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LPG Penetration in Rural Areas of Cambodia

Edited by

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Preface

LPG demand in Cambodia has been growing rapidly – from 77 kilotons of oil equivalent (ktoe) in 2010 to 402 ktoe in 2019 – reflecting an average annual growth rate of 20% over the past nine years. According to Cambodia's updated *National Energy Statistics 2022*, LPG is widely used across final energy consumption sectors: for cooking and water heating in residential and commercial areas, and for fuelling road transport vehicles such as three-wheeled tuk-tuks (e.g. those used by the ride-hailing service PassApp) and four-wheeled cars.

While LPG demand has significantly increased in Cambodia's urban residential sector, rural areas continue to rely heavily on biomass fuels, such as firewood. The General Department of Petroleum (GDP) under the Ministry of Mines and Energy recognises this imbalance and anticipates the expansion of LPG use in rural areas to improve air quality and reduce cooking time.

However, data on LPG consumption in rural areas remains limited – on both the supply and demand sides. In response, the GDP has invited ERIA to conduct a research study, including a comprehensive LPG consumption survey to assess the current situation in rural communities. The LPG penetration experience of other ASEAN Member States will also serve as a valuable benchmark to inform Cambodia's rural energy policy.

Despite the potential for increased rural LPG demand, initial uptake is expected to be modest. This may not present an immediate commercial incentive for LPG suppliers. Consequently, the GDP may need to consider policy support measures – targeting either end users or suppliers – to stimulate market development in underserved areas. ERIA has been tasked with formulating practical policy recommendations based on the study's findings.

As LPG is increasingly recognised as a clean, convenient, and reliable energy source, it is expected to become indispensable not only in urban centres but also in rural areas. This study aims to support the strategic expansion of Cambodia's LPG market, offering valuable insights and policy direction. The General Department of Petroleum will use the findings to guide management of the nationwide LPG supply network.

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The ERIA team included Mr Shigeru Kimura, Ms Citra Endah Nur Setyawati (Former Research Associate), and external experts:

- Mr Takahisa Hiruma, Vice President of the ASIAM Research Institute, who led the analysis of the LPG supply side;
- Mr Masao Shimanuki from Tsurugi Corporation, who focused on the LPG demand side; and
- Dr Weerawat Chantanakome, Senior Advisor to the Minister of Energy, Thailand.

The GDP team was led by H.E. Chea Channara, Director General of the General Department of Petroleum.

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ASEAN	Association of Southeast Asian Nations
COVID-19	novel coronavirus disease
ERIA	Economic Research Institute for ASEAN and East Asia
GDP	General Department of Petroleum
kg	kilogramme
LPG	liquefied petroleum gas
MME	Ministry of Mines and Energy
Mpa	megapascal
PTT	Petroleum Authority of Thailand
toe	tons of oil equivalent

Executive Summary

Between 2000 and 2019, liquefied petroleum gas (LPG) consumption in Cambodia recorded the highest growth amongst petroleum products, particularly in urban areas. In cities, LPG is widely used for residential cooking and in the transport sector, notably by three-wheeled tuk-tuks (such as those operating under PassApp). However, in rural areas, LPG consumption has grown more slowly. Most rural households continue to rely on traditional biomass fuels like firewood, which are free and readily available.

Despite this, the Cambodian government strongly recommends a shift from biomass to LPG, citing both health benefits – such as smoke-free indoor environments – and economic advantages, including shorter cooking times due to LPG's higher calorific value.

Several key barriers hinder rural LPG adoption: perceptions that LPG is dangerous, too expensive, complicated to use, or unnecessary given the availability of free firewood. To overcome these obstacles, the General Department of Petroleum under the Ministry of Mines and Energy (MME) plans to launch awareness campaigns focused on LPG safety in rural communities. Additionally, the government is considering economic incentives to make LPG more accessible.

International examples offer useful guidance. Indonesia's 2007 kerosene-to-LPG conversion programme included the distribution of subsidised 3-kg LPG cylinders to households. Thailand maintained affordable rural LPG prices through price regulations and transportation subsidies. Drawing on these experiences, Cambodia may consider a range of incentives, such as:

1. Providing free LPG cassettes and stoves;
2. Offering small LPG cylinders at subsidised prices;
3. Introducing regulated LPG pricing to lower rural LPG costs compared to urban areas.

Currently, LPG companies are reluctant to operate in rural areas due to high logistics costs and low initial demand. However, with proper incentives and rising demand, these areas – home to a larger share of Cambodia's population – could present significant growth potential for the LPG industry.

To realise this potential, the General Department of Petroleum must develop targeted policies and action plans that promote safe, affordable, and widespread use of LPG in rural Cambodia.

Chapter 1

Introduction

This study report, 'LPG Penetration in Rural Areas of Cambodia' consists of four parts: LPG business policies of LPG suppliers in the rural areas of Cambodia (Chapter 2), survey on actual LPG consumption in the rural areas (Chapter 3), reference to two other Association of Southeast Asian Nations (ASEAN) countries regarding policy support on LPG consumption in the household sector (Chapter 4), and key findings and recommendations (Chapter 5). The General Department of Petroleum, Ministry of Mines and Energy, Cambodia officially requested this LPG study.

First, interviews with LPG suppliers in Cambodia were conducted. We questioned three LPG suppliers on the following topics: 1) How do you see current LPG demand for the residential sector in the rural areas?, 2) How do you see future LPG demand in the rural areas?, 3) What is your company profile and how do you see LPG business in the rural areas?, 4) How do you see the current situation of fuel consumption in the rural areas?, and 5) What kind of support do you expect from the government?

Second, we conducted an LPG consumption survey in the rural areas. In total, 378 households were interviewed in seven villages in the three provinces of Kampong Thom, Kratie, and Pursat. The questions asked were: 1) number of family members, 2) LPG consumption per month, 3) cassette can or cylinder?, 4) how to supply LPG, buy/refill or delivery?, 5) how to use LPG?, 6) is LPG main use?, 7) other fuel consumption such as biomass, 8) to the households not using LPG, do you want to use LPG?, and 9) if the answer is no, what are the reasons?

For experiences of other ASEAN countries regarding LPG penetration in the household sector, we chose Indonesia and Thailand. For Indonesia, we focused on the fuel change programme from kerosene to LPG in the household sector. In Thailand, we investigated the LPG policies of the Ministry of Energy.

Finally, based on the study results mentioned above, we prepared a summary of the study results as well as extracting policy recommendations to be delivered to the General Department of Petroleum, Ministry of Mines and Energy, Cambodia.

Chapter 2

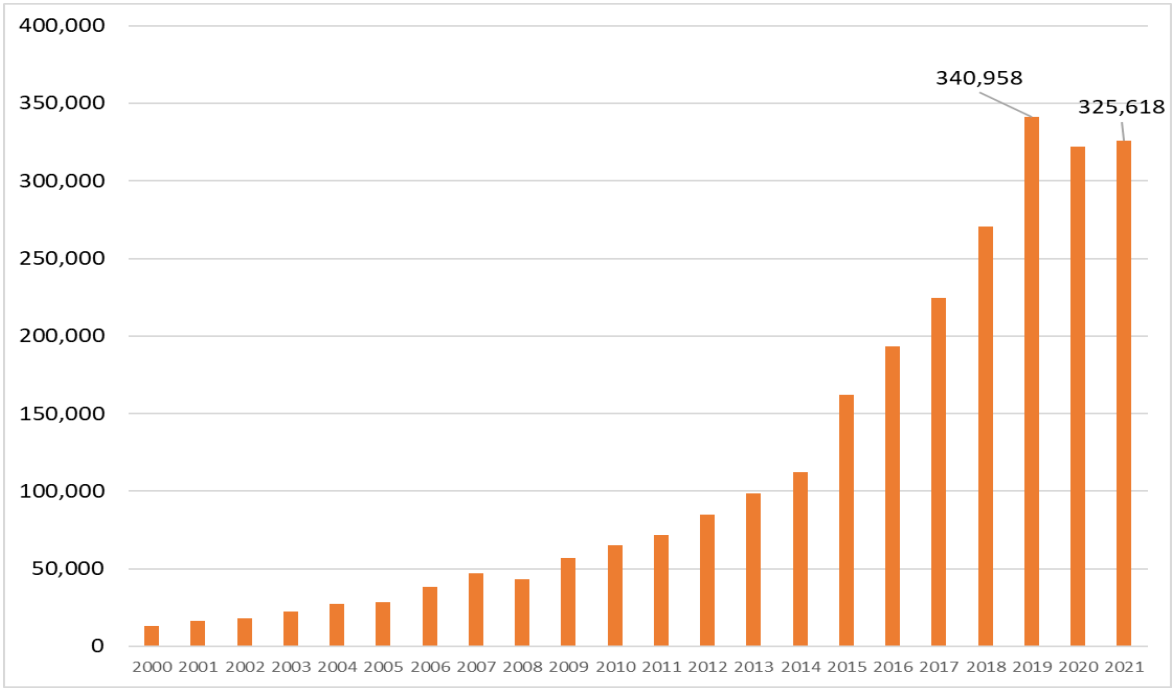
LPG Supply to Rural Areas in Cambodia

1. LPG Demand in Rural Areas in 2021

1.1. LPG Demand by Sector in 2021

Total demand for LPG in 2019 reached a record high of 340,958 tons, but decreased to 322,136 tons in 2020 due to the novel coronavirus disease (COVID-19) pandemic (Figure 2.1). In 2021, there was a slight recovery to 325,618 tons. The breakdown of demand by sector in 2021 is transport at 80,628 tons, residential at 116,044 tons, commercial at 127,000 tons, and industry at 1,946 tons. This survey focuses on the residential demand in the rural areas.

Figure 2.1 National Demand for LPG (ton)



Source: General Department of Petroleum.

Table 2.1 LPG Demand by Sector, 2021

Sector	LPG Demand (ton)	%
Transport	80,628	24.8
Residential	116,044	35.6
Commercial	127,000	39.0
Industry	1,946	0.6
	325,618	100.0

Source: ERIA (2024), LPG Supply Master Plan. ERIA Research Project Report FY2024, No 02.

1.2. Residential LPG Consumption in Rural Areas

Table 2.2 Distribution of Households by Type of Fuel Used for Cooking (%)

Area	Year	Number of Households	Type of Fuel							
			Total	Firewood	Charcoal	Kerosene	LPG	Electricity	None	Other
Total	2019	3,553,021	100.0	60.9	7.8	0.3	27.7	3.0	0.1	0.2
	2008	2,817,637	100.0	83.6	7.5	0.4	7.9	0.4	0.1	0.1
	1998	2,162,086	100.0	90.0	5.3	1.8	1.7	-	-	1.2
Urban	2019	1,328,501	100.0	31.0	7.9	0.4	56.2	4.2	0.2	0.1
	2008	506,579	100.0	34.7	25.6	0.4	37.3	1.5	0.4	0.1
	1998	364,581	100.0	62.9	24.6	2.8	8.8	-	-	0.9
Rural	2019	2,224,520	100.0	78.8	7.7	0.3	10.7	2.3	0.1	0.1
	2008	2,311,058	100.0	94.3	3.5	0.3	1.5	0.1	0.2	0.1
	1998	1,797,505	100.0	95.6	1.3	1.6	0.3	-	-	1.2

Source: National Institute of Statistics (2019).

According to the 2019 Cambodian national census, of the 2,224,520 households in rural areas, only 10.7% use LPG as their main cooking fuel, although this figure is increasing. Firewood and charcoal account for 78.8% and 7.7%, respectively, with biomass being the main cooking fuel in rural areas (Table 2.2) (National Institute of Statistics, 2019).

On the other hand, amongst the 1,328,501 households in urban areas, the number of households that primarily use LPG as cooking fuel is rapidly increasing, reaching 56.2% in 2019. Possible reasons for this include urban lifestyles, the inability to use biofuels in living environments, and high household incomes (Table 2.2).

2.1.1 Residential LPG Consumption Volume in Rural Areas

According to the 2019 national census, there were 2,224,520 rural households, accounting for 60% of the national total. There are 10 provinces in which the proportion of rural households exceeds 80% (Table 2.3) (National Institute of Statistics, 2019).

ERIA's 'LPG Supply Master Plan for Cambodia' (published in June 2024) estimates LPG consumption in the rural areas to be 21,356 tons, which is 18.4% of the total residential demand with 116,044 tons in Cambodia.

Table 2.3 LPG Demand for Residential Use by Province, 2021 (tons)

	Name of Province	Total Number of Households	Urban	Rural	Urban Ratio (%)	Rural Ratio (%)	LPG Demand Urban	LPG Demand Rural	LPG Demand Total
1	Banteay Meanchey	189,588	68,660	120,928	36.2	63.8	4,120	1,161	5,281
2	Battambang	227,237	45,556	181,681	20.0	80.0	2,733	1,744	4,477
3	Kampong Cham	217,197	30,386	186,811	14.0	86.0	1,823	1,793	3,617
4	Kampong Chhnang	126,299	28,523	97,776	22.6	77.4	1,711	939	2,650
5	Kampong Speu	195,882	114,380	81,502	58.4	41.6	6,863	782	7,645
6	Kampong Thom	160,766	16,118	144,648	10.0	90.0	967	1,389	2,356
7	Kampot	143,402	13,258	130,144	9.2	90.8	795	1,249	2,045
8	Kandal	265,803	170,782	95,021	64.3	35.7	10,247	912	11,159
9	Kohkong	28,027	12,359	15,668	44.1	55.9	742	150	892
10	Kratie	86,176	9,297	76,879	10.8	89.2	558	738	1,296
11	Mondolkiri	20,409	7,500	12,909	36.7	63.3	450	124	574
12	Phnom Penh	499,299	499,299	0.0	100.0	0.0	44,937	0.0	44,937
13	Preah Vihear	56,713	5,650	51,063	10.0	90.0	339	490	829
14	Prey Veng	266,934	14,168	252,766	5.3	94.7	850	2,427	3,277
15	Pursat	103,862	17,624	86,238	17.0	83.0	1,057	828	1,885
16	Ratanakkiri	49,741	6,877	42,864	13.8	86.2	413	411	824
17	Siem Reap	224,672	67,845	156,827	30.2	69.8	4,071	1,506	5,576
18	Preah Sihanouk	47,381	34,060	13,321	71.9	28.1	2,044	128	2,171
19	Stung Treng	35,833	9,761	26,072	27.2	72.8	586	250	836
20	Svay Rieng	132,492	37,285	95,207	28.1	71.9	2,237	914	3,151
21	Takeo	208,698	62,856	145,842	30.1	69.9	3,771	1,400	5,171
22	Oddar Meanchey	60,886	19,826	41,060	32.6	67.4	1,190	394	1,584
23	Kep	9,605	7,714	1,891	80.3	19.7	463	18	481
24	Pailin	17,177	13,050	4,127	76.0	24.0	783	40	823
25	Tbong Khmum	178,942	15,667	163,275	8.8	91.2	940	1,567	2,507

Total	3,553,021	1,328,501	2,224,520	37.4	62.6	94,689	21,355	116,044

Note: Urban is defined as towns identified based on statutory administration by decrees and laws, and total population of the commune in excess of 2,000, population density in excess of 200 per square kilometre, and percentage of employment in non-agricultural occupations in excess of 50%.
Sources: National Institute of Statistics (2019), ERIA (2024), LPG Supply Master Plan in Cambodia. ERIA Research Project Report FY2024, No 02.

2. Current Supply Means of LPG to Rural Areas

2.1. Filled New Cassette Cans

There are no factories in Cambodia that fill new empty cassette cans with LPG, so all LPG-filled new cassette cans are imported from overseas such as Viet Nam, China, and the Republic of Korea. According to additional interviews with gas dealers and others, as expected in Cambodia it has become common practice to fill reused cassette cans with LPG at retail shops. Refilled cassette cans are also sold at retail shops and grocery stores. The general answer is that the distribution of filled new cassette cans is limited. It is our understanding that small lots of filled new cassette cans are being imported. The total number of filled new cassette cans imported is unknown, but the following statistics exist (Table 2.4).

Table 2.4 Importation Data of LPG Facilities in Cambodia

Month	HS Code	Name of Product	Exports	Imports	Packs
October	84818030	Gas tank valve, (gas controller) Hang Moi 100%, (PACK 100 pieces – PACKage) #&VN	Viet Nam	Cambodia	500
October	73211100	IKURA Double Gas Stove 100% Brand New (1 stove-CTN), #&VN	Viet Nam	Cambodia	100
October	27111300	Bottled liquefied butane gas (IKURA mini canned gas for travel gas stoves), Hang Moi 100% (1 box of 28 bottles, PACK in 02 boxes-bale) #&VN	Viet Nam	Cambodia	1,200
October	73211100	Mini Flame Gas Stove 100% Brand New (PACK with 12 stoves-box), #&VN	Viet Nam	Cambodia	240
September	27111300	Bottled liquefied butane gas (IKURA mini canned gas for travel gas stoves), Hang Moi 100% (1 box of 28 bottles, PACK in 02 boxes-bale) #&VN	Viet Nam	Cambodia	1,100

HS = Harmonized System.
Note: HS Code: Harmonized Commodity Description and Coding System 27111300 is new cassette can.
Source: Volza (2024).

Filled new cassette cans were on sale at Aeon Mall and Lucky Supermarkets in Phnom Penh. At USD1.5 per can they are expensive, so they are used more for barbecues and camping than for daily cooking. As will be described later, for safety reasons, the filled new cassette cans are filled with 100% low pressure butane gas.

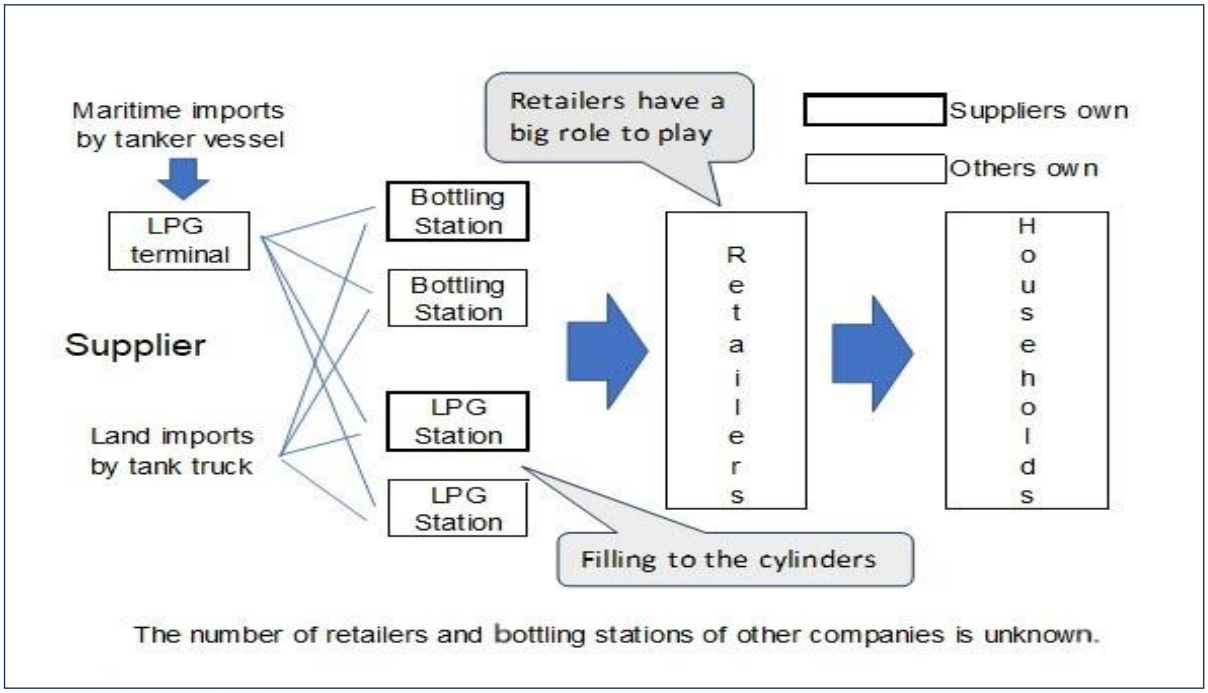
2.2. Refilled Cassette Cans

In the rural areas, refilled cassette cans are used because they are cheaper (KR1,500 per can, about USD0.375) than new filled cassette cans. Refilled cassette cans can be purchased or exchanged at retail shops and grocery stores. At retail shops, used cassette cans are refilled from cylinders. The refilled LPG is a commonly supplied standard product with 40% or more propane. According to the consumption survey, the median monthly consumption of households using cassette cans is estimated to be 3 to 4 kilogrammes (kg), about 12 to 16 cans per month.

2.3. Cylinders

Cylinders ranging from 4 kg to 48 kg are in circulation in Cambodia. In rural areas, it is estimated that cylinders of 4 kg, 12 kg, 15 kg, and 25 kg are used. In the residential and commercial sectors, LPG is mostly supplied in cylinders. Cylinder filling is mainly done at bottling stations, but also at LPG stations. Filled cylinders are transported by truck to retailers' warehouses or retail shops, and the retailer delivers them to the final consumer (households). In some cases, the final consumer brings empty cylinders to the LPG station for filling (Figure 2.2).

Figure 2.2 Supply Chain of LPG Cylinders in Rural Areas



Source: Authors.

2.4. Bottling Stations

Major LPG companies have bottling stations in the large cities such as Phnom Penh, Kandal, and Sihanoukville, but the number of bottling stations operated by small and medium-sized LPG companies is not known. The delivery volume of LPG to bottling stations by province is shown in Table 2.5.

Table 2.5 Delivery Volume of LPG to Bottling Stations by Province, 2021

Province	Total	%	Province	Total	%
Banteay Meanchey	0	0.0	Prey Veng	725	0.8
Battambang	600	0.7	Pursat	0	0.0
Kampong Cham	825	0.9	Ratanakkiri	0	0.0
Kampong Chhnang	0	0.0	Siem Reap	0	0.0
Kampong Speu	1,525	1.7	Preah Sihanouk	10,765	12.3
Kampong Thom	0	0.0	Stung Treng	0	0.0
Kampot	625	0.7	Svay Rieng	625	0.7
Kandal	25,006	28.6	Takeo	625	0.7
Kohkong	0	0.0	Oddar Meanchey	0	0.0
Kratie	0	0.0	Kep	0	0.0
Mondolkiri	0	0.0	Pailin	0	0.0
Phnom Penh	46,090	52.7	Tbong Khmum	0	0.0
Preah Vihear	0	0.0	**Total**	**87,411**	**100.0**

Source: General Department of Petroleum.

2.5 LPG Stations

There were 740 LPG stations in all provinces in 2021 (Table 2.6). LPG stations can fill cylinders with LPG.

Table 2.6 Number of LPG Stations by Province, 2021

Province	LPG Service Station	%	Province	LPG Service Station	%
Banteay Meanchey	67	9.1	Prey Veng	24	3.2
Battambang	79	10.7	Pursat	26	3.5
Kampong Cham	26	3.5	Ratanakkiri	5	0.7
Kampong Chhnang	18	2.4	Siem Reap	69	9.3
Kampong Speu	45	6.1	Preah Sihanouk	23	3.1
Kampong Thom	33	4.5	Stung Treng	7	0.9
Kampot	44	5.9	Svay Rieng	23	3.1
Kandal	15	2.0	Takeo	26	3.5
Kohkong	10	1.4	Oddar Meanchey	18	2.4
Kratie	10	1.4	Kep	2	0.3
Mondolkiri	5	0.7	Pailin	6	0.8
Phnom Penh	127	17.2	Tbong Khmum	17	2.3
Preah Vihear	15	2.0	Total	740	100.0

Source: General Department of Petroleum.

3. Views of LPG Suppliers on LPG Sales in the Rural Areas

Interviews were conducted with major LPG companies concerning the penetration of LPG in the rural areas. The results of the interviews are shown below. All the major LPG companies predict that LPG demand in the rural areas will expand, but there are differences in their views on how they will get involved.

3.1. Company A

- Our company is primarily a supplier and wholesaler of LPG. Although LPG service stations are spread all over the country, bottling stations are only located in major cities. The number of depos (small bottling stations) and retail stores in local areas will increase, so we will sell wholesale to them as a business. LPG demand for residential use in the rural areas will increase, but transportation cost is an issue, especially in mountainous areas. Our company will not build bottling stations. We will not take away their business.
- Households in the rural areas use firewood which is free. They do not spend money for cooking. If their income increases, they may use LPG. We do not sell cassette cans, but in the rural areas generally refilled cassette cans are sold by

retailers who refill LPG from cylinders, which is cheap but dangerous. Refilling used cassette cans is not prohibited yet, so people in the rural areas may buy refilled cassettes.

- What we want from the government is:
  - Prohibition of illegal activities (smuggling, tax evasion, refilling cassettes)
  - Safety education for consumer and retailer
  - Legislation for cylinder expiration management

3.2. Company B

- We have two bottling stations in major cities and 20 LPG service stations in 11 provinces. At LPG service stations we fill cylinders with LPG that are brought in by the customer. Our staff take heavy cylinders to the customer's house by motorbike.
- LPG demand for residential use in rural areas will increase, but whether we increase the number of bottling stations and LPG service stations depends on our competitiveness. We cannot beat LPG companies that are doing illegal business on price. But we intend to expand our import terminal in Sihanoukville.
- In rural areas, households use small cylinders or refilled cassette cans. The refilling cost of a cassette can is about USD0.5, it means USD2.0/kg because the LPG weight of a cassette can is 250g. New cans are expensive, costing USD1.5, that is USD6.0/kg. Households in Phnom Penh mainly use new cans for camping and barbecues, but they use cylinders for everyday cooking. Our company sells LPG for USD1/kg at every location and every size. Cylinders have a high initial cost but the lowest running costs.
- What we want from the government is:
  - Prohibition of illegal activities (smuggling, tax evasion, refilling cassettes)
  - Crackdown on gas companies that do not pay their customs duties in full
  - Legislation for cylinder expiration management

3.3. Company C

- We import LPG from Viet Nam by tank truck. We have one bottling station in Phnom Penh, and two LPG service stations in Siem Reap and Battambang. We plan to build LPG service stations in every province in the future. For residential

demand of LPG, we supply LPG from LPG service stations. Our staff take cylinders to the customer's house. That is the point of appeal to the customer.

- We plan the structure of LPG service stations is to place a dispenser on the roadside so that cylinders can be filled in the backyard. We call this the distributor.

Note: This backyard distributor should be regulated on safety points.

3.4. Company D

- For safety reasons, it is advisable for households in the rural areas to use LPG in cylinders. In order to expand the use of cylinders, it is necessary to build bottling stations, which requires investment in a large site, storage tanks, filling equipment, etc. If our company determines that the demand in the rural areas will expand and that the investment can be recovered, we will build additional bottling stations.

4. Issues of Ensuring Safety for LPG Penetration in Rural Areas

There were 85 reported LPG-related fire and explosion accidents between 2014 and 2023 (Table 2.7).

Table 2.7 Accident Cases Caused by LPG in Cambodia

Accident Case	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	Total
Fire and explosion in LPG service station	1	0	1	0	1	1	0	0	14	0	18
Fire and explosion in petroleum and LPG joint service station	0	1	1	2	0	2	2	1	1	0	10
Fire and explosion due to selling and refilling of LPG can	0	4	3	2	0	1	3	0	1	1	15
Gas transport accident by tank truck	1	1	0	0	0	0	0	0	0	0	2
Explosion due to using LPG cylinder and/or can	5	10	6	3	0	1	3	4	3	2	37
LPG cylinder warehouse fire	0	0	1	0	0	2	0	0	0	0	3
Total	**7**	**16**	**12**	**7**	**1**	**7**	**8**	**5**	**19**	**3**	**85**

Source: General Department of Petroleum (6 February 2024).

Of these, the most common accidents were related to cylinders and cassette cans, with 37 cases. The details of the cause are unclear, but possible causes are believed to be deterioration of the equipment and improper use.

In a survey on LPG consumption in the rural areas, one of the reasons given for not using LPG was that LPG is dangerous and scary. When promoting the use of LPG in the rural areas, it is important to place importance on ensuring safety. LPG can be used in households in the form of a cassette can and gas stove or a cylinder, hose, and gas stove. This section describes precautions to ensure safety when using each method.

4.1 Cassette Cans and Gas Stoves

New Cassette Cans and Gas Stoves

New cassette cans were not originally manufactured with the intention of being reused, and the recommended retention period is about 7 years (IWATANI).[1] This is because of rust, deformation, and deterioration of the rubber seal used at the injection port. New cassette cans are filled with low pressure butane gas for safety reasons. The internal pressure of a cassette can is 0.2 megapascals (Mpa) at 20°C and 0.25 Mpa at 30°C. These are 2 to 2.5 times the atmospheric pressure, respectively. During manufacturing, the cassette can is pressure tested at 1.5 Mpa, but it expands at 60° and bursts at 72°.[2]

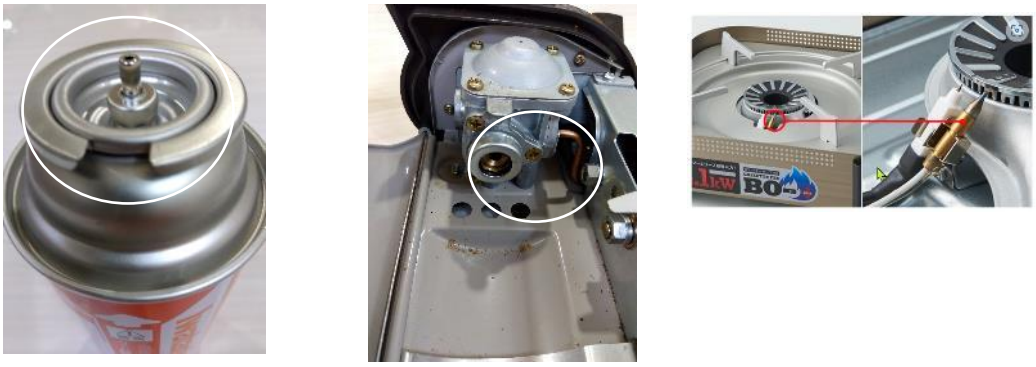
The recommended use period for new gas stoves for cassette cans is 10 years (IWATANI). Cassette stoves contain rubber parts to prevent gas leaks, and these deteriorate over time regardless of how often the stoves are used, so please be aware of this. In particular, gas leakage from the contact point between the cassette can's inlet and the stove is dangerous.

The latest gas stoves are equipped with flame-out sensors that shut off the gas if the flame goes out due to overflow or wind (Figure 2.3).

[1] IWATANI is a major LPG company in Japan, selling new filled cassette cans and gas stoves.
[2] Fire department of Mino city, Osaka, 18 April 2023.

Figure 2.3 Important Parts of Cassette Cans and Gas Stoves

Cassette can inlet | Stove receiving port | Flame-out sensor



Source: Authors.

Refilled Cassette Cans and Gas Stoves

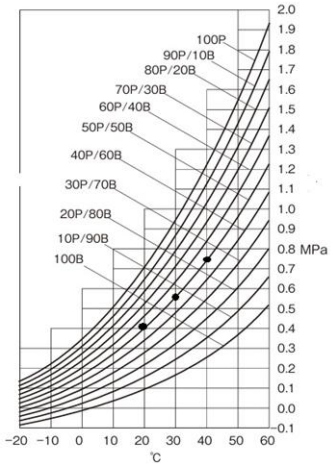
Refilled cassette cans are sold by retailers who refill the cans with LPG from cylinders. Refilled cassette cans are also sold at grocery stores. Since new cassette cans are expensive at USD1.5 per can (USD6/kg), refilled cassette cans, which are cheaper and cost only KR1,500 (USD0.375/can), are often used in the rural areas. In a survey on LPG consumption in rural areas, refilled cassette cans and gas stoves are mostly old and deteriorated. In addition, the gas that is refilled from cylinders at retail shops is not 100% butane gas, but the commonly supplied LPG, which is mixed with more than 40% propane and has a high pressure. Figure 2.5 shows pressure curve visually represents how pressure changes relative to another variable – in this case temperature – in a system. It is commonly used in industries like energy, manufacturing, and fluid dynamics to monitor and analyse pressure behaviour. If MPa (megapascal) pressure is higher, it means there is greater force per unit area within the system.

The vapour pressure of LPG mixed with 50% propane is 0.4 MPa at 20°C, 0.55 MPa at 30°C, and 0.75 MPa at 40°C. This is about twice the pressure of new cans made from 100% butane, increasing the accident risk. Figure 2.4 shows the refilled can and gas stove based on the LPG consumption survey in the field.

Figure 2.4 Refilled Can and Gas Stove

Source: Survey on LPG consumption.

Figure 2.5 Pressure Curve



Source: Kagla Vaportech Corp

Cylinders and Gas Stoves

Although the initial cost of using a cylinder is high, the LPG refilling cost is the cheapest (Table 2.8).

Table 2.8 Retail Price of LPG

	New Cassette	Refilled Cassette	Cylinder/kg
Retail Price	USD1.5/per can	USD0.375/can	
	USD6.0/kg	USD1.5/kg	USD1.0/kg

Source: Authors.

In the case of using a cylinder, a pressure regulator, hose, and gas stove are needed.

- Cylinder

  The steel plate of the cylinder is 3.5 millimetres thick or more, which is stronger than a cassette can. Pressure tests are carried out at 3.0 Mpa (pressure tests for cassette cans are 1.5 Mpa), and as long as there is no rust, cracks, or deformation, they can be used for a long time. Major LPG companies have requested that the government properly manage the expiration date of cylinders. Cylinder expiration date management requires that the manufacturing date and the last regular inspection date be checked before refilling, and cylinders that have passed the expiration date cannot be refilled without undergoing an inspection. During inspection, valves are also checked for malfunctions to prevent leaks.

- Pressure Regulator

  This is a device that adjusts the gas pressure to a level suitable for use with gas appliances. The gas in the cylinder is under high pressure, so it cannot be used as is in an ordinary home. This device lowers the gas pressure to adjust it so that it can be used at home.

- Hose

  Instead of a regular vinyl hose, a hose specifically for gas is used, and hose clamps are required at the connection parts (Figure 2.6).

Figure 2.6 Clamps

Source: LPG dealer catalogue.

- Gas Stove

If the flame goes out due to overflow or wind, and the stove is not turned off at the knob, gas will continue to leak. This is a common accident. The latest stoves are equipped with a flame-out sensor.

When using a gas stove with a cylinder, it is important to keep the cylinder at least 2 metres away from the fire to prevent a fire in the event of a gas leak from the cylinder.

Households in the rural areas using LPG for the first time may need help to set up the gas stoves and cylinders.

On Top Type 4-kg Cylinder

The cylinder and gas stove are integrated, so there is no need to connect a hose, and it can be placed anywhere. The precautions are the same as using a cylinder and gas stove: to take care if the flame goes out due to overflow or wind, and to keep the cylinder at least 2 metres away from flammable materials. It can be used outdoors, but when not in use it should be protected from rain and wind.

5. Supply Chain of Cylinders for Households in Rural Areas

5.1. From Bottling Station

The cylinders are transported from the bottling station to the retail shop or warehouse and then distributed from the retailer to households. Cylinders are filled at the bottling station (Figure 2.7).

Figure 2.7 From Bottling Station

Source: Authors.

5.2 From LPG Service Stations

There are 740 LPG service stations across the country where cylinders can be filled. In some cases, customers can bring empty cylinders to LPG service stations to have them filled (Figure 2.8). There are also small LPG stations called depos.

LPG service stations with ample space on their premises can set up cylinder storage warehouses or small-scale filling facilities whilst ensuring safety.

Figure 2.8 From LPG Service Station

SS = service station.

Source: Authors.

5.3 Cylinder Distribution Relay Stations

If the bottling station is located far away from the retail shop or warehouse, it may be possible to set up a large warehouse as a cylinder distribution relay station (Figure 2.9). If demand increases in the future, a bottling station can be built on the site.

Figure 2.9 Cylinder Distribution Relay Station

Source: Authors.

6. Subsidies for LPG Safety Campaign in Rural Areas

6.1 Purpose of LPG Safety Campaign

By using LPG correctly with new equipment, users can experience the safety and convenience of LPG.

- The General Department of Petroleum selects (300) households and delivers new equipment for free because the initial cost is expensive for households in the rural areas.
- The General Department of Petroleum explains how to use LPG correctly with videos and leaflets.
- It is necessary to consider LPG supply at affordable prices.

6.2 Safety Campaign Options (Use Types)

Option 1. Gas stove (USD12) and three new cans (USD4.5): total USD16.5, 16.5×300 = USD4,950[3]

Although the initial cost is the lowest, there is concern about purchasing refilled cans after the new cans are used up (a new can is USD1.5, a refilled can is USD0.375).

The use of refilled cans should be stopped. But new cans are miscellaneous goods, and the distribution route is complex, with no LPG companies involved.

Therefore, it is difficult to find a way to subsidise the price difference between a new can and a refilled can. The subsidy amount is large, and disposal of used empty cans are also a problem. (1.5-0.375) ×16cans/M×12month×300 = USD64,800)

Option 2. Gas stove, hose (USD45), and 4 kg cylinder (USD25): total USD70, 65×300 = USD21,000

Although the initial cost is the highest, this set up is suitable for indoor use. However, assistance is required for installation, such as connecting hoses between the cylinder and gas stove. On the other hand, it is easy to establish a cooperative system between LPG companies and retailers regarding cylinder filling and delivery. The running cost is the cheapest at USD1.0/kg.

For households using refilled cassettes, running costs will be lower if they switch to cylinders. However, price subsidies may be necessary for households no using LPG. In

[3] This amount is for 300 households.

this case, from the perspective of fairness, the same subsidy may be required for households using LPG. For example, subsidy of USD0.5/kg: 0.5×4kg/M×12×300 = USD7,200.

Option 3. On top 4-kg filled cylinder (USD25): total USD25×300 = USD7,500

The structure is simple and there is no need to connect hoses and no need for assistance. It is safer than refilled cassette cans and gas stoves. It is easy to establish a cooperative system between LPG companies and retailers regarding cylinder filling and delivery. Also in this option, price subsidies may be necessary.

Table 2.9 compares the costs of the three options.

Table 2.9 Comparison Table by Option

	Using Cassette Can		Using Cylinder	
	Continued use of new cassette	Continued use of refilled cassette	Gas stove and hose and 4-kg cylinder	On top type 4-kg cylinder
Gas stove	USD12	USD12	USD40	Set
Three new cassette cans	USD4.50	USD4.50	-	USD25
Filled cylinder				
Hose	-	-	USD25	
	-	-	USD5	
Running cost	High	Low	Very low	
Contents	Butane 100%	Generally available: 50% propane, 50% butane		
Pressure Test	Cassette can: 1.5 Mpa (15 atmospheric pressure		Cylinder: 3.0 Mpa (30 atmospheric pressure	
Total initial cost (per household)	**USD16.50**	**USD16.50**	**USD70**	**USD25**

Mpa = megapascal.

Source: Authors.

Chapter 3

Survey on LPG Consumption in Rural Areas

1. Purpose

This survey aims to collect data on consumption of liquefied petroleum gas (LPG) by households in the rural areas in Cambodia. We especially focused on finding out the number of households that use LPG in their daily life, and the amount of LPG they consume monthly.

2. Content of Survey

2.1. Survey Areas

For conducting the survey, we visited the following seven villages in three provinces:

Kampong Thom Province

Phum Kdam Ha, Khum Chhuk Ksach, Srok Baray (survey date 25 March 2024)

Phum Tnaot Chum, Khum Tnaot Chum/Brosat, Srok Baray (survey date 26 March 2024)

Phum Kdeicha/Pou, Khum Rong Reoung, Srok Stoung (survey date 27 March 2024)

Kratie Province

Phuom Thmey, Khum Sandan, Srok Sambour (survey date 23 April 2024)

Phuom Sereypheap, Khum Dar, Srok Chetr Borei (survey date 24 April 2024)

Pursat Province

Phum Sdok Khlouk, Khum Ou Ta Poang, Srok Bakan (survey date 7 May 2024)

Phum Ou Heng, Khum Samraong, Srok Phnom Kravanh (survey date 8 May 2024)

2.2. Number of Sample Households in Each Village

We visited the following number of households in each village:

Kampong Thom Province: 149

Phum Kdam Ha: 32

Phum Tnaot Chum: 56

Phum Kdeicha/Pou: 61

Kratie Province: 111

Phum Thmey: 59

Phum Sereypheap: 52

Pursat Province: 118

Phum Sdok Khlouk: 60

Phum Ou Heng: 58

Total: 378

2.3. Definition of Household

In this survey, household means a group of people who live in the same house and share income and/or expenses and daily meals.

We excluded the households that consume a substantial amount of LPG for purposes other than daily family life at home, such as the families operating restaurants at home or using LPG for vehicles.

Therefore, LPG consumption of households shows the amount of LPG consumption for daily family life only, or may include a small amount for small business at home such as making cookies for selling to neighbours.

3. Survey Results

3.1. Total Data of all Seven Villages

Amongst the 378 households, 178 households use LPG gas for their daily life (**LPG family**), whilst 200 households do not (**non-LPG family**). Amongst 178 LPG families, 86 families answered LPG is the main energy source for family cooking, whilst 92 families answered LPG is just a supportive energy source for family cooking.

Regarding other energy sources for family cooking, amongst 378 families, 320 families use firewood, 208 families use charcoal, 94 families use electric cooker and/or kettle, and 15 families use other energy sources (solar energy cooker, dried palm tree/fruit/flowers, rice skin, coconut skin, wood dust, gas generation system from animal manure).

Average monthly LPG consumption of 178 LPG families is 4.47 kilogramme (kg)/household, or 0.89 kg/person.

Average monthly LPG consumption of all 378 households including both LPG families and non-LPG families is 2.16 kg/household, or 0.44 kg/person.

Amongst the 178 LPG families, 111 families use small cans, and 70 families use cylinders. Amongst them, three families use both small cans and cylinders.

Regarding the method to get LPG, amongst the 178 LPG families, 102 families usually go to buy and/or refill LPG cans or cylinders at the grocery store, LPG dealer, or LPG station, whilst 83 families usually get LPG delivered to home by the grocery store or LPG dealer. Amongst them, seven families answered that they use both methods to get LPG.

Regarding the purpose of using LPG, amongst the 178 LPG-families, 170 families use LPG for family cooking, 82 families for boiling drinking water, 15 families for boiling shower water, and seven families for other purposes (warming up meals only, make cookies for sale as small family business, boiling water for chicken farming).

Amongst the 200 non-LPG families, 44 families answered that they are interested in using LPG, whilst 156 families answered that they are not interested in using LPG.

Regarding the reason for not using LPG, amongst 200 non-LPG families, 82 families raised safety reasons (e.g. LPG is dangerous), 78 families raised financial reasons (e.g. I have no money to buy LPG), 42 families raised utility reasons (e.g. I cannot use LPG), 68 families raised necessity reasons (e.g. we do not need LPG because there is plenty of free firewood available.), and three families raised other reasons (I will use LPG in the future but not yet, meals cooked by LPG are not tasty).

Table 3.1 shows the total data of all seven villages.

Table 3.1 Total Data of All Seven Villages in Three Provinces

	All	LPG Family	Non-LPG Family
Households	378	178	200
Family members (person)	1,889	890	999
Average monthly LPG consumption/household (kg)	2.16	4.47	NA
Average monthly LPG consumption/person (kg)	0.44	0.89	NA
Small can (household)	NA	111	NA
Cylinder (household)	NA	70	NA
Go to buy/refill (household)	NA	102	NA
Delivered to home (household)	NA	83	NA
Family cooking (household)	NA	170	NA
Boiling drinking water (household)	NA	82	NA
Boiling shower water (household)	NA	15	NA
Other (household)	NA	7	NA
Main (household)	NA	86	NA
Supportive (household)	NA	92	NA
Firewood (household)	320	NA	NA
Charcoal (household)	208	NA	NA
Electric cooker/kettle (household)	94	NA	NA
Other (household)	15	NA	NA

Interested in LPG (household)	NA	NA	44
Not interested in LPG (household)	NA	NA	156
Safety (household)	NA	NA	82
Financial (household)	NA	NA	78
Utility (household)	NA	NA	42
Necessity (household)	NA	NA	68
Other (household)	NA	NA	3

kg = kilogramme, not available.
Source: Author.

3.2. Data from Each Province

Kampong Thom Province

The collective data of three villages in Kampong Thom Province are shown in Table 3.2.

Table 3.2 Collective Data of Three Villages in Kampong Thom Province

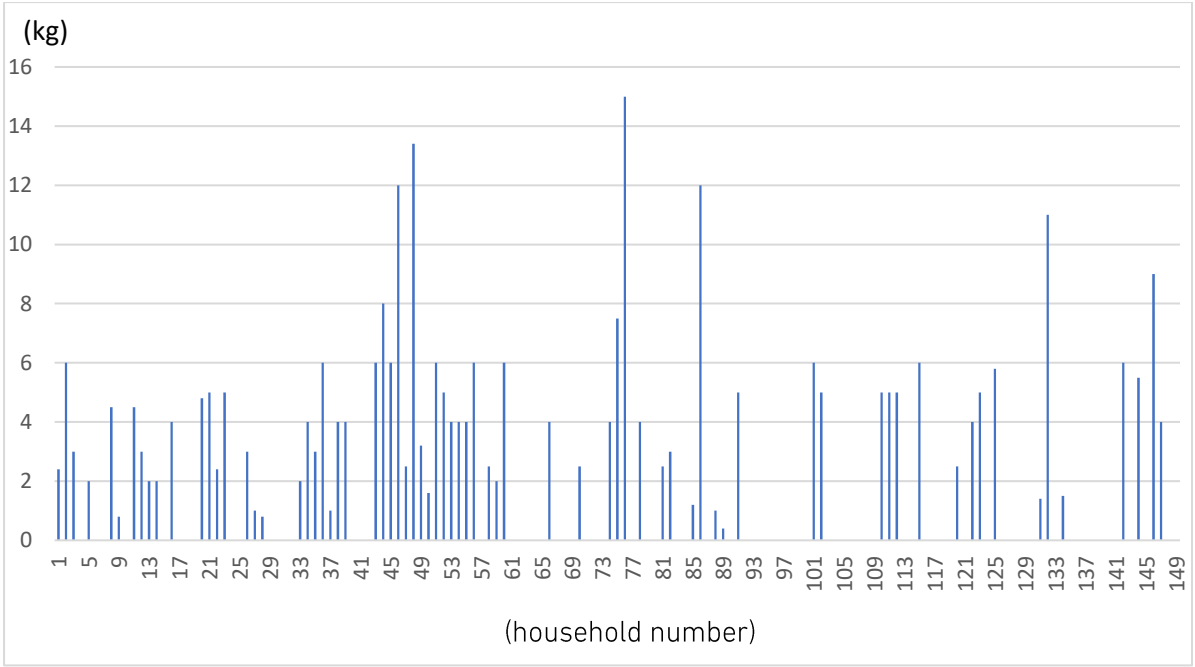
Kampong Thom Province			
	All	LPG Family	Non-LPG Family
Households	149	72	77
Family members (person)	695	342	353
Average monthly LPG consumption/household (kg)	2.16	4.48	NA
Average monthly LPG consumption/person (kg)	0.46	0.94	NA
Small can (household)	NA	34	NA
Cylinder (household)	NA	38	NA
Go to buy/refill (household)	NA	21	NA
Delivered to home (household)	NA	57	NA
Family cooking (household)	NA	68	NA
Boiling drinking water (household)	NA	37	NA
Boiling shower water (household)	NA	11	NA
Other (household) *1	NA	5	NA
Main (household)	NA	47	NA
Supportive (household)	NA	25	NA
Firewood (household)	129	NA	NA
Charcoal (household)	104	NA	NA

Electric cooker/kettle (household)	23	NA	NA
Other (household) *2	13	NA	NA
Interested in LPG (household)	NA	NA	11
Not interested in LPG (household)	NA	NA	66
Safety (household)	NA	NA	38
Financial (household)	NA	NA	32
Utility (household)	NA	NA	20
Necessity (household)	NA	NA	10
Other (household) *3	NA	NA	2

kg = kilogramme, NA = not available.
Notes: *1 warming up meals only, make cookies for sale for small family business, boiling water for chicken farming; *2 solar cooker, dried palm tree/flower/fruit, rice skin, coconut skin, wood dust; *3 I will use LPG in the future but not yet, meals cooked by LPG are not tasty.
Source: Authors.

Figure 3.1 shows the fluctuation in monthly LPG consumption across different households in Kampong Thom Province. The data reveals variability in LPG usage, with some households consuming significantly more than others. Peaks and troughs in the chart suggest that LPG consumption is not uniform across households, reflecting differences in household size, energy needs, or seasonal factors.

Figure 3.1 Monthly LPG Consumption of Each Household, Kampong Thom Province



kg = kilogramme.
Source: Authors.

Kratie Province

Table 3.3 shows the collective data of two villages in Kratie Province.

Table 3.3 Collective Data of Two Villages in Kratie Province

Kratie Province			
	All	LPG Family	Non-LPG Family
Households	111	54	57
Family members (person)	602	276	326
Average monthly LPG consumption/household (kg)	2.12	4.36	NA
Average monthly LPG consumption/person (kg)	0.39	0.85	NA
Small can (household)	NA	48	NA
Cylinder (household)	NA	9	NA
Go to buy/refill (household)	NA	34	NA
Delivered to home (household)	NA	22	NA
Family cooking (household)	NA	52	NA
Boiling drinking water (household)	NA	24	NA
Boiling shower water (household)	NA	2	NA
Other (household) *1	NA	1	NA
Main (household)	NA	20	NA
Supportive (household)	NA	34	NA
Firewood (household)	86	NA	NA
Charcoal (household)	39	NA	NA
Electric cooker kettle (household)	27	NA	NA
Other (household) *2	2	NA	NA
Interested in LPG (household)	NA	NA	15
Not interested in LPG (household)	NA	NA	42
Safety (household)	NA	NA	13
Financial (household)	NA	NA	27
Utility (household)	NA	NA	13
Necessity (household)	NA	NA	13
Other (household) *3	NA	NA	1

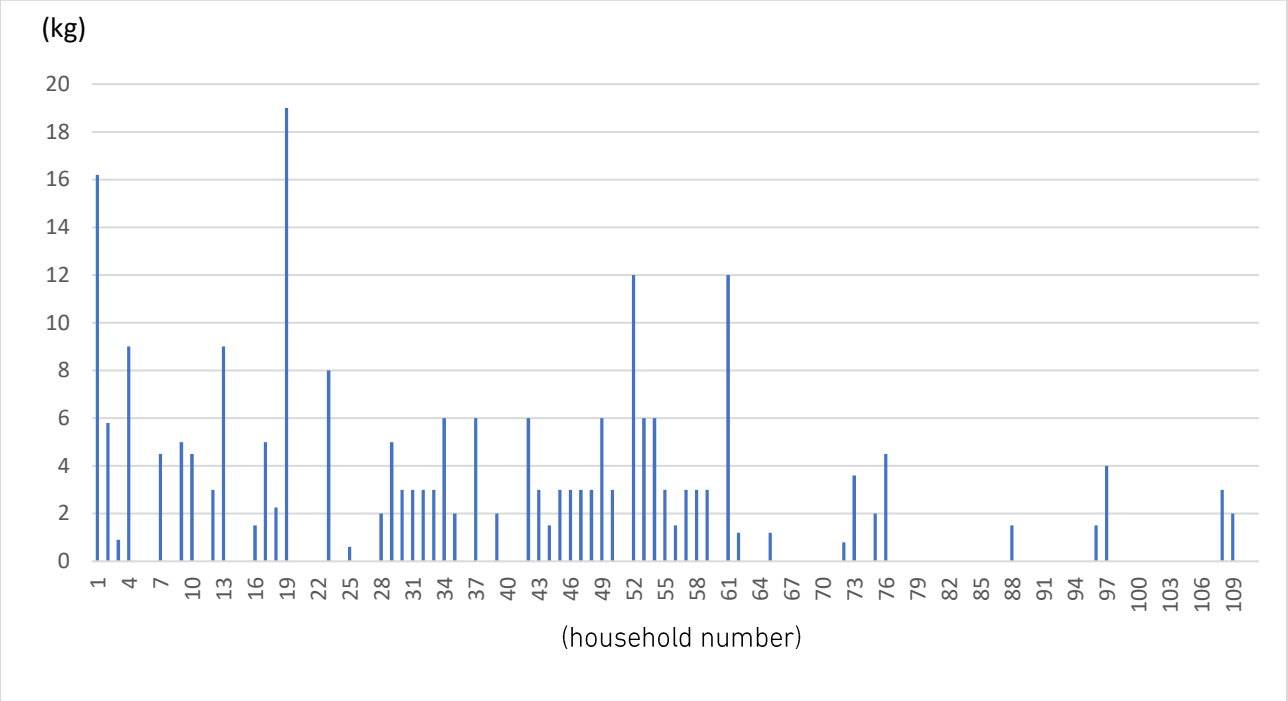
kg = kilogramme, NA = not available.

Notes: *1 warming up meals only; *2 solar cooker, gas generation system from animal manure; *3 meals cooked by LPG are not tasty.

Source: Author.

Figure 3.2 illustrates the monthly LPG consumption of each household in Kratie Province.

Figure 3.2 Monthly LPG Consumption of Each Household, Kratie Province



Source: Authors.

Pursat Province

Table 3.4 shows the collective data of three villages in Pursat Province.

Table 3.4 Collective Data of Three Villages in Pursat Province

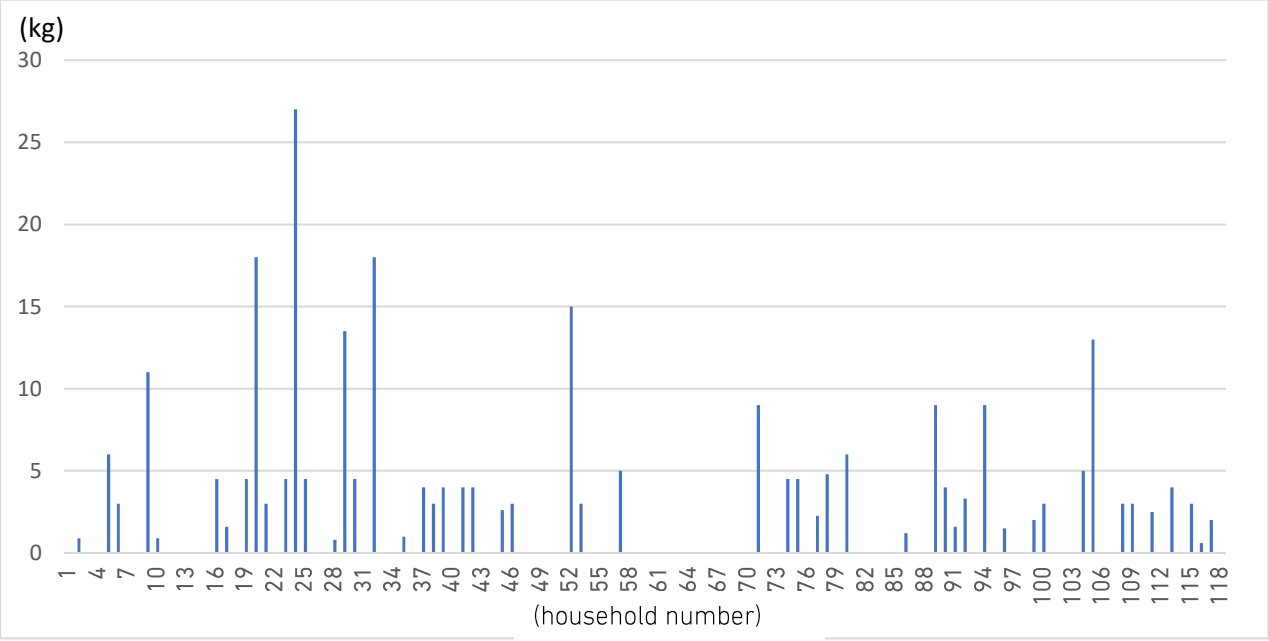
Pursat Province			
	All	LPG Family	Non-LPG Family
Households	118	52	66
Family members (person)	592	272	320
Average monthly LPG consumption/household (kg)	2.34	5.32	NA
Average monthly LPG consumption/person (kg)	0.47	1.02	NA
Small can (household)	NA	29	NA
Cylinder (household)	NA	23	NA
Go to buy/refill (household)	NA	47	NA
Delivered to home (household)	NA	4	NA
Family cooking (household)	NA	50	NA
Boiling drinking water (household)	NA	21	NA

Boiling shower water (household)	NA	2	NA
Other (household) *1	NA	1	NA
Main (household)	NA	19	NA
Supportive (household)	NA	33	NA
Firewood (household)	105	NA	NA
Charcoal (household)	41	NA	NA
Electric cooker/kettle (household)	44	NA	NA
Other (household)	0	NA	NA
Interested in LPG (household)	NA	NA	18
Not interested in LPG (household)	NA	NA	48
Safety (household)	NA	NA	31
Financial (household)	NA	NA	19
Utility (household)	NA	NA	9
Necessity (household)	NA	NA	45
Other (household)	NA	NA	0

kg = kilogramme, NA = not available.
Note: *1 warming up meals only.
Source: Author.

Figure 3.3 illustrates the monthly LPG consumption of each household in Pursat Province.

Figure 3.3 Monthly LPG Consumption of Each Household, Pursat Province



kg = kilogramme.
Source: Author.

3.3. Data of Each Village

Tables 3.5 to 3.11 show the data of each of the seven villages in three provinces.

Phum Kdam Ha, Khum Chhuk Ksach, Srok Baray, Kampong Thom Province (survey date 25 March 2024)

Table 3.5 Collective Data of Phum Kdam Ha, Khum Chhuk Ksach, Srok Baray, Kampong Thom Province

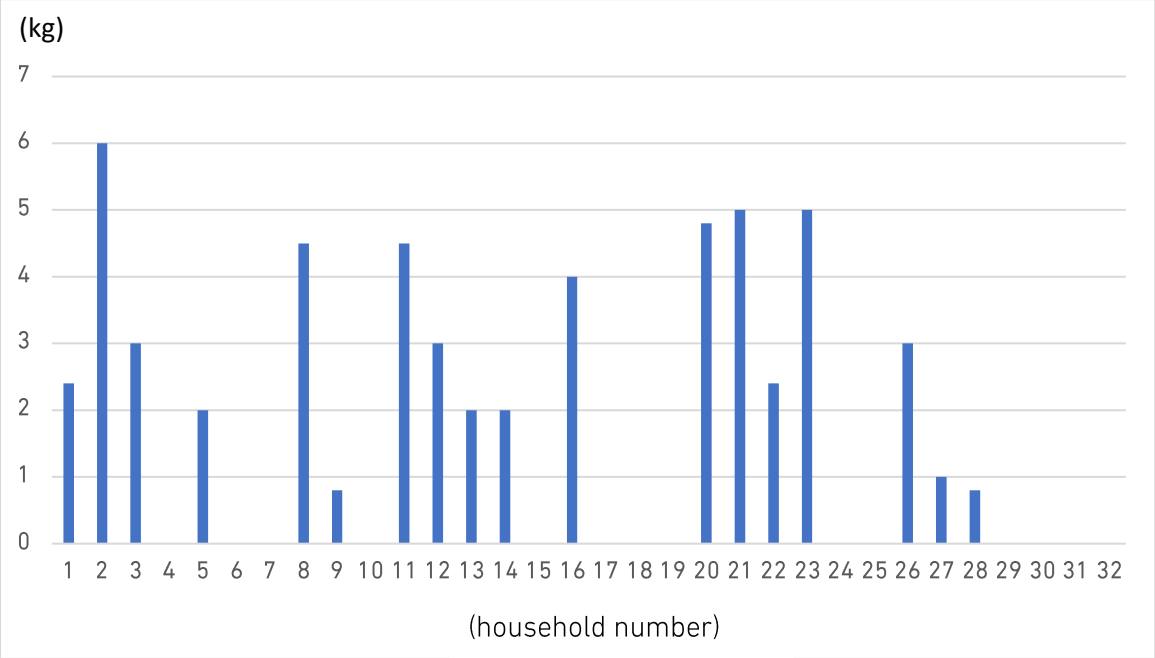
Phum Kdam Ha, Khum Chhuk Ksach, Srok Baray, Kampong Thom Province			
	All	LPG Family	Non-LPG Family
Households	32	18	14
Family members (person)	134	73	61
Average monthly LPG consumption/household (kg)	1.76	3.12	NA
Average monthly LPG consumption/person (kg)	0.42	0.77	NA
Small can (household)	NA	14	NA
Cylinder (household)	NA	4	NA
Go to buy/refill (household)	NA	4	NA
Delivered to home (household)	NA	17	NA
Family cooking (household)	NA	17	NA
Boiling drinking water (household)	NA	9	NA
Boiling shower water (household)	NA	2	NA
Other (household) *1	NA	1	NA
Main (household)	NA	9	NA
Supportive (household)	NA	9	NA
Firewood (household)	27	NA	NA
Charcoal (household)	17	NA	NA
Electric cooker/kettle (household)	4	NA	NA
Other (household) *2	4	NA	NA
Interested in LPG (household)	NA	NA	1
Not interested in LPG (household)	NA	NA	13
Safety (household)	NA	NA	12
Financial (household)	NA	NA	1
Utility (household)	NA	NA	2
Necessity (household)	NA	NA	2

Other (household)	NA	NA	0

kg = kilogramme, NA = not available.
Notes: *1 warming up meals only, *2 solar cooker.
Source: Authors.

Figure 3.4 illustrates the monthly LPG consumption of each household in Kdam Ha, Kampong Thom Province.

Figure 3.4 Monthly LPG Consumption of Each Household in Kdam Ha, Kampong



kg = kilogramme.
Source: Author.

Phum Tnaot Chum, Khum Tnaot Chum/Brosat, Srok Baray, Kampong Thom Province (survey date 26 March 2024)

Table 3.6 Collective Data of Phum Tnaot Chum, Khum Tnaot Chum/Brosat, Srok Baray, Kampong Thom Province

Phum Tnaot Chum, Khum Tnaot Chum/Brosat, Srok Baray, Kampong Thom Province			
	All	LPG Family	Non-LPG Family
Households	56	35	21
Family members (person)	266	171	95
Average monthly LPG consumption/household (kg)	3.09	4.94	NA
Average monthly LPG consumption/person (kg)	0.65	1.01	NA
Small can (household)	NA	15	NA
Cylinder (household)	NA	20	NA
Go to buy/refill (household)	NA	10	NA

Delivered to home (household)	NA	25	NA
Family cooking (household)	NA	32	NA
Boiling drinking water (household)	NA	17	NA
Boiling shower water (household)	NA	8	NA
Other (household) *1	NA	4	NA
Main (household)	NA	25	NA
Supportive (household)	NA	10	NA
Firewood (household)	47	NA	NA
Charcoal (household)	50	NA	NA
Electric cooker/kettle (household)	4	NA	NA
Other (household) *2	4	NA	NA
Interested in LPG (household)	NA	NA	1
Not interested in LPG (household)	NA	NA	20
Safety (household)	NA	NA	14
Financial (household)	NA	NA	10
Utility (household)	NA	NA	7
Necessity (household)	NA	NA	2
Other (household)	NA	NA	0

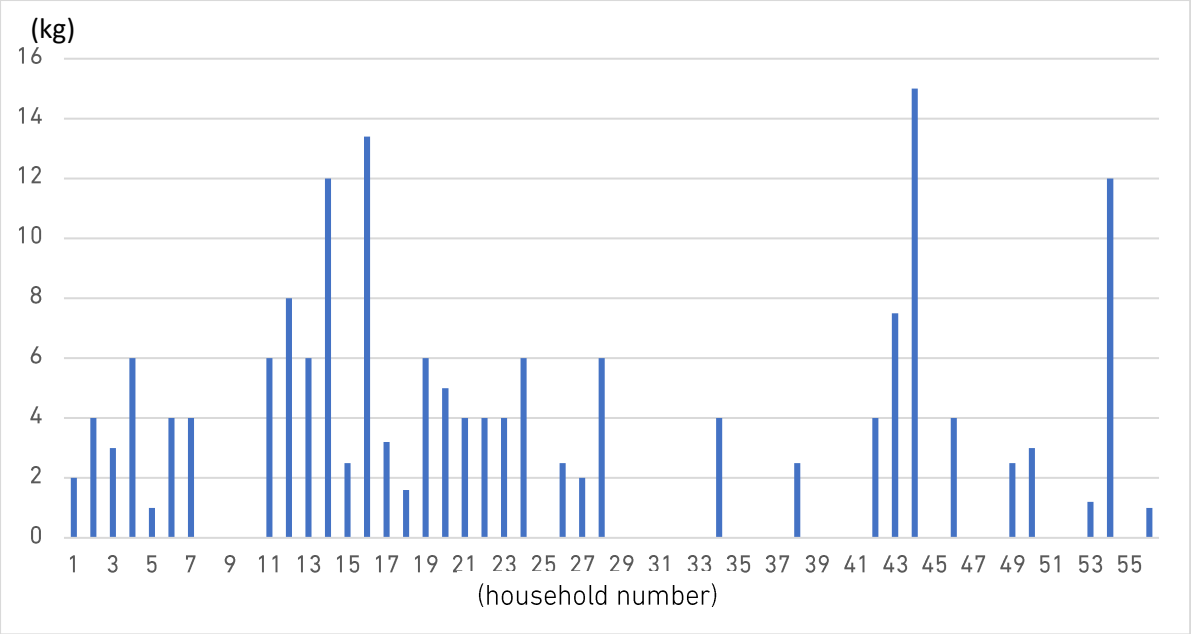
kg = kilogramme, NA = not available.

Notes: *1 make cookies for sale, warming up meals only, boiling water for chicken; *2 dried palm tree/flower/fruit, rice skin, coconut skin, wood dust.

Source: Author.

Figure 3.5 illustrates the monthly LPG consumption of each household in Tnaot Chum, Kampong Thom Province.

Figure 3.5 Monthly LPG consumption of Each Household in Tnaot Chum, Kampong Thom Province



kg = kilogramme.
Source: Author.

Phum Kdeicha/Pou, Khum Rong Reoung, Srok Stoung, Kampong Thom Province (survey date 27 March 2024)

Table 3.7 Collective Data of Phum Kdeicha/Pou, Khum Rong Reoung, Srok Stoung, Kampong Thom Province

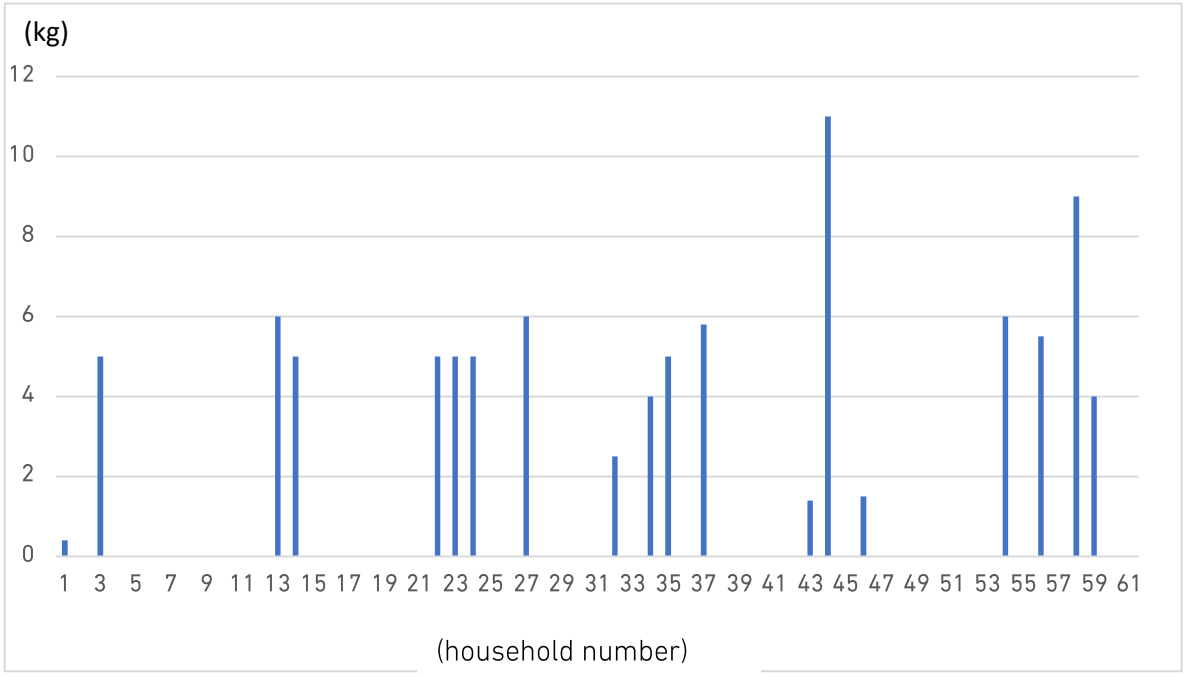
Phum Kdeicha/Pou, Khum Rong Reoung, Srok Stoung, Kampong Thom Province			
	All	LPG Family	Non-LPG Family
Households	61	19	42
Family members (person)	295	98	197
Average monthly LPG consumption/household (kg)	1.53	4.9	NA
Average monthly LPG consumption/person (kg)	0.32	0.95	NA
Small can (household)	NA	5	NA
Cylinder (household)	NA	14	NA
Go to buy/refill (household)	NA	7	NA
Delivered to home (household)	NA	15	NA
Family cooking (household)	NA	19	NA
Boiling drinking water (household)	NA	11	NA
Boiling shower water (household)	NA	1	NA
Other (household)	NA	0	NA

Main (household)	NA	13	NA
Supportive (household)	NA	6	NA
Firewood (household)	55	NA	NA
Charcoal (household)	37	NA	NA
Electric cooker/kettle (household)	15	NA	NA
Other (household) *1	5	NA	NA
Interested in LPG (household)	NA	NA	9
Not interested in LPG (household)	NA	NA	33
Safety (household)	NA	NA	12
Financial (household)	NA	NA	21
Utility (household)	NA	NA	11
Necessity (household)	NA	NA	6
Other (household) *2	NA	NA	2

kg = kilogramme, NA = not available.
Notes: *1 solar cooker, dried palm tree/flower; *2 I will use LPG in the future but not yet, meals cooked by LPG are not tasty.
Source: Authors.

Figure 3.6 illustrates the monthly LPG consumption of each household in Kdeicha/Phou, Kampong Thom Province.

Figure 3.6 Monthly LPG Consumption of Each Household in Kdeicha/Phou, Kampong Thom Province



kg = kilogramme.
Source: Authors.

Phum Thmey, Khum Sandan, Srok Sambour, Kratie Province (survey date 23 April 2024)

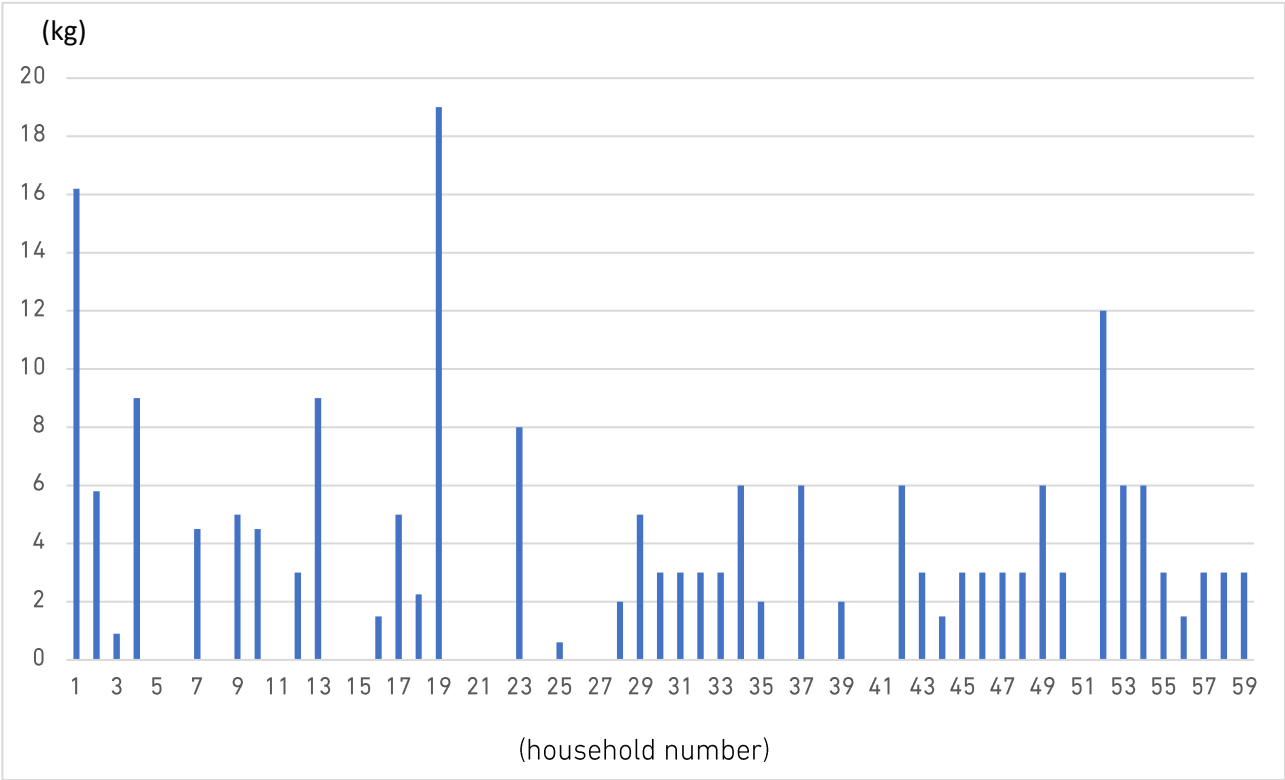
Table 3.8 Collective Data of Phum Thmey, Khum Sandan, Srok Sambour, Kratie Province

Phum Thmey, Khum Sandan, Srok Sambour, Kratie Province			
	All	LPG Family	Non-LPG Family
Households	59	42	17
Family members (person)	295	211	84
Average monthly LPG consumption/household (kg)	3.36	4.72	NA
Average monthly LPG consumption/person (kg)	0.67	0.94	NA
Small can (household)	NA	36	NA
Cylinder (household)	NA	9	NA
Go to buy/refill (household)	NA	25	NA
Delivered to home (household)	NA	19	NA
Family cooking (household)	NA	40	NA
Boiling drinking water (household)	NA	16	NA
Boiling shower water (household)	NA	2	NA
Other (household) *1	NA	1	NA
Main (household)	NA	19	NA
Supportive (household)	NA	23	NA
Firewood (household)	39	NA	NA
Charcoal (household)	20	NA	NA
Electric cooker/kettle (household)	20	NA	NA
Other (household) *2	2	NA	NA
Interested in LPG (household)	NA	NA	6
Not interested in LPG (household)	NA	NA	11
Safety (household)	NA	NA	0
Financial (household)	NA	NA	8
Utility (household)	NA	NA	2
Necessity (household)	NA	NA	7
Other (household)	NA	NA	0

kg = kilogramme, NA = not available.
Notes: *1 warming up meals only; *2 gas made from animal manure.
Source: Author.

Figure 3.7 shows the monthly LPG consumption of each household in Thymey, Kratie Province.

Figure 3.7 Monthly LPG Consumption of Each Household in Thymey, Kratie Province



kg = kilogramme.
Source: Author.

Phum Sereypheap, Khum Dar, Srok Chetr Borei, Kratie Province (survey date 24 April 2024)

Table 3.9 Collective Data of Phum Sereypheap, Khum Dar, Srok Chetr Borei, Kratie Province

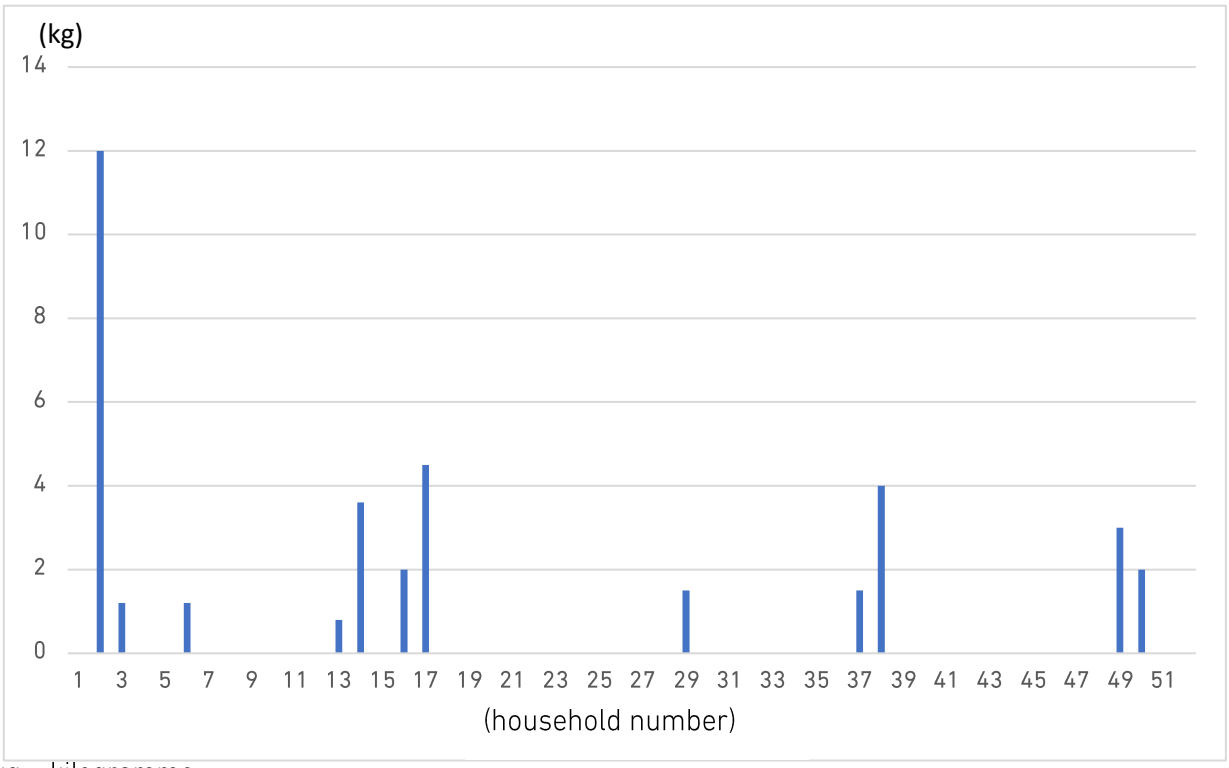
Phum Sereypheap, Khum Dar, Srok Chetr Borei, Kratie Province			
	All	LPG Family	Non-LPG Family
Households	52	12	40
Family members (person)	307	65	242
Average monthly LPG consumption/household (kg)	0.72	3.1	NA
Average monthly LPG consumption/person (kg)	0.12	0.57	NA
Small can (household)	NA	12	NA
Cylinder (household)	NA	0	NA

Go to buy/refill (household)	NA	9	NA
Delivered to home (household)	NA	3	NA
Family cooking (household)	NA	12	NA
Boiling drinking water (household)	NA	8	NA
Boiling shower water (household)	NA	0	NA
Other (household)	NA	0	NA
Main (household)	NA	1	NA
Supportive (household)	NA	11	NA
Firewood (household)	47	NA	NA
Charcoal (household)	43	NA	NA
Electric cooker/kettle (household)	7	NA	NA
Other (household)	0	NA	NA
Interested in LPG (household)	NA	NA	9
Not interested in LPG (household)	NA	NA	31
Safety (household)	NA	NA	13
Financial (household)	NA	NA	19
Utility (household)	NA	NA	11
Necessity (household)	NA	NA	6
Other (household) *1	NA	NA	1

kg = kilogramme, NA = not available.
Note: *1 meals cooked by LPG are not tasty.
Source: Author.

Figure 3.8 illustrates the monthly LPG consumption of each household in Sereypheap, Kratie Province.

Figure 3.8 Monthly LPG Consumption of Each Household in Sereypheap, Kratie Province



kg = kilogramme.
Source: Author.

Phum Sdok Khlouk, Khum Ou Ta Poang, Srok Bakan, Pursat Province (survey date 7 May 2024)

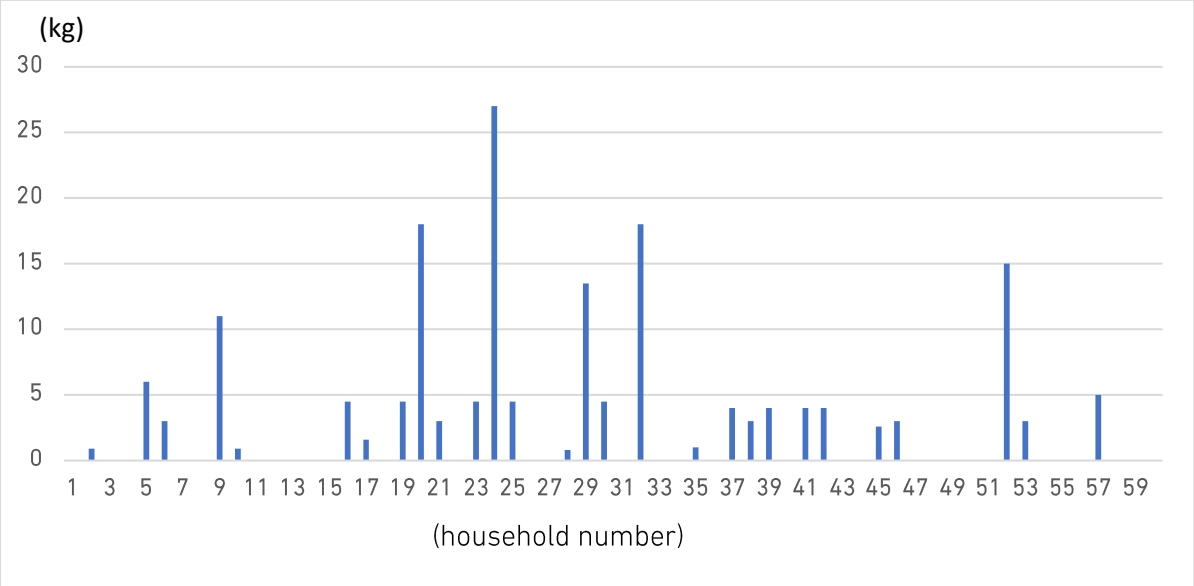
Table 3.10 Collective Data of Phum Sdok Khlouk, Khum Ou Ta Poang, Srok Bakan, Pursat Province

Phum Sdok Khlouk, Khum Ou Ta Poang, Srok Bakan, Pursat Province			
	All	LPG Family	Non-LPG Family
Households	60	28	32
Family members (person)	297	145	152
Average monthly LPG consumption/household (kg)	2.91	6.24	NA
Average monthly LPG consumption/person (kg)	0.59	1.2	NA
Small can (household)	NA	14	NA
Cylinder (household)	NA	14	NA
Go to buy/refill (household)	NA	25	NA
Delivered to home (household)	NA	2	NA
Family cooking (household)	NA	27	NA
Boiling drinking water (household)	NA	10	NA
Boiling shower water (household)	NA	1	NA
Other (household) *1	NA	1	NA
Main (household)	NA	12	NA
Supportive (household)	NA	16	NA
Firewood (household)	51	NA	NA
Charcoal (household)	21	NA	NA
Electric cooker/kettle (household)	24	NA	NA
Other (household)	0	NA	NA
Interested in LPG (household)	NA	NA	5
Not interested in LPG (household)	NA	NA	27
Safety (household)	NA	NA	19
Financial (household)	NA	NA	6
Utility (household)	NA	NA	3
Necessity (household)	NA	NA	21
Other (household)	NA	NA	0

kg = kilogramme, NA = not available.
Note: *1 warming up meals only.
Source: Author.

Figure 3.9 illustrates the monthly LPG consumption of each household in Sdok Khlouk, Pursat Province.

Figure 3.9 Monthly LPG Consumption of Each Household in Sdok Khlouk, Pursat Province



kg = kilogramme.
Source: Author.

Phum Ou Heng, Khum Samraong, Srok Phnom Kravanh, Pursat Province (survey date 8 May 2024)

Table 3.11 Collective Data of Phum Ou Heng, Khum Samraong, Srok Phnom Kravanh, Pursat Province

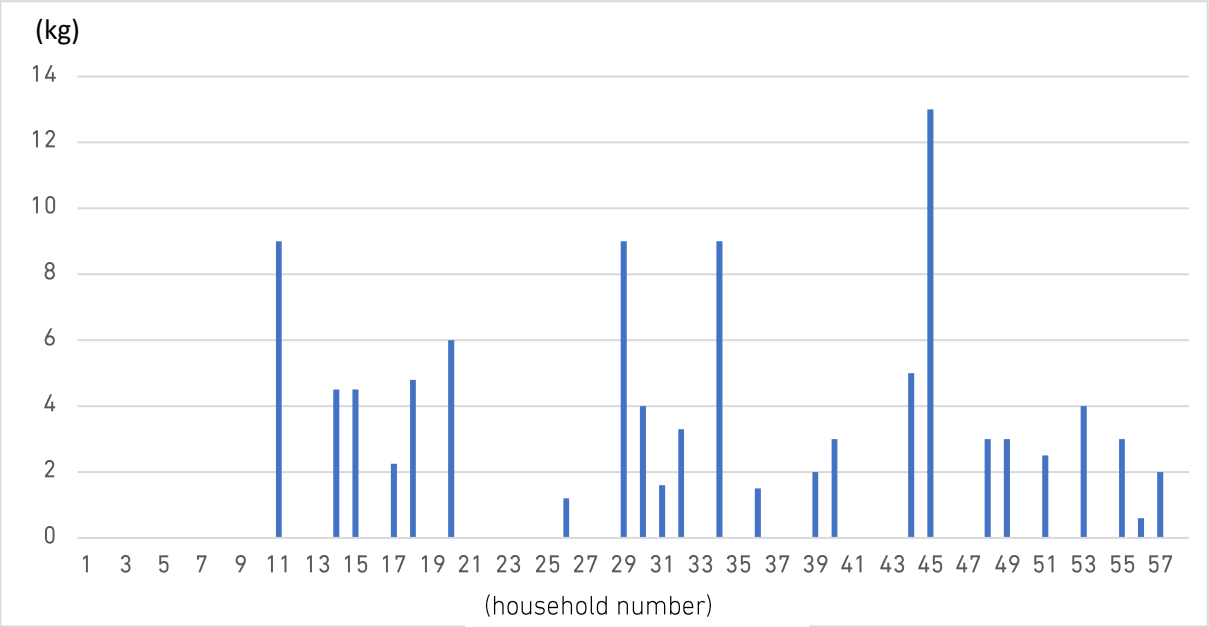
Phum Ou Heng, Khum Samraong, Srok Phnom Kravanh, Pursat Province			
	All	LPG family	Non-LPG Family
Households	58	24	34
Family members (person)	295	127	168
Average monthly LPG consumption household (kg)	1.75	4.24	NA
Average monthly LPG consumption/person (kg)	0.34	0.8	NA
Small can (household)	NA	15	NA
Cylinder (household)	NA	9	NA
Go to buy refill (household)	NA	22	NA
Delivered to home (household)	NA	2	NA

Family cooking (household)	NA	23	NA
Boiling drinking water (household)	NA	11	NA
Boiling shower water (household)	NA	1	NA
Other (household)	NA	0	NA
Main (household)	NA	7	NA
Supportive (household)	NA	17	NA
Firewood (household)	54	NA	NA
Charcoal (household)	20	NA	NA
Electric cooker/kettle (household)	20	NA	NA
Other (household)	0	NA	NA
Interested in LPG (household)	NA	NA	13
Not interested in LPG (household)	NA	NA	21
Safety (household)	NA	NA	12
Financial (household)	NA	NA	13
Utility (household)	NA	NA	6
Necessity (household)	NA	NA	24
Other (household)	NA	NA	0

kg = kilogramme, NA = not available.
Source: Author.

Figure 3.10 shows the fluctuation in monthly LPG consumption across different households in Ou Heng, Pursat Province.

Figure 3.10 Monthly LPG Consumption of Each Household in Ou Heng, Pursat Province



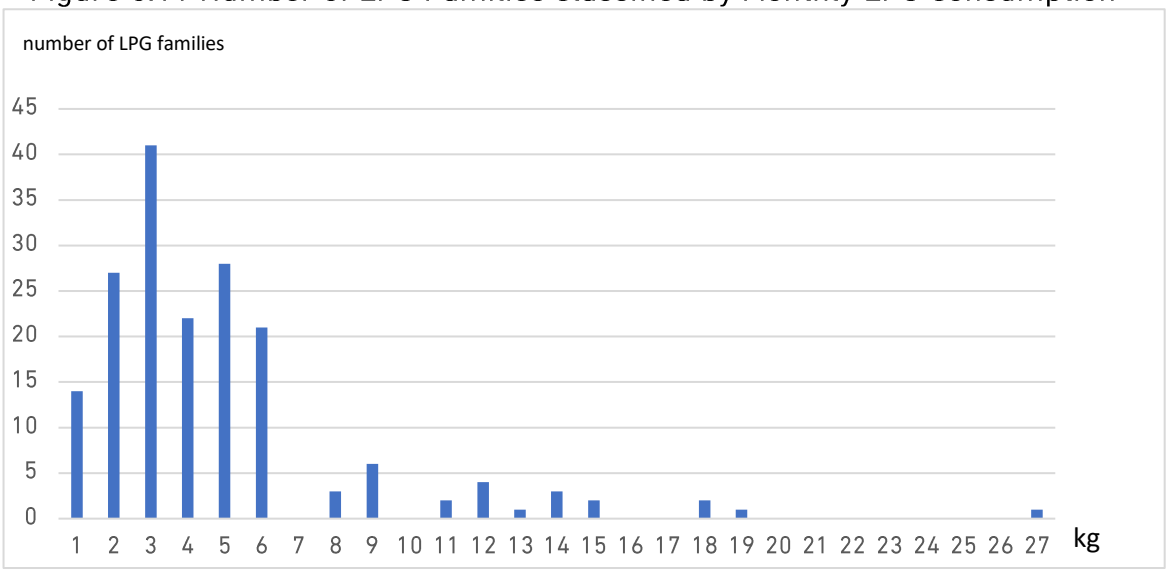
kg = kilogramme.
Source: Author.

4. Key Findings from this Survey

4.1 Factors Affecting the Amount of LPG Consumption

Amongst 178 LPG families, around 86% of LPG families consume 6 kg or less of LPG per month. On the other hand, there were six families consuming 15 kg or more per month, including one family consuming 27 kg per month (Figure 3.11).

Figure 3.11 Number of LPG Families Classified by Monthly LPG Consumption



kg = kilogramme.
Source: Author.

According to our study, the amount of LPG consumption depends on several factors such as:

Financial level of the family: If the family has high income from their work or business, they tend to buy more LPG to save time for their work or business.

Number of family members living together: If more people live together, they consume more LPG for daily cooking and boiling water.

Whether they need quick cooking or have enough time for slow cooking: For example, if the family operates its own farm and has enough time for cooking at home, they do not need LPG for quick cooking. On the other hand, if most family members have outside work and have to commute from home, they tend to need quick cooking at home for breakfast and lunch before going to work, and dinner after work. Especially, soup is one of the popular foods but making soup without LPG takes too long.

Whether there are enough trees nearby which can easily provide free firewood: If there are many trees near home, family members can easily collect firewood for free. They tend to not feel the need for LPG because free energy is always available.

Whether they boil water by LPG or by electric kettle: Some households have electric kettles for boiling drinking water but others do not. If the family uses LPG for boiling drinking water, they tend to consume more LPG.

Whether they have small babies who need more hot water: Families with small babies tend to need more boiled water or hot water than other families because they need to make milk for babies, wash babies, etc. These families tend to consume more LPG than other families.

4.2 Procurement of LPG: Buy or Delivery

Some LPG users buy LPG at the shop, and others get LPG delivered to home.

Regarding buying at the shop, users take their used empty LPG cans or cylinders to the local seller, which is usually a local grocery store or local LPG dealer. Then (i) the seller refills the can or cylinder on the spot and returns it to the user, or (ii) the seller keeps the used empty can or cylinder and gives the user another can or cylinder which is already refilled. In either case, the user pays only the price of LPG because the cans and cylinders are reused. In some cases when there is an LPG station nearby, a user may take the cylinder directly to the LPG station to refill.

Some local grocery stores or LPG dealers have delivery service. They deliver LPG cans or cylinders to the user's home in exchange for collecting the used empty can or cylinder.

4.3 Quality of LPG Cans

All LPG cans we observed were refilled cans. We saw some relatively new refilled cans, but never saw brand new (not refilled) cans at all.

LPG can users using relatively new refilled cans said that they sometimes buy brand new (not refilled) cans. When they use up these brand new cans, they will take these cans to

the local seller for refilling many times. Once these cans get too old, they buy brand new cans again and refill these cans many times.

4.4 Reasons for not using LPG

We asked every non-LPG family about the reason for not using LPG. We asked an open question and accepted multiple answers, but after all, most answers are classified into four categories as below:

Safety: LPG is dangerous, I am scared of explosive accident, I am scared of LPG because I feel I am too old to use LPG, I used to use LPG before but I stopped using LPG because I got a small accident of firing up by leaking gas which scared me, etc.

Financial: LPG is too expensive, I do not have money to buy LPG, etc.

Utility: LPG is difficult to use, I do not know how to use LPG, I cannot use LPG, etc.

Necessity: I do not need LPG because I can use firewood for free, I do not need LPG because I will use firewood until firewood becomes empty, I do not need LPG because I bought solar cooker already, I do not need LPG because I installed animal manure gas generation system already, etc.

Chapter 4

Experience of LPG Penetration in Indonesia and Thailand

1. Conversion Programme of of Kerosene to LPG in Indonesia

1.1. Background

Historically, Indonesia was a net oil and gas exporter until the 1990s and had thus provided energy subsidies to its citizens, justified as a form of social assistance. In 2005, the budget for energy subsidies reached 18% of total state expenditure (Thoday et al., 2018). Out of the huge energy subsidy, kerosene accounted for 57% of the subsidy in 2006 and 48% in 2007 (Budya and Arofat, 2011). Kerosene was the primary cooking fuel for 37% of households in 2007 (Budya and Arofat, 2011), accounting for 9.9 million kilolitres of annual demand (MEMR, 2013).

However, domestic kerosene supply was declining whilst at the same time, oil prices were increasing. Consequently, the subsidy of kerosene expanded from USD1.96 billion in 2005 to USD5.24 billion in 2008 (Budya and Arofat, 2011). To reduce the burden of energy subsidy to the state expenditure, the government increased the price of kerosene but was not well-received by the citizens. Being a fairly sensitive social issue, mass demonstrations happened in a few regions (Budya and Arofat, 2011).

Hugely reliant on kerosene, the government first tried to remove the subsidy for the industry sector in 2005. Whilst the subsidy for households is still occurring, this triggered another issue: the misuse of subsidised kerosene for households for industry use and smugglers exporting it and reselling it at a substantially higher price (Budya and Arofat, 2011). As a result, the subsidy became even higher.

Hence, the Indonesian government started the fuel conversion programme for cooking in 2007 to further reduce the domestic use of kerosene and shifting it to liquefied petroleum gas (LPG) for cooking purposes, which would decrease the total subsidy and protect households from economic shocks (Thoday et al., 2018). The objectives of this programme are to alleviate the financial burden on the government, diversify energy supply, and encourage the adoption of cleaner energy source.

Despite the higher economic price at the initial year, LPG's higher calorific value would result in lower subsidy price (MEMR, 2013). In addition, the supply chain of LPG was already available in Indonesia at that time, including storage tanks and filling plants. With Indonesia's archipelagic location, LPG was the easiest fuel to distribute across regions and rural areas (Thoday et al., 2018). In terms of emissions, kerosene emitted three times more carbon dioxide emissions than LPG and 30% higher particulate matter to the cooking pot, which translates to LPG being a clean cooking fuel (Thoday et al., 2018).

Globally, LPG is the primary and secondary cooking fuel for almost 3 billion people in both developing and developed countries (Thoday et al., 2018).

If compared to biomass fuels, shifting to LPG may reduce the overall cooking time, including gathering biomass fuels (Budya and Arofat, 2011). Despite that, some households in more remote regions still prefer fuel stacking or use two cooking fuels, a mix of LPG, firewood, and/or electricity (Thoday et al., 2018).

1.2. LPG Conversion Programme

After finalising the option to choose LPG, the government (through PT Pertamina) conducted initial social and market surveys to analyse its practicality, acceptance, and citizens' monthly expense for cooking. As the result, the 3-kilogramme (kg) cylinder was chosen for its easy-handling and citizen's ability-to-pay, as opposed to the available 12-kg cylinders (Rakyat, 2011).

Through Presidential Decree Number 104 of 2007 about Supply, Distribution, and Price of 3kg Cylinders of LPG, the conversion programme was ratified. The initial objective was to reduce kerosene demand from 9.9 million kilolitres to 2 million kilolitres and distribute 52.9 million starter package units for households and microbusinesses by 2010 (MEMR, 2013). The distribution target was achieved sooner than planned, in 2010, and the government set a more ambitious target of distributing 54–56 million units, which was exceeded in 2015 at 57 million units (Thoday et al., 2018). This was implemented in highly-populated kerosene-dependent areas.

The distributed starter package includes a 3-kg cylinder filled with LPG, a one-burner stove, a rubber hose, and a regulator (Thoday et al., 2018), at the cost of Rp300,000 in 2007. Based on the complex nationwide implementation, the programme launched in Jakarta as the area with LPG infrastructure readiness and area with huge consumption of kerosene. PT Pertamina also held market tests at small-scale (500 households) and medium-scale (25,000 households) before implementing a full-scale programme (Budya and Arofat, 2011). Before implementation in each region, programme socialisation and education activities were held, including how to operate LPG (MEMR, 2013).

The implementation also influenced behavioural change, and thus must be planned comprehensively. In its initial stage, the kerosene price was gradually increased whilst the supply decreased in the targeted area. With this, citizens were expected to shift to a cheaper fuel, LPG. The first targeted area in 2007–2008 included DKI Jakarta, Banten, West Java, East Java, Yogyakarta, Bali, and South Sumatra with existing LPG infrastructure (MEMR, 2013). From the supply side, the readiness of LPG supply and the distribution system was crucial, hence Pertamina converted kerosene retailers and agents to become LPG retailers and agents (Budya and Arofat, 2011).

1.3. Challenge in Programme Implementation

In the initial phase of this programme, there were several challenges such as riots and protests in the region about inflation of both kerosene and LPG prices. Moreover, due to the large scale of this programme, the government accelerated the production of LPG cylinders exceeding demand, which initiated illegal cylinders being circulated in the market. Challenges faced by each stakeholder were:

- For Pertamina: kerosene fuel unavailability in some regions, kerosene retailers showed opposition to this initiative, and other special interests from various parties (for instance, LPG retailers to have at a minimum the same profit margin compared to kerosene sales). To address this issue, PT Pertamina established loans and incentives, and also ensured LPG stock in those areas (Thoday et al., 2018)
- For provincial governments: remove kerosene sale licences, issue retail permits, segment distribution channels, and identify suitable beneficiaries for the subsidy (Budya and Arofat, 2011).
- For society or end users, the insecurity or fear of using gas stoves (fear of potential leakage, accidents, etc). The number of LPG incidents reported increased after 2 years of programme implementation (MEMR, 2013) (Table 4.1). This was mainly due to human error, lack of understanding on operating LPG, faulty product, and illegal manufacturing and distribution activities (MEMR, 2013).

Table 4.1 Reported LPG Incidents, 2007–2010

Region	2007		2008		2009		2010 as per June	
	Cumulative distribution	Incidents	Cumulative distribution	Incidents	Cumulative distribution	Incidents	Cumulative distribution	Incidents
Sumatra	50,000	NA	776,051	5	4,419,903	2	4,720,351	3
West Java	2,722,862	NA	12,063,751	32	17,128,323	16	17,307,730	26
Central Java	445,247	NA	2,970,016	7	10,318,294	8	10,318,294	8
East Java	758,341	NA	3,244,326	17	9,929,525	23	10,242,420	27
Sulawesi, Kalimantan	0	NA	0	-	1,613,454	1	1,875,713	6
Total	3,976,450	-	19,054,144	61	43,409,499	50	44,465,508	70

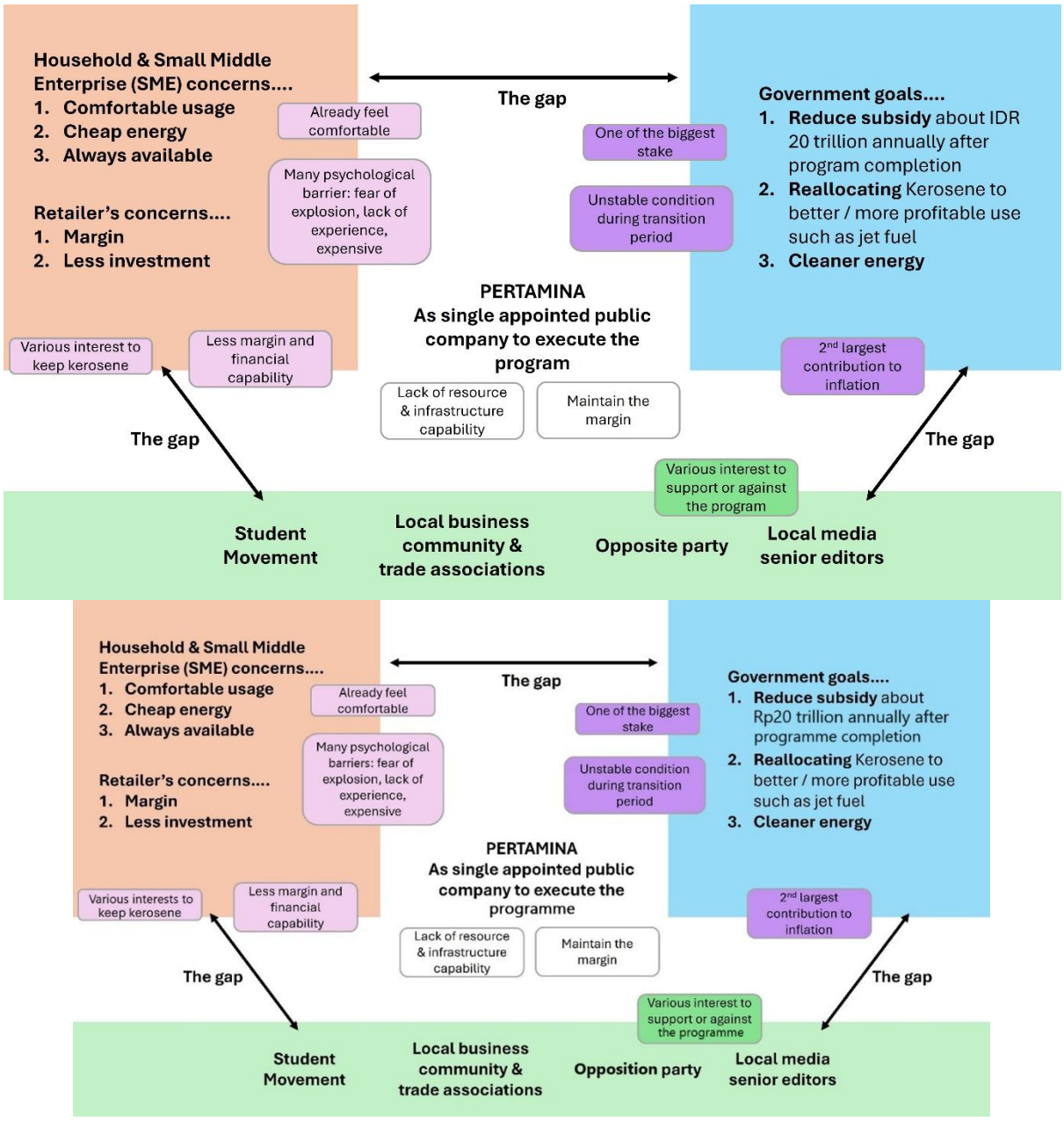
NA = not available.

Source: Pertamina analysis in Budya and Arofat (2011).

To address this issue, the government mandated each LPG manufacturer to comply with the standardised quality of SNI (Indonesian National Standard). In addition, LPG distribution was to be accompanied by operation simulation and socialisation with the end users (MEMR, 2013). Figure 4.1 illustrates the challenges faced by Pertamina during the

initial phase of the LPG conversion programme. According to Budya and Arofat (2011), these difficulties included logistical issues, public resistance, and infrastructure limitations. The chart highlights key obstacles such as distribution inefficiencies, inadequate public awareness, and supply chain management problems. These challenges reflect the complexity of transitioning from kerosene to LPG, requiring coordinated efforts across multiple sectors.

Figure 4.1 Difficulties Encountered by Pertamina at Outset of Conversion Programme



Source: Budya and Arofat (2011).

1.4. Success Factors in Programme Implementation

One of the key factors influencing the success of the programme was the strong government role and implementation, and also the effective vertical coordination between related institutions (Thoday et al., 2018). Jusuf Kalla, a former vice president of Indonesia, considered this programme as an urgent matter and monitored the implementation of the programme at both national and regional levels, and even approached all provincial governors to support this programme. Additionally, each related ministry and institution was assigned a role and responsibility:

- Ministry of Energy and Mineral Resources was the coordinator of programme implementation (Budya and Arofat, 2011)
- Ministry of Industry was responsible for ensuring the readiness of LPG starter packages and developing the Indonesian National Standard for LPG stoves, hoses, and regulators (Thoday et al., 2018)
- Ministry of Women's Empowerment was responsible for building consumer awareness about the programme (Thoday et al., 2018)
- Ministry of Small and Medium Enterprises was responsible for distributing LPG packages (Budya and Arofat, 2011)
- PT Pertamina was the sole executor of this programme, as Pertamina was responsible for both kerosene and LPG supply systems nationally (Budya and Arofat, 2011)
- Provincial government was responsible for licensing LPG distributors (to ensure its supply), regulating LPG price, and identifying household targets for conversion. For instance, the provincial government of Jakarta targeted households with a monthly income of USD167 or less, and without LPG stove (Thoday et al., 2018).

In addition, the LPG market model in Indonesia is operated through the 'cylinder recirculation model', where empty cylinders are exchanged for filled ones, which is considered the safest model. Thus, the conversion is not developed from scratch (Thoday et al., 2018).

1.5. Impact of Programme Implementation

Domestic kerosene consumption reduced significantly from 10 million kilolitres in 2006 to 0.8 million kilolitres in 2015. During the same period, LPG consumption increased from 1.1 million tons to 6.3 million tons (Thoday et al., 2018). Consequently, LPG consumption per capita increased from 4.7 kg in 2007 to 24.4 kg in 2015. Globally, the initial figure was comparable to the penetration level in several Sub-Saharan African countries, and by 2015 it reached a similar rate to mature LPG markets such as Brazil (25.5 kg/capita in 2014) (Thoday et al., 2018). In the initial 3 years of the conversion programme from

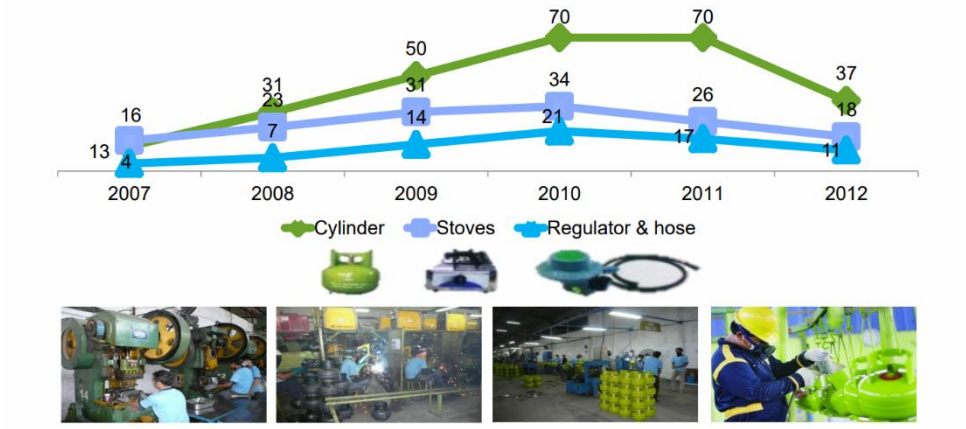
kerosene to 3-kg LPG cylinders, the Directorate General of Oil and Gas reported state subsidy savings of Rp5.53 trillion in 2008, Rp6.92 trillion in 2009, and Rp14.38 trillion in 2010 (MEMR, 2013).

According to data from the Ministry of Energy and Mineral Resources (ESDM), the cost of distributing 57.2 million initial conversion packages between 2007 and 2016 was estimated at Rp13.63 trillion (approximately USD1.02 billion). This expenditure covered the procurement and distribution of initial packages, which included LPG cylinders, stoves, and other supporting accessories as part of the transition from kerosene to LPG.

Furthermore, when compared to the historical kerosene subsidy scheme, the government allocated a total of Rp216.4 trillion (around USD15.6 billion) between 2006 and 2016. This figure accounts for historical subsidy expenditures, whilst factoring in the cost of distributing the initial conversion packages. Thus, the conversion programme was not only aimed at reducing reliance on kerosene but also at improving the efficiency of state budget allocations for energy subsidies (Thoday et al., 2018).

In terms of LPG infrastructure, 395 new bottling plants (refilling stations) were constructed during the conversion period on top of the 66 operating plants in 2007 (Zulfikar, 2017). Within this transition, new job opportunities were growing, including local manufacturing of cylinders and jobs associated with the new industrial LPG facilities (Thoday et al., 2018), estimated at 28,176 new jobs in 2009 (Budya and Arofat, 2011). The government's LPG conversion programme significantly influenced the domestic manufacturing sector, particularly in the production of LPG cylinders, stoves, and regulators from 2007 to 2012 (Figure 4.2).

Figure 4.2 Programme Impact on Cylinder, Stove, and Regulator Manufacture



Source: Pertamina report in Zulfikar (2017).

In 2007, 11% of LPG was imported. However, this percentage grew, reaching 64% in 2015 to fulfil the increasing demand. Therefore, the government seeks a new avenue for energy

diversification and produces dimethyl ether for domestic cooking fuel without major changes on equipment and distribution network (Thoday et al., 2018).

In terms of emissions, conversion to LPG was estimated to reduce 31% of emissions from the 2007 level. However, in fact, only 5% of emissions have been reduced from residential cooking. This is due to the continued use of solid fuel (biomass) (Thoday et al., 2018).

In terms of public health, conversion to LPG was projected to further reduce 4% mortality and 3.5% morbidity rate from exposure to household air pollution. Although the data suggest that there had been a decline of prevalence rate in diseases related to household air pollution – 0.3% decline in pneumonia, 6.1% in obstructive pulmonary disease, 6.1% in acute respiratory infection for children below 5 years old, and 0.59% in tuberculosis – it is the effect of overall improvement in healthcare, not only from this programme (Thoday et al., 2018).

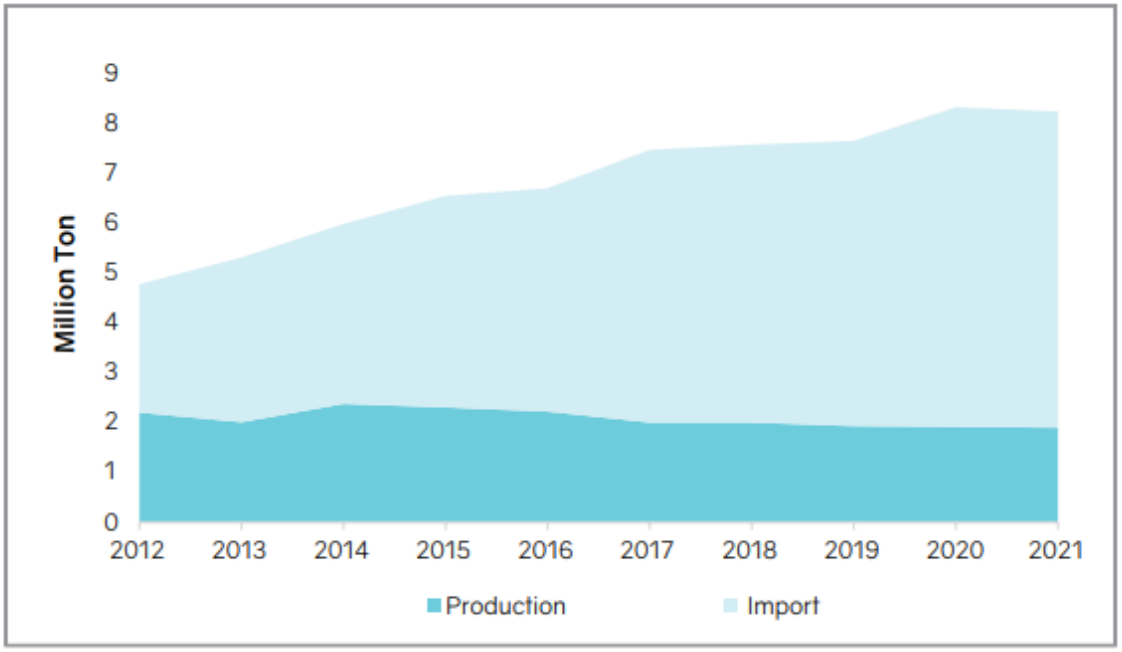
For the end users or the LPG conversion beneficiaries, most of them suggest that the programme brings benefits for them, including reduced cooking time, cleaner kitchen, and lower cooking fuel expenditure by 30% (Budya and Arofat, 2011).

1.6. Current State of LPG Conversion Implementation

As of 2015, LPG adoption is strongly correlated with household income and age of the main cook, as households with higher average income and level of education, also households with main cooks under 35 years old are more likely to use LPG (Thoday et al., 2018). Those with lower household income and biomass users were targeted in a programme called the Clean Stove Initiative in 2012.

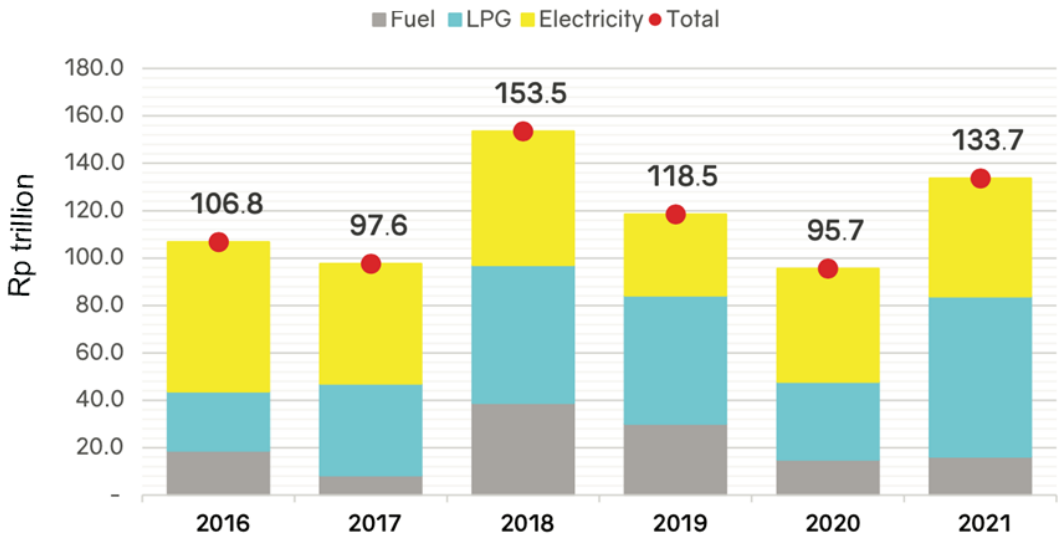
LPG consumption per capita increases every year, with an average growth rate of 4.4% in the last 5 years (DEN, 2022). With the increase of fuel demand, LPG supply (refinery and domestic oil refinery) is limited (DEN, 2019). Whilst LPG consumption reached 7.5 million tonnes in 2021, 74% of the supply comes from imported LPG (DEN, 2019). Thus, the energy subsidy continued to increase to Rp67.6 trillion in 2021 (DEN, 2022).

Figure 4.3 LPG Production and Imports, 2012–2021



Source: Dewan Energi Nasional (DEN) (2022).

Figure 4.4 Development of Energy Subsidy



Source: Dewan Energi Nasional (DEN) (2022).

An additional target of this programme was to reach 26 million households considered the poorest 40% in Indonesia, households in remote areas, farmers, and fishers to save operational costs.

In 2017, households were targeted through registration in social protection programmes, in which the subsidy was transferred through a smartcard technology, the Sejahtera Family Card. In the implementation, only a few registered for the initiative; technical issues were raised such as uncertain distribution points and provincial governments' reluctance to set the criteria target.

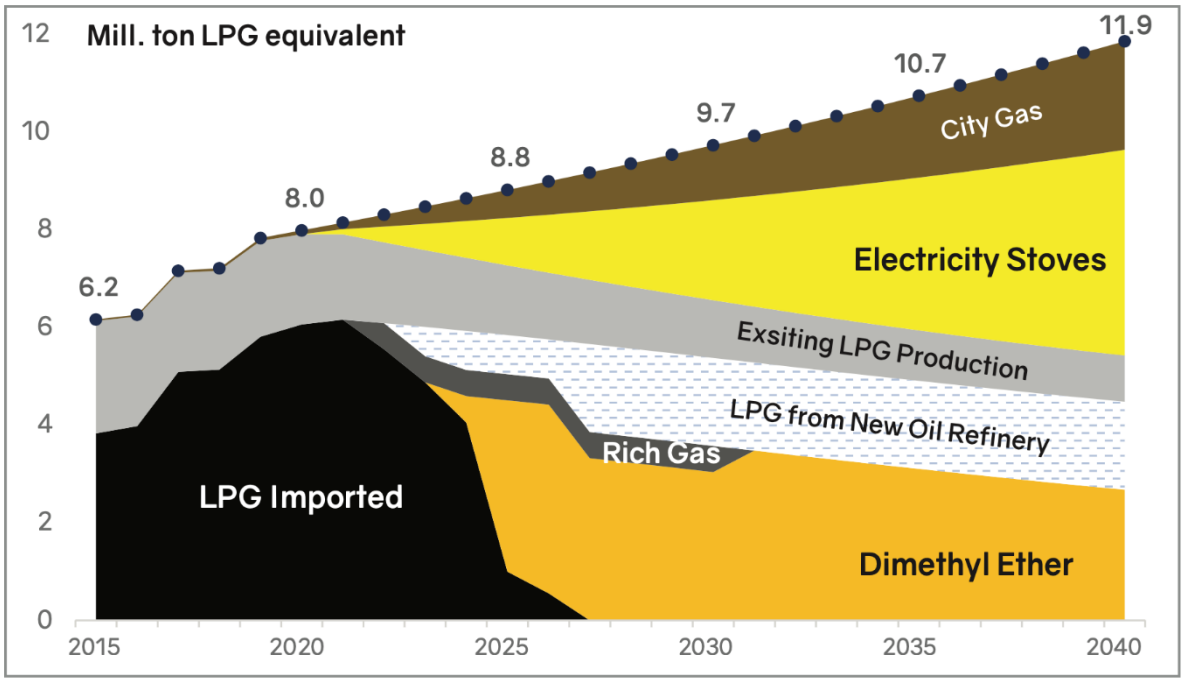
Despite targeting poor to low-income households, many high-income households and the commercial sector use 3-kg cylinder LPG. That implies that LPG conversion does meet the actual target (Budya and Arofat, 2011). Furthermore, the impact of this programme for households that use biomass for cooking remains limited.

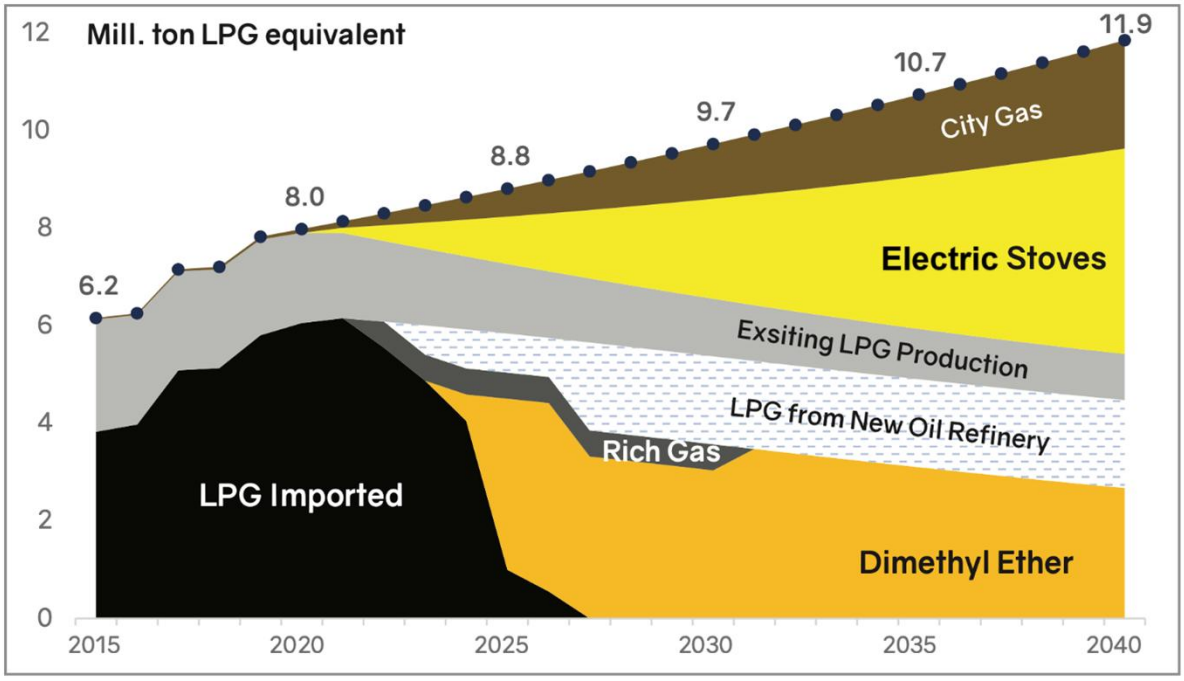
1.7. Lessons Learned

Despite the success of this programme, the reliance on fossil fuel only shifted from kerosene to LPG. To meet the increasing demand, Indonesia ended up importing a significant amount of LPG and the subsidy for LPG fluctuates with the unstable global crude oil price. For instance, the LPG subsidy cost to the government was almost twice as much in 2014 as in 2015, costing Rp48.9 trillion (USD4 billion) in 2014 compared to Rp25.8 trillion (USD2.1 billion) a year later (Thoday et al., 2018).

To reduce LPG imports and increase national energy security, the government initiated another plan mandated in the National Energy General Plan, from LPG conversion to city gas, dimethyl ether from coal, or LPG with induction stove. The target is to reduce LPG demand from 9.9 million tons of oil equivalent (toe) in 2021 to 7.6 million toe in 2032 (DEN, 2022). Figure 4.5 presents the grand strategy of the national energy programme to stop fuel imports by 2040.

Figure 4.5 Grand *Strategi Energi Nasional* Programme to Stop Fuel Imports





Source: Dewan Energi Nasional (DEN) (2022).

The subsidised LPG cylinder model is the 3-kg cylinder. Between 2008 and 2013, the price of 1-kg LPG refills were sold below market price. At the same time, some customers bought the 12-kg LPG refills at the subsidised price on the grey market (Thoday et al., 2018). Other than the loss for Pertamina, refilling on the grey market can have safety

issues (Thoday et al., 2018). The government then introduced a 5.5-kg cylinder, in anticipation of the end of 3-kg cylinder subsidies.

Another matter to be considered despite the speed of the conversion is the existing and investment for LPG infrastructure (bulk storage, filling plants, transportation, and cylinder inventory). To anticipate future demand, LPG terminals should be designed to be expandable (Budya and Arofat, 2011). In the initial phase of the programme implementation, simultaneous kerosene and LPG scarcity was anticipated (Budya and Arofat, 2011).

With the key success of a strong institutional role, the programme executor could utilise current fuel distributors (dealers and agents) to facilitate the conversion and provide simple funding if they required additional funds for new ventures. Additionally, it should communicate the programme effectively to targeted users through mass media, simple language, and integrated ongoing marketing campaigns (cooking demos, etc) (Budya and Arofat, 2011).

One thing worth mentioning is that Indonesia made small efforts in creating a demographic database for identification of beneficiaries. Hence, the implemented programme relied on the provincial government and would be more suitable to be an emergency relief rather than a long-term approach (Thoday et al., 2018).

Quoting from Pertamina, in Budya and Arofat (2011), 'a conversion program can run successfully by delegating program execution to a capable business entity and enabling normal business transactions, thus minimising the government's bureaucratic role. The business entity can also play a crucial role as program executor in the field to approach all relevant parties so that the program runs smoothly. It was also important that the business and implementation models could be replicated easily in all geographic areas to be converted' (Budya and Arofat, 2011).

4.2 Thailand's Policy for Penetration of LPG Consumption in Rural Areas

4.2.1 Introduction of LPG Policies in Thailand

Access to clean and sustainable energy is essential for rural development. In Thailand, LPG presents a promising solution for improving energy access in rural households, offering a cleaner and more efficient alternative to traditional biomass. This subsection 4.2 examines the Thai government's policies and action plans aimed at increasing LPG consumption in rural areas. It explores how these strategies and measures have facilitated LPG adoption in rural communities. It also identifies key factors contributing to the success of these initiatives and highlights ongoing challenges. Additionally, it proposes actionable plans to further boost LPG demand, focusing on financial incentives for households and suppliers and the establishment of a robust LPG supply chain in rural regions.

In summary, subsection 4.2 provides an overview of the efforts to promote LPG use in rural Thailand, offering insights and recommendations with ways forwards for enhancing clean energy access and supporting rural development hopefully to provide lessons learned for Cambodia.

4.2.2 Thailand's Policy Framework on LPG Development

Before 1981 LPG trade was from major oil companies such as Shell, Esso, and Summit. LPG use was not popular and limited only in Bangkok and some large provinces as the LPG price was not competitive with very low-cost firewood and charcoal.

By 1981, natural gas was found and produced in the Gulf of Thailand. The government had started the policy to promote LPG use for cooking to substitute firewood and charcoal for cooking, especially in the rural areas of Thailand with objectives to lessen deforestation and to provide clean energy for cooking.

At the same time, the first gas separation plant was set up in Rayong. A large LPG storage facility was also constructed in Chonburi to be the LPG logistics centre to transport LPG to the south by ship and to other regions by train.

4.2.3 Strategies and Measures to Facilitate LPG Adoption in Rural Communities

Major government policies to promote LPG use were setting the LPG price at LPG depots in regions with the same price over the whole country. Construction and maintenance costs of LPG storage facilities were done by the Petroleum Authority of Thailand (PTT) and compensated by the government at B0.58/kg for 9 years (1987–1996). The government also supported transportation costs from central LPG storage in Chonburi to regional LPG depots depending on the estimated cost of transportation in baht per kilogramme.

The government also set up an Oil Fund in 1979 (it was later formalised under the Oil Fund Act B.E. 2562 (2019) to lessen impacts from international oil price volatilities. This fund has also been used to subsidise the low LPG price policy. A common practice to operate the Oil Fund is using taxes received from several grades of gasoline and other petroleum products to support low prices of high-flow diesel and LPG.

For LPG, two types of price support have been implemented: the price difference between the estimated market price and the government's set price and transportation costs to regional depots.

To encourage new LPG players especially at regional levels, PTT allowed other LPG companies to use PTT LPG depots free of charge. This resulted in the emergence of new

players including Siam Gas, World Gas, Picnic Gas, Unique Gas, Star Gas, and Sangthong Gas. Hundreds of LPG filling plants were also set up in all regions over the country.

This study found the following positive impacts of the price-fixing policy for LPG (at a low level):

- Effectively promotes the use of LPG for cooking to substitute the traditional use of firewood and charcoal.
- Increases accessibility to clean energy for cooking in both urban and rural areas in a more equitable and affordable fashion.

Whilst the negative impacts involve:

- Increased use of LPG in other applications that are not targets of the government support policy for instance: as a fuel for industrial applications, as feedstock in the petrochemical industry, and as a fuel in vehicles.
- A huge financial burden for the Oil Fund.
- Lost export opportunities during low international LPG prices and illegal exports of LPG, particularly during high international LPG prices.
- Profit margin of LPG sellers was also controlled at a low level for too long. LPG sellers tried to cut costs to stay in business. This led to a decrease in service quality and standards that could cause dangerous incidents (gas leaks, fires, or explosions), the production and use of illegal 'white cylinders', and the avoidance of safety and quality checks of LPG gas tanks every 5 years (by law).
- LPG weight cheating.

4.2.4 LPG Price Structure

As mentioned above, the government has set the price under its subsidy policy. The price structure of one cylinder of cooking gas (15 kg) that is used in households consists of:

- LPG prices at the source (natural gas separation plants, oil and aromatic refineries, and imports)
- Excise tax
- Municipal tax
- Oil Fund (tax or support)
- Market value (margin)
- Value added tax

The price of LPG at the source is the largest proportion at approximately 70% of the price. If the price of LPG at the source increases, this will result in a higher price for the cooking gas tanks that are used in households.

However, the price that consumers currently pay is not the real price. This is because the Oil Fund tax is used to subsidise approximately 20%. For example, on 2 September 2022, a 15-kg tank of cooking gas costs B408 per tank, with the actual price being B509, and the Oil Fund tax subsidy at B101 per tank.

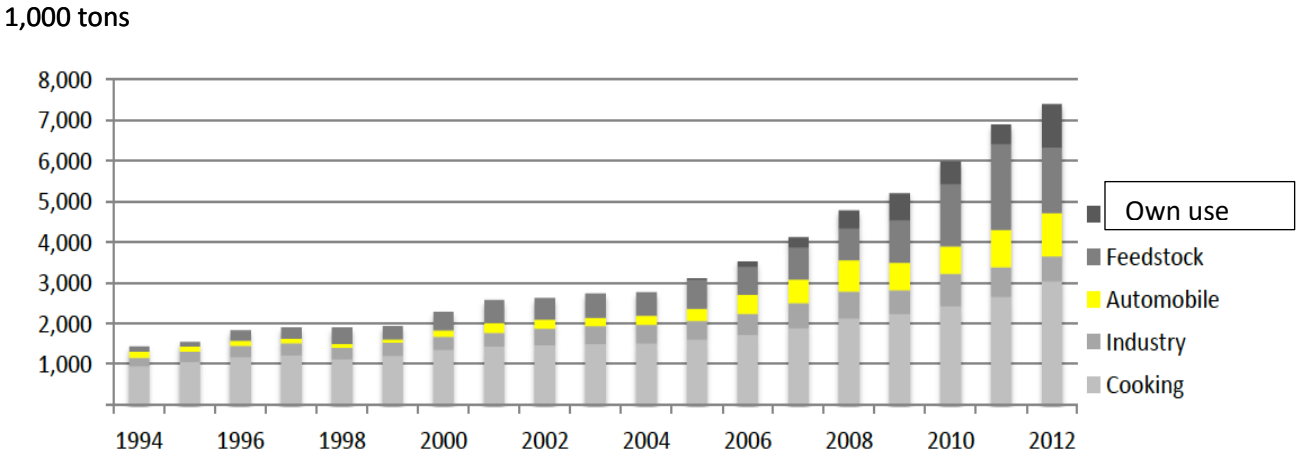
Previously, Thailand had a policy to control the price of LPG at the source both from gas separation plants, oil refinery, and imports. The price was set to be B10/kg until 2017 when the government had a policy to liberalise the LPG business (only control the retail price at destination with subsidy). The government claimed that liberalisation of the entire system would help stimulate more competition in the LPG business market and benefit all parties.

4.2.5 LPG Consumption in Residential and Commercial Sectors in Thailand

Energy Consumption in Urban and Rural areas

- Historical energy consumption of LPG, electricity, and biomass
- How to use LPG

Figure 4.6 LPG Consumption by Sector in Thailand, 1994–2012



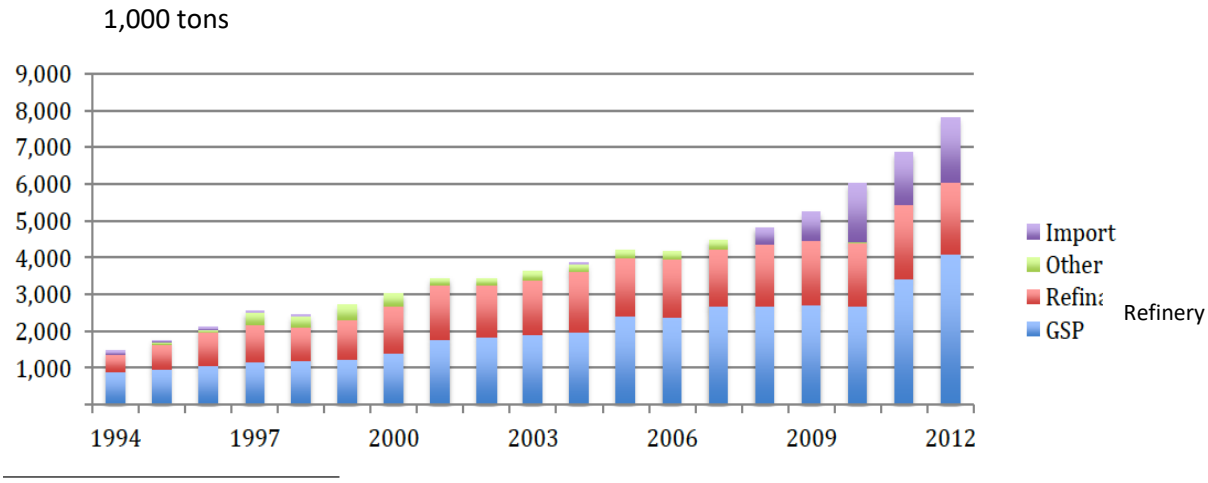
Source: Ninart (2013).

LPG consumption increased from about 1.4 million tons in 1994 to about 7.4 million tons in 2012. It had been a high average annual growth rate of 9.69% during the 18 years that the Thai government promoted the use of LPG for cooking by price fixing at a low and

competitive level. Although about half of the total consumption of LPG use was for cooking, which is the main objective of the policy, considerable growth of LPG use in industry, automobile, and feedstock in petrochemical industries was also found. Figure 4.6 shows increasing demand of LPG in sectors and about half the demand was for cooking.

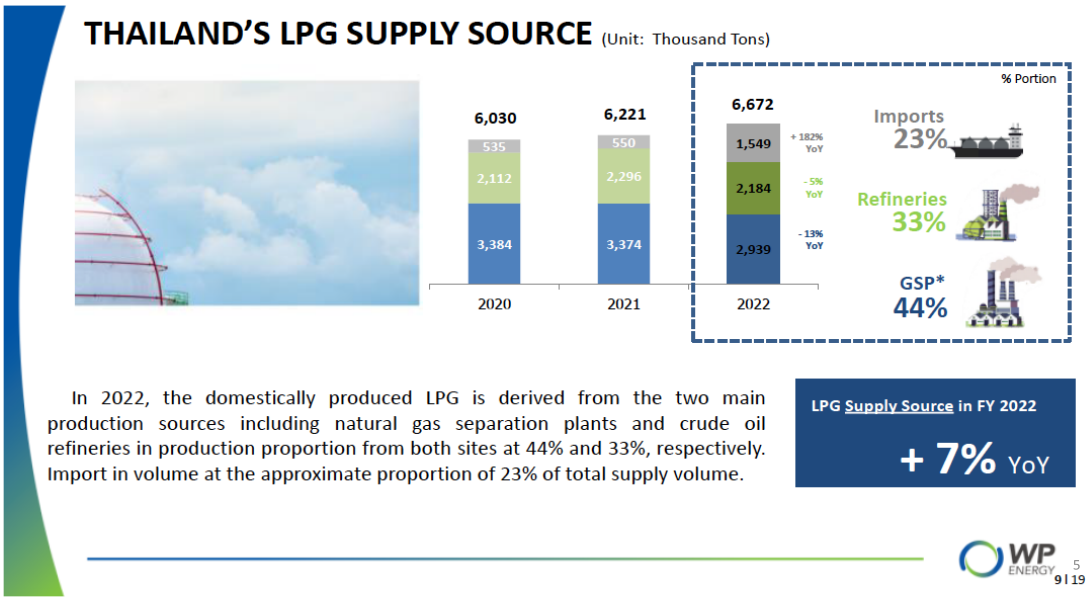
Figure 4.7 shows the main production of LPG was from oil refineries and gas separation plants from 1994 to 2007, with imports starting in 2008.

Figure 4.7 Supply of LPG in Thailand, 1994–2012



GSP = gas separation plant.
Source: Ninart (2013).

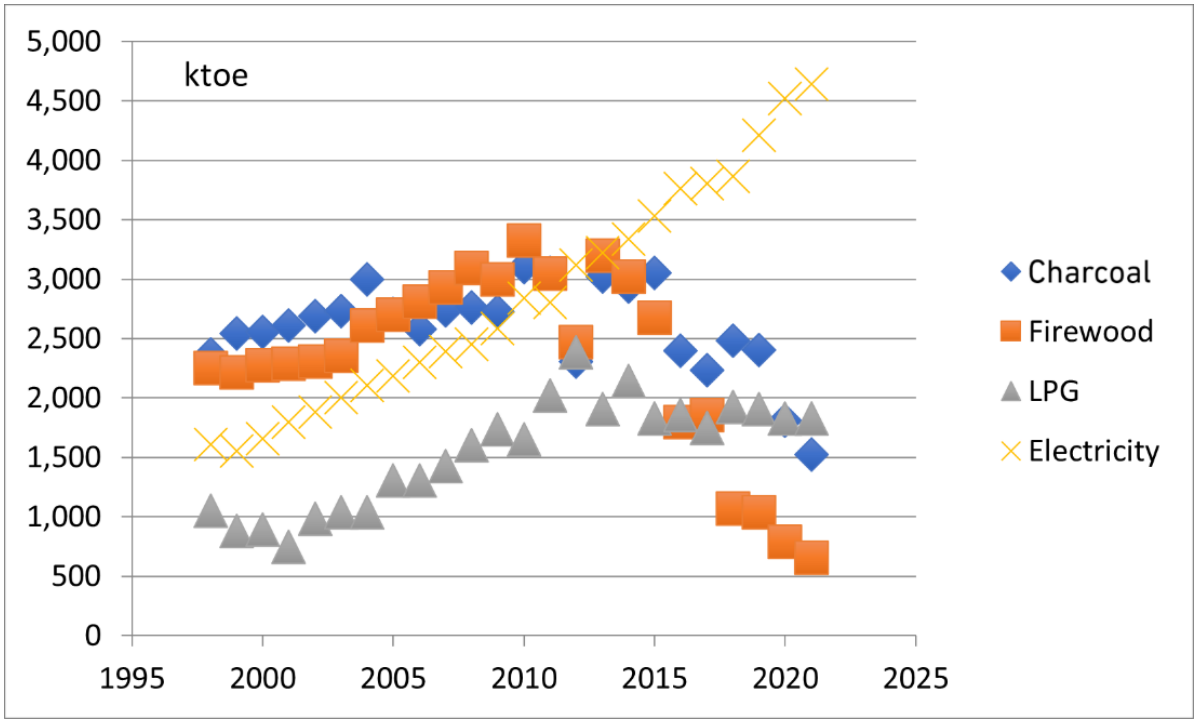
Figure 4.8 Supply of LPG, 2022



GSP = gas separation plant.
Source: WP Energy (2023).

In sum, the main domestic sources of LPG production were from oil refineries and gas separation plants. However, LPG production from domestic sources could not meet the growing demand and Thailand started importing LPG in 2008 as shown in Figure 4.8. As local production of oil and natural gas in Thailand has already passed the maximum capacity, future increasing demand of LPG will be dependent on imports. In 2022, a total supply of LPG was 6.672 million tons, 23% of the total amount was from imports as shown in Figure 4.8.

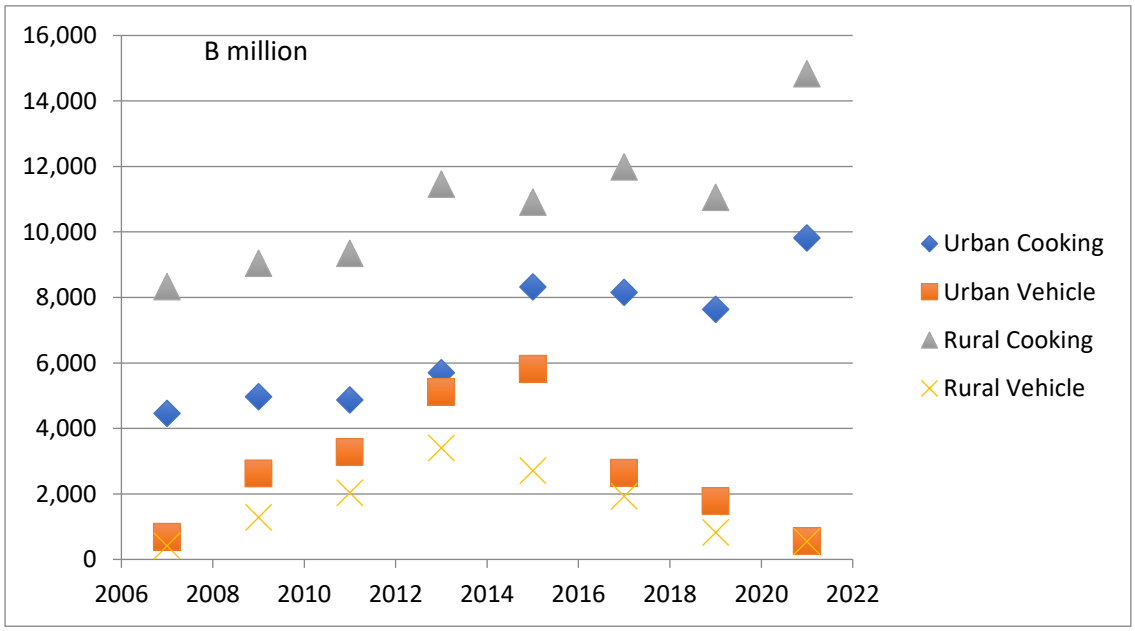
Figure 4.9 Plot of Selected Energy Use in Residential Sector, 1998–2021



ktoe = kilotons of oil equivalent.
Source: DEDE (2021).

LPG demand was more or less constant between 2012 and 2021, whilst demand for charcoal and firewood dropped sharply as shown in Figure 4.9. However, when we look closely at household energy expenses, LPG use for cooking was still increasing, whilst LPG use in vehicles was decreasing. Although the rural and urban populations in Thailand are more or less equal, LPG use for cooking per capita in rural areas was much higher than that in the urban areas as shown in Figure 4.10.

Figure 4.10 LPG Expense in Urban and Rural Households of Thailand



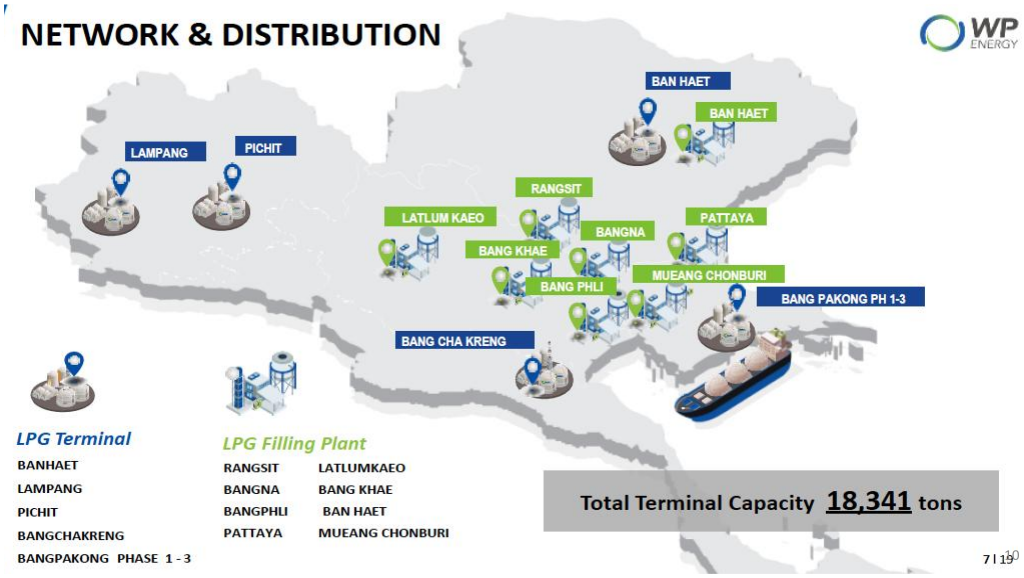
Source: National Statistical Office (2007–2021).

2.6.LPG Supply and Demand Policies and Distribution in Rural Areas

- Regulatory measures
- Infrastructure development for LPG sellers and retailers and distribution
- Subsidies for households and commercial entities
-

As domestic sources of LPG production are from natural gas separation plants and oil refineries, PTT, a state enterprise in the oil and petroleum business, has been assigned to be the main agency to produce, sell, and develop necessary logistics to deliver LPG all over the country with some agreed support from the government. A large LPG central storage in Chonburi and regional depots in several cities in all regions have been built, operated from PTT's budget. The government would then pay PTT back as compensation at B0.58/kg for 9 years (1987–1996). PTT also agreed to allow other parties to access and use regional depots free of charge. This has created an opportunity for interested private companies to invest and develop means to bring LPG from regional LPG depots to users in both urban and rural areas. To develop infrastructure that can bring LPG to every village over the whole country, there would be several LPG sell and service companies, some LPG cylinder makers, and many more LPG filling stations and retailers as shown in Figure 4.11.

Figure 4.11 LPG Network and Distribution of a Private Company



Source: WP Energy (2023).

To create demand for LPG for cooking, price fixing at a low and competitive level has been used. Compared with charcoal, LPG for cooking is cleaner and more convenient to use. Conversion efficiency of LPG stoves at 40%–50% is also higher than charcoal stoves at 20%–30%. The energy price of LPG can be set higher than that of charcoal but not too high. This is a main incentive to bring LPG to markets especially rural areas where the charcoal price is low and the LPG price (without support from the government) would be the most expensive due to relatively longer distances and more difficulty to transport from LPG storage facilities. The fixed price is therefore set at the same price at the LPG central storage and every regional depot. This will reduce the price difference between urban and rural areas. The difference between the estimated market price and fixed price and transportation cost from the LPG central storage to regional LPG depots will be paid by the Oil Fund. Various sizes of LPG cylinders have been engineered and manufactured to satisfy the requirements of diverse user groups. The weights are 4 kg, 8 kg, 13.5 kg, 15 kg, and 48 kg.

In sum, the Ministry of Energy, in cooperation with related government agencies, is responsible for creating the necessary regulatory measures to provide sufficient financial support, to regulate LPG business fairly, and to set a suitable code of practice and standards of equipment, devices, and LPG products to make sure that the LPG business performs in a fair, secure, and sustainable way.

2.7.Policy Recommendations for Cambodia

- Subsidies and Affordability

Implement targeted subsidies for LPG in rural areas to make it more affordable for households. This can significantly impact the shift from traditional biomass to cleaner LPG.

- Community Training Programmes

Establish community-based training programmes to educate rural residents on the proper use and benefits of LPG, addressing any safety concerns and promoting efficient utilisation.

- Local Entrepreneurship Support

Encourage local entrepreneurship by supporting the establishment of small-scale LPG distribution points in rural areas, ensuring a consistent supply chain.

- Customised LPG Cylinder Sizes

Provide LPG cylinders in sizes that suit the needs of rural households, considering factors like family size and cooking habits, to minimise waste and enhance efficiency.

- Incorporate Traditional Practices

Tailor LPG policies to incorporate and complement traditional cooking practices in rural areas, ensuring cultural acceptance and a smooth transition to LPG.

- Partnerships with Nongovernment Organisations

Collaborate with nongovernment organisations to implement community-driven initiatives, leveraging their expertise in grassroots outreach and sustainable development.

Price fixing at a low and competitive level with suitable financial support similar to what has been implemented in Thailand may be necessary and helpful to introduce and expand LPG use for cooking at the beginning of the programme. However, the level of financial support should be dynamic and suitably adjusted to allow more participation and investment from the private sector and lead to deregulation and improving effective market mechanisms. These recommendations aim to create a comprehensive framework for LPG consumption in both urban and rural areas of Cambodia, taking into account the specific needs and challenges of each setting.

2.8.Lessons Learned and Way Forwards

For lessons learned during the recent COVID-19 crisis situation, there was control over the price of LPG, but it was only to control the retail price at the destination. The price is

not controlled at the source from the gas separation plants and oil refineries including the price of imports.

The original price is calculated using a formula based on rising import prices from the global market. As a result, the Oil Fund is used to subsidise prices to maintain the government's announced retail price under price control measures. Other sectors, such as transportation and industry, also consume LPG and benefit from the lower prices, increasing the demand for imported LPG for households and further raising the subsidy burden. Additional challenges include illegal exports to neighbouring countries and the presence of illegal and non-standard cylinders in the market. These factors have collectively led to a negative balance in the Oil Fund account. For the way forward:

- LPG liberalisation policy in the future will lead to floating LPG prices.
- The government still needs to maintain LPG semi-floating prices and partial subsidies to help the people, i.e. control and regulate wholesale and retail prices.
- The government may need to float the urban price and support targeted subsidies on the rural price. This targeted subsidy can be conducted through a government campaign mechanism.
- In the future, deregulation (e.g. liberalisation of costs, partial control, private involvement, endorse measures, etc.) for the LPG price to reflect the costs but focus help on vulnerable groups as first priorities, etc.
- Last but not least, a floating price system would allow 'free trade in LPG' in the future.

Chapter 5
Key Findings and Recommendations

1. Key Findings

Chapter 2 reviews business policies of LPG companies on LPG markets in rural areas of Cambodia. LPG consumption in Cambodia marked the highest growth amongst petroleum products in 2000–2019, thus LPG companies will increase import capacity of LPG at Sihanoukville port and the border with Viet Nam. However so far, many LPG companies have less interest in establishing LPG bottling stations in the rural areas due to higher logistics costs. They utilise the existing LPG supply network such as retailers and LPG service stations to sell small LPG cylinders in the rural areas. The LPG companies also worry about refilling used cassettes with LPG at the retail shops. It is cheap but dangerous. According to this survey, new LPG cassettes are more expensive than small cylinders, so the LPG companies recommend people in the rural areas to use small LPG cylinders, but due to economic reasons, people in the rural areas tend to purchase used LPG cassettes. LPG companies expect the government (General Department of Petroleum, Ministry of Mines and Energy) to enforce the prohibition of illegal activities (e.g. refilling used cassettes) in the rural areas.

Chapter 3 reviews LPG consumption in the rural areas. According to the LPG consumption survey in the rural areas conducted under this project, which include Kampong Thom Province, Kratie Province, and Pursat Province, around half of the households are currently using LPG (47%). The share of LPG cassettes is 62% and cylinders is 39%. About 1% of households purchase both cassettes and cylinders. Many households use LPG mainly for cooking followed by boiling water. Some households using LPG still consume biomass such as firewood and charcoal. About 86% of households consume less than 6 kilogrammes (kg) of LPG per month and the mode is 3 kg per month. The average monthly LPG consumption across all households in the village, including those that do not use LPG, is 2.16 kg per household. Amongst households that use LPG, the average monthly consumption is 4.46 kg per household. We also interviewed the households not using LPG whether they want to use LPG or not. About 78% of households answer in the negative, and the reasons include LPG is dangerous, LPG is too expensive, LPG is difficult to use, and no need for LPG due to free firewood. Refilling used cans with LPG is again identified by this survey.

Chapter 4 introduces the LPG policies of Indonesia and Thailand in terms of how to penetrate LPG consumption in the household sector. Indonesia implemented a fuel conversion programme from kerosene to LPG in 2007. Its purpose was to reduce kerosene consumption and subsidies to kerosene consumption, and increase the use of

clean fuel in households. In this regard, 3-kg cylinders were delivered to households with subsidy; this programme has been successful. Finally, the achievements of this programme include (i) successful reduction of kerosene consumption and subsidies in households, (ii) creation of a new industry to produce LPG cooking stoves, rubber hoses, and regulators, (iii) increase in use of clean fuels in households, and (iv) reduction of carbon dioxide emissions compared to kerosene consumption. For Thailand, the Ministry of Energy opened its LPG market through deregulation (increase of LPG companies), provided subsidies for LPG transportation to rural areas (long distance transportation), and regulated the LPG price in the residential and commercial sectors.

2. Policy Recommendations

Based on the key findings mentioned above, the following recommendations are delivered to the General Department of Petroleum, the Ministry of Mines and Energy, Cambodia.

- Establish an educational campaign of the safe use of LPG to residents in the rural areas
- Emphasise the merit of LPG compared to firewood and charcoal
  - Clean (no smoke) and high calory (short cooking time)
- Provide incentives to deliver LPG cassettes and LPG cooking stoves to households in the rural areas free of charge (allocation of some budget)
- Prohibit refilling of used cassettes with LPG
- Encourage households using LPG cassettes to shift to small cylinders

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Appendix

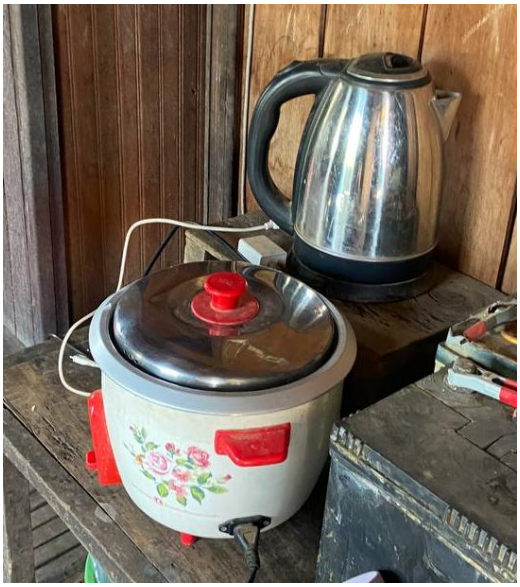
Photographs taken during the survey.

Biomass Stoves

LPG Can Stoves

LPG Cylinder Stoves

Electric Cookers and Kettles



Biomass Material

Firewood

Charcoal

Palm Leaves, Fruit, Flowers

Biomass Gas Generation Systems from Animal Manure