world pollutant emissions from vehicles in-use is expected to be even greater than measured by today's tailpipe standards which do not test many common driving conditions.

2.6.1 Emissions Characteristics

These characteristics are estimated based on CNG's inherently "cleaner" chemical properties with an engine that takes full advantage of these properties. Actual emission will vary with engine designs; for example, the potential reductions in carbon monoxide emission of 90 to 97 percent offered by compressed natural gas, relative to conventional gasoline.

Most of the environmental impact associated with motor vehicles occurs when they are used, due to pollution in their exhaust and pollution associated with supplying the fuel. In the United States, nearly all of today's automobiles use gasoline; a lesser number use diesel fuel. In some areas, various alternative fuels are being introduced, but these are not widely available for most drivers. When gasoline, diesel, or other fuels are burned in car engines, combustion is never perfect, and so a mix of hazardous pollutants come out from the tailpipe.

The focus in ACEEE's Green Book® is on air pollutants related to car and truck fuel consumption, because they are such a large part of a vehicle's environmental damage and because they are the main impacts that can be reduced through the choice of make and model. The adjoining figure shows the amounts of major air pollutants caused by the average new passenger car and light truck in a year. The pollution coming from vehicles can differ depending on the standards they meet (and how well their emission controls work), how they are driven and maintained, and the quantity and quality of the fuel they burn. Many vans, pickups, sport utilities, and other light trucks meet less stringent emissions and fuel economy standards than vehicles classified as passenger cars. As a result, and as the ratings in this guide indicate, the average light truck pollutes more than the average car.

(1) Particulate Matter (PM)

Fine airborne particles are an established cause of lung problems, from shortness of breath to respiratory and cardiovascular diseases, lung tissues damage, and cancer. Some people are allergic to polluted air particularly asthmatics, individuals with flu and with chronic heart or lung diseases, as well as children and the elderly. PM also soils and damages buildings and materials. It forms haze that obscures visibility in many

regions. Soot and smoke coming from exhaust pipes are obvious sources of PM, but the most deadly forms of airborne particulate matter are the invisible fine particles that lodge deeply in the lungs. PM has been regulated for some time, but the regulations were based on the amount of particles up to 10 microns in size (PM10). According to a recent U.S. Environmental Protection Agency report, PMs are more harmful than originally suspected, increasing respiratory and cardiovascular problems.

Diesel engines are the major source of direct PM emissions from motor vehicles. Although most such emissions come from heavy trucks and diesel buses, even the smaller diesel engines in some cars and light trucks emit significant amounts of fine PM.

Natural gas engines that operate in diesel applications (primarily medium-duty and heavy-duty) offer the opportunity to reduce PM10 emissions ten-fold.

(2) Nitrogen Oxides (NOx)

NOx refers mainly to two chemicals, nitrogen oxide (NO) and nitrogen dioxide (NO_2), that are formed when nitrogen gas, which comprises 78 percent of air, reacts with oxygen at high temperatures that occur during fuel combustion. Nitrogen monoxide (NO) is responsible for the brown haze prevalent in polluted cities, and also leads to the production of atmospheric ozone. Atmospheric ozone causes a variety of health problems; the least severe of which are respiratory tract irritation, breathing difficulty and headaches. NO slowly rises to the upper atmosphere, where it helps deplete the stratospheric ozone layer (the "good" ozone, which needs to be protected against ultraviolet radiation). Nitrogen dioxide (NO_2) also

poses breathing hazards, especially for sensitive people who suffer from asthma, emphysema, and chronic bronchitis. Nitrogen oxides, along with sulfur dioxide, are major precursors to smog and acid rain, and ozone damages crops and trees.

As an air pollutant, NOx is one of the most difficult to control since it is such a pervasive product of combustion. NOx is truly a noxious pollutant in many ways. Most NOx comes from electric power plants and industrial sources nationwide. NOx emissions come from heavy-duty diesel trucks, but cars and light trucks are also a major source. NOx has also been one of the most difficult pollutants to get out of our air. EPA air quality regulations have helped keep emissions from growing as fast as they might have, and inventories show a modest decline in NOx emissions over the past five years. Transportation-related NOx emissions continue to increase, however, preventing faster progress overall.

NO_X emissions can be reduced by 50 percent with natural gas engine technology.

(3) Sulfur Dioxide (SO_2)

Gasoline and diesel fuels also contain varying amounts of sulfur, which burns in the engine to produce sulfur dioxide (SO_2). This gaseous chemical is another source of secondary particulate formation, and itself is a lung irritant as well as a cause of acid rain. SO_2 also interferes with the operation of catalytic converters. Some of the cleaners, reformulated versions of gasoline have very low sulfur levels. Most gasoline sold nationwide still has too much sulfur, but levels are being reduced under recently established EPA regulations.

Cars and light trucks are not the largest source of SO_2 emissions, which come mainly from power plants and industrial facilities. However, because cars and light trucks are so numerous and gasoline has a high average sulfur content, cars and light trucks cause twice as much as fine PM pollution and heavy freight trucks do. Making all gasoline as clean as the cleaner, low-sulfur fuels already available in many countries would greatly reduce this PM pollution from all cars and trucks on the road, both new and used.

(4) Hydrocarbons (HC)

Hydrocarbons are a broad class of chemicals containing carbon and hydrogen, sometimes referred as non-methane hydrocarbons (NMHC) or non-methane organic gas (NMOG). Those hydrocarbons that cause various forms of air pollution are also known as volatile organic compounds since they are forms of HC that can be in the form of gas or readily evaporate into the air. Many forms of HC are directly hazardous, contributing to what are collectively called "air toxic." These compounds can be directly irritating the lungs and other tissues and they can also cause cancers, contribute to birth defects, and cause other illnesses. During daylight hours and particularly in hot weather, HC reacts with NOx to form ozone smog. Controlling ozone is one of the major environmental challenges. Although progress has been made over the past several decades, many cities and regions still have smog alerts when ozone levels get too high.

Gasoline vapor contains a mix of hydrocarbons. Thus, HC pollution is produced whenever we fill our tanks. Some regions have special nozzles on fuel pumps to help trap such vapors. Other HC vapors are released at

various stages along the way from the refinery to the filling station. Vapors seep out, even when a car is parked and turned off, due to the imperfect sealing of the fuel tank, pipes and hoses, and other components leading to the engine. HC also comes out of the tailpipe, as a result of incomplete combustion and the less-than-perfect cleanup of exhaust gases by catalytic converters and other vehicle emissions controls. Diesel fuel is less volatile than gasoline, so evaporation is less of a problem. Nevertheless, diesel exhaust still contains many toxic hydrocarbons and other compounds. Overall, transportation is responsible for about 36 percent of man-made HC emissions in the United States.

Using a natural gas vehicle can reduce hydrocarbon emissions by approximately 50 percent.

(5) Carbon Monoxide (CO)

Carbon monoxide is another main smog ingredient. It is an odorless, colorless, but potentially deadly gas that is created by the incomplete combustion of any carbon-containing fuel, including gasoline and diesel. When inhaled, CO combines with the hemoglobin in our blood, impairing the flow of oxygen to our brain and other parts of the body. We've all heard stories of people being killed by carbon monoxide poisoning, from vehicles in closed garages, during fires, or in homes when indoor CO concentrations are raised by malfunctioning stoves or furnaces. Even if it does not cause death, CO exposure can cause permanent damage to the nervous system. At lower concentrations, CO is still harmful, particularly for people with heart disease. Recent studies show that even low concentrations of CO can

possibly decrease pregnancy rate. In some areas, cars and trucks can create enough CO to cause health risks outdoors.

Large amounts of CO are produced when a vehicle first starts up and its engine is cold. Poorly designed and malfunctioning engines and emission controls systems are also responsible for excess CO pollution. Motor vehicles are responsible for about 60 percent of CO emissions nationwide.

NGVs reduce CO emissions by about 95 percent compared to gasoline vehicles.

2.6.2 Air Pollution in Thailand

The pollution in Thailand is mainly caused by the emission from industry factories and vehicles. Geographically, the most deteriorating air quality is in Bangkok and metropolitan areas. The air pollution problems are relentlessly escalating. Although the emission control measures applicable to stationary pollution sources such as factories have marked considerable progress and although efforts to control exhaust gas emission have also advanced for automobiles the fact remains that the environmental standards especially particulate matter (PM) are not being met in most roads in Bangkok. PM is a microscopic component of air pollution that penetrates deeply into the lungs. This could be because of the increase in the number of automobiles on Bangkok roads, mainly the increase in the number of diesel vehicles. In 1999, there are 20 million vehicles in Thailand, approximately 19% of them were diesel vehicles, and 11% were gasoline vehicles. Diesel vehicle exhaust gases are believed to be the main source of NOx and PM emissions while gasoline vehicle exhaust gas is the main source of CO and SO_2. NGVs do not contain benzene. Benzene, a common constituent of gasoline and gasoline engine exhaust, is a well-

known carcinogen and considered a toxic air contaminant. From the statistics of Pollution Control Department, main pollution qualities released from fuel consumption motor vehicles by type of vehicles and in Bangkok and Metropolitan areas are shown in the Table 2.2. The main pollution quantities released from fuel-consumption motor vehicles in Bangkok and Metropolitan areas are also shown in Table 2.3.

Table 2.2. Main Pollution Quantities Released From Fuel-Consumption Vehicles Provinces by Type of Vehicles (Pollution Control Department 2002).

Type of Vehicle	Pollution Quantities in Thailand (Ton/Year)									
	Nox		SO_2		CO		PM		HC	
	1997	2002	1997	2002	1997	2002	1997	2002	1997	2002
Bangkok	164,737	170,914	6,897	7,623	249,320	286,428	13,273	13,958	171,086	203,276
Metropolitan areas	77,572	53,785	2,406	2,074	77,584	75,835	5,603	3,986	45,963	50,596
Total	242,309	224,699	9,303	9,697	326,904	362,263	18,876	17,944	217,049	253,872

Table 2.3. Main Pollution Quantities Released From Fuel-Consumption Motor Vehicles in Bangkok and Metropolitan Areas (Pollution Control Department 2002).

Type of Vehicle	Pollution Quantities in Thailand (Ton/Year)									
	Nox		SO_2		CO		PM		HC	
	1997	2002	1997	2002	1997	2002	1997	2002	1997	2002
Gasoline	34,133	40,052	4,250	4,988	134,311	157,639	702	823	35,886	42,120
Light Duty Vehicle	65,836	62,272	1,868	1,768	34,821	32,936	6,366	6,022	15,739	14,887
Heavy Duty Vehicle	163,703	144,006	3,069	2,699	68,331	60,110	10,663	9,380	17,671	15,544
Motorcycle	976	1,193	786	961	112,308	137,313	2,871	3,510	163,677	200,119
Total	264,648	247,523	9,973	10,416	349,771	387,998	20,602	19,735	232,973	272,670

2.7 Discussion of NGV in Terms of Cost and Economy

The CNG market is more stable than the gasoline market. CNG generally costs 15 to 40 percent less than gasoline or diesel. However, CNG requires more frequent refueling because it contains only about a quarter of the energy by volume of gasoline. A CNG vehicle costs between US$ 3,500-6,000, more expensive than their gasoline-powered counterparts. This is primarily due to the higher cost of the fuel cylinders. As the popularity and production of CNG vehicles increase, vehicle costs are expected to decrease.

With all new technologies, NGVs are currently produced in limited production runs. This results in economies of scale loss for research and development cost recovery. Coupled with the increase in NGV cost and component complexity (gaseous fuel system and storage cylinder installation), there is an incremental cost above comparable baseline vehicles and engines. Clearly, these incremental costs must be incorporated into a life-cycle analysis of NGVs benefits.

Natural gas fuel cost is lower than gasoline. An economic analysis of natural gas as a vehicle fuel depends on many factors, including vehicle application (gasoline or

diesel), vehicle size (light-duty, medium-duty, or heavy-duty), fleet size, annual mileage, etc. The extent of the economic benefits will depend on these factors for each fleet or individual user.

NGVs are less expensive to operate than traditional gasoline powered vehicles. It could save up to 25% in Canada and at least 15% in the U.S. in fuel costs alone, not to mention the many incentives available. On an energy content basis, a gallon of natural gas approximately costs between $0.95 to $1.041, a gallon of gasoline costs the same in the southern California region. Since natural gas burns cleaner than most other fuels, it means that maintenance costs are often less. Engine parts such as spark plugs stay cleaner while operating on natural gas (The Barrows Report, May 1999). It is the fully allocated price of natural gas fuel with transportation, compression and tax costs. Compression includes the costs associated with the design, construction, operation and maintenance of natural gas fuel stations, or compressors. These prices will vary by region. It is noteworthy that many public fleets are tax exempt, so there is an opportunity for additional savings for these fleets. In most countries, governments' and auto manufacturers' incentives and grants are available when purchasing this kind of environmentally friendly alternative fuel vehicles (AFVs). Also, additional savings are possible if existing fuel station networks are utilized.

In Thailand, natural gas prices have exhibited significant price stability compared to petroleum-derived fuels. This stability is an important benefit of NGV use since more accurate long term cost planning may be conducted and expected savings may be projected. Generally speaking, NGV is cheaper than gasoline. To promote this clean fuel in Thailand, PTT has made NGV half the price of diesel oil, or 40% lower than gasoline price and 20% cheaper than the LPG whose price is currently subsidized.

The table comparison of retail oil price from oil refineries in Thailand and comparison of fuel consumption and its cost are shown in Table 2.4 and 2.5 respectively.

Table 2.4. Retail Oil Prices (http:\\www.eppo.go.th 2003).

Unit : Baht/Liter	PTT	SHELL	ESSO	CALTEX	TPI	Q8	SUSCO	BCP
95 GASOHOL	15.89	-	-	-	-	-	-	-
95 ULG 95 RON	16.39	16.39	16.39	16.39	16.39	16.39	16.39	16.39
91 UGR 91 RON	15.49	15.49	15.49	15.49	15.49	15.49	15.49	15.49
HSD 0.05%S	13.59	13.59	13.59	13.59	13.59	13.59	13.59	13.59
BIO-DIESEL	13.09	-	-	-	-	-	-	-
HSD PREMIUM	-	14.59	-	-	-	-	-	13.59
NGV (Baht/Kg)	7.12	-	-	-	-	-	-	-
LPG-AUTO	8.32	-	-	8.18	-	-	-	-
EFFECTIVE DATE	12 Sept	12 Sept	12 Sept	12 Sept	12 Sept	12 Sept	12 Sept	12 Sept

Table 2.5. Comparative Fuel Consumption and Costs (http:\\www.pttplc.com 2003).

Fuel	Volume	Mileage (km)	Cost (Baht)	Baht/km
ULR (91)	1 litre	11	15.49	1.40
ULP (95)	1 litre	11	16.49	1.49
LPG	1 litre	7.5	7.67	1.02
NGV	1 kg	10	7.65	0.76

The speed of recovering investment incurred in NGV conversion depends on how extensive a vehicle is used. In other words, the more the car runs, the sooner the cost can be reduced. For example, a calculation of a 1,600-cc taxi fuelled by NGV at 7.33 Baht/kg and covers a distance of 400 km a day can recover the investment of 30,000 Baht for conversion in only four months.

Baht/kg and covers a distance of 400 km a day can recover the investment of 30,000 Baht for conversion in only four months.

For diesel conversion and maintenance intervals, the conversion of an existing diesel engine to natural gas (NG) operation is not a straightforward task and could require significant testing to obtain optimum performance. It is not a job to be undertaken without adequate engineering and equipment back up. Some engine configurations may not be suitable. Most existing NGVs are conventionally fuelled vehicles that have been converted to run on natural gas. The essential equipment required to operate light and heavy-duty vehicles on natural gas are the engine management system and the high-pressure fuel storage cylinder. The carburetor/mixer fuel control equipment used on many early vehicles is giving way to readily available electronic engine management systems; these ensure that NGV emissions levels will be more favorable than vehicles using competing fuels. In the same way, high-pressure steel fuel storage cylinders which carry a weight penalty are being superseded by lighter composite cylinders.

The cost of converting a light-duty vehicle to vehicles which run on natural gas is between $US 900 and $US 3,500, depending on the country, the type of equipment and the local regulations. In the early stages of production the cost differential for OEM vehicles will be of this order, but will be reduced with time. For heavy-duty vehicles the differential will be set by range requirements that determine the size and cost of the vehicle storage cylinders.

More and more NGVs are on the road today and are factory-built. Some conversions of gasoline vehicles still take place on vehicles that are not yet available from the manufacturer. Factory-built NGV choices include both dedicated and bi-fuel options. Dedicated NGVs operate on natural gas only. Bi-fuel NGVs operate on natural

gas or gasoline at the flip of a switch. In summary, there are three types of NGV engine as follows:

(1) Dedicated NGV or the dedicated natural gas vehicle which operates using only natural gas. A vehicle that operates only on natural gas and is therefore optimized to take full advantage of the high octane inherent in natural gas, thus using the fuel more efficiently. A dedicated vehicle only operates on one fuel.

(2) Bi-fuel, a vehicle with two separate fuel systems designed to run on either an alternative fuel or a conventional fuel using only one fuel at a time. Typically, gasoline/natural gas bi-fuel vehicles are gasoline vehicles converted to bi-fuel operation by adding natural gas fuel storage, pressure regulation and control systems.

(3) Diesel Dual Fuel, a vehicle designed to operate on some combination of both an alternative fuel and conventional fuel at the same time. Dual-fuel vehicles have two separate fuel systems, though a duel-duel vehicle can operate on one fuel or the other.

For its maintenance, NGV is up to four times longer maintenance intervals than diesel engine. It could go up to 25,000 miles between recommended oil changes with a natural gas engine. A distributor less ignition system and electronic fuel introduction are just two examples of the durability and reliability features built into engine. Proper training is required for all maintenance personnel working on CNG vehicles. The oil in a CNG vehicles does not need to be changed frequently because CNG burns cleaner than gasoline, producing less deposits in the oil.

2.8 Discussion of NGV in Terms of Refueling

Filling up with natural gas is virtually the same as filling up with gasoline. Figure 2.4 shows the typical NGV station system. For refueling, gas is taken from the distribution mains and pumped to the vehicle storage cylinder. Compressed gas is stored in the vehicle cylinder at a stabilized pressure of 200 bar. During off-peak periods gas can be stored temporarily in the station high-pressure storage. Because of technological advances in the development of on-site refueling devices, stations can be located almost anywhere that natural gas can be piped. This greatly increases availability and convenience. In many countries, it is commonplace to see compressed natural gas (CNG) refueling dispensers alongside liquid fuel outlets at service stations. There are now several thousand such stations around the world. Refueling time is comparable or less than refueling for conventional fuels (2 - 5 minutes is typical). Vehicles can also be "slow filled" by a compressor running overnight.

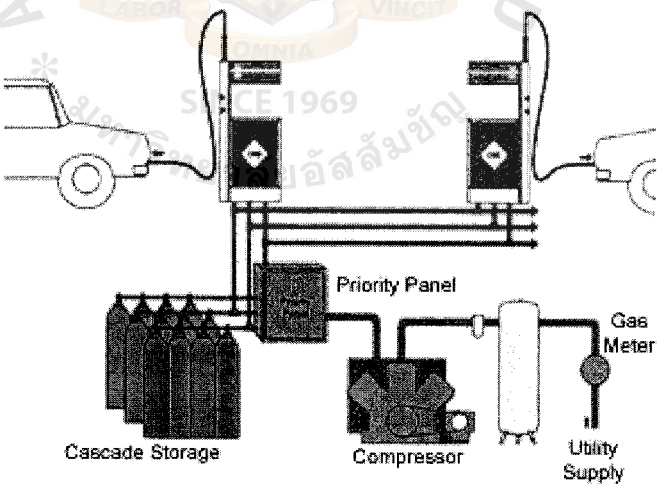


Figure 2.4. Typical NGV Station System (http:\\www.epa.gov 2002)

Regarding NGV stations, refueling facilities have also been established to support those vehicles along with the development of NGV vehicles. In October 1993, the first NGV refueling station in Thailand has been constructed and operated by Petroleum Authority of Thailand (PTT) at BMTA bus depot in Rangsit area (north Bangkok) for fuelling NGV buses. There are three types of NGV stations in Thailand:

(1) Conventional stations are located along gas pipelines and are capable of only filling gas to cars.

(2) Mother stations are built along gas pipelines and fill gas to cars and gas tankers.

(3) Daughter stations receive gas from tankers which transports gas from Conventional stations for filling on cars.

Existing natural gas pipelines have been established to serve general industries and, therefore, are situated in the remote area in view of NGV utilization. For this reason mother-daughter station type arrangement has been the only choice for NGV distribution inside the Bangkok Metropolitan area. However, the more extensive natural gas pipeline system has been planned to cover the area needed for NGV distribution. Following the completion of the mentioned pipeline system the more extensive NGV distribution system will be available to serve NGV vehicles.

Up to the year 2003 there are 8 operating refueling stations servicing more than 1000 NGV vehicles in Bangkok. The eight NGV filling stations on service now are as follows:

(1) Rangsit NGV Filling Station at BMTA Garage

(2) PTT service station operated by Sricharoen Phan Partnership on Vibhavadi-Rangsit Road

(3) PTT service station run by Kim Jin Ci near Anusorn Sathan Intersection

(4) PTT service station managed by the State Railways of Thailand Cooperative near Mor Chit II Terminus

(5) PTT service station near Three head-Elephant museum, Samutprakarn province

(6) PTT service station on Krungthep-Nontaburi Road

(7) PTT service station on Pattanakarn Road

(8) PTT service station on Rama III Road

According to the NGV project plan, up to 30 refueling stations will be available for public uses before the year 2006.

III. RESEARCH METHODS AND PROCEDURES

This chapter presents the research methods and procedures used in the present study including subject selection, instrumentation, the collection of data, the structure of the analyses, and the limitation of the study.

3.1 Subject Selection

The selected company used in this research is Unocal Thailand, Ltd. (UOT). Four work position groups of the employees in Operations Department were selected as samples in this study. The four groups of work positions are Bangkok Petroleum Engineers, Bangkok Production Engineers, Offshore Production Staff and Operators, and Offshore Maintenance Staff and Operators. This target population includes a total of two hundred employees. The sample size of population in this study has a level of confidence at 95% and error level allowed at 5% (Krejcie & Morgan 1970). Based on the table, only one hundred and thirty employees were asked to complete the questionnaire. The participants consist of fifteen persons from the group of Bangkok Petroleum Engineers, twenty persons from the group of Bangkok Production Engineers, forty-five persons from the group of Offshore Production Staff and Operators, and fifty persons from the group of Offshore Maintenance Staff and Operators. The number of population and the sample size from population is shown in Table 3.1.

Table 3.1. Sample Population Size.

Work Position of Employee	Number of Population	Size of Sample from Population
Bangkok Petroleum Engineer	23	15
Bangkok Production Engineer	31	20
Offshore Production Staff and Operator	69	45
Offshore Maintenance Staff and Operator	77	50
Total	200	130

3.2 Instrumentation

In this research, the questionnaires were developed in the English version and translated into Thai for better understanding for the participants. The selected participants were asked to fill out the Thai version of the questionnaires. The questionnaires consists of two parts which are:

Part 1: Demographic profiles of the respondents.

Part 2: NGV factors on safety, environment, cost and economy, and refueling.

The first part of questionnaire is about demographic profiles, which consists of nine questions. Data for this part was collected by using multiple choice format of personal profile focused on the subject's gender, age, marital status, education level, classification of employees, work position, years of service, income, and awareness of NGV availability.

The second part concerned NGV in terms of safety, environment, cost and economy, and refueling. There are twenty-six questions in this part. A five-point Likert scale was used for participants to respond to each factor, with options ranging

from 1, "Strongly Disagree" to 5, "Strongly Agree". The arrangement of questionnaire is shown in Table 3.2.

Table 3.2. Arrangement of Questionnaire.

Part	Main Variables	Sub Variables	Questionnaire Items
1	Demographic	Gender Age Marital Status Education Level Classification Of Employees Work Position Years Of Service Income Awareness of NGV Availability	1-9
2	NGV Factors	Safety Environment Cost and economy Refueling	10-16 17-22 23-29 30-35

3.3 Research Procedures

The questionnaires were distributed to the participants in Bangkok office by mail. For offshore location, an electronic memorandum explaining the general purpose of the study had been issued to Offshore Installation Managers (OIMs) who are in charge of each offshore location. This is to ask for their permissions to allow employees to spend time answering the questionnaire, and also let a clerk as the point of contact for distributing and collecting the questionnaire for the researcher in the time frame. The questionnaires were collected during the month of September 2003.

3.4 Data Analysis

In the research hypothesis stated in Chapter 1, there are two variables in this research which are independent variables and dependent variables. Independent variables are consumer satisfaction factors on NGV in terms of safety, environment, cost and economy, and refueling. Dependent variable is a demographic profile, which focused on education level together with work positions of the respondents. Figure 3.1 is the diagram represents the conceptual framework of research hypothesis, which integrated with different variables discussed in Chapter 2.

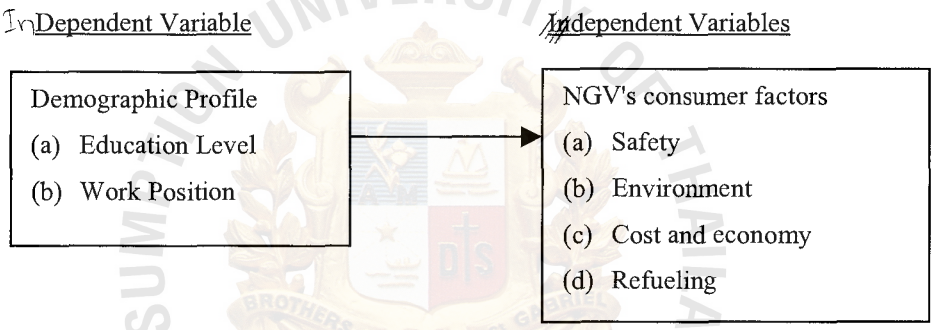


Figure 3.1. Conceptual Framework.

The researcher used SPSS FW Version 10 for statistical analysis. The statistic tools are used to answer the following research questions which are based on the research hypothesis.

(1) 1st Question – Frequencies were used to determine demographic profiles.

(2) 2nd Question – Frequencies were used to determine the perceptions of the respondents on NGV in terms of safety, environment, cost and economy, and refueling.

(3) 3rd Question – Cross-tabulation and Partial Correlation Coefficients were used to determine the perceptions of the different three education levels and four work positions of the respondents on NGV in terms of safety, environment, cost and economy, and refueling.

(4) 4th Question – Partial Correlation Coefficients were used to determine the perceptions of the different three education levels together with four work positions of the respondents on NGV in terms of safety, environment, cost and economy, and refueling. A probability level of less than or equal to 0.05 was specified to establish the significance of the results of the analysis.

IV. DATA PRESENTATION AND CRITICAL ANALYSIS OF RESULTS

This chapter presents the results from data analysis and interpretation of findings in various topic issues. The analysis concerns the descriptive statistics of the respondents and the testing of the hypotheses. The result of data analysis was based on the attitudes of the employees in the selected company.

The questionnaires were collected during the month of September 2003 at Unocal Thailand, Ltd., Operations Department. The data analyses presented included demographic profiles, the satisfactory perception, three different education levels and four different work positions of the respondents on NGV in terms of safety, environment, cost and economy, and refueling. There was an 80% response rate of the total of 130 copies launched with 104 completed questionnaires returned to the researcher. They are 8 responses from Bangkok Petroleum Engineer, 18 responses from Bangkok Production Engineer, 30 from Offshore Production Staff and Operator, and 48 from Offshore Maintenance Staff and Operator.

4.1 Demographic Profile

This section focused on the demographic profile of the respondents. The sample of the respondents represented the employees in the selected company. From the survey, it was found that the total number of employees in the selected company attending this surveyed study was 104 out of the total of 130 employees, or 80%.

4.1.1 Gender of the Respondents

Gender of the respondents are summarized and shown in Table 4.1 and Figure 4.1. The majority of the respondents are males, which accounted for 96% of the respondents while the percentage of female was only 4%.

Table 4.1. Gender of the Respondents.

Demographic	Frequency	Percent
Valid:		
Male	100	96
Female	4	4
Total	104	100.0

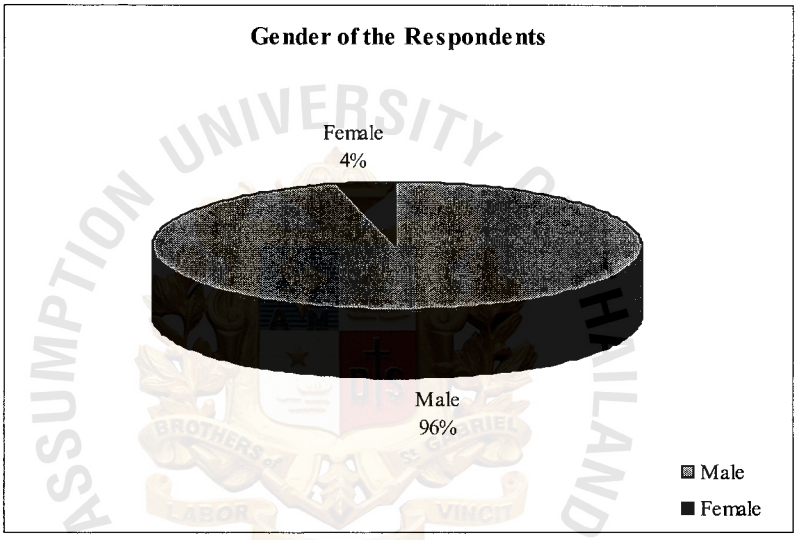


Figure 4.1. Gender of the Respondents.

4.1.2 Age of the Respondents

Age of the respondents are summarized and shown in Table 4.2 and Figure 4.2. As can be seen from the table, the majority of the respondents in this study were between 41-50 years of age, which accounted for 42%. It was followed by those between 31-40 years of age 34% and between 20-30 years of age 17%, and only 7% of

the respondents were over 50 years of age. It indicated that the majority of the respondents in the study belonged to adult group.

Table 4.2. Age of the Respondents.

Demographic	Frequency	Percent
Valid:		
20-30 years of age	18	17
31-40 years of age	35	34
41-50 years of age	44	42
Over 50 years of age	7	7
Total	104	100.0

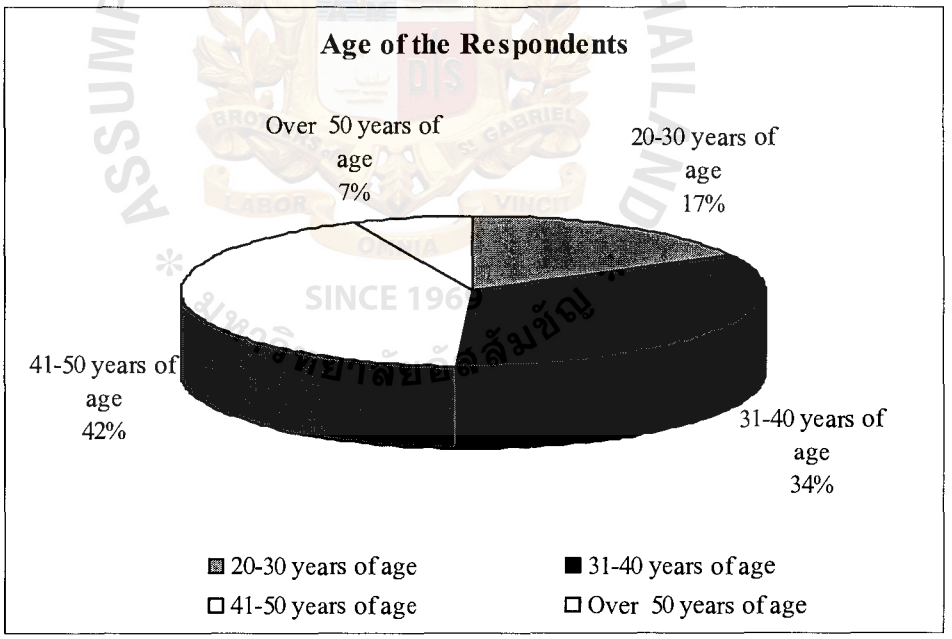


Figure 4.2. Age of the Respondents.

4.1.3 Marital Status of the Respondents

Marital status of respondents are summarized and shown in Table 4.3 and Figure 4.3. As can be seen in the table, the majority of the respondents in this study were married which accounted for 75%, and single and divorced 22% and only 3% respectively.

Table 4.3. Marital Status of the Respondents.

Demographic	Frequency	Percent
Valid:		
Single	23	22
Married	78	75
Divorced	3	3
Total	104	100.0

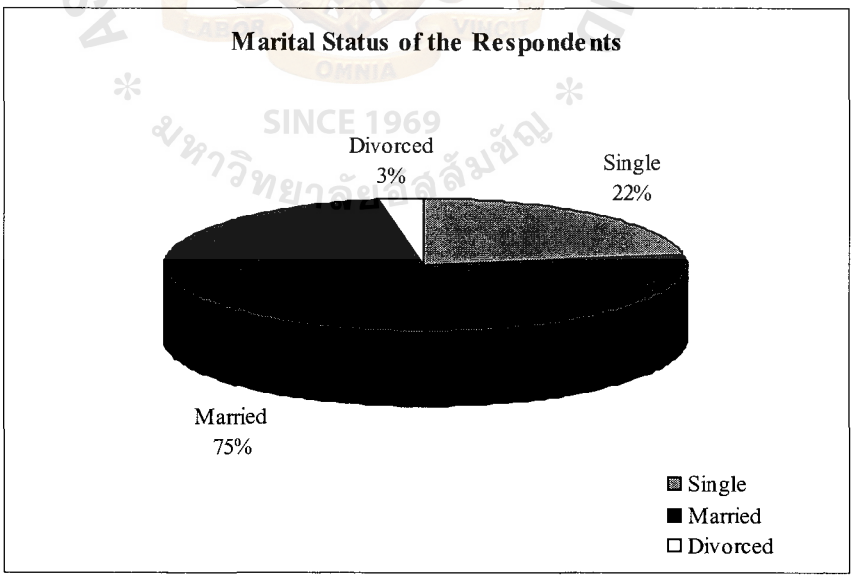


Figure 4.3. Marital Status of the Respondents.

4.1.4 Education Level of the Respondents

Education level of respondents are summarized and shown in Table 4.4 and Figure 4.4. As can be seen in the table, more than half of the respondents hold Diploma which accounted for 60%, followed by those who hold Bachelor Degrees or equivalents 27%, and those who hold Post Graduate Degrees 13%. It indicated that more than half of the respondents had high level of educational attainment.

Table 4.4. Education Level of the Respondents.

Demographic	Frequency	Percent
Valid:		
Diploma	62	60
Bachelor Degree or equivalent	28	27
Post Graduate Degree	14	13
Total	104	100.0

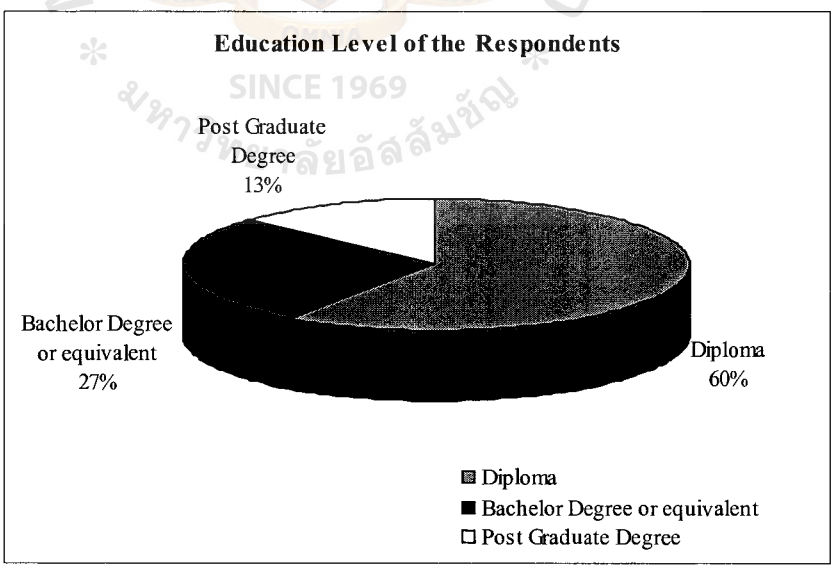


Figure 4.4. Educational Level of the Respondents.

4.1.5 Employee Classification of the Respondents

Employee's classification of the respondents are summarized and shown in Table 4.5 and Figure 4.5. As can be seen in the table, more than half of the respondents are offshore employees which accounted for 62%, followed by those who are onshore employees 21% and those who are offshore contractors 17%. It indicated that more than half of the respondents are offshore employees.

Table 4.5. Employee Classification of the Respondents.

Demographic	Frequency	Percent
Valid:		
Offshore employees	64	62
Onshore employees	22	21
Offshore contractors	18	17
Total	104	100.0

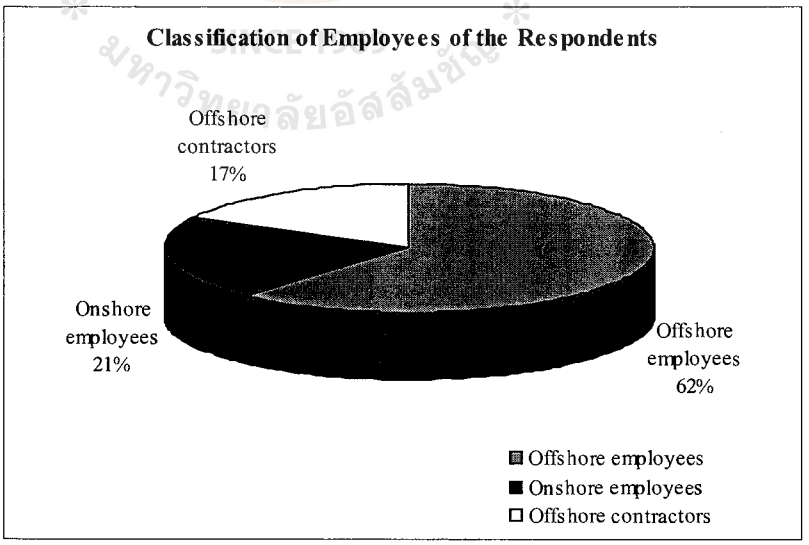


Figure 4.5. Employee Classification of the Respondents.

4.1.6 Work Position of the Respondents

Work position of the respondents are summarized and shown in Table 4.6 and Figure 4.6. As can be seen in the table, the largest respondents group was "Offshore Maintenance Staff and Operator" which accounted for 48 respondents or 46%. It was followed by "Offshore Production Staff and Operator" which accounted for 30 respondents or 29%, "Bangkok Production Engineer" 18 respondents or 17%, and "Bangkok Petroleum Engineer" 8 respondents or 8%.

Table 4.6. Work Position of the Respondents.

Demographic	Frequency	Percent
Valid:		
Bangkok Petroleum Engineer	8	8
Bangkok Production Engineer	18	17
Offshore Production Staff and Operator	30	29
Offshore Maintenance Staff and Operator	48	46
Total	104	100.0

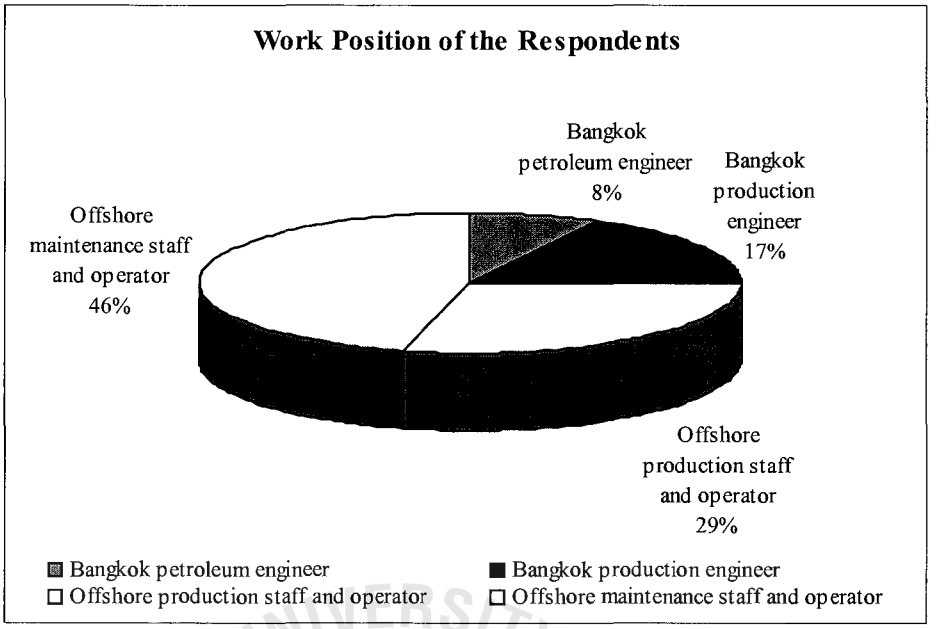


Figure 4.6. Work Position of the Respondents.

4.1.7 Years of Service of the Respondents

Years of service of respondents are summarized and shown in Table 4.7 and Figure 4.7. As can be seen from the table, the majority of the respondents in the study have worked in the current company for 11-15 years which accounted for 39%. It was followed by those who have been working for more than 15 years accounted for 32%, 1-5 years 16%, and 6-10 years 13% respectively. It indicated that the majority of respondents have been working in the current company for over 10 years.

Table 4.7. Years of Service of the Respondents.

Demographic	Frequency	Percent
Valid:		
1-5 years	17	16
6-10 years	13	13
11-15 years	41	39
More than 15 years	33	32
Total	104	100.0

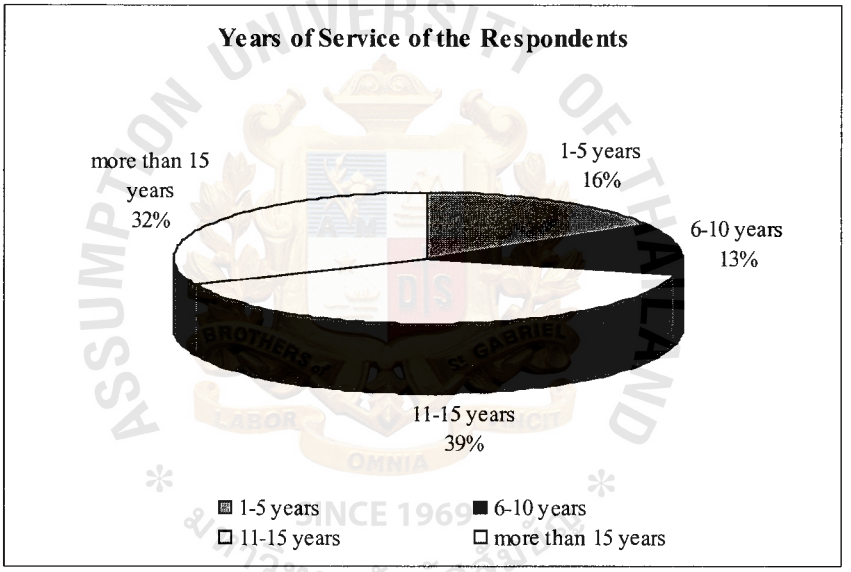


Figure 4.7. Years of Service of the Respondents.

4.1.8 Income of the Respondents

Income per month of the respondents are summarized and shown in Table 4.8 and Figure 4.8. As can be seen from the table, the majority of the respondents in this study have incomes of 50,000 Baht above per month which accounted for 52%. It was

followed by those with 40,001-50,000 Baht per month income, accounted for 22%, income 30,001-40,000 Baht per month 11%, and 10,000-20,000 Baht per month 8%. Those whose incomes are 20,001-30,000 Baht per month accounted for only 7%, the lowest percentage. It indicated that the majority of the respondents in the study had incomes of 50,000 Baht above per month.

Table 4.8. Income Per Month of the Respondents.

Demographic	Frequency	Percent
Valid:		
10,000-20,000	8	8
20,001-30,000	7	7
30,001-40,000	11	11
40,001-50,000	23	22
Above 50,000	55	52
Total	104	100.0

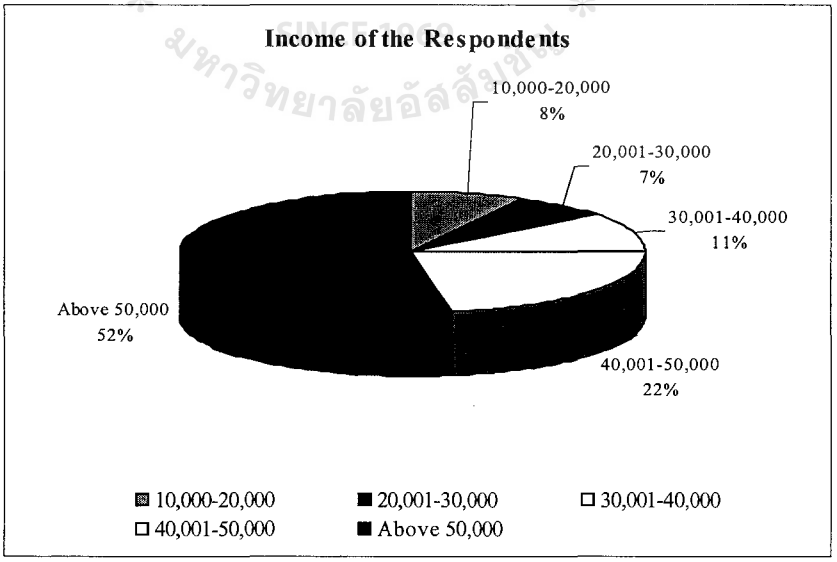


Figure 4.8. Income of the Respondents.

4.1.9 Awareness of NGV Availability

The respondents' awareness of NGV availability in Thailand is summarized and shown in Table 4.9 and Figure 4.9. As can be seen in the table, the majority of the respondents are aware of NGV availability, which accounted for 96% while the percentage of the respondents who are not aware of it were only 4%.

Table 4.9. Awareness of NGV Availability of the Respondents.

Demographic	Frequency	Percent
Valid:		
Yes	100	96
No	4	4
Total	104	100.0

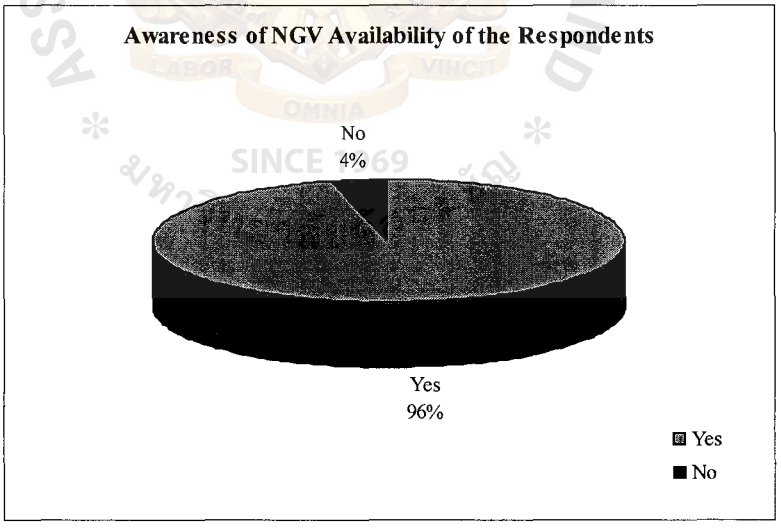


Figure 4.9. Awareness of NGV Availability of the Respondents.

4.2 Perception of the Respondents on NGV

4.2.1 Safety

As can be seen in the result shown in Table 4.10, the respondents agreed that the transportation of natural gas by pipeline to the station is safe and its cylinders for vehicles are safer than cylinders of gasoline or diesel tanks. However, the overall respondents' perception on NGV in terms of safety factor is found to be "Neutral" rating. This means that the respondents are not so sure that NGV would be safer than the conventional gasoline and diesel vehicles. In addition, they did not agree that transportation of gasoline and diesel by tank truck over the highway would be safe, and also did not agree that gasoline and diesel are more flammable than natural gas. Because of the facts mentioned above, the respondents would not decide to use NGV in the future because of its safety.

Table 4.10. Perception of the Respondents on NGV in Terms of Safety.

Item	Safety			
	N	X	SD.	Finding
(a) Natural gas vehicle (NGV) is as safe as, or safer than,) conventionally fueled vehicles (gasoline and diesel).	104	2.98	0.90	Neutral
(b) Gasoline and diesel are more flammable than natural gas.	104	2.18	1.05	Disagree
(c) Natural gas is lighter than air and will not pool as a liquid or vapor on the ground in case of spill.	104	3.32	1.57	Neutral
(d) Gasoline and diesel are more dangerous because it was delivered to fueling stations by tank trucks over the highway.	104	2.28	1.17	Disagree
(e) Transportation of natural gas is safe because it flows by pipeline directly to its station.	104	4.28	0.93	Agree

Table 4.10. Perception of the Respondents on NGV in Terms of Safety (Continued).

Item	Safety			
	N	X	SD.	Finding
(f) Natural gas cylinders are much thicker and stronger than gasoline or diesel tanks.	104	3.89	1.19	Agree
(g) You will decide to use NGV in the future because of its safety.	104	3.43	1.10	Neutral
Total	104	3.20	0.73	Neutral

4.2.2 Environment

As can be seen from the result shown on table 4.11, the overall respondents' perception on NGV in terms of environment factor is found to be "Agree" rating. This means that the respondents agreed that pollution in Thailand is mainly caused by emissions from vehicles. Natural gas is an environmentally friendly fuel and can reduce emissions to a lesser extent than gasoline and diesel because it is a cleaner burning fuel than gasoline. NGV could help to improve the problem of air quality. Due to the facts mentioned above, the respondents agreed to use NGV in the future because it is environmental friendly.

Table 4.11. Perception of the Respondents on NGV in Terms of Environment.

Item	Environment			
	N	X	SD.	Finding
(a) The pollution in Thailand is mainly caused by emissions from vehicles.	104	4.25	1.02	Agree
(b) Natural gas is an environmentally friendly fuel.	104	4.39	1.14	Agree
(c) NGV could help to improve the problem of air quality.	104	4.20	0.90	Agree
(d) NGV is potentially a cleaner burning fuel than gasoline.	104	4.31	0.98	Agree

Table 4.11. Perception of the Respondents on NGV in Terms of Environment (Continued).

Item	Environment			
	N	X	SD.	Finding
(e) As a motor fuel, natural gas reduces emissions better than gasoline and diesel.	104	4.39	0.96	Agree
(f) You will decide to use NGV in the future because it is environmental friendly.	104	3.62	1.11	Agree
Total	104	4.19	0.75	Agree

4.2.3 Cost and Economy

As can be seen from the result shown on Table 4.12, the respondents were not sure that NGV is more cost-effective than gasoline and diesel vehicles in terms of vehicles' life because NGV conversion and components are costly (gaseous fuel system and storage cylinder installation). They were not sure that NGV is approximately up to four times longer maintenance intervals than diesel engine. However, the overall respondents' perception on NGV in terms of environment factor is found to be "Agree" rating. This means that respondents agreed that using more NGV could save the country from importing crude oil to produce gasoline and diesel. The speed of recovering investment incurred in NGV conversion depends on how extensive a vehicle is used. The more the car is run, the sooner the cost can be recouped. In addition, they agreed that the maintenance cost of NGV is less than gasoline and diesel vehicles because natural gas burns cleaner than most of the other fuels and its price is much lower. Because of the facts mentioned above, the respondents would decide to use NGV in the future because of its benefit on cost and economy.

Table 4.12. Perception of the Respondents on NGV in Terms of Cost and Economy.

Item	Cost and Economy			
	N	X	SD.	Finding
(a) Using more NGV can save the country from importing crude oil to produce gasoline and diesel.	104	4.35	0.92	Agree
(b) Natural gas fuel price is much lower than gasoline and diesel.	104	4.10	1.23	Agree
(c) NGV conversion and components are costly (gaseous fuel system and storage cylinder installation), but compared to the vehicles' life, NGV is more cost-effective than gasoline and diesel vehicles.	104	3.38	0.82	Neutral
(d) The maintenance cost of NGV is less because natural gas burns cleaner than most other fuels.	104	3.69	0.78	Agree
(e) NGV is approx. up to four times longer maintenance intervals than diesel engine.	104	3.15	0.72	Neutral
(f) The speed of recovering investment incurred in NGV conversion depends how extensive a vehicle is used. The more the car is run, the sooner the cost can be recouped.	104	3.51	0.76	Agree
(g) You will decide to use NGV in the future because of its benefit on cost and economy.	104	3.71	0.82	Agree
Total	104	3.69	0.55	Agree

4.2.4 Refueling

As can be seen from the result shown on Table 4.13, the respondents were not sure that it would be easy for refueling by merely going to the station and the gas is pumped to the vehicle storage cylinder like typical gasoline refueling. They also disagreed that NGV refueling station is easily found in their area. However, the overall respondents' perception on NGV in terms of refueling factor is found to be "Agree" rating. The respondents agreed that they want to have more refueling stations available for public in Bangkok and Metropolitan area, have NGV refueling stations developed

and available along the natural gas pipelines over the country, and have NGV refueling stations developed in the existing oil stations over the country. Moreover, the respondents agreed to use NGV in the future if it is convenient in refueling.

Table 4.13. Perception of the Respondents on NGV in Terms of Refueling.

Item	Refueling			
	N	X	SD.	Finding
(a) You know it is easy like gasoline refueling, NGV is only to go to the station and have the vehicle storage cylinder pumped.	104	3.06	1.13	Neutral
(b) You can easily find NGV refueling station in your area.	104	2.13	1.12	Disagree
(c) You want to have more refueling stations available for public in Bangkok and Metropolitan area.	104	4.11	1.11	Agree
(d) You want to have NGV refueling stations developed and available along the natural gas pipelines over the country.	104	3.97	1.05	Agree
(e) You want to have NGV refueling stations developed in the existing oil stations over the country.	104	4.06	1.05	Agree
(f) You will decide to use NGV in the future because of its refueling convenient.	104	3.86	1.05	Agree
Total	104	3.53	0.79	Agree

4.3 Perception of Three Different Education Levels and Four Different Work Positions of the Respondents on NGV

4.3.1 Safety

Safety in this case is related to the items on the questionnaire as follows:

(a) Natural gas vehicle (NGV) is as safe as, or safer than, conventionally fueled vehicles (gasoline and diesel).

In reference to the finding in Table 4.10, the overall rating for this item is "Neutral". The result on Table 4.14 and 4.15 showed that the "Neutral" rating was voted by 45% or 28 respondents who hold Diplomas, 46% or 13 respondents who hold Bachelor Degrees or equivalent, 88% or 7 Bangkok Petroleum Engineers, 39% or 7 Bangkok Production Engineers, 53% or 16 Offshore Production Staff and Operators, and 35% or 17 Offshore Maintenance Staff and Operators. However, 43% or 6 respondents who hold higher than Bachelor Degrees, and 39% or 7 Bangkok Production Engineers voted for "Neutral" and "Disagree" rating equally.

Table 4.14. The Cross-Tabulation of Education Level and Safety Item (a).

Education Level	Respondents	Count by Scale		
		Scale	Count	%
Diploma	62	Neutral	28	45
Bachelor Degree or equivalent	28	Neutral	13	46
Higher than Bachelor Degree	14	Neutral	6	43
		Disagree	6	43

Table 4.15. The Cross-Tabulation of Work Position and Safety Item (a).

Work Position	Respondents	Count by Scale		
		Scale	Count	%
Bangkok Petroleum Engineer	8	Neutral	7	88
Bangkok Production Engineer	18	Neutral	7	39
		Disagree	7	39
Offshore Production Staff and Operator	30	Neutral	16	53
Offshore Maintenance Staff and Operator	48	Neutral	17	35

(b) Gasoline and diesel are more flammable than natural gas.

In reference to the finding in Table 4.10, the overall rating for this item is "Disagree". The result on Table 4.16 and 4.17 showed that the "Disagree" rating was voted by 44% or 27 respondents who hold Diplomas, 43% or 12 respondents who hold Bachelor Degrees or equivalent, 43% or 6 respondents who hold higher than Bachelor Degrees, 50% or 9 Bangkok Production Engineers, 53% or 16 Offshore Production Staff and Operators, and 40% or 19 Offshore Maintenance Staff and Operators. However, 50% or 4 Bangkok Petroleum Engineers voted for "Neutral" rating.

Table 4.16. The Cross-Tabulation of Education Level and Safety Item (b).

Education Level	Respondents	Count by Scale		
		Scale	Count	%
Diploma	62	Disagree	27	44
Bachelor Degree or equivalent	28	Disagree	12	43
Higher than Bachelor Degree	14	Disagree	6	43

Table 4.17. The Cross-Tabulation of Work Position and Safety Item (b).

Work Position	Respondents	Count by Scale		
		Scale	Count	%
Bangkok Petroleum Engineer	8	Neutral	4	50
Bangkok Production Engineer	18	Disagree	9	50
Offshore Production Staff and Operator	30	Disagree	16	53
Offshore Maintenance Staff and Operator	48	Disagree	19	40

(c) Natural gas is lighter than air and will not pool as a liquid or vapor on the ground in case of spill.

In reference to the finding in Table 4.10, the overall rating for this item is "Neutral". The result on Table 4.18 and 4.19 showed that the "Agree" rating was voted by 35% or 22 respondents who hold Diplomas, 29% or 8 respondents who hold Bachelor Degrees or equivalent, 29% or 4 respondents who hold higher than Bachelor Degrees, 50% or 4 Bangkok Petroleum Engineers, 28% or 5 Bangkok Production Engineers, and 33% or 16 Offshore Maintenance Staff and Operators. However, the "Disagree" rating was voted by 33% or 10 Offshore Production Staff and Operators, 28% or 5 Bangkok Production Engineers. The "Neutral" rating was also voted by 29% or 4 respondents who hold higher than Bachelor Degrees.

Table 4.18. The Cross-Tabulation of Education Level and Safety Item (c).

Education Level	Respondents	Count by Scale		
		Scale	Count	%
Diploma	62	Agree	22	35
Bachelor Degree or equivalent	28	Agree	8	29
Higher than Bachelor Degree	14	Neutral	4	29
		Agree	4	29

Table 4.19. The Cross-Tabulation of Work Position and Safety Item (c).

Work Position	Respondents	Count by Scale		
		Scale	Count	%
Bangkok Petroleum Engineer	8	Agree	4	50
Bangkok Production Engineer	18	Agree	5	28
		Disagree	5	28
Offshore Production Staff and Operator	30	Disagree	10	33
Offshore Maintenance Staff and Operator	48	Agree	16	33

(d) Gasoline and diesel are more dangerous because it was delivered to fueling stations by tank trucks over the highway.

In reference to the finding in Table 4.10, the overall rating for this item is "Disagree". The result on Table 4.20 and 4.21 showed that the "Disagree" rating was voted by 45% or 28 respondents who hold Diplomas, 39% or 11 respondents who hold Bachelor Degrees or equivalent, 36% or 5 respondents who hold higher than Bachelor Degrees, 63% or 5 Bangkok Petroleum Engineers, 44% or 8 Bangkok Production Engineers, 43% or 13 Offshore Production Staff and Operators, and 38% or 18 Offshore Maintenance Staff and Operators.

Table 4.20. The Cross-Tabulation of Education Level and Safety Item (d).

Education Level	Respondents	Count by Scale		
		Scale	Count	%
Diploma	62	Disagree	28	45
Bachelor Degree or equivalent	28	Disagree	11	39
Higher than Bachelor Degree	14	Disagree	5	36

Table 4.21. The Cross-Tabulation of Work Position and Safety Item (d).

Work Position	Respondents	Count by Scale		
		Scale	Count	%
Bangkok Petroleum Engineer	8	Disagree	5	63
Bangkok Production Engineer	18	Disagree	8	44
Offshore Production Staff and Operator	30	Disagree	13	43
Offshore Maintenance Staff and Operator	48	Disagree	18	38

(e) Transportation of natural gas is safe because it flows by pipelines directly to its station.

In reference to the finding in Table 4.10, the overall rating for this item is "Agree". The result on Table 4.22 and 4.23 showed that the "Agree" rating was voted by 52% or 32 respondents who hold Diplomas, 64% or 18 respondents who hold Bachelor Degrees or equivalent, 57% or 8 respondents who hold higher than Bachelor Degrees, 75% or 6 Bangkok Petroleum Engineers, 56% or 10 Bangkok Production Engineers, 50% or 15 Offshore Production Staff and Operators, and 56% or 27 Offshore Maintenance Staff and Operators.

Table 4.22. The Cross-Tabulation of Education Level and Safety Item (e).

Education Level	Respondents	Count by Scale		
		Scale	Count	%
Diploma	62	Agree	32	52
Bachelor Degree or equivalent	28	Agree	18	64
Higher than Bachelor Degree	14	Agree	8	57

Table 4.23. The Cross-Tabulation of Work Position and Safety Item (e).

Work Position	Respondents	Count by Scale		
		Scale	Count	%
Bangkok Petroleum Engineer	8	Agree	6	75
Bangkok Production Engineer	18	Agree	10	56
Offshore Production Staff and Operator	30	Agree	15	50
Offshore Maintenance Staff and Operator	48	Agree	27	56

(f) Natural gas cylinders are much thicker and stronger than gasoline or diesel tanks.

In reference to the finding in Table 4.10, the overall rating for this item is "Agree". The result on Table 4.24 and 4.25 showed that the "Agree" rating was voted by 46% or 13 respondents who hold Bachelor Degrees or equivalent, 57% or 8 respondents who hold higher than Bachelor Degrees, 38% or 3 Bangkok Petroleum Engineers, 37% or 11 Offshore Production Staff and Operators, and 42% or 20 Offshore Maintenance Staff and Operators. However, "Neutral" rating has also been voted by 35% or 22 respondents who hold Diplomas, 38% or 3 Bangkok Petroleum Engineers, 50% or 9 Bangkok Production Engineers, and 37% or 11 Offshore Production Staff and Operators.

Table 4.24. The Cross-Tabulation of Education Level and Safety Item (f).

Education Level	Respondents	Count by Scale		
		Scale	Count	%
Diploma	62	Neutral	22	35
Bachelor Degree or equivalent	28	Agree	13	46
Higher than Bachelor Degree	14	Agree	8	57

Table 4.25. The Cross-Tabulation of Work Position and Safety Item (f).

Work Position	Respondents	Count by Scale		
		Scale	Count	%
Bangkok Petroleum Engineer	8	Agree	3	38
		Neutral	3	38
Bangkok Production Engineer	18	Neutral	9	50
Offshore Production Staff and Operator	30	Agree	11	37
		Neutral	11	37
Offshore Maintenance Staff and Operator	48	Agree	20	42

(g) You will decide to use NGV in the future because it is safe.

In reference to the finding in Table 4.10, the overall rating for this item is "Neutral". The result on Table 4.26 and 4.27 showed that the "Neutral" rating was voted by 44% or 27 respondents who hold Diplomas, 43% or 12 respondents who hold Bachelor Degrees or equivalent, 57% or 8 respondents who hold higher than Bachelor Degrees, by 44% or 8 Bangkok Production Engineers, 53% or 16 Offshore Production Staff and Operators, and 42% or 20 Offshore Maintenance Staff and Operators. However, 63% or 5 Bangkok Petroleum Engineers, and 44% or 8 Bangkok Production Engineers voted for the "Agree" rating.

Table 4.26. The Cross-Tabulation of Education Level and Safety Item (g).

Education Level	Respondents	Count by Scale		
		Scale	Count	%
Diploma	62	Neutral	27	44
Bachelor Degree or equivalent	28	Neutral	12	43
Higher than Bachelor Degree	14	Neutral	8	57

Table 4.27. The Cross-Tabulation of Work Position and Safety Item (g).

Work Position	Respondents	Count by Scale		
		Scale	Count	%
Bangkok Petroleum Engineer	8	Agree	5	63
Bangkok Production Engineer	18	Agree	8	44
		Neutral	8	44
Offshore Production Staff and Operator	30	Neutral	16	53
Offshore Maintenance Staff and Operator	48	Neutral	20	42

4.3.2 Environment

Environment in this case is related to the items on the questionnaire as follows:

(a) The pollution in Thailand is mainly caused by emissions from industry factories and vehicles.

In reference to the finding in Table 4.11, the overall rating for this item is "Agree". The result on Table 4.28 and 4.29 showed that the "Strongly Agree" rating was voted by 57% or 16 respondents who hold Bachelor Degrees or equivalent, 43% or 6 respondents who hold higher than Bachelor Degrees, 50% or 4 Bangkok Petroleum Engineers, 44% or 8 Bangkok Production Engineers, and 53% or 16 Offshore Production Staff and Operators, and 40% or 19 Offshore Maintenance Staff and Operators. However, 44% or 27 respondents who hold Diplomas, and 40% or 19 Offshore Maintenance Staff and Operators voted for "Agree" rating.

Table 4.28. The Cross-Tabulation of Education Level and Environment Item (a).

Education Level	Respondents	Count by Scale		
		Scale	Count	%
Diploma	62	Agree	27	44
Bachelor Degree or equivalent	28	Strongly Agree	16	57
Higher than Bachelor Degree	14	Strongly Agree	6	43

Table 4.29. The Cross-Tabulation of Work Position and Environment Item (a).

Work Position	Respondents	Count by Scale		
		Scale	Count	%
Bangkok Petroleum Engineer	8	Strongly Agree	4	50
Bangkok Production Engineer	18	Strongly Agree	8	44
Offshore Production Staff and Operator	30	Strongly Agree	16	53
Offshore Maintenance Staff and Operator	48	Agree	19	40
		Strongly Agree	19	40

(b) Natural gas is an environmentally friendly fuel.

In reference to the finding in Table 4.11, the overall rating for this item is "Agree". The result on Table 4.30 and 4.31 showed that the "Agree" rating was voted by 57% or 8 respondents who hold higher than Bachelor Degrees, 50% or 4 Bangkok Petroleum Engineers, and 50% or 9 Bangkok Production Engineers. In addition, 40% or 25 respondents who hold Diplomas, 54% or 15 respondents who hold Bachelor Degrees or equivalent, 47% or 14 Offshore Production Staff and Operators, and 42% or 20 Offshore Maintenance Staff and Operators voted for the "Strongly Agree" rating.

Table 4.30. The Cross-Tabulation of Education Level and Environment Item (b).

Education Level	Respondents	Count by Scale		
		Scale	Count	%
Diploma	62	Strongly Agree	25	40
Bachelor Degree or equivalent	28	Strongly Agree	15	54
Higher than Bachelor Degree	14	Agree	8	57

Table 4.31. The Cross-Tabulation of Work Position and Environment Item (b).

Work Position	Respondents	Count by Scale		
		Scale	Count	%
Bangkok Petroleum Engineer	8	Agree	4	50
Bangkok Production Engineer	18	Agree	9	50
Offshore Production Staff and Operators	30	Strongly Agree	14	47
Offshore Maintenance Staff and Operators	48	Strongly Agree	20	42

(c) NGV could help to improve the problem of air quality.

In reference to the finding in Table 4.11, the overall rating for this item is "Agree". The result on Table 4.32 and 4.33 showed that the "Agree" rating was voted by 55% or 34 respondents who hold Diplomas, 50% or 14 respondents who hold Bachelor Degrees or equivalent, 57% or 8 respondents who hold higher than Bachelor Degrees, 63% or 5 Bangkok Petroleum Engineers, 50% or 9 Bangkok Production Engineers, 63% or 19 Offshore Production Staff and Operators, and 48% or 23 Offshore Maintenance Staff and Operators.

Table 4.32. The Cross-Tabulation of Education Level and Environment Item (c).

Education Level	Respondents	Count by Scale		
		Scale	Count	%
Diploma	62	Agree	34	55
Bachelor Degree or equivalent	28	Agree	14	50
Higher than Bachelor Degree	14	Agree	8	57

Table 4.33. The Cross-Tabulation of Work Position and Environment Item (c).

Work Position	Respondents	Count by Scale		
		Scale	Count	%
Bangkok Petroleum Engineer	8	Agree	5	63
Bangkok Production Engineer	18	Agree	9	50
Offshore Production Staff and Operators	30	Agree	19	63
Offshore Maintenance Staff and Operators	48	Agree	23	48

(d) NGV is potentially a cleaner burning fuel than gasoline.

In reference to the finding in Table 4.11, the overall rating for this item is "Agree". The result on Table 4.34 and 4.35 showed that the "Agree" rating was voted by 45% or 28 respondents who hold Diplomas, 50% or 7 respondents who hold higher than Bachelor Degrees, 63% or 5 Bangkok Petroleum Engineers, and 50% or 15 Offshore Production Staff and Operators. In addition, the "Strongly Agree" rating was also voted by 43% or 12 respondents who hold Bachelor Degrees or equivalent, 50% or 9 Bangkok Production Engineers, and 42% or 20 Offshore Maintenance Staff and Operators.

Table 4.34. The Cross-Tabulation of Education Level and Environment Item (d).

Education Level	Respondents	Count by Scale		
		Scale	Count	%
Diploma	62	Agree	28	45
Bachelor Degree or equivalent	28	Strongly Agree	12	43
Higher than Bachelor Degree	14	Agree	7	50

Table 4.35. The Cross-Tabulation of Work Position and Environment Item (d).

Work Position	Respondents	Count by Scale		
		Scale	Count	%
Bangkok Petroleum Engineer	8	Agree	5	63
Bangkok Production Engineer	18	Strongly Agree	9	50
Offshore Production Staff and Operators	30	Agree	15	50
Offshore Maintenance Staff and Operators	48	Strongly Agree	20	42

(e) As a motor fuel, natural gas releases lesser emissions better than gasoline and diesel.

In reference to the finding in Table 4.11, the overall rating for this item is "Agree". The result on Table 4.36 and 4.37 showed that the "Agree" rating was voted by 44% or 27 respondents who hold Diplomas, 43% or 6 respondents who hold higher than Bachelor Degrees, and 50% or 15 Offshore Production Staff and Operators. Moreover, the "Strongly Agree" rating was also voted by 44% or 27 respondents who hold Diplomas, 46% or 13 respondents who hold Bachelor Degrees or equivalent, 43% or 6 respondents who hold higher than Bachelor Degrees, 50% or 4 Bangkok Petroleum Engineers, 56% or 10 Bangkok Production Engineers, and 46% or 22 Offshore Maintenance Staff and Operators.

Table 4.36. The Cross-Tabulation of Education Level and Environment Item (e).

Education Level	Respondents	Count by Scale		
		Scale	Count	%
Diploma	62	Agree	27	44
		Strongly Agree	27	44
Bachelor Degree or equivalent	28	Strongly Agree	13	46
Higher than Bachelor Degree	14	Agree	6	43
		Strongly Agree	6	43

Table 4.37. The Cross-Tabulation of Work Position and Environment Item (e).

Work Position	Respondents	Count by Scale		
		Scale	Count	%
Bangkok Petroleum Engineer	8	Strongly Agree	4	50
Bangkok Production Engineer	18	Strongly Agree	10	56
Offshore Production Staff and Operators	30	Agree	15	50
Offshore Maintenance Staff and Operators	48	Strongly Agree	22	46

(f) You will use NGV in the future because it is environmentally friendly.

In reference to the finding in Table 4.11, the overall rating for this item is "Agree". The result on Table 4.38 and 4.39 showed that the "Agree" rating was voted by 34% or 21 respondents who hold Diplomas, and 40% or 12 Offshore Production Staff and Operators. However, the "Neutral " rating was voted by 46% or 13 respondents who hold Bachelor Degrees or equivalent, 64% or 9 respondents who hold higher than Bachelor Degrees, 50% or 4 Bangkok Petroleum Engineers, 50% or 9 Bangkok Production Engineers, and 46% or 22 Offshore Maintenance Staff and Operators.

Table 4.38. The Cross-Tabulation of Education Level and Environment Item (f).

Education Level	Respondents	Count by Scale		
		Scale	Count	%
Diploma	62	Agree	21	34
Bachelor Degree or equivalent	28	Neutral	13	46
Higher than Bachelor Degree	14	Neutral	9	64

Table 4.39. The Cross-Tabulation of Work Position and Environment Item (f).

Work Position	Respondents	Count by Scale		
		Scale	Count	%
Bangkok Petroleum Engineer	8	Neutral	4	50
Bangkok Production Engineer	18	Neutral	9	50
Offshore Production Staff and Operators	30	Agree	12	40
Offshore Maintenance Staff and Operators	48	Neutral	22	46

4.3.3 Cost and Economy

Cost and economy in this case are related to the items on the questionnaire as follows:

(a) Using more NGV can save the country from importing crude oil to produce gasoline and diesel.

In reference to the finding in Table 4.12, the overall rating for this item is "Agree". The result in Table 4.40 and 4.41 showed that the "Agree" rating was voted by 46% or 13 respondents who hold Bachelor Degrees or equivalent, 43% or 6 respondents who hold higher than Bachelor Degrees, 50% or 4 Bangkok Petroleum Engineers, and 50% or 15 Offshore Production Staff and Operators. In addition, the "Strongly Agree" rating was also voted by 47% or 29 respondents who hold Diplomas, 46% or 13

Bangkok Production Engineers, 50% or 15 Offshore Production Staff and Operators, and 54% or 26 Offshore Maintenance Staff and Operators.

Table 4.40. The Cross-Tabulation of Education Level and Cost and Economy Item (a).

Education Level	Respondents	Count by Scale		
		Scale	Count	%
Diploma	62	Strongly Agree	29	47
Bachelor Degree or equivalent	28	Agree	13	46
		Strongly Agree	13	46
Higher than Bachelor Degree	14	Agree	6	43

Table 4.41. The Cross-Tabulation of Work Position and Cost and Economy Item (a).

Work Position	Respondents	Count by Scale		
		Scale	Count	%
Bangkok Petroleum Engineer	8	Agree	4	50
Bangkok Production Engineer	18	Strongly Agree	9	50
Offshore Production Staff and Operators	30	Agree	15	50
Offshore Maintenance Staff and Operators	48	Strongly Agree	26	54

(b) Natural gas fuel price is much cheaper than that of gasoline and diesel.

In reference to the finding in Table 4.12, the overall rating for this item is "Agree". The result on Table 4.42 and 4.43 showed that the "Agree" rating was voted by 35% or 22 respondents who hold Diplomas, 39% or 11 respondents who hold Bachelor Degrees or equivalent, 50% or 7 respondents who hold higher than Bachelor Degrees, 38% or 3 Bangkok Petroleum Engineers, 56% or 10 Bangkok Production Engineers, and 37%

or 11 Offshore Production Staff and Operators. In addition, the "Strongly Agree" rating was also voted by 38% or 18 Offshore Maintenance Staff and Operators.

Table 4.42. The Cross-Tabulation of Education Level and Cost and Economy Item (b).

Education Level	Respondents	Count by Scale		
		Scale	Count	%
Diploma	62	Agree	22	35
Bachelor Degree or equivalent	28	Agree	11	39
Higher than Bachelor Degree	14	Agree	7	50

Table 4.43. The Cross-Tabulation of Work Position and Cost and Economy Item (b).

Work Position	Respondents	Count by Scale		
		Scale	Count	%
Bangkok Petroleum Engineer	8	Agree	3	38
Bangkok Production Engineer	18	Agree	10	56
Offshore Production Staff and Operators	30	Agree	11	37
Offshore Maintenance Staff and Operators	48	Strongly Agree	18	38

(c) NGV conversion and component are costly (gaseous fuel system and storage cylinder installation), but in terms of vehicles' life, NGV is more cost-effective than gasoline and diesel vehicles.

In reference to the finding in Table 4.12, the overall rating for this item is "Neutral". The result on Table 4.44 and 4.45 showed that the "Neutral" rating was voted by 48% or 30 respondents who hold Diplomas, 68% or 19 respondents who hold Bachelor Degrees or equivalent, 71% or

10 respondents who hold higher than Bachelor Degrees, 75% or 6 Bangkok Petroleum Engineers, 56% or 10 Bangkok Production Engineers, 67% or 20 Offshore Production Staff and Operators, and 48% or 23 Offshore Maintenance Staff and Operators.

Table 4.44. The Cross-Tabulation of Education Level and Cost and Economy Item (c).

Education Level	Respondents	Count by Scale		
		Scale	Count	%
Diploma	62	Neutral	30	48
Bachelor Degree or equivalent	28	Neutral	19	68
Higher than Bachelor Degree	14	Neutral	10	71

Table 4.45. The Cross-Tabulation of Work Position and Cost and Economy Item (c).

Work Position	Respondents	Count by Scale		
		Scale	Count	%
Bangkok Petroleum Engineer	8	Neutral	6	75
Bangkok Production Engineer	18	Neutral	10	56
Offshore Production Staff and Operators	30	Neutral	20	67
Offshore Maintenance Staff and Operators	48	Neutral	23	48

(d) The maintenance cost of NGV is low because natural gas burns cleaner than other fuels.

In reference to the finding in Table 4.12, the overall rating for this item is "Agree". The result on Table 4.46 and 4.47 showed that the "Agree" rating was voted by 47% or 29 respondents who hold Diplomas, 43% or 6 respondents who hold higher than Bachelor Degrees, 63% or 5

Bangkok Petroleum Engineers, 39% or 7 Bangkok Production Engineers, and 53% or 16 Offshore Production Staff and Operators. However, the "Neutral" rating was also voted by 46% or 13 respondents who hold Bachelor Degrees or equivalent, and 42% or 20 Offshore Maintenance Staff and Operators.

Table 4.46. The Cross-Tabulation of Education Level and Cost and Economy Item (d).

Education Level	Respondents	Count by Scale		
		Scale	Count	%
Diploma	62	Agree	29	47
Bachelor Degree or equivalent	28	Neutral	13	46
Higher than Bachelor Degree	14	Agree	6	43

Table 4.47. The Cross-Tabulation of Work Position and Cost and Economy Item (d).

Work Position	Respondents	Count by Scale		
		Scale	Count	%
Bangkok Petroleum Engineer	8	Agree	5	63
Bangkok Production Engineer	18	Agree	7	39
Offshore Production Staff and Operators	30	Agree	16	53
Offshore Maintenance Staff and Operators	48	Neutral	20	42

(e) NGV is approximately up to four times longer maintenance intervals than diesel engines.

In reference to the finding in Table 4.12, the overall rating for this item is "Neutral". The result on Table 4.48 and 4.49 showed that the "Neutral" rating was voted by 68% or 42 respondents who hold Diplomas,

86% or 24 respondents who hold Bachelor Degrees or equivalent, 86% or 12 respondents who hold higher than Bachelor Degrees, 88% or 7 Bangkok Petroleum Engineers, 83% or 15 Bangkok Production Engineers, 80% or 24 Offshore Production Staff and Operators, and 67% or 32 Offshore Maintenance Staff and Operators.

Table 4.48. The Cross-Tabulation of Education Level and Cost and Economy Item (e).

Education Level	Respondents	Count by Scale		
		Scale	Count	%
Diploma	62	Neutral	42	68
Bachelor Degree or equivalent	28	Neutral	24	86
Higher than Bachelor Degree	14	Neutral	12	86

Table 4.49. The Cross-Tabulation of Work Position and Cost and Economy Item (e).

Work Position	Respondents	Count by Scale		
		Scale	Count	%
Bangkok Petroleum Engineer	8	Neutral	7	88
Bangkok Production Engineer	18	Neutral	15	83
Offshore Production Staff and Operators	30	Neutral	24	80
Offshore Maintenance Staff and Operators	48	Neutral	32	67

(f) The speed of recovering investment incurred in NGV conversion depends on how extensive a vehicle is used. The more the car is run, the sooner the cost can be recouped.

In reference to the finding in Table 4.12, the overall rating for this item is "Agree". The result on Table 4.50 and 4.51 showed that the

"Neutral" rating was voted by 48% or 30 respondents who hold Diplomas, 61% or 17 respondents who hold Bachelor Degrees or equivalent, 63% or 5 Bangkok Petroleum Engineers, 50% or 9 Bangkok Production Engineers, 63% or 19 Offshore Production Staff and Operators, and 42% or 20 Offshore Maintenance Staff and Operators. The "Agree" rating was also voted by 50% or 7 respondents who hold higher than Bachelor Degrees.

Table 4.50. The Cross-Tabulation of Education Level and Cost and Economy Item (f).

Education Level	Respondents	Count by Scale		
		Scale	Count	%
Diploma	62	Neutral	30	48
Bachelor Degree or equivalent	28	Neutral	17	61
Higher than Bachelor Degree	14	Agree	7	50

Table 4.51. The Cross-Tabulation of Work Position and Cost and Economy Item (f).

Work Position	Respondents	Count by Scale		
		Scale	Count	%
Bangkok Petroleum Engineer	8	Neutral	5	63
Bangkok Production Engineer	18	Neutral	9	50
Offshore Production Staff and Operators	30	Neutral	19	63
Offshore Maintenance Staff and Operators	48	Neutral	20	42

(g) You will use NGV in the future because of its benefit on cost and economy.

In reference to the finding in Table 4.12, the overall rating for this item is "Agree". The result on Table 4.52 and 4.53 showed that the "Agree" rating was voted by 47% or 29 respondents who hold Diplomas,

50% or 7 respondents who hold higher than Bachelor Degrees, 50% or 9 Bangkok Production Engineers, and 50% or 24 Offshore Maintenance Staff and Operators. However, the "Neutral" rating was also voted by 46% or 13 respondents who hold Bachelor Degrees or equivalent, 50% or 4 Bangkok Petroleum Engineers, and 53% or 16 Offshore Production Staff and Operators.

Table 4.52. The Cross-Tabulation of Education Level and Cost and Economy Item (g).

Education Level	Respondents	Count by Scale		
		Scale	Count	%
Diploma	62	Agree	29	47
Bachelor Degree or equivalent	28	Neutral	13	46
Higher than Bachelor Degree	14	Agree	7	50

Table 4.53. The Cross-Tabulation of Work Position and Cost and Economy Item (g).

Work Position	Respondents	Count by Scale		
		Scale	Count	%
Bangkok Petroleum Engineer	8	Neutral	4	50
Bangkok Production Engineer	18	Agree	9	50
Offshore Production Staff and Operators	30	Neutral	16	53
Offshore Maintenance Staff and Operators	48	Agree	24	50

4.3.4 Refueling

Refueling in this case is related to the items on the questionnaire as follows:

(a) You know it is as easy as gasoline refueling, NGV is only to go to the station and the gas is pumped to the vehicle storage cylinder.

In reference to the finding in Table 4.13, the overall rating for this item is "Neutral". The result on Table 4.54 and 4.55 showed that the "Neutral" rating was voted by 39% or 24 respondents who hold Diplomas, 50% or 14 respondents who hold Bachelor Degrees or equivalent, 57% or 8 respondents who hold higher than Bachelor Degrees, 88% or 7 Bangkok Petroleum Engineers, 50% or 9 Bangkok Production Engineers, and 42% or 20 Offshore Maintenance Staff and Operators. In addition, the "Disagree" rating was also voted by 37% or 11 Offshore Production Staff and Operators.

Table 4.54. The Cross-Tabulation of Education Level and Refueling Item (a).

Education Level	Respondents	Count by Scale		
		Scale	Count	%
Diploma	62	Neutral	24	39
Bachelor Degree or equivalent	28	Neutral	14	50
Higher than Bachelor Degree	14	Neutral	8	57

Table 4.55. The Cross-Tabulation of Work Position and Refueling Item (a).

Work Position	Respondents	Count by Scale		
		Scale	Count	%
Bangkok Petroleum Engineer	8	Neutral	7	88
Bangkok Production Engineer	18	Neutral	9	50
Offshore Production Staff and Operators	30	Disagree	11	37
Offshore Maintenance Staff and Operators	48	Neutral	20	42

(b) You can easily find NGV refueling stations in your area.

In reference to the finding in Table 4.13, the overall rating for this item is "Disagree". The result on Table 4.56 and 4.57 showed that the "Disagree" rating was voted by 32% or 20 respondents who hold Diplomas, 39% or 11 respondents who hold Bachelor Degrees or equivalent, 43% or 6 respondents who hold higher than Bachelor Degrees, 75% or 6 Bangkok Petroleum Engineers, 33% or 6 Bangkok Production Engineers, and 40% or 12 Offshore Production Staff and Operators. In addition, the "Strongly Disagree" rating was also voted by 33% or 6 Bangkok Production Engineers, and 33% or 16 Offshore Maintenance Staff and Operators. However, the "Neutral" rating was voted by 32% or 20 respondents who hold Diplomas, and 33% or 16 Offshore Maintenance Staff and Operators.

Table 4.56. The Cross-Tabulation of Education Level and Refueling Item (b).

Education Level	Respondents	Count by Scale		
		Scale	Count	%
Diploma	62	Neutral	20	32
		Disagree	20	32
Bachelor Degree or equivalent	28	Disagree	11	39
Higher than Bachelor Degree	14	Disagree	6	43

Table 4.57. The Cross-Tabulation of Work Position and Refueling Item (b).

Work Position	Respondents	Count by Scale		
		Scale	Count	%
Bangkok Petroleum Engineer	8	Disagree	6	75
Bangkok Production Engineer	18	Disagree	6	33
		Strongly Disagree	6	33
Offshore Production Staff and Operators	30	Disagree	12	40
Offshore Maintenance Staff and Operators	48	Neutral	16	33
		Strongly Disagree	16	33

(c) You want to have more refueling stations available for public in Bangkok and its Metropolitan area.

In reference to the finding in Table 4.13, the overall rating for this item is "Agree". The result on Table 4.58 and 4.59 showed that the "Agree" rating was voted by 45% or 28 respondents who hold Diplomas, 43% or 12 respondents who hold Bachelor Degrees or equivalent, 36% or 5 respondents who hold higher than Bachelor Degrees, 50% or 4 Bangkok Petroleum Engineers, 44% or 8 Bangkok Production Engineers, and 57% or 17 Offshore Production Staff and Operators. However, 44% or 21 Offshore Maintenance Production Staff and Operators voted the "Strongly Agree" rating.

Table 4.58. The Cross-Tabulation of Education Level and Refueling Item (c).

Education Level	Respondents	Count by Scale		
		Scale	Count	%
Diploma	62	Agree	28	45
Bachelor Degree or equivalent	28	Agree	12	43
Higher than Bachelor Degree	14	Agree	5	36

Table 4.59. The Cross-Tabulation of Work Position and Refueling Item (c).

Work Position	Respondents	Count by Scale		
		Scale	Count	%
Bangkok Petroleum Engineer	8	Agree	4	50
Bangkok Production Engineer	18	Agree	8	44
Offshore Production Staff and Operators	30	Agree	17	57
Offshore Maintenance Staff and Operators	48	Strongly Agree	21	44

(d) You want to have NGV refueling stations developed and available along the natural gas pipelines over the country.

In reference to the finding in Table 4.13, the overall rating for this item is "Agree". The result on Table 4.60 and 4.61 showed that the "Agree" rating was voted by 50% or 31 respondents who hold Diplomas, 50% or 14 respondents who hold Bachelor Degrees or equivalent, 29% or 4 respondents who hold higher than Bachelor Degrees, 50% or 4 Bangkok Petroleum Engineers, 50% or 9 Bangkok Production Engineers, 57% or 17 Offshore Production Staff and Operators, and 40% or 19 Offshore Maintenance Production Staff and Operators. In addition, the "Strongly Agree" rating was also voted by 29% or 4 respondents who hold higher than Bachelor Degrees. However, the "Neutral" rating was voted by 29% or 4 respondents who hold higher than Bachelor Degrees.

Table 4.60. The Cross-Tabulation of Education Level and Refueling Item (d).

Education Level	Respondents	Count by Scale		
		Scale	Count	%
Diploma	62	Agree	31	50
Bachelor Degree or equivalent	28	Agree	14	50
Higher than Bachelor Degree	14	Neutral	4	29
		Agree	4	29
		Strongly Agree	4	29

Table 4.61. The Cross-Tabulation of Work Position and Refueling Item (d).

Work Position	Respondents	Count by Scale		
		Scale	Count	%
Bangkok Petroleum Engineer	8	Agree	4	50
Bangkok Production Engineer	18	Agree	9	50
Offshore Production Staff and Operators	30	Agree	17	57
Offshore Maintenance Staff and Operators	48	Agree	19	40

(e) You want to have NGV refueling stations developed in the existing oil stations over the country.

In reference to the finding in Table 4.13, the overall rating for this item is "Agree". The result on Table 4.62 and 4.63 showed that the "Agree" rating was voted by 52% or 32 respondents who hold Diplomas, 43% or 12 respondents who hold Bachelor Degrees or equivalent, 43% or 6 respondents who hold higher than Bachelor Degrees, 63% or 5 Bangkok Petroleum Engineers, 53% or 16 Offshore Production Staff and Operators, and 48% or 23 Offshore Maintenance Production Staff and Operators. In

addition, Bangkok Production Engineers have voted equally for "Agree" and "Strongly Agree" by 33% or 6.

Table 4.62. The Cross-Tabulation of Education Level and Refueling Item (e).

Education Level	Respondents	Count by Scale		
		Scale	Count	%
Diploma	62	Agree	32	52
Bachelor Degree or equivalent	28	Agree	12	43
Higher than Bachelor Degree	14	Agree	6	43

Table 4.63. The Cross-Tabulation of Work Position and Refueling Item (e).

Work Position	Respondents	Count by Scale		
		Scale	Count	%
Bangkok Petroleum Engineer	8	Agree	5	63
Bangkok Production Engineer	18	Agree	6	33
		Strongly Agree	6	33
Offshore Production Staff and Operators	30	Agree	16	53
Offshore Maintenance Staff and Operators	48	Agree	23	48

(f) You will use NGV in the future because of its convenient refueling system.

In reference to the finding in Table 4.13, the overall rating for this item is "Agree". The result on Table 4.64 and 4.65 showed that the "Agree" rating was voted by 47% or 29 respondents who hold Diplomas, 39% or 11 respondents who hold Bachelor Degrees or equivalent, 43% or 13 Offshore Production Staff and Operators, and 48% or 23 Offshore Maintenance Production Staff and Operators. The Bangkok Petroleum Engineers have voted equally for "Agree" and "Neutral" by 38% or 3. In

addition, the "Neutral" rating was voted by 43% or 6 respondents who hold higher than Bachelor Degrees, and 33% or 6 Bangkok Production Engineers.

Table 4.64. The Cross-Tabulation of Education Level and Refueling Item (f).

Education Level	Respondents	Count by Scale		
		Scale	Count	%
Diploma	62	Agree	29	47
Bachelor Degree or equivalent	28	Agree	11	39
Higher than Bachelor Degree	14	Neutral	6	43

Table 4.65. The Cross-Tabulation of Work Position and Refueling Item (f).

Work Position	Respondents	Count by Scale		
		Scale	Count	%
Bangkok Petroleum Engineer	8	Neutral	3	38
		Agree	3	38
Bangkok Production Engineer	18	Neutral	6	33
Offshore Production Staff and Operators	30	Agree	13	43
Offshore Maintenance Staff and Operators	48	Agree	23	48

4.4 Perception of Three Different Education Levels together with Four Different Work Positions of the Respondents on NGV

4.4.1 Safety

Three variables are selected, which are education level, work position, and controlling for the total rating of safety factor. The result on Table 4.66 showed that Partial Correlation Coefficients between education level and work position is -0.6019.

Degree of freedom is 101 (104 respondents and 3 used variables). The 2-tailed Significance P=0.000, which means a probability level is less than 0.05 which was specified to establish the significance of the results of the analysis.

Table 4.66. The Partial Correlation Coefficients of Education Level, Work Position, and Total Safety Rating.

Controlling for.. Total Safety		
	Education Level	Work Position
Education Level	1.0000 (0) P= .	-.6019 (101) P= .000
Work Position	-.6019 (101) P= .000	1.0000 (0) P= .

4.4.2 Environment

Three variables are selected, which are education level, work position, and controlling for the total rating of environment factors. The result on Table 4.67 showed that Prattle Correlation Coefficients between education level and work position is -0.6042. Degree of freedom is 101 (104 respondents and 3 used variables). The 2-tailed Significance P=0.000, which means a probability level is less than 0.05 which was specified to establish the significance of the results of the analysis.

Table 4.67. The Partial Correlation Coefficients of Education Level, Work Position, and Total Environment Rating.

Controlling for.. Total Safety		
	Education Level	Work Position
Education Level	1.0000 (0) P= .	-.6042 (101) P= .000
Work Position	-.6042 (101) P= .000	1.0000 (0) P= .

4.4.3 Cost and Economy

Three variables are selected, which are education level, work position, and controlling for the total rating of cost and economy factors. The result on Table 4.68 showed that Partial Correlation Coefficients between education level and work position is -0.6037. Degree of freedom is 101 (104 respondents and 3 used variables). The 2-tailed Significance P=0.000, which means a probability level is less than 0.05 which was specified to establish the significance of the results of the analysis.

Table 4.68. The Partial Correlation Coefficients of Education Level, Work Position, and Total Cost and Economy Rating.

Controlling for.. Total Safety		
	Education Level	Work Position
Education Level	1.0000 (0) P= .	-.6037 (101) P= .000
Work Position	-.6037 (101) P= .000	1.0000 (0) P= .

4.4.4 Refueling

Three variables are selected, which are education level, work position, and controlling for the total rating of refueling factor. The result on Table 4.69 showed that Partial Correlation Coefficients between education level and work position is -0.6059. Degree of freedom is 101 (104 respondents and 3 used variables). The 2-tailed Significance P=0.000, which means a probability level is less than 0.05 which was specified to establish the significance of the results of the analysis.

Table 4.69. The Partial Correlation Coefficients of Education Level, Work Position, and Total Refueling Rating.

Controlling for.. Total Safety		
	Education Level	Work Position
Education Level	1.0000 (0) P= .	-.6059 (101) P= .000
Work Position	-.6059 (101) P= .000	1.0000 (0) P= .

V. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

This chapter contains a brief summary of the research and the conclusions obtained from the results. This chapter also presents the interpretations of the findings, recommendations, and implications for further research.

5.1 Summary

The purpose of this study was to identify and study the respondents and their perceptions for each NGV factor in terms of safety, environment, cost and economy, and refueling which affects the use of NGV. A questionnaire, comprising 35 items, was used to collect data. There were two parts in the questionnaire. The first part is demographic profile. There nine questions utilized to gather personal information on several subjects such as gender, age, marital status, education level, classification of employee, work position, year of service, income per month, and their awareness of NGV availability. The second part concerned with NGV in terms of safety, environment, cost and economy, and refueling. There are twenty-six questions in this part. A five-point Likert scale was used for participants to respond to each factor, with options ranging from 1, "Strongly Disagree" to 5, "Strongly Agree".

The statistic tools including frequencies, cross-tabulation, and partial correlation coefficients were used for data analyzing to answer the research questions and hypothesis. A probability level of less than or equal to 0.05 was specified to establish the significance of the results of the analyses. There was an 80% response rate of the survey, a total of 130 copies launched with 104 questionnaires returned.

5.2 Conclusions

According to questions and research hypotheses that followed directly from the research questions, the summary of finding is as follows:

(1) Respondents profile in terms of gender, age, marital status, education level, classification of employee, work position, year of service, and income.

The analysis of the demographic profile of this study shows that out of 104 respondents in the study, the majority of them are male, aged between 41-50 years, married, offshore employees, work as Offshore Maintenance Staff and Operators, and hold Diplomas. A greater percentage of them have worked in the current company for 11-15 years, and have incomes of above 50,000 Baht per month. Most of them are aware that NGV is available in Thailand.

(2) Perceptions of respondents on NGV in terms of safety, environment, cost and economy, and refueling.

Out of four factors on the consumer's perception of respondents for NGV factors, the respondents agreed with three factors. These factors were of environment, cost and economy, and refueling.

One factor that respondents have doubts and voted for "Neutral" rating was safety. This meant that they were not sure that NGV would be safer than the conventional gasoline and diesel vehicles. They did not agree that transportation of gasoline and diesel by tank truck over the highway would be safe, and that gasoline and diesel are more flammable than natural gas either. In addition, they would not decide to use NGV in the future because of its safety. However, they had agreed that the transportation of natural gas by pipeline to the station was safe and its cylinders for vehicles were safer than cylinders of gasoline or diesel tanks.

As for environment factor, the respondents agreed that pollution in Thailand is mainly caused by emissions from vehicles. Natural gas is an

environmentally friendly fuel and releases lesser emissions than gasoline and diesel as it burns cleaner than gasoline. NGV could help to improve the air quality. In addition, they agreed to use NGV in the future because it is environmentally friendly.

For cost and economy factor, the respondents agreed that using more NGV could save the country from importing crude oil to produce gasoline and diesel. The speed of recovering investment incurred in NGV conversion depends on how extensive a vehicle is used. The more the car is run, the sooner the cost can be recouped. In addition, they also agreed that the maintenance cost of NGV is lower than that of gasoline and diesel vehicles because natural gas burns cleaner than other fuels and its price is much lower. They would decide to use NGV in the future because of its benefit on cost and economy. However, they were not sure that NGV was more cost-effective than gasoline and diesel vehicles in terms of vehicles' life because NGV conversion and component are costly (gaseous fuel system and storage cylinder installation). They also doubted that NGV had approximately up to four times longer maintenance intervals than diesel engines.

For refueling, the respondents agreed that they want to have more refueling stations available for public in Bangkok and its Metropolitan area, have NGV refueling stations developed and available along the natural gas pipelines over the country, and have NGV refueling stations developed in the existing oil stations over the country. They also agreed to use NGV in the future if refueling is convenient. However, they were not sure that it would be easy in refueling, that all they had to do was going to the station

and the gas would be pumped to the vehicle storage cylinder like gasoline refueling. On the other hand, they disagreed that NGV refueling station is easily found in their area.

(3) Perceptions of three different education levels and four different work positions of respondents on each factor of NGV in terms of safety, environment, cost and economy, and refueling.

For safety, the overall rating of each item is used to determine the summary of the findings. The finding results that nearly half of the respondents in all education level groups and the majority of Bangkok Petroleum Engineers were in doubt that NGV would be safer than the conventional vehicles driven by gasoline and diesel.

Nearly half of the respondents in all education level groups and almost half of work position groups did not agree that gasoline and diesel were more flammable than natural gas. The respondents in all groups agreed, were in doubt, and also disagreed that natural gas would not pool as a liquid or vapor on the ground in case of spill. However, the largest groups who agreed are the groups of respondents that hold Diplomas and Bangkok Petroleum Engineers.

The respondents in all groups disagreed that the transportation of gasoline and diesel by tank truck to the station over the highway was safe. However, the largest groups who disagreed are the groups of respondents that hold Diplomas and Bangkok Petroleum Engineers.

The respondents in all groups agreed that the transportation of natural gas by pipeline to the station was safe. However, the largest groups who

agreed are the groups of respondents that hold Bachelor Degrees or equivalent and Bangkok Petroleum Engineers.

The respondents in all groups agreed and also were in doubt that cylinders of NGV vehicles are thicker, stronger, and safer than cylinders of gasoline or diesel tanks. However, the largest groups who agreed are the groups of respondents that hold higher than Bachelor Degrees and Offshore Maintenance Staff and Operators.

Nearly half of the respondents in all groups were in doubt about the use of NGV in the future. The largest groups who were in doubt are the groups of respondents that hold higher than Bachelor Degrees and Offshore Production Staff and Operators. However, more than half of Bangkok Petroleum Engineers agreed to use NGV.

They also had an additional concern about NGV safety. They commented that the government should provide knowledge about NGV to public, and have procedures to set natural gas cylinder standard. They were not sure about the equipment used and the service men who work at the station. They were not sure if the service men were really able to handle the NGV and its cylinder safely. They were also concerned about spills or leaks from their car cylinders and how the spill could be detected. Moreover, they were not sure how dangerous NGV accidents could be.

For environment, the finding results show that nearly half of the respondents in all groups agreed that pollution in Thailand is mainly caused by the emissions from vehicles. The largest groups who strongly agreed are the groups of respondents that hold Bachelor Degrees or equivalent and Offshore Production Staff and Operators.

Nearly half of the respondents in all groups agreed that natural gas was an environmentally friendly fuel. The largest groups who agreed are the groups of respondents that hold higher than Bachelor Degrees, Bangkok Petroleum Engineers, and Bangkok Production Engineers.

More than half of the respondents in all groups agreed that NGV could help improve air pollution problems and when burnt NGV is cleaner than gasoline. The largest groups who agreed are the groups of respondents that hold higher than Bachelor Degrees, Bangkok Petroleum Engineers, and Offshore Production Staff and Operators.

Nearly half of the respondents in all groups agreed that the use of natural gas as a motor releases lesser emissions than gasoline and diesel. The largest groups who agreed are the groups of respondents that hold Bachelor Degrees or equivalent and Bangkok Production Engineers.

The respondents in all groups agreed to decide to use NGV in the future because it is environmentally friendly but they were not sure about that. However, the largest groups who agreed are the groups of respondents that hold Diplomas and Offshore Production Staff and Operators.

They also made an additional comment that there should be a better means of public transportation such as electric sky train which could reduce the number of private cars and the emission accordingly.

For cost and economy, the finding results showed that almost half of the respondents in all groups agreed that using more NGV could save the country from importing crude oil to produce gasoline and diesel. The largest groups who agreed are the groups of respondents that hold Diplomas and Offshore Maintenance Staff and Operators.

The respondents in all groups agreed that natural gas fuel price is much lower than gasoline and diesel price. However, the largest groups who agreed are the groups of respondents that hold higher than Bachelor Degrees and Bangkok Production Engineers.

Most of the respondents in all groups doubted that NGV is more cost-effective than gasoline and diesel vehicles in terms of vehicles' life because NGV conversion and components were costly (gaseous fuel system and storage cylinder installation). The largest groups who were in doubt are the groups of respondents that hold higher than Bachelor Degrees and Bangkok Petroleum Engineers.

The respondents in all groups agreed and also doubted that maintenance cost of NGV is lower than that of gasoline and diesel vehicles because natural gas burns cleaner than most other fuels. However, the largest groups that agreed are the groups of respondents that hold Diplomas and Bangkok Petroleum Engineers.

More than half of the respondents in all groups doubted that NGV had approximately up to four times longer maintenance intervals than diesel engine. The largest groups who were in doubt are the groups of respondents that hold Bachelor Degrees and higher and also Bangkok Petroleum Engineers.

Most of the respondents in all groups were in doubt, but only the respondents that hold higher than Bachelor Degrees agreed that the speed of recovering investment incurred in NGV conversion depends on how extensive a vehicle is used (the more the car is run, the sooner the cost can be recouped).

Nearly half of the respondents in all groups agreed and also were in doubt about the use of NGV in the future because of its benefit on cost and economy. The largest groups who agreed are the groups of respondents that hold higher than Bachelor Degrees, Bangkok Petroleum Engineers, and Offshore Production Staff and Operators.

They also made comments that there was not enough information for them about cost and price. They also commented that the government should provide more in giving knowledge about NGV to public, and have procedures to convert or modify the existing cars into ones which use natural gas as fuel. They also suggested more expertise and enough service shops to service and maintain NGVs.

For refueling, the finding results showed most of the respondents in all groups doubted that it would be easy in refueling and what they had to do is only going to the station and the gas was pumped to the vehicle storage cylinder like gasoline refueling. The largest groups who were in doubt are the groups of respondents that hold higher than Bachelor Degrees, and Bangkok Petroleum Engineers.

The respondents in all groups did not agree that NGV refueling station was easily found in their area. The largest groups who did not agree are the groups of respondents that hold higher than Bachelor Degrees, and Bangkok Petroleum Engineers.

Nearly half of the respondents in all groups agreed that they wanted to have more refueling stations available for public in Bangkok and its Metropolitan area and have NGV refueling stations developed and available along the natural gas pipelines over the country. The largest groups who

agreed are the groups of respondents who hold Diplomas, and Offshore Production Staff and Operators.

The respondents in all groups agreed that they wanted to have NGV refueling stations developed in the existing oil stations over the country. The largest groups who agreed are the groups of respondents that hold Diplomas, and Bangkok Petroleum Engineers.

Less than half of the respondents in all groups agreed to use NGV in the future if refueling was convenient. However, the largest groups who agreed are the groups of respondents that hold Diplomas, and Offshore Maintenance Staff and Operators.

(4) Hypothesis

The research hypothesis is to determine the perception of the different three education levels together with four work positions of the respondents towards the use of NGV in terms of safety, environment, cost and economy, and refueling. A probability level of less than or equal to 0.05 was specified to establish the significance of the results of the analysis.

Hypothesis 1 stated that there would be a significant interaction between education level and work position of the respondents towards the use of NGV in terms of safety. In this case, there was an interaction between variables. Hypothesis 1 is accepted.

Hypothesis 2 stated that there would be a significant interaction between education level and work position of the respondents towards the use of NGV in terms of environment. In this case, there was an interaction between variables. Hypothesis 2 is accepted.

Hypothesis 3 stated that there would be a significant interaction between education level and work position of the respondents towards the use of NGV in terms of cost and economy. In this case, there was an interaction between variables. Hypothesis 3 is accepted.

Hypothesis 4 stated that there would be a significant interaction between education level and work position of the respondents towards the use of NGV in terms of refueling. In this case, there was an interaction between variables. Hypothesis 4 is also accepted.

5.3 Recommendations

Since the purpose of this study was to identify and study the perceptions and the factors that affect the use of NGV, those factors are of safety, environment, cost and economy, and refueling. In order to promote consumers to use more NGV and develop NGV market, the organizations concerned should consider these factors. However, the study also showed that there is the significance interaction between education level and work position of people towards the use of NGV in all proposed factors.

According to the respondents perceived unfavorable rating (Neutral) in safety factor, the organization concerned should give more knowledge to the public regarding safety measures for NGV and the transportation of natural gas in order to help the public understand and know more about NGV. The government sector is also required to give knowledge to the public for better understanding about natural gas and NGV, and take more measures to control the safety standard of equipment and the refueling stations and in turn to build confidence in consumers' mind.

However, the respondents made favorable rating (Agree) in environment, cost and economy, and refueling factors. This means that they were already aware of NGV's

benefit as the natural gas is an environmentally friendly fuel, using more NGVs could help to improve air pollution problems caused mainly by emissions from vehicles. The other benefits that they were already aware is the price of the natural gas which is much lower than other fuels, and could also reduce the maintenance cost of vehicles. These advantages could help encourage the public to use more NGVs. However, the organization concerned should promote more about the cost and the speed of recovering investment of NGV conversion and components. More refueling stations are recommended to serve more NGVs in the future.

5.4 Suggestions for Future Research

The following is a list of some suggestions that further work in this might pursue:

(1) Similar or identical studies should be conducted in other organizations or other areas of population to obtain different perceptions of consumers.

(2) Further research should study more about other factors that could affect the use of NGV.

(3) Similar or identical studies should be conducted for other alternative fuels for vehicles.

APPENDIX A

QUESTIONNAIRE - ENGLISH VERSION

Questionnaire

Information:

This questionnaire is a part to fulfill the requirement for the Degree of Master of Science in Computer and Engineering Management of Ms. Tipkunchorn Paitoon.

The purpose of this questionnaire is to study the consumer's perception on natural gas vehicles (NGV) and to study factors that affect consumer's perception. The result of this study would be a guideline for government sectors or concerned organizations to promote consumers to use more NGV that would enhance the growth of NGV market and save the country cost in importing oil in which to use as gasoline.

It would be thankful and highly appreciated if you would participate in this study by completing the following questionnaire. Your information will be held strictly confidential.

Direction:

The question has 2 parts, total 35 items. Part 1 is personal data and background. Part 2 is NGV safety, environment, cost and economy, and refueling.

Part 1 : Personal Data and Background
Please select the most appropriate items.

Item	Description	
1	Gender	
	(a) Male	(b) Female
2	Age	
	(a) 20-30 years old	(b) 31-40 years old
	(c) 41-50 years old	(d) More than 50 years old
3	Marital Status	
	(a) Single	(b) Married
	(c) Divorced	(d) Widow
4	Education Level	
	(a) Diploma	(b) Bachelor Degree or equivalent
	(c) Higher than Bachelor Degree	
5	Classification of Employees	
	(a) Offshore employees	(b) Onshore employees
	(c) Offshore contractors	(d) Onshore contractors
6	Work Position	
	(a) Bangkok petroleum engineer	(b) Bangkok production engineer
	(c) Offshore production staff and operator	(d) Offshore maintenance staff and operator
7	Years of service	
	(a) 1-5 years	(b) 6-10 years

(c) 11-15 years (d) more than 15 years

8 Income

(a) 10,000-20,000 (b) 20,001-30,000

(c) 30,001-40,000 (d) 40,001-50,000

(e) Above 50,000

9 You know that there is NGV, available in Thailand eg. Taxis, buses, and private cars.

(a) Yes (b) No

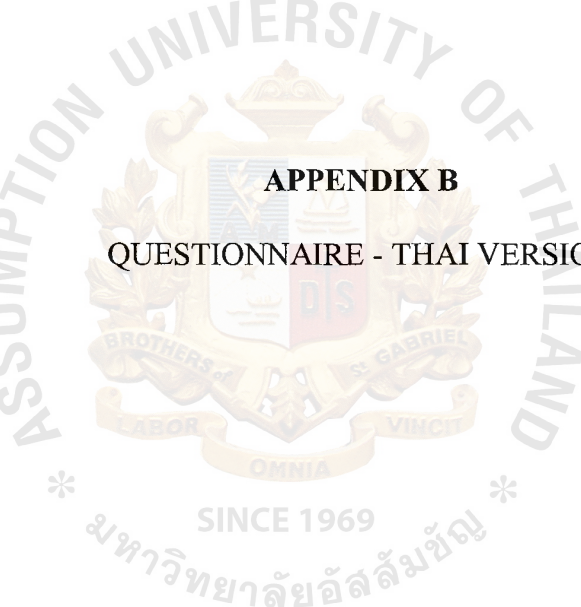
Part 2 : NGV safety, environment, cost and economy, and refueling.

Please select the number which most fit your thought and describe the extent to which you agree or disagree with that particular statement.

Item	Description	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Safety						
10	Natural gas vehicle (NGV) is as safe as, or safer than, conventionally fueled vehicles (gasoline and diesel).	1	2	3	4	5
11	Gasoline and diesel are more flammable than natural gas.	1	2	3	4	5
12	Natural gas is lighter than air and will not pool as a liquid or vapor on the ground in case of spill.	1	2	3	4	5
13	Gasoline and diesel are more dangerous because they are delivered to fueling stations by tank trucks over the highway.	1	2	3	4	5
14	Transportation of natural gas is safe because it flows by pipeline directly to its station.	1	2	3	4	5
15	Natural gas cylinders are much thicker and stronger than gasoline or diesel tanks.	1	2	3	4	5
16	You will use NGV in the future because of it is safe.	1	2	3	4	5
Any additional comment regarding safety:						
Environment						
17	The pollution in Thailand is mainly caused by the emission from vehicles.	1	2	3	4	5
18	Natural gas is an environmentally friendly fuel.	1	2	3	4	5
19	NGV could help to improve problem of air quality.	1	2	3	4	5
20	NGV is potentially a cleaner burning fuel than gasoline.	1	2	3	4	5
21	As a motor fuel, natural gas reduces emissions better than gasoline and diesel.	1	2	3	4	5
22	You will use NGV in the future because it is environmental friendly.	1	2	3	4	5

Any additional comment regarding environment:						
Cost and economy						
23	Using more NGV can save country from importing crude oil to produce gasoline and diesel.	1	2	3	4	5
24	Natural gas fuel price is much lower than gasoline and diesel.	1	2	3	4	5
25	There is cost on NGV conversion and component (gaseous fuel system and storage cylinder installation), but compared to the vehicles' life, NGV is more cost-effective than gasoline and diesel vehicles.	1	2	3	4	5
26	The maintenance cost of NGV is less because natural gas burns cleaner than most other fuels.	1	2	3	4	5
27	NGV is approx. up to four times longer maintenance intervals than diesel engine.	1	2	3	4	5
28	The speed of recovering investment incurred in NGV conversion depends how extensive a vehicle is used. The more the cars run, the sooner the cost can be recouped	1	2	3	4	5
29	You will use NGV in the future because of its benefit on cost and economy.					
Any additional comment regarding cost and economy:						
Refueling						
30	You know it is easy like gasoline refueling, NGV is only to go to the station and it is pumped to the vehicle storage cylinder.	1	2	3	4	5
31	You can easily find NGV refueling station in your area.	1	2	3	4	5
32	You want to have more refueling stations available for public uses in Bangkok and Metropolitan area.	1	2	3	4	5
33	You want to have NGV refueling stations developed and available along the natural gas pipelines over the country.	1	2	3	4	5
34	You want to have NGV refueling stations developed in the existing oil stations over the country.	1	2	3	4	5
35	You will use NGV in the future because of its refueling convenience.	1	2	3	4	5
Any additional comment regarding refueling:						

Thank you for your time in completing this questionnaire.



APPENDIX B

QUESTIONNAIRE - THAI VERSION

แบบสอบถาม

ข้อมูลทั่วไป

แบบสอบถามนี้จัดทำขึ้นโดยนางสาวทิพย์กุญชร ไพฑูรย์ แบบสอบถามนี้เป็นส่วนหนึ่งของการศึกษาในหลักสูตรปริญญาโทสาขาวิชาการจัดการงานคอมพิวเตอร์และวิศวกรรม มหาวิทยาลัยอัสสัมชัญ

วัตถุประสงค์ของแบบสอบถามเพื่อศึกษาการรับรู้ของผู้บริโภค ที่มีต่อรถยนต์ใช้ก๊าซธรรมชาติเป็นเชื้อเพลิงหรือ NGV ผลของการศึกษาสามารถนำไปใช้เป็นข้อมูลสำหรับภาครัฐหรือเอกชนที่เกี่ยวข้องเพื่อจัดการส่งเสริมให้มีการพัฒนาและขยายการบริโภครถยนต์ประเภทนี้มากขึ้นในอนาคต

จึงขอความกรุณาท่านช่วยตอบแบบสอบถามนี้ด้วยจักขอบคุณยิ่ง ข้อมูลที่ท่านให้จะถูกเก็บรักษาไว้เป็นความลับ

คำชี้แจง

แบบสอบถามนี้ประกอบด้วย 2 ส่วน รวมทั้งสิ้น 35 ข้อ , ส่วนที่ 1 ข้อมูลส่วนตัว และส่วนที่ 2 รถยนต์ใช้ก๊าซธรรมชาติ (NGV) ด้านความปลอดภัย, สิ่งแวดล้อม, ค่าใช้จ่ายและความคุ้มค่า, และการเติมเชื้อเพลิง

ส่วนที่ 1 : ข้อมูลส่วนตัว

คำชี้แจง: โปรดทำเครื่องหมาย x ลงบนหัวข้อ ที่ตรงกับความเป็นจริงของท่านในปัจจุบัน

ลำดับที่	รายการ	
1	เพศ	
	(c) ชาย	(d) หญิง
2	อายุ	
	(e) 20-30 ปี	(f) 31-40 ปี
	(g) 41-50 ปี	(h) มากกว่า 50 ปี
3	สถานภาพการสมรส	
	(e) โสด	(f) แต่งงาน
	(g) หย่าร้าง	(h) ม่าย
4	การศึกษาขั้นสูงสุด	
	(d) ประกาศนียบัตร/ประกาศนียบัตรขั้นสูง	(e) ปริญญาตรี/เทียบเท่า
	(f) สูงกว่าปริญญาตรี	
5	ประเภทของพนักงาน	
	(e) พนักงานประจำ นอกฝั่ง (Offshore employee)	(f) พนักงานประจำ บนฝั่ง (Onshore employees)
	(g) พนักงานนอกฝั่ง ที่มีกำหนดระยะเวลาการจ้างแน่นอน (Offshore contractors)	(h) พนักงานบนฝั่ง ที่มีกำหนดระยะเวลาการจ้างแน่นอน (Onshore contractors)

6 ตำแหน่งงานในปัจจุบัน

(e) วิศวกรด้านปิโตรเลียม (Petroleum Engineer) (f) วิศวกรด้านการผลิต (Production Engineer)

(g) พนักงานฝ่ายการผลิตบนแท่นผลิต (Offshore Production staff and operator) (h) พนักงานฝ่ายซ่อมบำรุงรักษาบนแท่นผลิต (Offshore Maintenance staff and operator)

7 จำนวนปีที่ท่านทำงานในบริษัทปัจจุบัน

(e) น้อยกว่า 6 ปี (f) 6-10 ปี

(g) 11-15 ปี (h) มากกว่า 15 ปี

8 รายได้รวมของท่านต่อเดือนประมาณ

(f) 10,000-20,000 บาท (g) 20,001-30,000 บาท

(h) 30,001-40,000 บาท (i) 40,001-50,000 บาท

(j) สูงกว่า 50,000 บาท

9 ท่านทราบหรือไม่ว่า ในปัจจุบันมีการใช้รถยนต์ก๊าซธรรมชาติ (NGV) สำหรับรถรับจ้าง รถโดยสารประจำทาง และรถยนต์ส่วนบุคคลในประเทศไทย

(a) ทราบ (b) ไม่ทราบ

ส่วนที่ 2 : รถยนต์ใช้ก๊าซธรรมชาติ (NGV) ด้านความปลอดภัย, สิ่งแวดล้อม, ค่าใช้จ่ายและความคุ้มค่า, และการเติมเชื้อเพลิง

คำชี้แจง: โปรดอ่านข้อคำถามในแบบสอบถามทุกข้ออย่างละเอียด แล้วพิจารณาว่าโดยทั่วไปแล้ว ท่านมีความเห็นกับแต่ละข้อความในระดับใด แล้วทำเครื่องหมาย x ลงบนตัวเลขที่ตรงกับความเห็นของท่าน

ระดับความเห็นแบ่งออกเป็น 5 ระดับดังนี้

เห็นด้วยอย่างยิ่ง	หมายถึง	5
เห็นด้วย	หมายถึง	4
ไม่แน่ใจ	หมายถึง	3
ไม่เห็นด้วย	หมายถึง	2
ไม่เห็นด้วยอย่างยิ่ง	หมายถึง	1

ลำดับ	รายการ	ไม่เห็นด้วยอย่างยิ่ง	ไม่เห็นด้วย	ไม่แน่ใจ	เห็นด้วย	เห็นด้วยอย่างยิ่ง
ความปลอดภัย						
10	รถยนต์ใช้ก๊าซธรรมชาติมีความปลอดภัยสูง หรือสูงกว่ารถยนต์เบนซินและดีเซล	1	2	3	4	5
11	น้ำมันเบนซินและดีเซล จุดติดไฟได้ง่ายกว่าก๊าซธรรมชาติ	1	2	3	4	5
12	เมื่อมีการรั่วไหลของก๊าซธรรมชาติ จะไม่เกิดการตกค้างบนพื้นผิวเพราะมีสภาพเป็นไอ ทำให้เกิดความปลอดภัยกว่าน้ำมันเบนซินและดีเซล	1	2	3	4	5
13	การขนส่งน้ำมันสู่สถานีน้ำมันโดยการใช้รถขนส่งไปตามท้องถนน มีความปลอดภัยสูง	1	2	3	4	5

14	การขนส่งก๊าซธรรมชาติไปสู่สถานีปลายทาง โดยท่อส่งก๊าซธรรมชาติ มีความปลอดภัยสูง	1	2	3	4	5
15	ถังเก็บก๊าซธรรมชาติสำหรับรถยนต์ (CNG) มีความแข็งแรงและทนทานมากกว่าถังน้ำมันเบนซินและดีเซลในรถยนต์ทั่วไป	1	2	3	4	5
16	คุณมีความมั่นใจในด้านความปลอดภัยของการใช้รถยนต์ก๊าซธรรมชาติ (NGV)	1	2	3	4	5

ข้อคิดเห็นเพิ่มเติม เกี่ยวกับความปลอดภัยของรถยนต์ก๊าซธรรมชาติ

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สิ่งแวดล้อม

17	ปัญหามลพิษในประเทศไทย ส่วนใหญ่เกิดจากควันไอเสียจากรถยนต์	1	2	3	4	5
18	ก๊าซธรรมชาติเป็นพลังงานที่สะอาด และเป็นมิตรต่อสิ่งแวดล้อม	1	2	3	4	5
19	การใช้รถยนต์ก๊าซธรรมชาติ (NGV) ช่วยลดปัญหาคุณภาพและมลพิษทางอากาศได้	1	2	3	4	5
20	การเผาผลาญเชื้อเพลิงของรถยนต์ก๊าซธรรมชาติ (NGV) จะดีกว่าการเผาผลาญเชื้อเพลิงในรถยนต์น้ำมันเบนซินและดีเซล	1	2	3	4	5
21	ก๊าซธรรมชาติสำหรับรถยนต์ สามารถลดเขม่าควันจากเครื่องยนต์ได้ดีกว่าเครื่องเบนซินและดีเซล เพราะเผาไหม้ได้ดีกว่า	1	2	3	4	5
22	คุณจะเลือกใช้รถยนต์ก๊าซธรรมชาติ เพราะสามารถช่วยลดปัญหาสิ่งแวดล้อมได้ดีขึ้น	1	2	3	4	5

ข้อคิดเห็นเพิ่มเติม เกี่ยวกับสิ่งแวดล้อมกับการใช้รถยนต์ก๊าซธรรมชาติ

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ค่าใช้จ่ายและความคุ้มค่า

23	การใช้รถยนต์ก๊าซธรรมชาติ (NGV) สามารถช่วยชาติประหยัดค่าใช้จ่ายในการนำเข้านำมันดิบเพื่อผลิตน้ำมันเบนซิน และดีเซล และก๊าซธรรมชาติสามารถผลิตได้เองในประเทศ	1	2	3	4	5
24	ราคาก๊าซธรรมชาติสำหรับรถยนต์ มีราคาถูกว่าน้ำมันเบนซินและดีเซล	1	2	3	4	5
25	รถยนต์ก๊าซธรรมชาติ (NGV) มีอายุการใช้งานที่ยาวนาน ทำให้คุ้มค่าต่อการใช้ เมื่อเปรียบเทียบกับการลงทุนติดตั้งอุปกรณ์เพิ่ม เช่น ถังเก็บก๊าซธรรมชาติสำหรับรถยนต์ (CNG)	1	2	3	4	5
26	ก๊าซธรรมชาติมีการเผาไหม้ที่หมดจด ทำให้ยืดอายุเครื่องยนต์ และประหยัดค่าซ่อมบำรุงมากกว่า	1	2	3	4	5
27	รถยนต์ก๊าซธรรมชาติ (NGV) มีระยะเวลาซ่อมบำรุงนานกว่ารถยนต์เบนซินและดีเซล โดยประมาณถึง 4 เท่า	1	2	3	4	5

28	ความคุ้มค่าการลงทุนของรถยนต์ก๊าซธรรมชาติ ขึ้นอยู่กับระยะเวลาของการใช้งาน ยิ่งใช้งานมาก ยิ่งคุ้มค่าเร็ว	1	2	3	4	5
29	คุณคิดว่าคุ้มค่าและเป็นการประหยัดในระยะยาวสำหรับการใช้รถยนต์ก๊าซธรรมชาติ	1	2	3	4	5
ข้อคิดเห็นเพิ่มเติม เกี่ยวกับค่าใช้จ่ายและความคุ้มค่าในการใช้รถยนต์ก๊าซธรรมชาติ .... การเติมเชื้อเพลิง						
30	การเติมก๊าซธรรมชาติสำหรับรถยนต์ (CNG) ไม่ยุ่งยากและสะดวกเหมือนกับรถยนต์เบนซินและดีเซลทั่วไป	1	2	3	4	5
31	คุณสามารถหาสถานีเติมก๊าซธรรมชาติสำหรับรถยนต์ได้ง่ายในบริเวณพื้นที่โดยรอบของคุณ	1	2	3	4	5
32	คุณต้องการให้เพิ่มสถานีเติมก๊าซธรรมชาติสำหรับรถยนต์ให้มากขึ้น	1	2	3	4	5
33	คุณต้องการให้มีการพัฒนาและ สร้างสถานีบริการเติมก๊าซธรรมชาติสำหรับรถยนต์ตามแนวท่อก๊าซธรรมชาติ ซึ่งมีอยู่แล้วทั่วประเทศ	1	2	3	4	5
34	คุณต้องการให้มีการพัฒนาและ ขยายสถานีน้ำมันในปัจจุบัน ให้สามารถบริการเติมก๊าซธรรมชาติสำหรับรถยนต์ได้ด้วย	1	2	3	4	5
35	คุณจะใช้รถยนต์ก๊าซธรรมชาติ ถ้ามีความสะดวกในการเติมเชื้อเพลิง หรือมีสถานีบริการที่เพียงพอ	1	2	3	4	5
ข้อคิดเห็นเพิ่มเติม เกี่ยวกับการเติมเชื้อเพลิงสำหรับรถยนต์ก๊าซธรรมชาติ						

ขอขอบคุณที่ท่านตอบแบบสอบถามนี้

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