GUIDE TO GOOD INDUSTRY PRACTICES FOR LPG IN INSTITUTIONAL KITCHENS

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LPG
EXCEPTIONAL ENERGY

FOREWORD

> When people use clean cooking fuels instead of firewood or charcoal, they are saving their lives, saving their forests and saving their farming and fishing industries

José Andrés,
World Central Kitchen

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ACKNOWLEDGMENTS

This update to the original guide was drafted by David Tyler, WLGA, with the support and guidance from Michael Kelly, Chief Advocacy Officer, WLGA, and members of the WLGA, especially those participating in the WLGA Core Safety Group.

Valuable input was received from Vic Mariñas (the Philippines), Nigel Bruce and Daniel Pope (Clean-Air AFRICA), Christina Espinosa (WCK) and Sebastien Lamerre (The Manor Tavern).

The draft was reviewed by members of the WLGA Cooking for Life Africa (CFLA) working group and the WLGA Core Safety Group. Valuable advice was received from Fernando Covas, S & P Global.

Alison Abbott, Communications Director, WLGA, edited the document.

EXECUTIVE SUMMARY

This publication updates the *Guide to Good Industry Practices – LPG in Commercial Kitchens*, originally published by the World Liquid Gas Association (WLGA) in 2014. That guide focused on the global opportunities for LPG use in larger institutional kitchens where traditional fuels—such as wood, charcoal, and kerosene—are commonly used.

Like its predecessor, this guide takes a global perspective but also highlights specific opportunities for LPG adoption in African institutions, particularly school kitchens. As part of the *Clean Cooking for Africa* initiative, LPG is aiming to replace traditional cooking fuels in schools, universities, and training centres as well as other institutional settings. These include social institutions - hospitals, orphanages, and care homes - and commercial institutions such as hotels, restaurants, and catering businesses.

Globally, nearly half of LPG demand is consumed in the residential and commercial sectors, where it is primarily used for cooking (*WLGA Statistical Review of Global LPG – 2024, Argus Media*). However, LPG also serves numerous other applications, including heating, drying, and various industrial processes that require clean energy (LPG Apps - The LPG applications database).

Transitioning institutional kitchens—such as those in schools and hospitals—from wood, charcoal or kerosene to LPG can have a ripple effect. Schoolchildren, cooks, teachers, and medical staff who experience the benefits of LPG firsthand can become advocates for change in their own homes and communities.

Traditional fuels like wood, charcoal, and kerosene are often linked to energy poverty. Increasing household access to LPG is one of several strategies to achieve universal clean cooking and heating solutions by 2030. This goal aligns with the *UN Sustainable Energy for All (SE4All) initiative*, which also aims to double the global rate of improvement in energy efficiency and double the share of renewable energy in the global energy mix.

This guide serves as a toolkit for stakeholders considering the shift to LPG. It addresses common misconceptions, such as the belief that LPG is dangerous, unaffordable, or a luxury fuel.

Chapter Two presents case studies, including a powerful example from Kenya. Research by *Nigel Bruce and Daniel Pope of CLEAN-Air (Africa)* documents the transformative impact of switching from wood to LPG in Kenyan school kitchens, improving the health and well-being of cooks, staff, and students. This case study stands as a model for every African school still reliant on harmful traditional fuels.

In addition to making the case for LPG adoption, this guide provides essential insights into:

- The decision-making process for transitioning to LPG
- Designing LPG systems for institutional kitchens
- Safe operation and maintenance of LPG fired kitchens
- Kitchen safety best practices

In 2012, the WLGA launched the *Cooking for Life* campaign to promote the health benefits of transitioning from harmful traditional fuels—such as wood, charcoal, coal, and kerosene—to LPG. A year later, SE4All and the WLGA set a target to support the transition of one billion people from traditional fuels to LPG.

Achieving this goal requires overcoming regulatory, financial, and logistical barriers. A multi-stakeholder partnership was established to support sustainable business models and best practices. This guide contributes to that effort.

LPG is a clean-burning, efficient, and versatile fuel derived from natural gas extraction and crude oil refining. Key benefits include:

- Up to five times more efficient (higher calorific value) than traditional fuels
- Lower air pollution levels than wood, charcoal, coal and kerosene
- 20% lower CO_2 emissions than heating oil and 50% lower than coal
- Reduction in harmful black carbon emissions
- Flexible transportation options, from large shipments to small, portable cylinders

While LPG is highly flammable and requires safety precautions, accidents are rare when proper handling procedures are followed (Simply Safety - World Liquid Gas (WLGA)).

To support a smooth transition, this guide includes six training modules (Section 7.2), developed by *World Central Kitchen (WCK)*. These modules provide essential guidance on maintaining safety and hygiene in kitchens using LPG.

By adopting LPG, institutions can improve air quality, enhance energy efficiency, and create healthier cooking environments—helping pave the way for a cleaner, more sustainable future.

KEY BENEFITS INCLUDE:

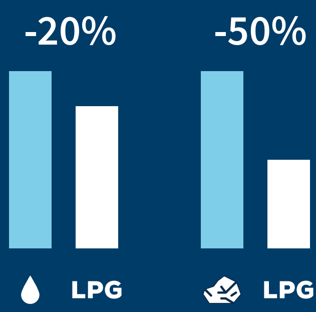
5X

MORE EFFICIENT

Up to five times more efficient (higher calorific value) than traditional fuels

LOWER AIR POLLUTION

Lower air pollution levels than wood, charcoal, coal and kerosene



LOWER CARBON POLLUTION

20% lower CO_2 emissions than heating oil and 50% lower than coal

LOWER HARMFUL BLACK CARBON

Reduction in harmful black carbon emissions

FLEXIBLE TRANSPORTATION

Flexible transportation options, from large shipments to small, portable cylinders

01

The Background

1.1 The Need for this Document

The World Liquid Gas Association (WLGA) is dedicated to providing independent guidance to LPG stakeholders, ensuring the safe operation of LPG equipment.

For over twenty years, the WLGA Guidelines – *Good Business Practices and Good Safety Practices* have been widely used across the global LPG industry. These guidelines offer practical recommendations throughout the LPG supply and distribution chain and have become flagship documents helping to eliminate unsafe practices (*Simply Safety - World Liquid Gas (WLGA)*).

Building on the success of these two guidelines, the WLGA has developed more detailed, prescriptive guides for critical areas within the LPG supply and distribution chain. These include LPG Cylinder Management, Bulk LPG Road Transport and Bulk LPG Storage.

This latest publication, *LPG in Institutional Kitchens*, has been developed with support from the *Cooking For Life Africa* project and contributions from industry working groups.

This guide addresses key factors influencing the transition from traditional fuels to LPG in institutional kitchens, such as those in schools, orphanages, and hospitals. It also includes training materials (Chapter 7.2), provided by *World Central Kitchen*, to equip cooks with essential skills for safe and sanitary food preparation and handling—ensuring they can prepare healthy meals efficiently.

While the guidance in this document is globally applicable, the urgency for transitioning to cleaner cooking fuels like LPG is most critical in Africa, where nearly 1.0 billion people seek access to cleaner energy alternatives.

The information in this guide is based on globally recognised LPG standards and codes of practice, as well as best practices from leading LPG distribution companies.

For optimal safety and efficiency, it is recommended that the guidance provided here be used alongside local laws and regulations to enhance overall LPG safety performance.

1.2 Who Is the Audience for this Guide?

This document is a valuable resource for all stakeholders involved in transitioning institutional kitchens from traditional fuels—such as wood, charcoal, coal, animal waste, and kerosene—to LPG, particularly for cooking. It is intended for a wide range of decision-makers, including:

- Policymakers and investors evaluating the switch
- Establishment owners, architects, and kitchen designers planning LPG integration
- Chefs and kitchen staff adapting to LPG cooking methods
- Maintenance teams responsible for equipment safety and efficiency

This guide provides key insights into traditional fuels, highlighting the risks they pose to public health, safety, the environment, and economic sustainability in institutional kitchens.

- Chapters Two and Three present the case for switching to LPG, offering key arguments for decision-makers
- Chapters Four, Five, and Six provide practical guidance on designing and sizing LPG storage and distribution systems, essential for planners and project managers
- Chapter Seven offers step-by-step guidance for kitchen staff on using LPG safely and efficiently, including appliance maintenance and best practices. The World Central Kitchen (WCK) training modules (Section 7.2) further support staff in maintaining a safe and hygienic kitchen environment.

This guide aims to answer every question stakeholders may have about transitioning from traditional fuels to LPG, ensuring a smooth and informed transition.

1.3 General Introduction

Today, more than two billion people worldwide lack access to modern energy, relying instead on traditional fuels such as wood, charcoal, coal, animal waste, and rice husks for cooking. In many impoverished communities, anything that can burn and generate heat is considered a fuel source.

Most of these people live far beyond the reach of gas and electricity grids, making LPG the only viable solution to escape the traditional fuel trap. In the short term, LPG represents the highest attainable step on the energy ladder for these communities.

LPG's portability, high energy content, cleanliness, and ease of use make it a transformative energy source. Switching to LPG eliminates many of the challenges associated with traditional fuels:

- No more hazardous hours spent collecting firewood—a task that typically falls on women and children. Instead, this time can be used for education and economic activities
- No more struggling to light fires with damp fuel on rainy days
- No more exposure to harmful indoor air pollution, which poses severe health risks to entire families
- No more continuous fire maintenance throughout the day just to prepare meals.

Institutional kitchens using wood or coal require large storage areas to keep fuel dry and secure, particularly in monsoon seasons or winter months.

- The poor hygiene in these kitchens is often evident from the soot-covered floors and walls (see Figure 1.3.a)
- Coal briquettes, used as an alternative in some countries, create flame control issues, dirty cooking environments, and poor air quality. Finding coal dust in food is a common issue

While some aspire to switch to kerosene, it comes with significant hazards. Kerosene is often stored in repurposed bottles, such as those previously used for water or soft drinks. This leads to accidental poisoning, especially among children. Kerosene is highly flammable and presents a serious fire risk when handled improperly.

For communities without access to a gas grid or reliable electricity, LPG provides the most realistic alternative to traditional fuels. Even in areas with access to these grids, LPG remains an attractive option due to its affordability, efficiency, and ease of integration into existing kitchen setups.

LPG as a cooking fuel has several advantages:

- High-energy flame with precise heat control, ideal for simmering and wok cooking
- Clean and efficient, both in usage and storage
- Multi-purpose versatility—LPG can power generators, refrigerators, and water heaters, improving hygiene and overall kitchen functionality (see Chapter Seven)

Figure 1.3a - Wood fired stove in an institutional kitchen (source: LPGas Business)

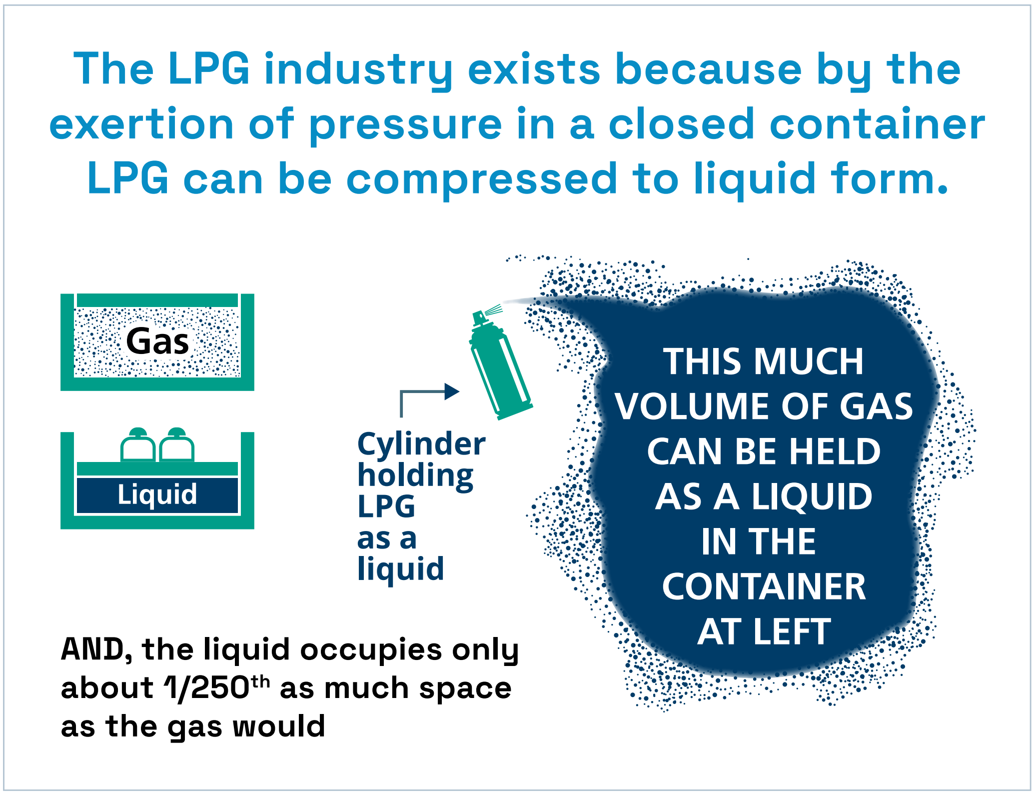


Figure 1.3b - Illustrative diagram showing the power of LPG (source: LPGas Business)

Compared to traditional fuels, LPG offers higher energy content and greater controllability. Its ability to be liquefied and stored efficiently makes it a convenient and practical choice.

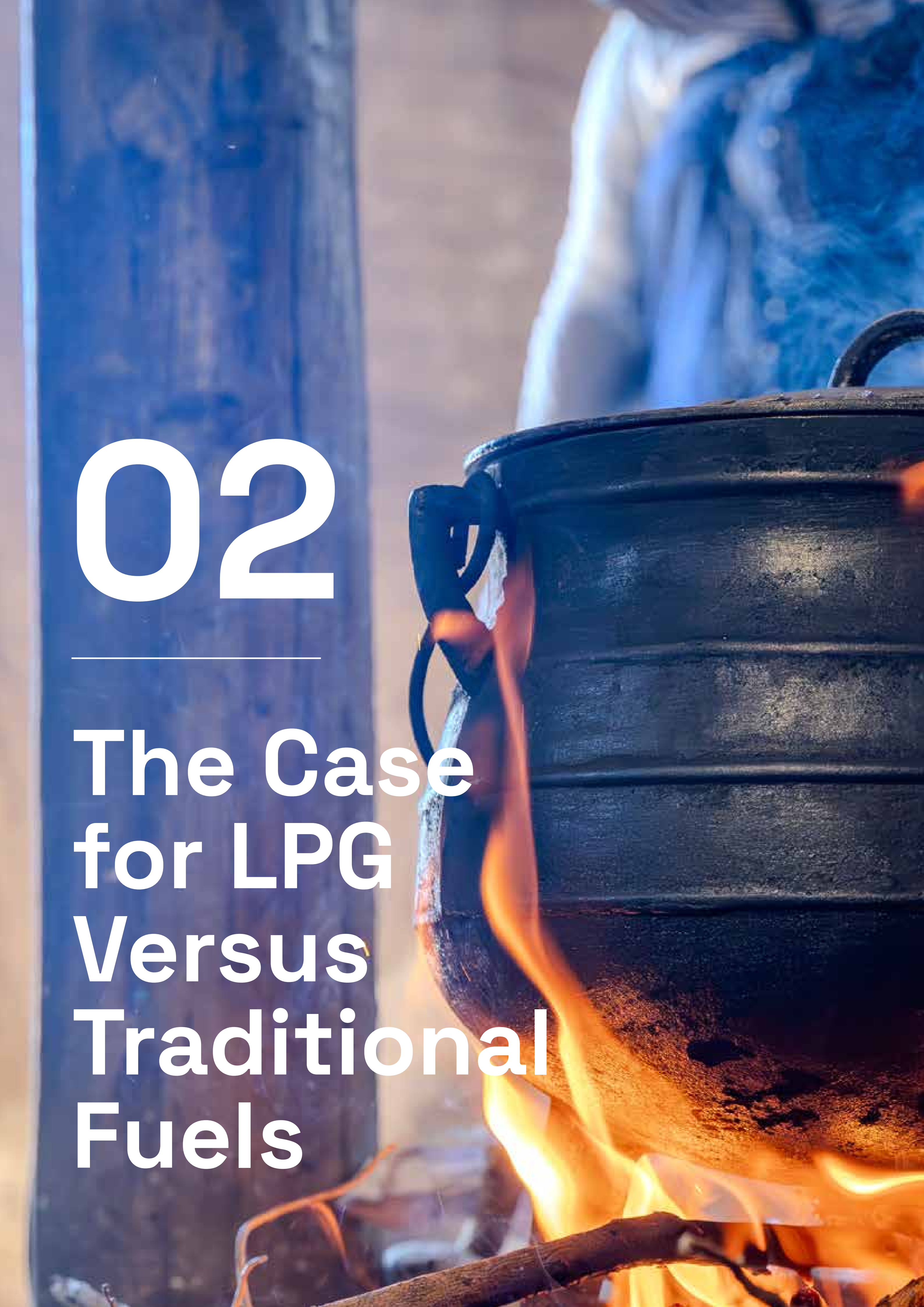
- In liquid form, LPG contains 250 times more energy than in its gaseous state (see Figure 1.3.b)
- LPG is stored in steel cylinders, which last for years with proper care
- Composite plastic cylinders are now available, offering lighter weight, corrosion resistance, and visibility of LPG levels

For kitchens with a high energy demand the LPG can be supplied in larger cylinders. Automatic changeover devices detect empty cylinders and switch to full ones seamlessly, also alerting users to reorder replacements.

Small bulk tanks can be installed for higher demand kitchens, allowing deliveries via bulk trucks. Both storage methods are covered in this document, including their design implications and benefits.

Unlike traditional fuels, the LPG industry is highly regulated, ensuring consumers receive a safe, reliable, and standardised product. LPG is available in a variety of cylinder sizes, providing secure and consistent energy for homes, businesses, and institutions.

For further details on LPG properties, safety considerations, and hazards, see Appendix One.



02

The Case for LPG Versus Traditional Fuels

2.1 Summary of Benefits of LPG Over Traditional Fuels (Health, Social, Environmental, Economic)

The use of wood, charcoal, coal, and kerosene as cooking fuels comes with significant dangers and challenges that impact health, safety, and the environment. Coal mining has a long history of injuries and fatalities, and the dangers don't end once it reaches the surface. Transportation, storage, and combustion of coal contribute to air pollution and serious health risks, especially when used in old, inefficient equipment.

In many communities, women and children are responsible for collecting firewood, a painstaking task that can take several hours each day (Figure 2.1a). The journey to remote forests is often dangerous, with risks including personal attacks and assaults, and conflicts with wild animals in forested areas. Young saplings—not fully grown trees—are cut down, threatening the future of forests.

This daily routine also has social and economic consequences:

- Lost educational opportunities for children who accompany their parents
- Reduced economic participation for women who could otherwise engage in income-generating activities
- Increased strain on families, as younger children are often left in the care of elderly relatives while their mothers and siblings collect wood.

When burned, traditional fuels release harmful emissions, particularly in poorly ventilated kitchens (Figure 2.1b). This exposure contributes to respiratory and cardiovascular diseases caused by smoke inhalation. Other serious risks include burn injuries, especially among children, and fire hazards, leading to property damage and loss of life.

Figure 2.1a - Women carrying wood (source: WLGA)

Figure 2.1b - Woman burning wood (source: WLGA)

Figure 2.1c - Children buying charcoal (source: LPGas Business)

Charcoal, while lighter and easier to transport than firewood, presents similar issues. Children are often sent to purchase charcoal, making them vulnerable to theft and assault as they carry money (Figure 2.1c).

LPG offers a safe, efficient, and environmentally friendly alternative to traditional fuels. Unlike the informal supply chains of traditional fuels, LPG is distributed by trained professionals, ensuring safe delivery and handling. LPG is cleaner to store and use. Unlike kerosene, which when spilt, smells, and poses a fire hazard, LPG disperses quickly in the event of a small leak.

LPG burns cleanly, producing significantly fewer pollutants than wood, charcoal, or coal. The LPG flame is hot, easy to control, and does not require continuous maintenance like wood and coal stoves, which must be kept burning all day.

For institutional kitchens, LPG can be supplied via large cylinder banks or small bulk tanks, providing a reliable and scalable solution to meet high demand. By switching to LPG, institutions and households can reduce health risks, improve safety, and protect the environment, while also freeing up valuable time for education and economic activities.

2.2 Case Study Kenya - Schools (Wood To LPG)

2.2.1 CLEARING THE AIR FOR AFRICAN SCHOOLS

Researchers from the CLEAN-Air (Africa) programme, based at the University of Liverpool, UK, are conducting the first comprehensive analysis of the substantial health gain that can be realised when switching African schools from polluting fuels to clean fuels such as LPG. (https://www.liverpool.ac.uk/population-health/research/groups/energy-air-pollution-health/research/nihr-clean-air-africa/); (https://cleanairafrica.com/)

Daniel Pope and Nigel Bruce from the University of Liverpool,have investigated the extent to which Kenyan schools use firewood for cooking meals for the students and staff. They visited schools that use firewood and examined the impact the resulting smoke emissions have on the cooks, teaching staff and schoolchildren.

This case study has been developed from a video they produced, which can be accessed here (Healthy kitchens: Clearing the air for African schools).

More than 90% of African schools rely on firewood and charcoal for cooking meals for students and staff. In Kenya alone this results in more than 1.3 million metric tonnes of wood being consumed each year by schools and colleges.

This has a huge environmental impact on forest reserves in the region. The dangerous levels of air pollution from burning wood fuel in open stoves adversely affects the health of those working and learning in the school environment. The toxic smoke from the kitchens also contaminates the classrooms, school playgrounds, as well as the surrounding communities.

NJENGA PRIMARY SCHOOL, MUKURU KWA NJENGA, KENYA

The head teacher of Njenga Primary School, Ms Lenah Kariuki, explains that for many of the 2,300 pupils attending her school, their school meal may be the only meal they have all day. The food requires hours of cooking time to produce a soft, palatable meal, so the cooks have to arrive early to work in order to light the wood, and they leave late.

She says, '*…Burning firewood for the cookstove results in a very smoky environment causing the cooks to suffer wet and stinging eyes, runny noses, sore throats and they get bad chest infections from inhaling the smoke. They also suffer burns from the firewood as they have no protective gloves…*'

In order to quantify the level of pollution, monitors were installed in the kitchens, classrooms and playgrounds. The cooks also wore monitors. The results showed that the WHO recommended limits for PM2.5 and

Figure 2.2a - Cooking with wood generates up to 5 times the WHO maximum levels of PM 2.5 and CO (source: Nigel Bruce & Daniel Pope)

Figure 2.2b - Kitchens and classrooms are often open plan and share the same environment (source: Nigel Bruce & Daniel Pope)

carbon monoxide (CO) were exceeded in all areas, with average levels in the kitchen exceeding up to five times the maximun WHO limits, with massive peaks during the day (https://www.who.int/publications/i/item/9789240034228).

Ms Lenah Kariuki said it was important to engage all stakeholders of any plan to transition away from wood to LPG and for everyone to agree the financing, and make the investment to install the LPG equipment.

She said *'…apart from the economics and health advantages, identifying other potential benefits helps to gain support to the scheme (e.g. stopping local deforestation around the school)..' '…She said when the wood is wet it is difficult to burn, creates more smoke and cooks get sick and cannot work….'* Wood trucks get stuck in wet weather delaying deliveries of wood which is sourced up to 100km away from the school. The Njenga Primary School spends almost KES500,000 (US$3,800) a year

Figure 2.2c - A truck carrying firewood stuck in mud – (source: CLEAN-Air (Africa) who sourced the image from Shutterstock)

on wood. This is more than the equivalent cost of cooking with LPG.

ALLIANCE HIGH SCHOOL, NAIROBI, KENYA

The Alliance High School in Nairobi is a public secondary school with 1,900 boarders. David Kaman, the Head teacher at Alliance, said the school initially invested in a biogas plant using cow manure but it couldn't meet the demand and was inefficient. The reverted to firewood in 2019. The school switched to LPG in March 2021 after a successful pilot scheme.

Converting cookstoves from wood to LPG is not complicated but it does require investment in LPG storage and handling facilities. Only 2% of schools in Kenya currently use LPG.

EQUITY GROUP FOUNDATION (EGF)

Alliance High School was the first in a programme of school kitchen conversions supported by loans from The Equity Group Foundation (EGF) with all schools in the country targeted (https://equitygroupfoundation.com/wp-content/uploads/2021/03/Press-Release-Equity-Launches-Clean-Cooking-Initiative-to-Support-Learning-Institutions-Transition-to-Cleaner-Suatainable-Environment-Friendly-Sources-of-Cooking.pdf).

Dubbed the 'Clean Cooking Project', the EGF initiative aims at supporting learning institutions to install modern technologies for cooking that are environmentally safe

including LPG. They will provide financing for the equipment and other installation costs based on an institution's needs.

Speaking during the launch of the initiative at Alliance High School, Equity Group Managing Director and CEO, Dr. James Mwangi said, *'…Wood-fuel is not a sustainable model for our planet as it has led to adverse environmental degradation and depletion of our much-needed forest cover. Lack of appropriate financing and innovative technologies has been the biggest barrier to clean energy transition. To close this gap, we have decided to partner with learning institutions to facilitate them access and install more environmentally friendly cooking and lighting facilities…'.*

Figure 2.2d - Converting a wood burning stove to LPG is relatively cheap and simple to achieve (source: Nigel Bruce & Daniel Pope)

Eric Naivasha, Assistant Director, Energy Environment and Climate Change at the EGF, explained how the Foundation provides a loan facility to convert from cooking with wood to LPG with repayment over a five year time frame. He said the economics are so attractive the loan can often be paid back in shorter timeframes, as quickly as 12 – 24 months.

The conversion is relatively simple as the cooking infrastructure is not replaced. The gas burner is installed inside the stove - where the wood was burnt - with the rest of the investment limited to the gas piping, storage facility, and safety infrastructure, including cut-off valve. The EGF is fully committed to working with all learning institutions in Kenya for them to realize the multiple benefits of modern and clean energy.

KENYAN GOVERNMENT

In 2021, the Kenyan government's Education Cabinet Secretary at the time, Prof. George Magoha, who presided over the launch, said, *'…Alliance High School has traditionally used wood for cooking, harvested from trees in its compound. With the installation of clean cooking infrastructure, the school can now reap the benefits of cleaner and environmentally friendly cooking solutions. This is a project that is transformative and in line with the Government's agenda. When you look at the negative effects of climate change you will understand its importance…'.*

He went on to say *'…My call today is for all schools in Kenya to quickly follow suit and embrace clean energy solutions. This will contribute to reverse environmental degradation, saving costs and improving health outcomes. If all schools switched to cleaner alternatives, we will not only preserve our trees but will also significantly reduce our carbon footprint. By transitioning to cleaner fuels like LPG, institutions can realize up to 40% savings in their cooking budget with better health and environmental outcomes, improved kitchen hygiene and motivation of workers…' '…I am very grateful to Alliance High School, Equity and its technical partners for making it possible to have Alliance transition from a heavy consumer of wood fuel to modern and cleaner cooking technology that preserves the environment. The school's kitchen will be used as a model for all institutions that want to adopt this technology…'* added Prof. Magoha.

KENYAN COMMERCIAL BANK (KCB)

The KCB has also stepped in to support the schools wood to LPG transition scheme with a discounted loan facility. These schemes are supporting the Kenyan governments target to transition all schools away from wood to LPG in the next few years. The Ministry or Education is working closely with both banks to achieve this. The banks are also targeting other African countries where they operate to encourage similar transitions including Uganda, Ruanda, Tanzania, DRC and South Sudan. Programmes have been developed for schools in these countries.

Figure 2.2e - School children are great advocates for clean cookstoves in kitchens (Nigel Bruce & Daniel Pope)

KENYAN MEDICAL RESEARCH INSTITUTE

Using new laboratory facilities at the Kenyan Medical Research Institute in Nairobi, CLEAN-Air (Africa) will be measuring improvements in air quality and health resulting from transition away from wood to LPG in the kitchens. The evidence will be used to help inform policies to ensure progress towards clean cooking for all schools in Kenya and the wider sub-Saharan African region.

As well as improved air quality in the school environment – necessary for the health and wellbeing of school staff and learners, reducing reliance on wood will also ensure energy security, allowing regular nutrition for children which is vital for the education of Africa's up and coming generation. There are also plans in the future to look at educational outcomes (evidence of improvements on cognitive performance).

This case study was drafted with support from: **Daniel Pope & Nigel Bruce - University of Liverpool**

Thanks also go to:

- Kenya Medical Research Institute (KEMRI)
- Clean Air Africa – Global Health Research Unit
- National Institute for Health Research – UK Aid

2.3 Case Study Pakistan - Tandoor Oven (Wood to LPG)

Figure 2.3a - Tandoor oven burning wood
(source: LPGas Business)

The traditional way to cook naan bread, commonly used in the Indian sub-continent, is in a tandoor oven fuelled by wood. This example is of a small restaurant outside Karachi in Pakistan using four tandoor ovens that the owner wanted to convert to LPG.

In this example the change was driven by the owner who wanted to make savings on his fuel costs. He decided to arrange for the conversion of one of the ovens from wood to LPG, and invited a major LPG company to advise him on the process.

There were concerns from several stakeholders about changing from wood to LPG.

One of the key concerns was the fear that the customers eating the naan bread in the restaurant would notice any difference in taste. The owner believed there would be significant economic benefits from switching to LPG from wood, but he did not want any adverse impact on his clientele who were mostly regular customers.

He decided not to tell his customers about the switch beforehand and to seek their comments and feedback afterwards.

The trial was conducted by modifying one of the ovens to run on LPG instead of wood. The same oven was used except the wood grate was removed and an LPG burner was fitted into the base of the one of the tandoor ovens. The owner was expected to create space for LPG storage later, but for the trial he used an LPG cylinder connected directly to the tandoor oven.

The time taken to cook the naan bread, and the amount of gas used, were both measured. The staff were thoroughly trained in the storage, handling and operations of using LPG beforehand.

The restaurant ran a trial for two weeks and then the results were assessed. The customers of the restaurant were asked about their views of the taste of the naan bread, especially the ones receiving the bread from the LPG fired oven. The owner made an excuse about a new oven but didn't mention the change of fuel.

The result of the trial was positive with a number of benefits:

- The restaurant owner was happy because the fuel cost, per cooked naan, was much lower with LPG
- The customers did not notice any difference in taste (which was positive)
- The wood distributor was concerned about losing a key customer (until he was told he could become an LPG distributor and supply the restaurant, and others who were to switch later)
- One of the head cooks in the kitchen was unhappy. It was discovered he regularly inhaled the smoke from the wood fired tandoor oven and that activity would stop with a total switch of all ovens to LPG

Following the trial a calculation was done on the amount of LPG used and a small storage installation was designed based on large LPG cylinders. All four ovens were subsequently converted to run on LPG enabling the transition to be made with minimum change to the facilities. At that stage the individual who had been inhaling wood smoke in the kitchen was replaced.

After the conversion the delivery time for getting the naan bread to the tables was shortened and savings were made on the restaurant's energy costs because the ovens could be heated quicker, and the flame could be controlled more efficiently.

The key lessons learned were that all stakeholders need to be fully involved with any change process and the impact of the change needs to be fully understood.

Secondly there needs to be an accurate measure of the energy costs in order to quantify the savings. In the case of the restaurant that was measurement of the amount of energy used during the opening hours and linking that to the output of the ovens (number of naan bread cooked in a shift versus kg of LPG used).

2.4 Case Study China - Street Restaurant (Coal To LPG)

Conversion of a coal briquette fired restaurant to LPG in China.

This example looks at a roadside commercial kitchen that was using coal briquettes, and targeted to switch to LPG.

The coal briquettes (Figure 2.4a) are small cylindrical blocks of compressed coal dust, held together with a binder, with several holes running though their length in order for the air to circulate.

These coal briquettes are dirty to store, handle and burn and difficult to control the heat output once lit. Often the stall holder will control the heat by having several stoves with the fires at various stages of intensity (Figure 2.4b).

The challenge was to convert this application to LPG without disrupting the commercial operation of the restaurant.

The owner of the stall was interested in the proposition to switch away from coal, but needing convincing about using LPG, was nervous about the impact that running a trial would have on his business, and needed evidence that it would save him money.

Demonstrating the benefits of LPG to the owner was not so difficult. A small demonstration, with a LPG cylinder and hot plate, and boiling a kettle of water was simple enough.

Figure 2.4a - Coal briquettes in basket (source: LPGas Business)

Figure 2.4b - Commercial wood burning stove (source: LPGas Business)

Especially when running the demonstration with a coal briquette stove alongside with a similar kettle of water (three kettles of water could be boiled on an LPG flame while the one on the coal stove was still waiting to boil).

Apart from the interruption in the kitchen during any trial, the main challenge was the compatibility of the LPG stove with the existing appliances in the kitchen (woks, pans etc.) and how the LPG stove would fit into the kitchen environment.

It was decided to run the trial in a way that two objectives could be met:

(i) **The concept of using LPG would be tested in a separate stove that had the same configurations, and height, as the coal briquette stove.** This would allow the existing pans to be used, and replicating the environment of the existing kitchen.

(ii) **The existing coal briquette stoves would be converted to run on LPG rather than introduce new equipment.** This would not only reduce costs it would minimise change.

A clay coal briquette stove commonly found in domestic kitchens (Figure 2.4c) was used for the trial. The stove is used in domestic households not only as a cooking stove but also a room heater in the winter months.

The conversion of the stove shown in Figure 2.4c allowed the existing cooking equipment to be used.

Also, the workers at the restaurant were very familiar with the clay stove and this limited the degree of change they would face in the trial. The alternative would have been to use an LPG stove.

To conduct the trial, a simple LPG burner head was modified and placed inside the clay stove with the hose running down the centre and out the bottom to the cylinder.

This allowed the existing equipment to be used on the LPG fired stove alongside the existing five burner coal fired stove.

The result was very positive with all workers keen to switch because of the ease of use, powerful and controllable flame, and cleanliness of operation.

Having run the trial, the existing coal stove was quickly converted using the same configuration shown in Figure 2.4c and the restaurant had switched from coal to LPG in less than an hour.

One of the benefits of such a highly visible application as a street side restaurant is the number of people who have the opportunity to see it in operation. As a result of this successful conversion, not only did other restaurants in the town switch to LPG but many domestic users also switched because the conversion was so simple.

The trial demonstrated the inefficiency of burning wood and coal as the temperature cannot be easily adjusted leading to a waste of energy. A correctly regulated gas flame burns blue.

Figure 2.4c – Coal briquette burner modified to use LPG [4.5kg cylinder] (source: LPGas Business)

The key lessons from this example are the need to keep the switch simple by minimising the amount of change.

The use of a popular, clay, coal burning stove removed a barrier that the LPG stove might otherwise have presented. By modifying this stove to use LPG allowed the kitchen equipment to be re-used with LPG. It also opened up bigger opportunities in the domestic sector where the conversion from the clay coal burning stove to LPG could be done using the same equipment.

Finally minimising the disruption to the day-to-day operation of the busy restaurant by retaining the existing five burner stove and converting to LPG with confidence was important to everybody involved, especially the restaurant owner.

After this successful conversion a vigorous campaign was run targeting the domestic users focussing on a demonstration outside the LPG dealer's retail outlet. The crowds stopped traffic in what was to be a very successful campaign that saw the beginning of the demise of the coal briquette stove in both small restaurants and domestic households. The LPG cylinder shown in the photo is 4.5kg. This was used to penetrate the domestic market because the total weight of a full 4.5kg cylinder was no more than the weight of a large bag of rice which the woman in the household could carry. The stove used for the launch sat on top of the cylinder, replicating the dimensions of a clay coal fired oven (source: LPGas Business).

03

Converting from Traditional Fuels To LPG

3.1 Preparation for The Transition To LPG

For so many people in the world the use of traditional fuels is not challenged. There simply is no alternative.

The chore and hazards of collecting the fuel, storing it in a dry secure place, struggling to light the fire every day, tolerating the filth and dangers that come with the smoke emissions; these are never questioned.

Aspiring to an alternative, cleaner and more efficient fuel is often not considered simply because of the lack of knowledge, availability and understanding of alternatives.

This presents a significant challenge to all stakeholders when there is an opportunity to convert to an alternative fuel, especially LPG.

Unlike traditional fuels, which are very visible, LPG is a gas.

LPG is contained as a liquid under pressure inside a cylinder or tank under pressure. It cannot be seen or touched or stacked. Traditional fuels, such as a pile of wood, creates a constant visual reminder of the energy available to the distributor or user.

The difference between using traditional fuels and LPG as a primary energy source in kitchens is significant and impacts all the stakeholders in the supply and distribution channel.

Figure 3.1a - Wood pile at retail outlet
(source: LPGas Business)

3.1.1 ENGAGING STAKEHOLDERS

Identifying and engaging the stakeholders who are impacted by the change to LPG from traditional fuels is an important first step to take in the change process in order to gain their acceptance.

Who are these stakeholders? The diagram below suggests some of the stakeholders that can have an influence in the change process, either in a positive way and/or a negative way.

Some of the most important stakeholders are the ones involved in the fuel supply and distribution chain. For the traditional fuel suppliers, like the ones shown in Figure 3.1c, the emergence of LPG as a competing fuel will be a threat. To lose commercial business for these suppliers of wood would be a big blow and they will resist change.

During the conversion programme in Indonesia when tens of millions of kerosene users, including small and medium sized enterprises were switching to LPG, there were complaints from kerosene distributors about the impact on their business. That had to be managed. (kerosene-to-lp-gas-conversion-programme-in-indonesia.pdf)

Often these distributors can readily change their fuel supply business from traditional fuels to LPG, but it may take persuasion, and will certainly take education and training, before they can take on that new role.

They have to understand the benefits of change. Not simply the benefits to their bottom line but also they need to become champions of LPG and promote the benefits to health, to the environment and to the economy.

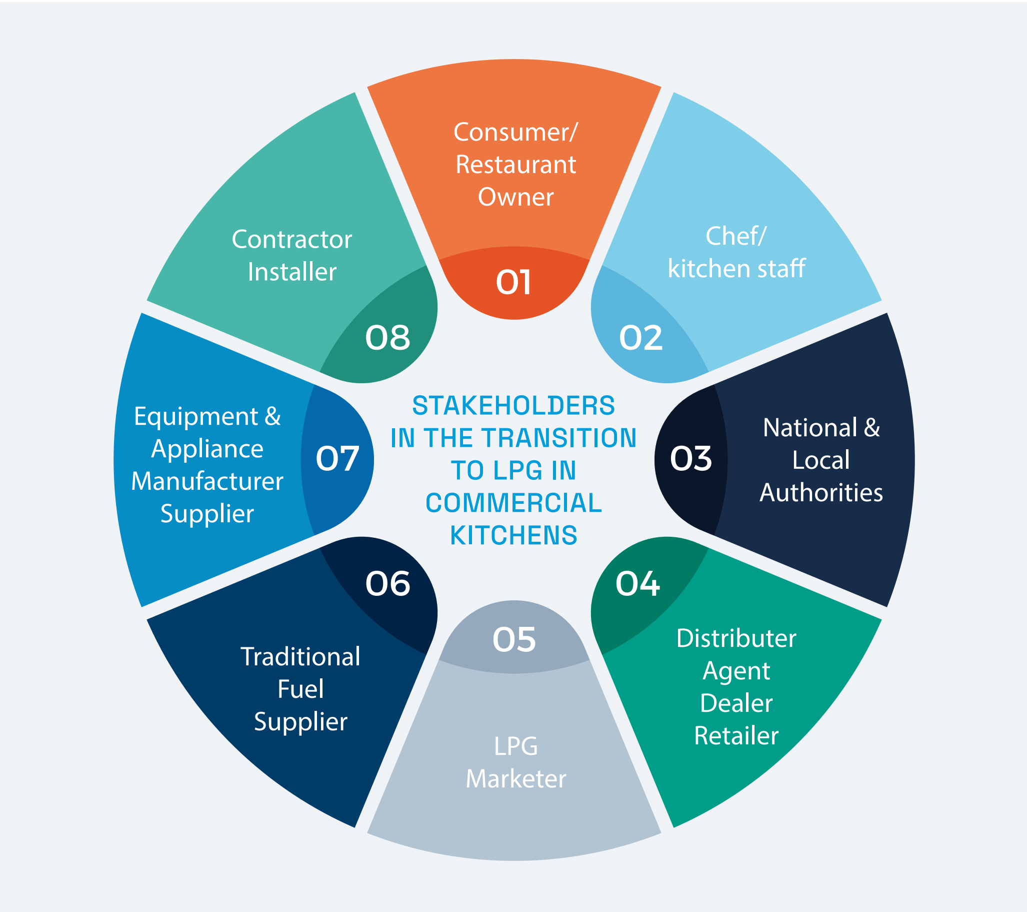


Figure 3.1b - Stakeholders in the LPG transition process (source: LPGas Business)

Figure 3.1c - Wood seller in East Timor
(source: LPGas Business)

Figure 3.1d - Multi fuel outlet in Indonesia
(source: LPGas Business)

This fuel supplier in Indonesia (Figure 3.1d) saw the opportunity of diversification and was able to supply wood, charcoal, kerosene and LPG depending on the consumers choice. But he admitted the introduction of LPG was seen at first as a threat, and then an opportunity.

This is a business in transition. The move from the old game to the new game. By still retaining an interest in the traditional fuels allows him to protect his business during the transition to LPG.

Equipment suppliers are also impacted by change. The need to understand modern gas appliances and all the associated equipment such as pipework, regulators, vapourisers etc.

3.1.2 SECURING BUDGET FOR THE TRANSITION

To convert an institutional kitchen from traditional fuels to LPG requires investment. Unlike wood or coal, LPG is a fuel stored under pressure in a purposely designed and manufactured container and requires a system of pipework and equipment to operate safety and efficiently.

System design is covered under CHAPTER FOUR and the equipment and appliances needed to switch to LPG is fully explained. The investment for designing and installing a system to convert an institutional kitchen from traditional fuels to LPG will need to be found. This may be achieved through government, private or non - government support.

Justification for transitioning away from traditional fuels to LPG will not be difficult when all the benefits are factored in. Apart from the obvious improvements in hygiene, cleanliness, and health and safety in the work environment, there are the tangible economic benefits in energy consumption.

The easy to control ‘turn down’ or ‘turn off’ of an LPG flame will eliminate the need for sustaining a fire under a traditional fuel stove and associated wasted fuel. These will benefit the stakeholders in the kitchen and encourage investment in LPG.

Then there are the environmental benefits associated with cutting back on deforestation and these might encourage investment or grants from a government keen to assist in arresting the use of wood as an institutional fuel.

It is mentioned elsewhere but it is worth repeating the need for planning for expansion. An option to add an additional storage tank or new kitchen appliances should be factored into the design to minimise the need for additional investment when time occurs.

3.1.3 ESTABLISHING THE REGULATORY FRAMEWORK, ENFORCEMENT AND COMPLIANCE

Although LPG may be a new product for organisations and consumers looking to transition from traditional fuels it is far from a new fuel. LPG has been in use for over 100 years in many countries and during this time there have been some sound standards and codes of practice developed to ensure safety and minimising the risk of accident when using LPG.

LPG is a hazardous product and must be stored, handled and used correctly. It is important for new users to know and understand these good safety practices and equally important for regulatory authorities to ensure enforcement and compliance to these. If standards/code of practices are not in existence in your area, industry will have to work with the local authorities to put standards in place.

The LPG business sometimes attracts illegal activities such as using recycled cylinders that have already been scrapped, under filling of cylinders and illegal filling of other company's cylinders.

It is important these illegal activities are stopped, and all efforts should be made to outlaw them, both by the LPG industry through vigilant attention to the distribution channel and by government through an effective and enforceable legal structure.

3.1.4 DEVELOPING THE SUPPLY CHAIN

Although LPG is used in most countries in the world, there are places where the supply chain for LPG is not well established, particularly where traditional fuels still remain as the dominant household fuel.

LPG is a by-product from the crude oil refining process and natural gas production. In countries where there is no, or insufficient, local LPG production, it is necessary to import LPG to meet the demand. LPG can be transported using ships, rail cars or road tankers. The choice of which mode of transport to use will depend largely on the quantity of LPG to transport and the geography between the source and receiving point. LPG import cargoes are usually unloaded into big terminals situated in isolated areas for safety reasons and the product is further transported to smaller depots and filling plants nearer demand centres where the product is either filled into cylinders for distribution by a network of dealers or delivered in bulk to end users. A typical established supply chain is shown in APPENDIX TWO

LPG cylinders come in various capacities. The majority of cylinders supplied to the household sector are generally below 15kg in capacity but for small institutional kitchens, cylinders used can be typically between 45kg to 50kg capacity. These cylinders when consumed are replaced with newly filled ones and the empty cylinders are taken back by distributors to the filling plants for refilling. Refer to CHAPTER FOUR for more details.

Unlike cylinders, LPG bulk tanks are replenished onsite using road tankers. These road tankers are equipped with their own pumps, hoses and other appurtenances necessary to fill up bulk tanks at the site. This arrangement is suitable for end users with big consumption. Countries in transition from traditional fuels to LPG will require a supply chain to develop the market. Initially this might focus on cylinders but as the market develops the need for bulk supplies will grow.

3.1.5 CONVERTING TRADITIONAL FUEL SUPPLIERS TO LPG DEALERS/ RETAILERS

One of the obvious opportunities for stakeholders in the traditional fuel business is to move with the transition and become involved in the LPG business as part of the supply and distribution chain. This creates a less complicated transition by preserving their livelihood and removing some of the obstacles to change.

This stakeholder group, like other groups new to this fuel must undergo basic LPG training and comply with all safety requirements.

Figure 3.1e - Hands on training in India (source: IOC, India)

3.1.6 TRAINING ON LPG SAFETY AND REGULATIONS FOR ALL STAKEHOLDERS

With this developing supply chain comes a need for education and training. Training of cylinder filling plant operators, contractors, dealers, retailers and consumers. It is possible that training facilities are available in the country of transition, but it is probably more likely that training courses are organised in country using overseas resources with expert knowledge on LPG operations.

On-site, and virtual training and education are powerful tools that can be used. Taking the information to the user through demonstrations is an effective method.

As a minimum, the training should cover basic characteristics and properties of LPG, safe handling procedures and emergency response actions.

This LPG supplier in India (Figure 3.1e) was able to educate new users of LPG of its benefits and important properties by taking a small ‘road show’ into the community together with personnel having expert knowledge on LPG operations.

3.2 Basic Considerations When Converting To LPG

3.2.1 CHOOSING LPG SUPPLIER AND INSTALLER

LPG suppliers play an important role in the success of the conversion programme. They may be a producer, primary marketer, or a distributor appointed by a marketer. LPG suppliers should be selected based on their track record of providing reliable supply and compliance to safety standards.

LPG suppliers are responsible for the quality of the LPG supplied i.e. conformance to agreed specifications or declared standards and for the quantity of LPG delivered i.e. declared volume in bulk delivery or weight in the cylinders filled.

LPG suppliers should ensure reliable supply to consumers by maintaining sufficient inventory in its terminal or depot or in the case of distributor should have sufficient filled cylinders in their warehouse to meet the requirements of its consumers. Reliable supply also means having the logistics capability to bring the products to the consumers when they need it. Any disruption in supply will discourage consumers from converting to LPG.

LPG suppliers that provide cylinders and tanks to consumers should ensure these containers meet applicable standards and are always maintained to safe working conditions i.e. cylinders supplied should always be within their requalification validity date. This minimises risks of any incidents associated with poor LPG cylinders or tanks.

Installers provide the service for connecting the LPG containers to the consuming appliance. They are responsible for designing the piping system suitable to the consumer’s needs and for ensuring that the pipework conforms to statutory or code requirements.

Installers should be competent and possess the correct qualifications to carry out LPG piping works. Some countries have accreditation or licensing requirements for installers which should be one of the factors for choosing installers.

Installers are also responsible for instructing the consumer on the correct way of using the LPG installation and the safety features and actions to take in case of an emergency. These should be done when the piping works have been completed and before they are handed over to the consumer.

It is not unusual for LPG suppliers to be installers as well. In this case, the whole LPG system from container to piping up to the appliance is under the responsibility of one party.

3.2.2 LPG SUPPLY CONTRACTS

There are different types of LPG supply contracts between consumer and suppliers. Each of these will have their own advantages and disadvantages, and consumers must choose the supply contract most beneficial to them based on their own situation. Some examples of the more common LPG supply contracts are as follows:

(i) LPG Supplier owns and provides cylinders, tanks and piping

This is the preferred business model, called Branded Cylinder Recirculation Modal (BCRM). Under this model, the LPG supplier provides the consumer with the LPG container and piping and is responsible for maintaining it to a safe and serviceable condition. The LPG supplier retains ownership over these assets and if any of these become defective i.e. corrosion, dents, leaking, etc., the LPG supplier is responsible to repair or replace them. The cost of the LPG facility provided by the LPG supplier is typically recovered through the LPG price and binds the consumer to an exclusive supply contract over a period. The contract duration is typically long enough for LPG supplier to recover his investment and make a reasonable return.

(ii) Consumer owns the LPG cylinders, tanks and piping

Under this contract, the consumer buys and owns the LPG cylinders, tanks and piping. He is responsible for maintaining the entire LPG facility in safe and operating condition and this should be contracted out to a trained installer. The LPG supplier's role is to deliver the gas. Since the consumer owns the LPG facility, he is not tied down to any exclusive supply contract with one supplier and has the benefit of shopping around for the best price whenever he needs LPG. For this type of contract, it is critical that the consumer takes out a maintenance agreement to ensure the cylinders, tanks and pipework are always kept in a safe and serviceable condition.

(iii) Other Contracts

There are variations to the above contracts. One is where the consumer owns the cylinders, tanks and piping and opts to have an exclusive supply contract with one LPG supplier. This type of contract is useful if LPG supply in the locality is unstable and having an exclusive contract will guarantee continuous supply and minimise risks of stock outs. The consumer should include inspection and maintenance of the equipment as part of the supply contract. This contract typically has a shorter duration since the supplier does not have any upfront investment to recover. Another variation is one where the containers and piping are invested initially by the LPG supplier and paid by the consumer through a monthly amortisation scheme over the duration of the contract. By the end of the contract, the containers and piping become of the property of the consumer. Throughout the period the equipment must be serviced and maintained in a safe and fit for purpose condition.

3.2.3 SPACE FOR LPG INSTALLATION

Consumers converting from traditional fuels to LPG must be prepared to allocate a suitable space for their LPG installation. The location must comply with safety standards so as not to pose a hazard to people in the building as well as the surrounding community (see section 4.2).

LPG installations should be outdoors, and the space required will depend on the quantity of LPG to be stored. The quantity of LPG stored also determines the safety distance to the nearest buildings or structures i.e. the bigger the quantity of LPG, the farther it should be from the nearest building. Cylinder installations will typically require a smaller footprint compared to bulk tank installations because of the smaller amount of LPG stored.

Where cylinder installations are allowed by law to be indoors, they must be in an isolated section of the building and ventilated to outside air. It must comply with all safety requirements.

The location of the LPG installation should be accessible to delivery trucks, particularly bulk storage facilities. Deliveries can take a few minutes to an hour depending on the quantity of LPG to be unloaded. This should be considered when selecting a site to avoid inconvenience to occupants of the building and minimise any risks during delivery. The reversing of delivery trucks should be avoided in the design.

The installer is usually the person qualified to assess the suitability of a space for LPG installation and to give recommendations, if any, to meet safety requirements.

3.2.4 LPG APPLIANCE

To be able to cook with LPG the use of an appropriate appliance is required. LPG appliances are efficient and convenient to use compared to traditional stove using charcoal or firewood. They provide a flame with just one turn of a knob and that is easily controlled for a steady and consistent heat. This reduces cooking time significantly.

LPG appliances emit no smoke and other toxic fumes that can be health hazards. They must however be placed in a location with sufficient ventilation supply needed air for combustion and as well as to disperse the products of combustion consisting mainly of carbon dioxide and water vapour. This minimises risks of build-up of carbon monoxide and asphyxiating (oxygen deficient) conditions.

There are many types of LPG appliance available that can meet the different cooking needs of the consumer i.e. burners, ovens, etc. The right appliance should be chosen for consumers to optimise the benefits of switching to LPG.

Consumers must buy appliances that are certified and/or meet applicable standards or regulations. Buying uncertified appliances may pose a risk to the user.

The LPG appliance chosen must be compatible with the grade of LPG used. Propane burners are typically adaptable for use with LPG with minor adjustments of the air vent. The installer must be consulted regarding any adjustments to be made on the appliance.

LPG appliances used should have automatic igniter and flame failure device. The latter is a safety feature that cuts off the flow of LPG to the burner in case the flame is extinguished for some reason (i.e. blown out by weather) to avoid the discharge of unburnt gas.

A conventional LPG burner follows a simple combustion principle. Gas passing through the injector draws in about half of the air required (called primary air) for combustion which then mixes together in the burner mixing tube. The rest of the air required (called secondary air) is drawn into the outer envelope of the flame itself from the surrounding atmosphere.

The amount of primary air entering the burner mixing tube can be adjusted on some appliances by an aeration screw or shutter to achieve a clean blue flame that does not result in soot. On other appliances where there is no provision for adjustment, the burner has a fixed aeration pre-set by the manufacturer, to entrain the correct amount of primary air. The amount of secondary air is not normally regulated and is dependent on the ventilation of the room.

Insufficient air will result in yellow tipping of flame. On the other hand, excessive air will cause lifting flames. It is the appliance installer's responsibility to ensure there is adequate supply of air for combustion and for the comfort and safety of the occupant.

It is recommended that LPG appliances are installed and serviced by an approved installer.

3.3 Some General Observations From School Conversion Programmes

The following general observations are provided from discussions with stakeholders who have been involved when successfully transitioning school kitchens from wood to LPG:

3.3.1

Ensure a sustainable long-term feeding programme, together with the associated financial support, is already established before investing in kitchen infrastructure and equipment

3.3.2

Focus investments on schools with larger student populations for higher impact outcomes

3.3.3

Assess schools for appropriate kitchen facilities, adequate ventilation, and storage space for LPG cylinders/ tanks together with the associated equipment

3.3.4

Assess and address any gaps in hygiene, food safety, and distribution facilities to meet comprehensive feeding programme needs

3.3.5

Match the equipment selection with the complexity and type of meals served

3.3.6

Prioritise durable, institutional-grade cook stoves and compatible LPG systems tailored to the local needs

3.3.7

Ensure there is an equipment maintenance programme in place, with the capacity to be sustainable long term for the schools

3.3.8

Programmes with designated cooks rather than volunteers tend to be more successful

3.3.9

Provide hands-on training for cooks to ensure safe LPG usage, proper meal preparation, and hygienic kitchen operation and maintenance (see also CHAPTER SEVEN)

3.3.10

Avoid 'drop-and-go' models; analyse infrastructure and hygiene needs comprehensively before deployment

3.3.11

Implement regular monitoring and evaluation of equipment functionality, programme impact, and food quality

3.3.12

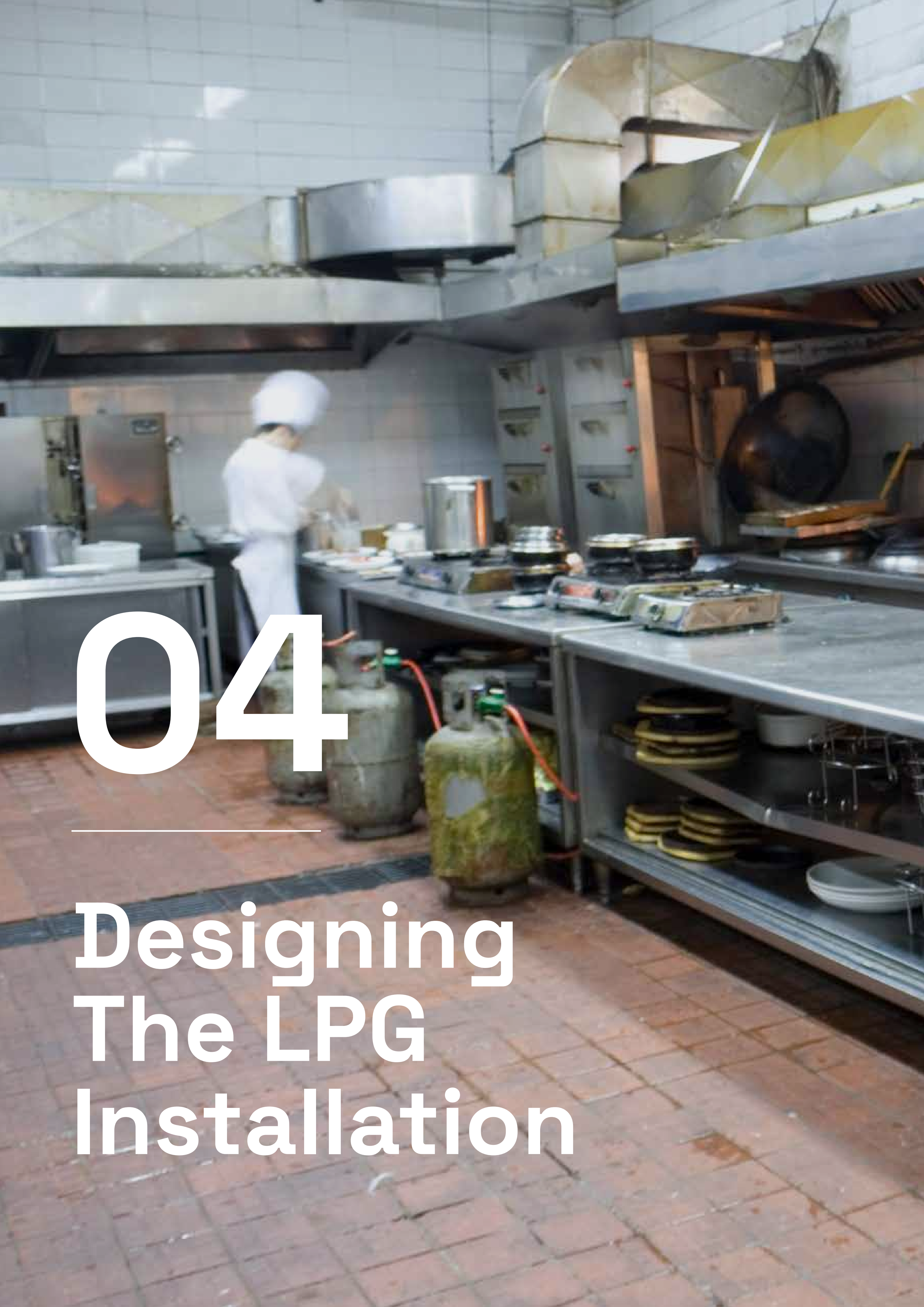
Ensure a robust and continuous LPG supply chain is in place for the school and flexibility of purchase options exist for schools that operate on scheduled funding payment cycles

3.3.13

Use targeted messaging to address LPG safety concerns and misconceptions

3.3.14

Leverage schools as hubs for broader LPG adoption, extending benefits to surrounding households through children/parent interaction



04

Designing The LPG Installation

4.1 General

A properly designed LPG installation ensures safe and reliable usage. This benefits both the consumer and LPG supplier and encourages non-users to convert from traditional fuel to LPG.

A good installation is one that has the correct storage capacity, uses the right pipe size, is sited in a safe location and is fully compliant to local regulations and international LPG standards or codes of practice.

All materials and equipment used must be compatible to the grade of LPG used.

LPG installations should be designed and installed by a competent and qualified installer.

4.2 Components of LPG System

A basic LPG system consists essentially of the LPG container (cylinder or tank), piping or tubing, a regulator and an appliance. The container stores LPG under pressure in liquid form and generates vapour when pressure is released. The container can be cylinder(s) or bulk tank(s) depending on the needs of the consumer. The piping or tubing conveys the vapour from the container to the appliance where it is ignited to create the flame for cooking. LPG vapour pressure inside the container fluctuates with changes in temperature which is not good for the appliance. The regulator is used to control the vapour pressure to a constant and appropriate level for efficient performance of the appliance.

In cases where containers do not have capacity to generate sufficient vapour for the appliances connected, a vapouriser is used. The vapouriser withdraws liquid LPG from the container and vapourises it by means of electrical power or circulating hot water supplied from a boiler or water heater.

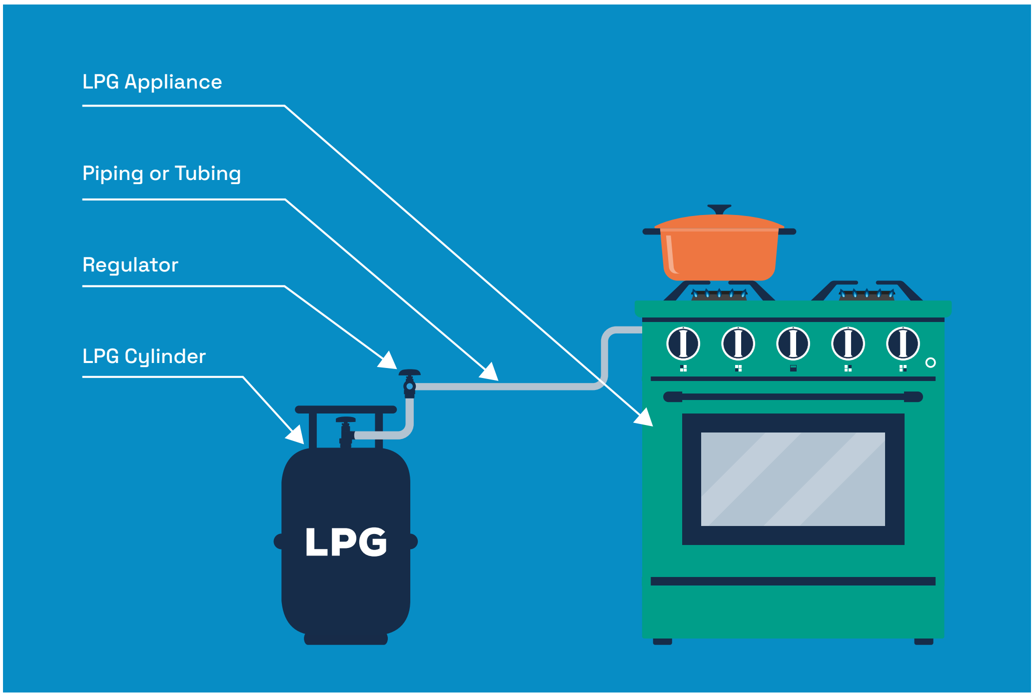


Figure 4.2a - Basic components of an LPG system (source: LPGas Business)

4.3 Sizing the LPG Installation

4.3.1 DETERMINE THE TOTAL LOAD

In order to properly determine the size of the LPG installation, regulator to be used, the pipe size, etc., the total consumption must first be estimated. This can be determined by adding up the rated consumption of all the appliances to be connected to the gas pipeline. The rated consumption (or BTU input) can be found on the nameplate of the appliance, or it can be obtained from the manufacturer's manual. The rated consumption of some appliances may be expressed in CFH (cubic feet per hour) in which case must be converted to BTU by multiplying with the unit heating value of LPG (refer APPENDIX ONE).

Additional appliances to be installed in the future must be considered when planning the LPG installation to eliminate the need for a later revision of the piping and storage facilities.

The size of the installation should also take into account the frequency of replenishment and delivery lead time of the supplier.

4.3.2 EVAPORATIVE CAPACITY OF LPG CONTAINERS

The LPG container's capacity to generate vapours (also called evaporative capacity) depends on the ambient temperature and the 'wetted' surface which is the area in the container in contact with liquid LPG. Heat from the surroundings entering the container through the 'wetted' surface helps in 'boiling off' LPG to turn it into vapour. The bigger the 'wetted' surface, the more vapours the container can generate. The evaporative capacity of the container therefore is higher when the container is full and diminishes as the liquid level drops.

The evaporative capacity of LPG containers is a key input in deciding how many cylinders or what tank size to install. For a typical commercial LPG cylinder of 50kg capacity, the rule of thumb is to take the evaporative capacity of a 1/3rd full cylinder, and this can range anywhere from 50,000 to 140,000 BTU/hr depending on the climactic conditions of the area and the consumption pattern i.e. intermittent or continuous (see Appendix Three). For bulk tanks, the evaporative capacity can be estimated if the tank dimensions are known.

When extremely high vapour withdrawal rates are applied to the container, the temperature of the liquid LPG will drop and the 'wetted' surface will cause condensation to collect on the container's exterior. In cold weather the condensate may freeze and become a barrier for the heat transfer needed for vapourisation. This will result in a high level of residual LPG inside the cylinder that is unused. It is critical to ensure that the evaporative capacity of the LPG facility is sufficient to meet the requirements of the connected appliances when designing an LPG system.

4.3.3 DECIDING ON CYLINDERS OR BULK TANKS

LPG installations can either use cylinders or bulk tanks. There are pros and cons for each, and the installer is the best person to recommend which type will best serve the needs of the consumer.

Generally, a bulk installation is preferred for consumers with high consumption while cylinder installations are used mostly for low consumption or where space is limited. Both require properly identified areas that satisfy all storage and hazard precautions.

A comparison of bulk versus cylinder installation is shown below:

CYLINDER INSTALLATIONS:	BULK TANK INSTALLATIONS:
Generally for low consumption applications but can serve large requirements by adding more cylinders	For high consumption application
Requires less space	Needs bigger space
Allowed indoors in some countries	Must be outdoor and away from building
Installation is comparatively simpler Cylinder handling can be tedious for big installations	Can be installed above or underground Higher initial cost of installation
May have residual gases left inside cylinder	No losses due to residual gas
Flexibility of replenishment – deliveries can be arranged by the consumers, or the supplier, depending on the agreement	Replenishment via road tanker entails less manual handling but … …requires road access

Vapourisers can be used with both cylinder and bulk tank installations to improve the evaporative capacity of the site. Vapourisers for small commercial applications are usually electrically heated. For larger applications the vapouriser system may be designed to use circulating hot water from a boiler or water heater. Vapourisers using other heat sources have been introduced into the market recently.

4.4 Selecting Location For LPG Installation

4.4.1 COMPLIANCE WITH LOCAL REGULATIONS AND LPG STANDARDS

LPG is highly flammable, and its storage and handling is usually governed by strict rules. If the local regulations are less stringent than international standards or codes of practice, then the more stringent requirements must be followed.

NFPA 58 (US) and the the [Liquid Gas UK Codes of Practice] are useful references for storage and handling of LPG and used widely across the world.

4.4.2 SAFETY CONSIDERATIONS FOR LPG INSTALLATION SITE

Some requirements that should be considered when deciding on location for LPG installation are:

CYLINDER INSTALLATION:

- Must be outdoor and in a well-ventilated area
- Base must be firm, level, non–combustible, not resting on soil, clean, and dry
- Must not be below ground level i.e. basement, etc. (LPG vapour is heavier than air)
- Away from entrance and exit of buildings
- At least 1m away from any openings i.e. drains, culverts, doors, etc.
- At least 1.5m from any source of heat i.e. air conditioner, steam pipes and boilers
- At least 3m away from any open flames
- Preferably on ground level unless suitable lifting facilities are available to transfer cylinders to higher floors
- Must be accessible to changing and quick removal in case of emergency
- Must not be stored together with oxygen and other flammable material i.e. gasoline, etc.
- Should be protected from vehicular collision or damage
- Secured by suitable fence to prevent unauthorised tampering
- If permitted indoors by local regulations, this should be in a separate and isolated section of the building exclusively for this purpose. It must have access to outside air for ventilation.
- In some countries cylinders shall be restrained against seismic activity

BULK TANK INSTALLATION:

- Must comply with applicable safety distance requirement (see NFPA 58 Table 6.3.1.1 in Appendix Four – note: use the latest edition) and the regulations/standards of the country in use
- No open drains, or ducts located within the storage tank safety distance. If this is unavoidable, they must be fitted with a water trap or suitably sealed to prevent passage of LPG vapours

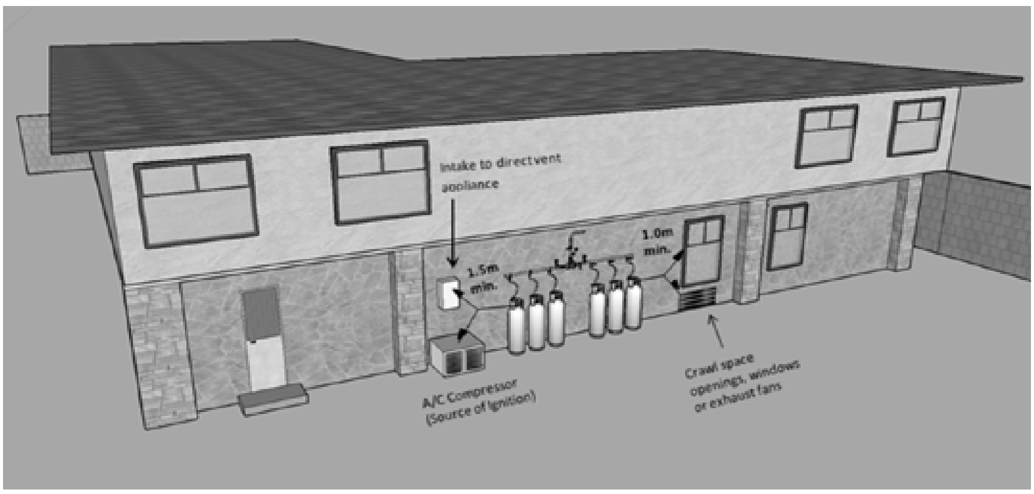


Figure 4.4a - LPG cylinder installation location

- The ground beneath or adjacent to tank connections or ancillary equipment should be cemented or compacted and arranged to prevent either the accumulation of any liquid beneath them or its flow affecting other tanks or important areas
- Provision should be made for handling the run-off of cooling water applied under fire conditions
- The vicinity of LPG storage tanks should be free from pits and depressions within the required separation distance to prevent the formation of gas pockets
- Must not be stored within the bunded enclosure with oxygen and other flammable materials i.e. gasoline, etc.
- At least 1.8m away from high voltage power lines
- Site must be accessible to delivery vehicles for unloading. It must allow truck to be positioned in a way that does not require reversing to drive off in case of an emergency
- To improve the evaporative capacity of the tank, the site must be exposed to direct sun rays and not be in shade

Where the initial capacity planned caters only to current requirements only, consideration should be given to allocating space for additional cylinders or tanks in the future if there are plans to expand.

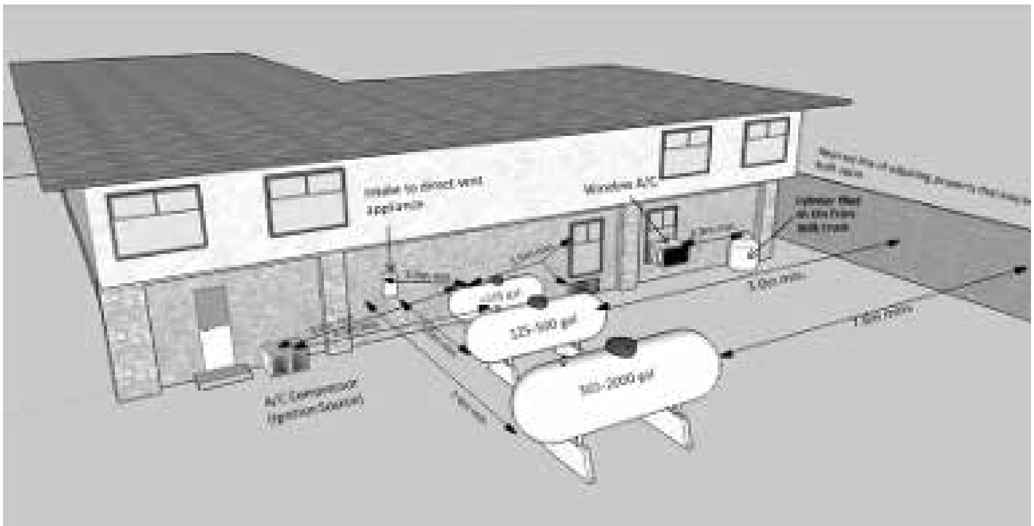


Figure 4.4b - Bulk tank installation location

4.5 Installing LPG Piping And Other Equipment

4.5.1 PIPE AND PIPE FITTINGS

Materials used for LPG piping should be suitable for the range of temperatures and pressures that could occur in service. Acceptable materials include carbon steel, copper, brass, and polyethylene plastics.

Carbon steel pipes are very common material used in LPG pipeline. They are rigid and strong and can withstand mechanical damage better than other materials. Carbon steel pipes used may either be black or galvanised and should be at least standard weight (Schedule 40). Extra strong pipe (Schedule 80) may be required depending on pipe size, working pressure and method of jointing. Jointing can be by thread, welding or flange connections.

Cast iron fittings must not be used.

Copper tubing is often used for domestic and small commercial installations. Although tubing costs much more than steel pipes of the same capacity, there is considerable saving of labour in its installation and maintenance. Since tubing may be bent readily to follow certain configuration, it is more easily installed and requires fewer fittings. However, it is more vulnerable to mechanical damage and it does not generally produce neat piping unless it is installed with particular care. Copper tubing can be affected by sulphur so it must be used with an LPG low in sulphur content.

Polyethylene (PE) pipes are normally used for buried pipe sections. They are lightweight and corrosion resistant. Jointing can be by means of compression fitting, factory assembled fitting or heat fusion. The latter is usually done automatically with a fusion machine which ensures a good joint. PE pipes and pipe fittings used should be PE80 or PE100 rating.

Other materials used for LPG piping includes Corrugated Stainless-Steel Tubing (CSST) and multilayer pipes. These materials are flexible and corrosion-resistant and jointing method is by use of proprietary fittings and tools. Additional information should be sought from manufacturer when such materials will be used.

All piping and tubing must only be installed by approved installers.

4.5.2 FLEXIBLE HOSES

Flexible hoses if used should be of the correct pressure rating and material designed for LPG. This is usually reinforced rubber or plastic with metal braiding and marked with ‘LPG Hose’.

There are no specific recommendations on the replacement intervals for hoses, but five years is considered a normal useful life for rubber hoses which should not be exceeded. Note that adverse operating conditions could shorten the useful life of hoses.

Metal flexible hoses made of corrugated stainless steel are also available for connecting appliances to the gas pipe. These hoses have a longer life span and in some countries are allowed to be used for 10 years before they are replaced.

It is important to use qualified and approved flexible hoses.

There are flexible hoses in the market made of inferior material and using them may lead to accidents.

4.5.3 PRESSURE REGULATION

LPG appliances supplied with incorrect inlet pressure will result in inefficient burner performance or may not function at all.

LPG piping is typically designed to have two-stage pressure regulation to minimise risks of the regulator freezing and condensation in the pipeline. First stage pressure reduces tank pressure to not more than 1.4 bar (20 psig). The second stage further reduces the LPG pressure entering the building to not more than what the cooking appliance required which is typically 300mm water column water column (WC) (11 inch WC).

Twin stage regulators are available that combines the first and second stage pressure regulation in one device and is usually used for sites with low consumption.

Some LPG piping design may require three stages of pressure regulation i.e. if the appliance is located far from the second stage regulator. In this case, the second stage regulator will reduce it to an intermediate pressure of 340 mbar (5 psig) or the maximum allowed by local regulation whichever is lower. The third and final stage regulator reduces the pressure to the appliance requirement of 300mm WC (11-inch WC).

Pressure regulators are available with Over Pressure Shut Off (OPSO) and Under Pressure Shut Off (UPSO) devices. These devices shut off the flow of LPG downstream of the regulator when the pressure exceeds or falls below the set levels to prevent any incident from arising due to abnormal LPG line pressures. Some local regulations may require use of such devices on the LPG piping.

4.5.4 PIPE SIZING

The proper selection of pipe and tubing sizes is critical to the efficient performance of the LPG appliance. Piping must be sized to provide sufficient gas to meet the maximum demand without undue loss of pressure.

Pipe size is essentially determined based a combination of operating pressure and length of piping. It is usual for segments of LPG

piping which operate at different pressures to have different pipe sizes. The lower the operating line pressure, the bigger the pipe diameter required to achieve the same flow capacity.

Pressure loss increases with length of piping and number of fittings on the piping. Choosing the right pipe size will ensure pressure loss is kept to within allowable limits and the correct pressure is delivered at the inlet of the appliance.

Pipe sizes can be calculated using gas flow formulas or using pipe sizing charts available from engineering or LPG serviceman's handbook.

4.5.5 GOOD PRACTICES ON PIPING INSTALLATION

LPG piping conveys a flammable product from the container to the appliance and faulty workmanship can lead to a hazardous situation. Below are good piping practices which should be considered.

Piping shall be adequately supported with a gap between the piping and any wall or structure carrying it. The piping must also be secured in position to prevent it being moved accidentally from its original position.

Piping should not run in or through air or ventilation ducts, elevator shaft, chimney or flues.

Piping that passes through concrete walls or floors should be suitable sleeved and the gap between sleeve and pipe should be sealed.

Concealed piping must be protected against inadvertent damage (from nails, impact) either by location, type of material used, or by sheathing.

Provision shall be made to avoid damage to the piping by its expansion, contraction, vibration or by settlement of the building by which it is carried.

Underground pipes should be buried at least two feet (600mm), and if butane or mixtures rich in butane are used, the pipe should be buried deep enough to avoid frost and to prevent condensation. Pipes should be buried in backfilled trenches.

Steel piping if buried and/or located in corrosive atmospheres must be suitably protected against corrosion. This may be done by painting, galvanising or wrapping with anti -corrosion tapes.

Piping shall be free internally and externally of cutting burrs, loose scale, dirt, dust and other foreign matter before the installation is completed. Foreign matter left in the piping may end up damaging regulators and appliances.

Threaded connections if used shall have tapered threads. Sealing tape or jointing compound which is resistant to the action of LPG shall be used to provide gas tight joints. These must be applied only on the male threads.

Hoses used shall be kept as short as possible with a maximum length of two meters and secured appropriately at the ends i.e. by metal clamps, etc. They shall not be use in concealed places and exposed to high temperatures.

Ends of piping should be suitably plugged with pipe caps and plugs to prevent accidental discharge of LPG. Cork, wood, paper, etc. should not be used as plug.

Suitable shut-off valves should be fitted for every appliance and should be installed at every point where safety, convenience of operation and maintenance demands.

If LPG piping needs to be distinguished from piping of other services, it should be painted yellow and/or marked with 'LPG' for identification.

4.5.6 LEAK TESTING

After the piping has been completed and before it is put into service, the whole piping system must be subjected to a leak test. This is an important step in the installation and should be made with great care and in strict compliance with local regulations wherever such exists. Basic points to consider are:

- Appliances and equipment which are not included in the test or are designed for operating pressure less than the test pressure must be isolated or disconnected from the piping during the test
- The test medium introduced in the gas line for testing leaks may be air, nitrogen, carbon dioxide or any inert gas. In no instance must oxygen be used for this

purpose as this will create an inflammable mixture. LPG may be used as a test medium for testing gas piping joints between the low-pressure regulator and low pressure appliance

- Where any part of the piping is to be enclosed or concealed, the test must be done prior to the work of closing in, unless the concealed sections of the piping have been pretested. Piping should be tested before they are painted or applied with any corrosion protection which would inhibit detection of a leak
- The test should be carried out at appropriate pressures
- For section of the piping subjected to full cylinder pressure, the test pressure should be 1.5 times the normal working pressure or 10 bars (150 psig) whichever is greater
- For piping section after first stage regulator with pressure above 500mm WC, the test pressure should be 2.5 times the maximum expected working pressure or 3.5bars (50psig) whichever is greater
- For piping sections subject to 20 inches (600mm) WC or less, the test pressure should be 5 times the expected operating pressure or 5 psig whichever is greater
- Test duration should not be less than 10 minutes for LPG installation used by single family house. For longer pipeline, test should not be less than 30 minutes for every 14m3 of pipe volume or fraction thereof. In no case is the test duration required to go beyond 24 hours
- A drop in pressure as indicated by a pressure gauge shall be a sign of the presence of a leak. The source of leakage should be determined by the use of non-corrosion leak detection fluid or an approved gas detector. Soapy solution is commonly used to identify the source of leak. A match or other open flame should never be used to test for leaks
- Any leak detected should be rectified by applying correct procedure and retested before the piping system is commissioned
- The consumer or any other responsible party should witness and confirm that the test has been satisfactorily completed
- A pressure test certificate must be kept for record

4.5.7 COMMISSIONING AND HANDOVER OF COMPLETED INSTALLATION

4.5.7.1 PURGING

After testing, the piping should be purged of air or other test medium used for leak testing up to the appliance using LPG vapour. Any residual air or other test medium left in the pipeline can interfere with the proper functioning of the burner.

Care must be taken to prevent accumulation of gas-air mixtures released during purging inside premises or in confined spaces.

When purging through individual appliances a source of ignition shall be held adjacent to the burner to ensure immediate ignition when the gas is rich enough.

Steps shall be taken to ensure no other sources of ignition are present and to prevent inadvertent operation of electric switches or appliances and to prohibit smoking or naked lights in the vicinity of the purge point.

Purging is completed when all appliances connected to the piping can be lighted without problem.

4.5.7.2 DELIVERY AND LOCK-UP PRESSURE

After purging the piping, the gas delivery pressure at the appliances as well as the lock-up pressure must be tested.

The delivery pressure must not fall below the required minimum for efficient functioning of the appliance with all burners operating. Lock-up pressure is the pressure of the gas between the low-pressure regulator and the appliances when all outlets are closed and there is pressure on the container side of the regulator. Lock up pressure which is more than twenty percent of the regulator outlet setting indicates a problem with the regulator.

4.5.7.3 CUSTOMER INSTRUCTION

Once all the tests have been completed, the consumer must be instructed on the safe operation of the LPG piping system before this is handed over. This will be the responsibility of the installer. The safety instructions should include:

- How to recognise LPG leaks
- Action to be taken in case of leakage
- Action to be taken in case of fire
- Action to be taken in case of damage to, or failure of, any part of the installation
- When to re-order LPG
- Cylinder or bulk LPG delivery procedure

Consumers must also be instructed on good practice of keeping the LPG tank site or cylinder storage area free from combustible materials. The area should be secured to prevent unauthorised entry and access to the site should not be blocked.

The need for periodic maintenance of the appliance and the piping system must be emphasized to the consumer to ensure a safe and reliable use of LPG.

4.5.8 FIRE PROTECTION EQUIPMENT

A sufficient number of 9kg dry powder fire extinguishers should be provided near the cylinder and/or tank storage site and other locations around the premises. These are to be used for extinguishing small fires around the cylinders or tanks.

Larger installations may be required by regulation to have fixed water sprays over the tanks or fire hose reels nearby.

4.5.9 SAFETY DEVICES

The use of other safety devices, while not prescribed by regulations or LPG standards, can enhance safety and should not be discouraged. Consumers should however not be overly dependent on them since such devices have their limitations.

Gas detectors and alarms are useful in alerting end users in case of accumulation of gas i.e. LPG or Carbon Monoxide for people with impaired sense of smell. Some gas detection devices are linked to shut off valves that can cut off LPG supply automatically when leakage is detected.

Excess flow valves and valves equipped with a thermal fuse if installed on the appliance end can stop the flow of gas in case of hose rupture or fire.

It is also good practice to have a valve to isolate the flow of LPG in the line that is independent of the cylinder or storage tank valve.

4.6 Sample Diagrams Of LPG Installations (Some Examples)

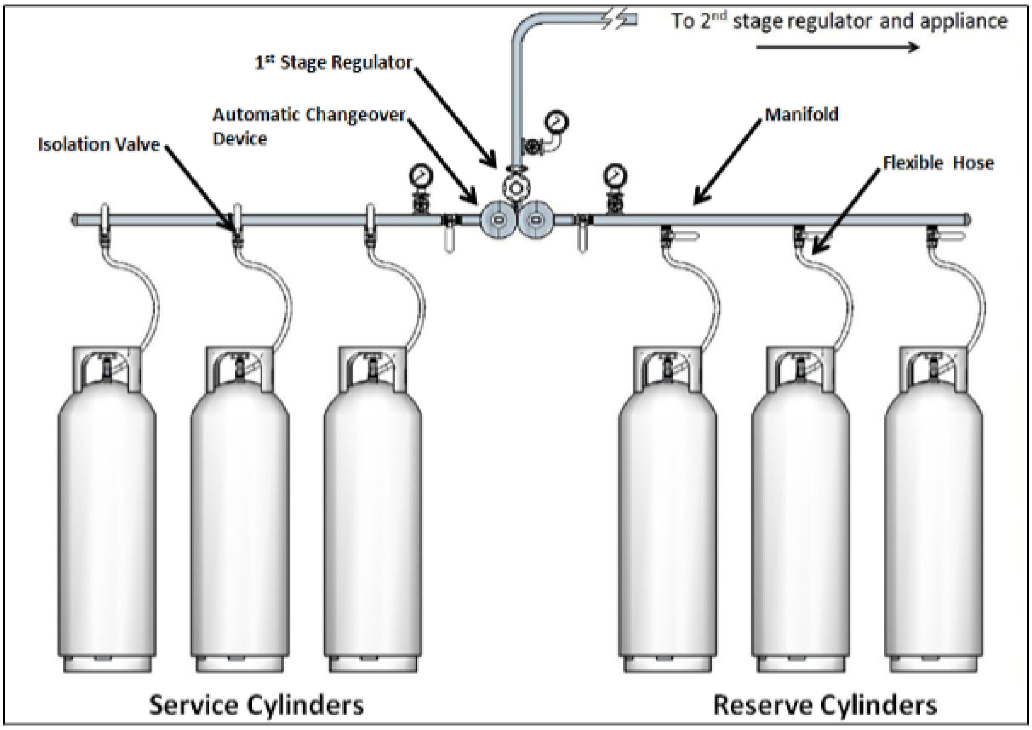


Figure 4.6a – Typical cylinder installation

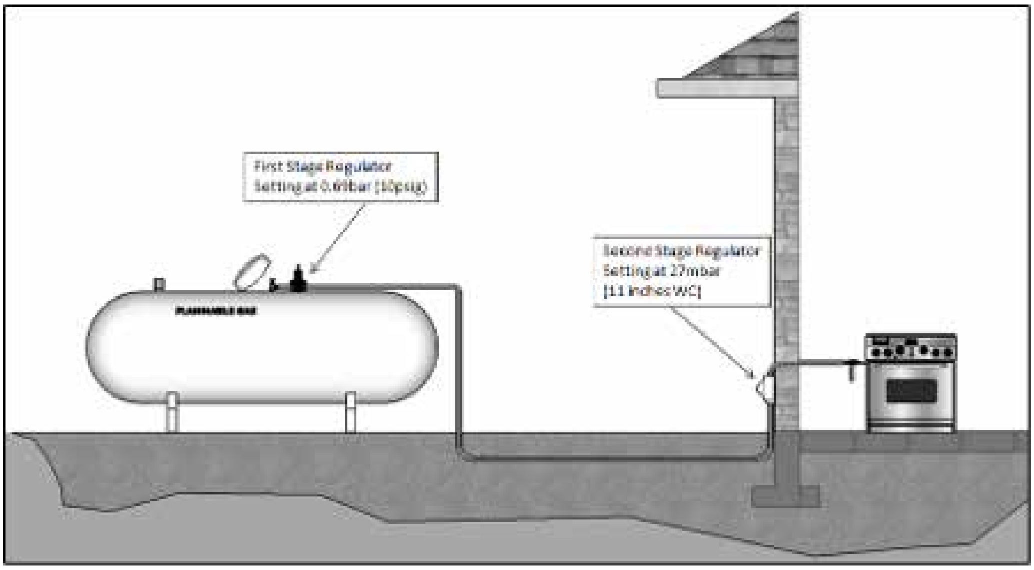
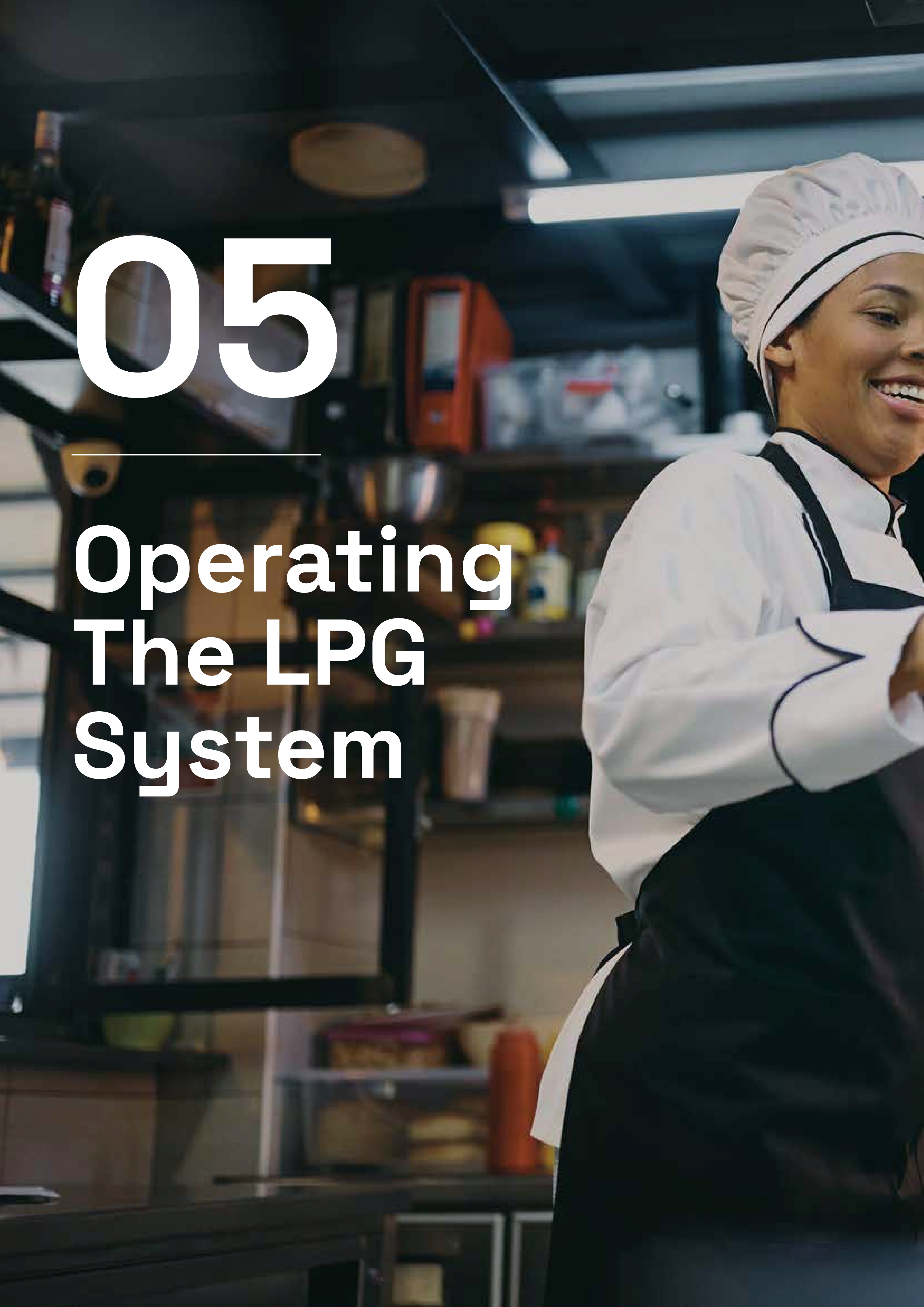


Figure 4.6b – Typical LPG bulk Installation

An A P & I diagram of an underground tank installation is shown in APPENDIX FIVE.



05

Operating The LPG System

5.1 Safety Tips on using The LPG Installation

Everyone involved in handling and using LPG should be given training on basic LPG product knowledge and safe handling to increase safety awareness and avoid bad practices which can result in accidents. Below are some safety tips consumers should be aware of.

- LPG is stored under pressure and any small gaps and pinholes can cause LPG to leak out. Pipes must never be stepped on or used to hang kitchen equipment or other objects that may create undue force on them.
- The boiling point of LPG is low and any contact with liquid LPG on bare skin can cause cold burns. People handling liquid LPG i.e. during bulk delivery should wear proper personal protection equipment (PPE) that includes suitable gloves, long sleeves and eye goggles
- LPG can be detected by means of its 'rotten egg' odour. It is odorised in such a concentration that even the presence of a small amount of LPG is discernible by smell. Once LPG is detected by smell gas valves must be closed immediately, all ignition sources must be put out and the room must be ventilated to dilute and disperse the LPG vapour. The latter can be done by opening all windows and doors to let outside air into the space
- Use leak detection fluid or soapy water to check for leaks on the piping system. Apply on all joints and hoses and check for bubbles which indicate a source of leak. Never use naked flames
- When appliances are disconnected from the gas piping for servicing or, removed to clean the area, the connection should be checked for vapour tightness when they are reconnected
- Cooking utensils should match the burners used. A burner whose flame exceeds the base of a pan throws away heat and wastes LPG
- Appliance gas valves should always be closed when the appliance is not being used. When LPG will not be used for an extended period of time, the main gas valve and LPG container valves should be shutoff for safety reasons
- When using appliance without a spark igniter, the lighter or match must be lighted before opening the appliance gas valve to avoid accumulation of LPG vapour which could cause a flash fire
- Never leave the cooking appliance unattended with the flame on
- Keep the cooking area well-ventilated to dispose of products of combustion and ensure sufficient supply of air for combustion. Some kitchens may be equipped with an exhaust fan which needs to be turned on before cooking begins
- Cylinders should always be used in the upright position. Never shake the cylinder or turn it upside down to draw out residual LPG. This may result in heavy ends clogging the valve and/or regulator

5.2 Managing Stocks and Re-Ordering

5.2.1 MAXIMUM TANK FILL LEVEL

Liquid LPG has a high co-efficient of volumetric expansion which is why they should never be allowed to become liquid full inside the container. An ullage or space is left in the container to allow liquid LPG to expand when temperature rises.

Overfilling of LPG containers can result in the container being subjected to hydraulic pressure and the pressure relief valve popping to relieve LPG. This is a hazardous situation which should be avoided.

The maximum fill level is dependent on climactic conditions of the location and typical figures would be 85% for small bulk tanks and 80% for LPG cylinders.

Bulk tanks are equipped with maximum level gauges to indicate when the maximum fill level has been reached, and filling should be terminated. Overfill prevention devices on filler valves are also available which can automatically stop the filling when the maximum level is reached.

5.2.2 MONITORING CONSUMPTION PATTERN

Some consumers will have a steady pattern of consumption while others may experience seasonal fluctuations. In either case, it is essential to monitor consumption so that replenishment can be scheduled and risks of stock outs minimised.

Consumption for bulk users can be tracked using the level gauge on bulk tanks which is typically in percentage or a fraction of the tank capacity. For cylinder users, consumption rate can be established during the first few cylinder replacement periods. Alternatively, consumption can be tracked using gas meters. The gas meter reading is in volume which has to be converted to weight.

Out of pattern consumption may indicate a problem with the appliance, an undetected leakage in the piping or even pilferage which needs to be investigated.

5.2.3 REPLENISHING STOCKS

LPG suppliers require lead time for delivery therefore consumers must always maintain sufficient stocks until replenishment. Delivery lead times may vary among suppliers and distance to source may be a key factor. This should be taken into consideration when selecting supplier.

Cylinder installations usually have two equal banks of cylinders connected on the manifold. One side is in service and the other reserve. When the service side has been consumed, supply is shifted to the reserve bank and order for replenishment should be placed with the supplier.

Bulk users should take note of the critical stock level in their tank beyond which the tank can no longer supply sufficient vapour for the appliance. Factoring in the normal lead time for the supplier would give the point where order must be placed for replenishment to avoid stock out.

5.3 Ensuring Safe LPG Delivery

5.3.1 BASIC SAFETY PRECAUTIONS

During delivery all sources of ignition around the LPG storage area should be extinguished. If the ignition sources cannot be controlled, then delivery should not proceed.

A notice must be displayed near the filling point indicating “NO SMOKING, NO NAKED FLAMES”

Electrical equipment not needed during the delivery should be switched off and removed from the area i.e. mobile phones, two-way radios, etc.
Any piles of rubbish and/or combustible material within the LPG storage area should be removed from the site by the consumer.
Access to the LPG site should be clear and free of obstruction. Delivery truck must be able to park in such a way as to drive away without reversing in case of emergency.
Delivery personnel must be using the required personal protective equipment i.e. gauntlet, safety shoes, goggles, etc.
LPG containers, piping and other equipment installed at the site should be inspected to confirm that they are in safe working condition before delivery.

5.3.2 CYLINDER DELIVERY PROCEDURE

Cylinders must be moved in a manner that avoids damage to the floor. Pushcarts or similar equipment should be used for transferring cylinders between truck and the storage site.

Cylinders to be replaced must be checked by delivery personnel that they are indeed empty before removing from the manifold.

Close all cylinder valves and individual isolation valves on the manifold and slowly disconnect the empty cylinders. Allow the gas in the flexible hose to bleed down before entirely disconnecting the cylinder. If the residual gas continues to bleed off, the source of leakage should be identified. If necessary, other cylinders should be shut off to prevent escape of LPG. Any defective valve identified should be replaced to prevent leakage.

Remove the empty cylinder and position the full cylinder where flexible hoses can reach without straining. The condition of the hose end coupling threads should be examined to check for wear and if necessary they should be replaced.

Check the connection for leaks by opening the cylinder valve slightly to let gas flow and apply soap solution. If connection is leak free, open fully all the cylinder valves and individual isolation valves on the manifold. The cylinder bank is now ready for service when the other bank becomes empty.

Delivery crew should ensure everything is in order before leaving the site.

5.3.3 BULK DELIVERY PROCEDURE

Check to make sure the correct grade of LPG is to be unloaded.

Confirm that the quantity to be unloaded fits the ullage without overfilling.

Confirm that the bulk truck coupling is compatible with tank fittings.

Layout the bulk truck hose and ensure it is not place on public path or pavement that may pose a significant hazard.

Connect the bulk truck coupling to tank filler valve and open liquid line partially to check for tightness of connection. If there are no signs of leak, fully open the liquid line and start truck pump to unload.

The driver should stay within the vicinity to monitor the liquid level of the tank while unloading and to lookout for any signs of leakage. The driver should never leave the site while unloading is ongoing.

Reduce the pumping rate when the tank content approaches the maximum fill level. The maximum fixed ullage gauge should be used to prevent overfilling.

Stop the pump when the maximum fill level is reached and close all valves on the bulk truck and tank.

Disconnect the bulk truck coupling slightly to bleed off residual LPG between the coupling and the tank filler valve. If LPG continues to vent off, the coupling should be reconnected and the source of the leak investigated. If venting stops, fully disconnect the road tanker coupling and stow the hose back on the truck. If the tank is inadvertently overfilled, the driver should inform his supervisor and the consumer and take appropriate action to remove the excess LPG in a safe manner. Overfilled tanks must not be left in an unsafe condition.

The driver should ensure everything is in order before leaving the site.

5.4 Training Of Personnel Involved In LPG

Training is an essential element of ensuring safety in handling and using LPG. It helps create awareness for the hazards and risk associated with LPG and minimises bad practices that may lead to an incident with serious consequences.

It is the responsibility of the people in charge to ensure all personnel involved with handling LPG undergoes training by a competent person before they are allowed to carry on with their normal activities. The personnel who should be trained include managers, kitchen staff, administrative staff, maintenance workers, and security guards.

The LPG supplier should be responsible for training their drivers and delivery personnel.

Training should cover topics such as LPG product knowledge, relevant procedures, and emergency actions.

In particular, the following topics should be covered:

- Basic characteristics and properties of LPG
- Cylinder handling procedures
- Bulk LPG delivery procedures
- Proper use and maintenance of LPG appliances
- Basic principles of combustion
- Actions in case of emergency
- First aid

The amount of training for each person will depend on his/her level of involvement with LPG. Training should be done on a periodic basis and whenever there are new staff joining the organisation.

Training should include regular emergency exercise with the participation of local fire service.

Training records should be kept with the site owner.

5.5 Actions In Case Of Emergency

5.5.1 BASIC PRINCIPLES

The primary objective in emergency response is to prevent harm to people who include those working in the site as well as the public. Being prepared on how to handle emergency situations can minimise the risk of minor incidents becoming major incidents.

An emergency team should be organised within the organization and the roles and responsibilities of each member of the team should be clearly defined.

Emergency procedures should be documented in clear and concise language and a copy posted near the LPG storage site where it is easy to read.

5.5.2 BASIC GUIDELINES ON HANDLING LPG EMERGENCIES ARE AS FOLLOWS:

Assess the situation and organise appropriate response.

Evacuate all people (staff, general public, etc.) not needed to handle the emergency to a predetermined safe location.

Call the local fire and emergency services for assistance.

If safe to do so, emergency response teams to tackle the emergency wearing appropriate Personal Protective Equipment.

Treat any injuries.

Account for all personnel – Carry out a roll call.

5.5.3 HANDLING A LEAK WITHOUT A FIRE

Keep personnel upwind of the leak.

Remove ignition sources downwind of the leak. Do not switch on or off any electrical switch which might cause a spark.

Close a valve upstream of the leak if possible. If the leak is indoors, open windows and doors to increase ventilation.

If the leak is on a cylinder, remove and position it in a well-ventilated location with the leak uppermost if safe to do so. Clearly marked the cylinder as defective to alert supplier.

A leak may be stopped by 'freezing' by wrapping with a wet cloth and spraying water. Disperse vapour with water spray/monitor/fan sprays.

Check if there is vapour still in the area with portable gas detectors before allowing people to enter.

Constantly monitor wind direction and take necessary action if the direction changes.

5.5.4 HANDLING A LEAK WITH A FIRE

If a vapour cloud ignites it will be of short duration before becoming a jet fire.

Give first aid to any personnel caught in the cloud and get immediate medical attention. Extinguish any secondary fires caused by the ignited vapour cloud.

Try to stop the jet fire by closing an upstream valve.

Do not extinguish the flame unless the leak has been stopped.

Keep all nearby equipment, especially storage tanks, cool with water from fixed sprays or monitors

If the jet fire is impinging on other equipment "bend" the flame away using water spray.

5.5.5 EMERGENCY EXERCISE

Regular emergency exercise should be conducted to test the preparedness of the local response team in handling emergencies.

Learnings from each exercise should be discussed with the team during the de-briefing session and practiced in the succeeding exercise. Emergency exercise should involve local fire service.

06

Inspection and Maintenance

6.1 General

LPG installations should be kept in a safe and good working condition by a combination of routine and periodic inspection and maintenance. This is a legal requirement in most countries with defined scope and frequency.

Failure to comply not only increases risks of incidents but may result in penalties and shutdown of LPG facilities by authorities.

Inspection and maintenance can be the responsibility of either the consumer or the LPG supplier depending on the signed contract stipulations. Whatever the case, only trained and competent personnel should be allowed to carry out work on the LPG installation.

Inspection and maintenance should cover LPG containers, piping and all other equipment that affects the integrity of the LPG system.

Where inspections reveal defects or significant deterioration, this should be recorded and the inspection methods used plus any remedial action taken should be detailed. The competent person should also assess the effects of such deterioration, defect or repair and either endorse or revise the safe working limits of the tank or equipment.

6.2 Routine Inspection and Maintenance

Frequency of routine inspection should be risk-based and recommended by a competent person. It should cover external inspection of visible parts of containers, pipe and pipe fittings, vapourisers if used, fire protection equipment and other equipment installed. It should be carried out by an appropriately trained person and should cover the following:

 **FOR CYLINDER INSTALLATIONS:**	Inspect the storage site and surrounding area for any flammable materials stored and sources of ignition
	Inspect the cylinders and piping for signs of corrosion, damage and leakage
	Particular emphasis should be paid to the undersides of cylinders, pipes and areas in contact with supports
	Check hoses for signs of cracks or leakage and if they are suitably clamped. They should be replaced when damaged or have reached the end of their recommended useful life
 **FOR BULK INSTALLATIONS:**	Inspect the storage site and surrounding area for any flammable materials stored and sources of ignition
	Check tank and tank fittings for signs of corrosion, damage or leakage
	Inspect the pressure relief valve for corrosion and if drain holes are blocked which can cause water retention leading to corrosion
	Check if the thread on the filler valve is worn out and needs replacement
	Inspect piping for signs of corrosion, damage and leakage. Particular emphasis should be paid to the undersides of pipe and areas in contact with supports
	Check hoses for signs of crack or leakage and if they are suitably clamped. They should be replaced when damaged or have reached the end of its recommended useful life

LPG **FOR BULK INSTALLATIONS:**	
	Check that the grounding cable is connected to tank and in satisfactory condition
	Check the concrete piers and pads for damages and differential settlement
	Cathodic protection system of underground installation if provided should be checked if readings are still within specification

Vapourisers should be checked for signs of corrosion, damage and leaks. For indirectly heated types, check for sufficiency of water level and satisfactory condition of electrical connections.

Fire extinguishers should be inspected if still in satisfactory condition and properly recorded. Test fixed water sprays of bulk installation if provided to check for blockage of nozzles and if water pressure is sufficient.

All inspection and maintenance records should be kept on site.

6.3 Periodic Inspection and Maintenance

6.3.1 FREQUENCY

Periodic inspection and maintenance apply to bulk tanks and should be carried out based on frequency stated under local regulations.

If the frequency is not prescribed under local regulations, the following WLGA guideline may be adopted:

EQUIPMENT	FREQUENCY
Above ground tank	Every five years
Underground tank	
• with Cathodic Protection	• Every ten years
• without Cathodic Protection	• Every five years
Pipework	
• Aboveground	• Every ten years
• Underground	• Every five years
Vapouriser	
• Direct fired	• Annual
• Indirectly fired	• Every five years

Figure 6.3a

6.3.2 SCOPE OF WORK

Periodic inspection and maintenance should be carried out to a written scheme of examination prepared by a competent person. In addition to the scope covered under routine inspection it should include the following:

ABOVEGROUND TANK:

- Visual examination of external surfaces and all welds for signs of defects such as damage, corrosion, cracking, erosion, deformation, leakage, etc
- A check of wall thickness by internal visual examination or a wall thickness survey (e.g. by the use of an ultrasonic thickness gauge)
- Inspection of pressure relief valves for any signs of corrosion or damage and replacement with new or reconditioned units after ten years in service
- Inspection of shut off valves, regulators and other tank fittings for effective operation, corrosion or damage or replacement. Shut off valves, regulators and other tank fittings should be replaced when they reached 20 years of service regardless of condition

UNDERGROUND TANK:

- A visual check of exposed surfaces for signs of corrosion, damage, leakage, etc
- Inspection of pressure relief valves for any sign of corrosion or damage and replacement with new or reconditioned units after ten years in service
- Where cathodic protection is provided, the operation of sacrificial anodes or impressed current systems should be checked in accordance with a written procedure and replaced as necessary. Records should be maintained to allow comparisons of the readings obtained to allow investigation of any anomalous readings
- Where cathodic protection is not provided, an internal visual examination should be conducted and either a wall thickness check or a hydraulic test. Where internal examination is not reasonably practicable the external surfaces of the tank should be exposed for examination as directed by the competent person
- Inspection of shut off valves, regulators and other tank fittings for effective operation, corrosion or damage or replacement. Shut off valves, regulators and other tank fittings should be replaced when they reached 20 years of service regardless of condition

PIPEWORK:

- Aboveground piping should be inspected for signs or corrosion, damage or leaks with emphasis on the areas where pipe passes thru supports. Piping should be pressure tested
- Buried piping should be tested for leakage by appropriate means i.e. pressure testing, gas detection, etc. In some cases, the piping should be exposed by excavation to check for corrosion

VAPOURISERS:

- Check for satisfactory operation of items such as level control, heat input controls, emergency valves (other than pressure relief valves), flame control devices, pressure controllers, etc. Safety devices such as solenoid valves and similar items should be given particular attention
- Check for corrosion and damage. Flame impingement areas of direct fired equipment should be given special attention
- Check for LPG leakage under normal operating pressure and with hydraulic test

6.4 Appliance Maintenance

It is unavoidable for LPG appliances to not develop undesirable flame characteristics with constant use. Regular inspection and maintenance will keep them functioning safely and efficiently. Manufacturers usually provide instruction manuals accompanying their appliance on how to care of their product which should be followed.

Here are some simple tips on maintaining a typical LPG appliance:

- The best type of flame is shown by a bluish and evenly distributed halo of flame surrounding the burner. Flames showing yellow tip or lifting from the burner ports require maintenance. The air flow path should be inspected for any blockage and/orthe air shutter adjusted to attain the bluish flame
- Burners with difficulty lighting should have their spark igniter inspected and/or cleaned
- Burner ports should also be cleared of any blockage from food debris, soot or other particles. Use only suitable tools to avoid damage to burner ports
- Exhaust kitchen hood if installed should be regularly cleaned to prevent accumulation of grease which is often the cause of fire
- Some ovens may require calibration of their thermostat to keep the settings accurate
- Always use genuine parts when replacement is needed
- Always use trained technicians to repair and maintain LPG appliances

07

Kitchen Skills and Safety [KSS] by World Central Kitchen

7.1 About World Central Kitchen

World Central Kitchen (WCK), founded by Chef José Andrés, is a non-profit organisation that responds to humanitarian crises with the power of food. WCK provides fresh meals to communities impacted by disasters and advocates for resilient food systems that strengthen local economies. Through innovative solutions, WCK is committed to ensuring that food is a lifeline and a catalyst for sustainable recovery.

The Kitchen Skills and Safety (KSS) programme is a legacy initiative of WCK that provided essential training in food safety, hygiene, and kitchen efficiency. This program equips cooks, food handlers, and kitchen staff with the knowledge and skills necessary for safe food preparation, emphasising clean cooking, sanitation, and sustainability.

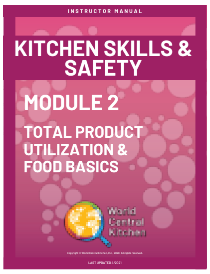
7.2 Kitchen Skills And Safety (KSS) Training Modules By World Central Kitchen

WCK uses the power of food to nourish communities and strengthen economies in times of crisis and beyond. Through locally led approaches, their food resilience programmes advances human and environmental health, offers access to professional culinary training, creates jobs, and improves food security for the people they serve.

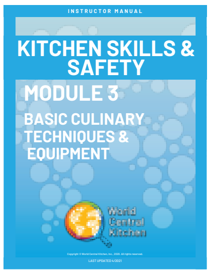
The programme will provide cooks in institutional kitchens the necessary skills to make and serve healthy meals by teaching the fundamental practices of safe and sanitary food preparation and handling.

The WCK has kindly provided access to six training modules (below), covering kitchen skills and safety, that can be used in support of the conversion of institutional kitchens from traditional fuels to LPG. The links to these training modules are included below.
A recipe has been included in **APPENDIX SIX** from José Andrés.

KSS Module 1 - INSTRUCTOR.pdf

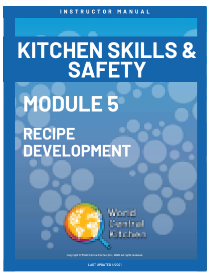


KSS Module 2 - INSTRUCTOR.pdf



KSS Module 3 - INSTRUCTOR.pdf

KSS Module 4 - INSTRUCTOR.pdf



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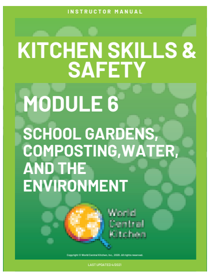

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APPENDIX 1

Properties of LPG

LPG	Comprises commercial propane and commercial butane, and mixtures of the two. They are hydrocarbon gases that can be changed into a liquid and changed back into a gas by the simple application and release of moderate pressure.
Density	LPG vapour is heavier than air and tends to gather in low areas such as drains, pits, cellars and other depressions. As a colourless liquid, LPG occupies around 0.4% of its vapour volume, but is about half the density of water and will float on water before vapourising.
Cooling effect	LPG liquid vapourises and cools rapidly; it can therefore inflict severe cold burns if it comes in contact with bare skin.
Non-toxic	LPG is not toxic. However, it has an anaesthetic effect when mixed in high concentrations with air. The greater the concentration (i.e. as available oxygen declines) the greater the risk of asphyxiation.
Smell	What people know and recognise as the 'LPG smell' is usually added to LPG before distribution. This smell can be detected if the LPG content of air is as little as 0.4% (or just 20% of the lower limit of flammability). However, odour is not the only means of detection. Large leaks will also be obvious through hissing or condensation or frosting around the leak; small leaks will show up as bubbles if detergent mixed with water is applied to the suspected leak area. **NEVER try to detect leaks with a naked flame or other kinds of ignition!**
Flammability	LPG can ignite when it forms between 2% and 10% of a vapour/air mixture, so the risks associated with poor handling, storage or usage are obvious. Uncontrolled ignition of LPG can cause serious fires or explosions (i.e. if ignited within a confined space). A fire that has started some distance from an LPG leak can very quickly travel back to the source of the leak itself. An LPG cylinder involved in a fire may overheat and rupture violently. The power and intensity of an LPG fire or explosion should never be underestimated.
Liquid Expansion	LPG liquid has a high coefficient of expansion. Tanks, cylinders, pipelines and equipment must be protected against the high pressure resulting from liquid expansion with temperature rise. To allow for the liquid to expand when heat is applied cylinders and tanks are never completely filled. An ullage of around 20% of the total is always left when containers are filled.

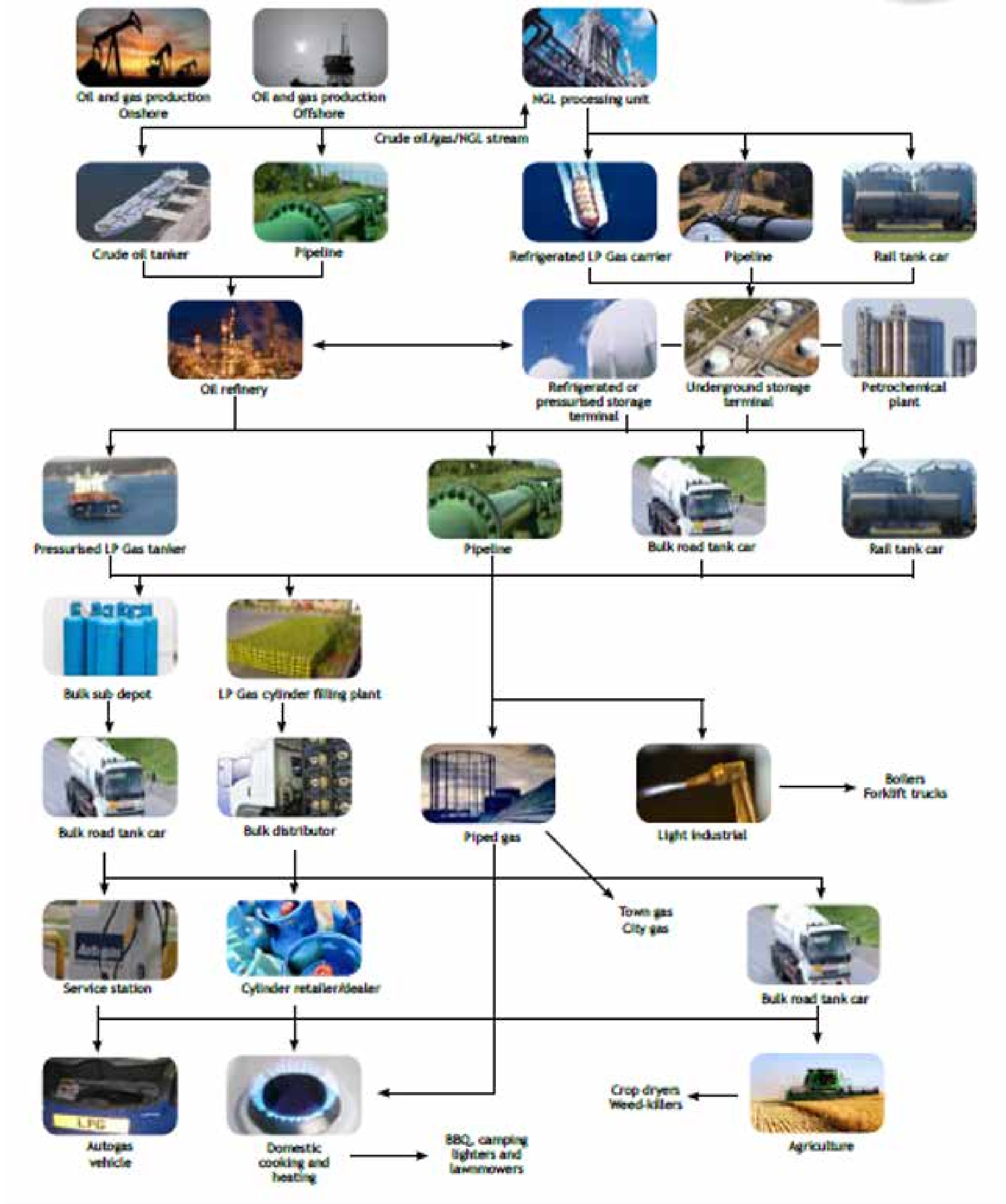
Table 1 overleaf shows some typical physical properties of LPG

Table 1

Typical Characteristics of Propane and Butane **PHYSICAL PROPERTY**		**COMMERCIAL PROPANE**	**COMMERCIAL BUTANE**
• Litres/tonne of liquid at 15°C • Litres/ton of liquid • Litres/kg of liquid • US barrels/tonne		• 1,965 – 2,019 • 1,996 – 2,051 • 1.96 - 2.02 • 12.4 – 12.7	• 1,723 – 1,760 • 1,750 - 1788 • 1.72 - 1.76 • 10.8 – 11.1
Relative density (to water) of liquid at 15°C		0.50 - 0.51	0.57 - 0.58
Ratio of gas to liquid volume at 15°C and 1015.9 mbar		274	233
Relative density (to air) of vapour at 15°C and 1013.25 mbar		1.40 - 1.55	1.90 - 2.10
Volumes of gas/air mixture at lower limit of flammability from 1 volume of liquid at 15°C and 1015.9 mbar		12,450	12,900
Boiling point °C		Minus 45	Minus 2
• Vapour pressure at 0°C	barg	4.5	0.9
• Vapour pressure at 15°C	barg	6.9	1.93
• Vapour pressure at 38°C	barg	14.5	4.83
• Vapour pressure at 45°C	barg	17.6	5.86
Upper limit of flammability,	% v/v	10.0	9.0
Lower limit of flammability,	% v/v	2.2	1.8
Gross calorific value	MJ/m^3 dry	93.1	121.8
	BTU/ft^3 dry	2,500	3,270
	MJ/kg	50.0	49.3
	BTU/lb	21 500	21 200
Net calorific value	MJ/m^3 dry	86.1	112.9
	BTU/ft3 dry	2,310	3,030
	MJ/kg	46.3	45.8
	BTU/lb	19,900	19,700
• Latent heat of vapourisation • Latent heat of vapourisation	kJ/kg at 15 °C BTU/lb at 60 °F	• 358.2 • 154	• 372.7 • 160

APPENDIX 1

LPG Supply Chain



Courtesy of Argus Media

APPENDIX 3

Evaporative Capacity of LPG Cylinders

PRODUCT	CYLINDER SIZE (KG)	TEMPERATE		TROPICAL	
		Continuous (kg/hr)	Intermittent (kg/hr)	Continuous (kg/hr)	Intermittent (kg/hr)
Propane	12.5	0.5	1.0	1.0	2.0
	50.0	1.0	2.0	2.0	4.0
Butane	12.5	0.35	0.6	0.6	1.2
	50.0	0.7	1.2	1.2	2.4

APPENDIX 4

Extract from NFPA 58

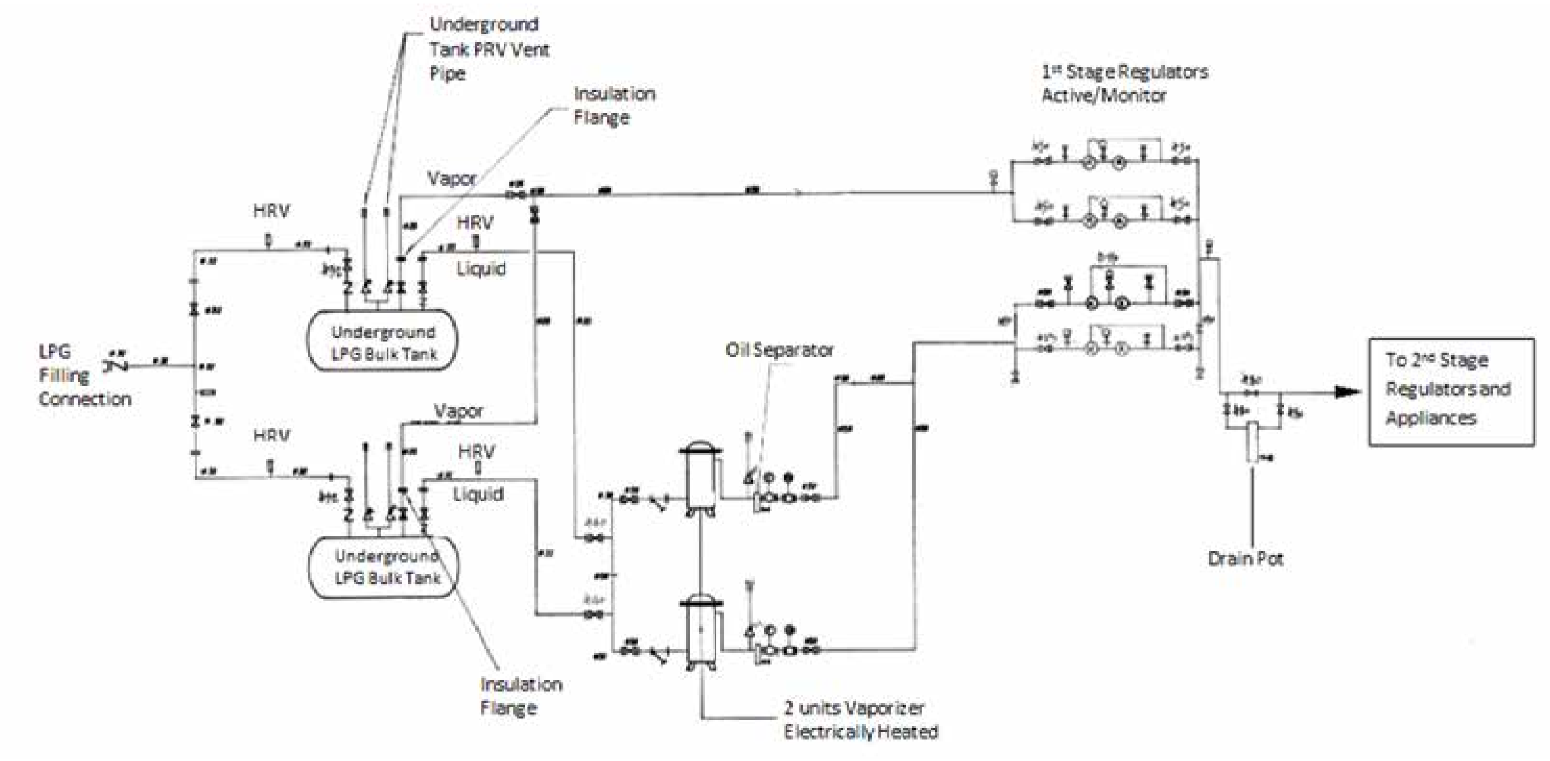
TANK WATER CAPACITY PER CONTAINER (LITRES)	MINIMUM SEPARATION DISTANCES		
	Mounded or underground Containers[a] (metres)	Aboveground Containers (metres)	Between Containers[b] (metres)
<500[c]	3	0[d]	0
500 – 1000	3	3	0
>1,000 – 1,900	3	3	1
>1,900 – 7,600	3	7.6[e]	1
>7,600 – 11,4000	15	15	1.5
>114,000 – 26,5000	15	23	1/4 of sum of diameters of adjacent tanks

[a] See NFPA 58 2020 6.4.2.1
[b] See NFPA 58 2020 6.4.4.5
[c] See NFPA 58 2020 6.4.4.4
[d] See NFPA 58 2020 6.4.4.1, 6.4.4.2, 6.4.4.3 and 6.4.4.4
[e] See NFPA 58 2020 6.4.1.1

[NFPS 58 2020 used here for illustration - use latest edition]
Courtesy - NFPA

APPENDIX 5

Underground Bulk Tank Installation with Vapouriser, Piping and Instrumentation Diagram (Example)



APPENDIX 6

Recipe from José Andrés, World Central Kitchen

POLLO AL CHILINDRÓN

Chicken with Peppers, Tomatoes, Onions and Spanish Ham
Serves 4

INGREDIENTS

- ¼ cup extra-virgin olive oil, plus 1 tablespoon
- 4 chicken legs, thighs and drumsticks separated
- Salt, to taste
- 2 cups diced onions
- ½ cup diced green bell pepper
- ½ cup diced red bell pepper
- 2 tablespoons minced garlic
- 1 cup dry white wine
- ½ cup thinly sliced and diced jamón Serrano (Spanish cured ham)
- ½ teaspoon sweet pimentón (Spanish smoked paprika)
- 2 cups plain canned tomato sauce
- 1 fresh rosemary sprig
- 1 bay leaf
- 2 cups water

POLLO AL CHILINDRÓN
Photo courtesy of Thomas Schauer

Heat 1 tablespoon of the olive oil in a 12-quart pot over medium-high heat. Season the chicken pieces with salt. Working in batches, brown them on all sides. Transfer the chicken to a platter and set aside.

Add ¼ cup olive oil to the same pot and, when the oil is hot, add the onions and peppers. Reduce the heat to low and cook slowly until the vegetables are dark golden brown, about 30 minutes. Add 1 tablespoon of water if the onions start to burn. Add the garlic and cook for 5 more minutes. Add the white wine and cook until it evaporates, 4 to 5 minutes.

Add the jamón and browned chicken pieces, as well as any juices that have collected, and cook for 5 more minutes. Stir in the pimentón, tomato sauce, rosemary, bay leaf and the water and simmer over low heat for 1 hour or until the meat starts to fall off the bone. Season with salt, to taste, before serving.

REFERENCES

World Central Kitchen (www.wck.org)

The State of Cooking Energy Access in Schools – The World Bank (World Bank Group - International Development, Poverty and Sustainability)

Nigel Bruce and Daniel Pope – CLEAN Air (Africa) (CLEAN-Air(Africa))

Link to video on the CLEAN Air (Africa) laboratory and facilities:
https://www.youtube.com/watch?v=upNlH_Hv3RA
and full video: https://www.youtube.com/watch?v=jo3kEcncgeM

https://www.integrityalliance.biz/news/2024/05/31/steam-cooking-in-kenya-school-setting-pace-to-net-zero/

WLGA Core Safety Group – www.worldliquidgas.org

WLGA – Guidelines for Good Safety Practices in the LPG Industry

WLGA – Guidelines for Good Business Practices in the LPG Industry

NFPA 58

ISO 22991 - Gas cylinders -Transportable Refillable Welded Steel Cylinders for Liquefied Petroleum Gas (LPG) – Design and Construction

ISO 10691 - Gas Cylinders – Refillable welded steel cylinders for liquefied petroleum gas (LPG) -- Procedure for checking before, during and after filling.

EN 1439 - LPG equipment and accessories - Procedure for checking LPG cylinders before, during and after filling

ISO 10464 - Gas Cylinders – Refillable welded steel cylinders for liquefied petroleum gas (LPG) --Periodic Inspection and Testing

BS 5355: 1976 - Specification for filling ratios and developed pressures for liquefiable and permanent gases

EN 1442 - LPG equipment and accessories - Transportable refillable welded steel cylinders for liquefied petroleum gas (LPG) -- Design and construction, European Committee for Standardisation

EN 1440 - LPG equipment and accessories - Transportable refillable welded steel cylinder for LPG -- Periodic requalification,
European Committee for Standardisation

Liquid Gas UK - Code of Practice 12 Recommendations for the Safe Practice in the Design and Operation of LPG Cylinder Filling Plants

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