Opportunities for using LPG in Humanitarian Settings

WLPGA

The World LPG Association

The World LPG Association (WLPGA) was established in 1987 in Dublin, Ireland, under the initial name of The World LPG Forum.

The WLPGA unites the broad interests of the vast worldwide LPG industry into one organisation. It was granted Category II Consultative Status with the United Nations Economic and Social Council in 1989.

The WLPGA exists to provide representation of LPG use through leadership of the industry worldwide.

Acknowledgments

This report is a desk top study. However, there were opportunities during the drafting to meet and talk to some of people who are closely involved with the running of some of the largest refugee camps in Africa and the Middle East.

This provided a unique insight into what happens inside these challenging environments and the WLPGA would like to thank all the people who participated in this work and made valuable contributions. In particular, Glada Lahn (Chatham House), Ben Good (GVEP International), Paul Quigley (UNHCR), Kathleen Callaghy and Katherine Arnold (Global Alliance for Clean Cookstoves).

Finally, thanks to others on the Cooking for Life Steering Committee who provided valuable comments on the draft.

David Tyler drafted this report and Michael Kelly from the WLPGA coordinated this project.

FOREWORD

UNHCR is pleased to support the WLPGA with this report which focuses on the opportunities for using LPG in humanitarian settings. There are now over 65 million people forcibly displaced from their homes, most of whom rely on solid fuel for cooking, creating serious social, health and environmental issues. Children and women are disproportionately affected. Universal access to clean energy could vastly improve the health and well-being of millions of persons and UNHCR is actively promoting the increased use of alternative, clean fuels. LPG is already used by thousands of families in refugee settings across several countries with plans to expand to other countries. UNHCR welcomes this initiative by the WLPGA and we look forward to working more closely with the LPG industry to make that happen.

Paul Quigley
Senior Energy Officer - UNHCR

Far too many people affected by crises must risk their health, safety, and livelihoods to cook a meal for their families. Without access to modern cookstoves and fuels, refugees may face assault, injury, and even rape while searching for fuel to cook with. Many refugees sell or exchange a portion of their food rations in order to procure the firewood needed to cook their remaining food, which can lead to malnutrition. Women and children are also exposed to health risks including respiratory infections from smoke produced by inefficient stoves and fuels.

The good news is that over the past five years the humanitarian community has placed increased emphasis on improving energy access. The Global Alliance for Clean Cookstoves is working closely with UNHCR and many additional partners to help guide decisions on the stove and fuel interventions most appropriate for crisis settings. Clean fuels such as LPG, ethanol, biogas and others can deliver widespread benefits to health, safety, livelihoods, and the environment. By scaling these effective solutions, thousands of lives can be improved.

As the title of this report suggests, there are opportunities for using LPG in humanitarian settings. With the help and guidance of partners such as WLPGA and the other contributing experts to this report, meeting basic household energy needs with advanced fuel options can become a reality. As a key stakeholder and partner in our clean cooking efforts, we look forward to continuing to engage with WLPGA in their efforts to ensure that cooking no longer kills.

Radha Muthiah, CEO, Global Alliance for Clean Cookstoves

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EXECUTIVE SUMMARY

This document is one of a series published by the WLPGA aimed at promoting the safe and sustainable use of LPG around the world. This subject addresses one of the most challenging situations that the world is facing today: the issue of displaced populations, caused by civil unrest and natural disasters. It has been written with support from the Office of the United Nations High Commissioner for Refugees (UNHCR), or UN Refugee Agency.

- **Over 65 million people were displaced from their homes by conflict and persecution in 2015**
- **This included asylum-seekers, internally displaced people and refugees**
- **This is equivalent to the population of the United Kingdom**
- **Most rely on traditional fuels such as wood and charcoal as their primary cooking fuel**
- **Collecting traditional fuels causes serious social and environmental issues**
- **Burning traditional fuels creates serious indoor air pollution which can kill**
- **The UNHCR is a United Nations programme mandated to protect and support refugees**
- **LPG is a proven alternative to traditional fuels and is being used in some refugee camps**
- **There is an opportunity to significantly increase the use of LPG for cooking in this sector**
- **LPG generators can also provide electricity to refugee camps and areas of natural disasters**
- **This document provides background to the challenges and opportunities for LPG in this sector**
- **Displacing traditional fuels with LPG is challenging but possible**
- **It is recommended that the LPG industry and UNHCR seek ways to make that happen**

Over 65 million people, equivalent to the population of the UK, were displaced from their homes by conflict and persecution in 2015. That's one in every 113 of the world's population.

The collection and use of wood for cooking is one of the causes of desertification where a relatively dry land region becomes increasingly arid, affecting vegetation and wildlife

Many of these people are living away from their homes, in remote communities with no or little access to modern energy. They rely on traditional fuels – such as wood and charcoal – for their primary cooking fuel.

The wood collected is often the small saplings that have no chance to mature

Collecting this fuel is dangerous, time consuming and causes deforestation, especially as the wood is collected from small saplings which have no opportunity to mature. In parts of the world this also causes desertification that has an impact on farming and biodiversity.

Burning wood creates serious indoor air pollution. This is unhealthy and in some cases life threatening. The World Health Organisation (WHO) estimates that over 4 m people die from indoor air pollution every year. The burning of wood is also very inefficient.

The Office of the United Nations High Commissioner for Refugees (UNHCR), or UN Refugee Agency, is a United Nations programme mandated to protect and support refugees at the request of a government or the UN itself. It assists in their voluntary repatriation, local integration or resettlement to a third country. It was created in 1950, during the aftermath of the Second World War, to help millions of Europeans who had fled or lost their homes.

This document presents the opportunity to provide these displaced populations with LPG in order to transition them away from traditional fuels. It describes the case for LPG and provides a proposition for change. How to deal with

populations that have been forcibly displaced and how to meet their basic energy needs are challenges facing the authorities that are responsible for them.

The Moving Energy Initiative (MEI) carried out an energy survey in 2015 (https://www.chathamhouse.org/sites/files/chathamhouse/publications/research/2016-05-19-mei-energy-situation-dadaab-refugee-camps-okello-final.pdf) in the Dadaab refugee camps in Kenya which demonstrated this. The research paper - *The Energy Situation in the Dadaab Refugee Camps, Kenya* - edited by Stephen Okello (GVEP International) Energy, Environment and Resources Department, was published in May 2016.

The Moving Energy Initiative (MEI) is a collaboration between GVEP International, Chatham House, the Office of the United Nations High Commissioner for Refugees (UNHCR), the Norwegian Refugee Council (NRC) and Practical Action Consulting. The MEI seeks to identify how innovation in policy and practice within the humanitarian sector can improve access to sustainable energy among displaced populations and camp operators. Funded by the United Kingdom's Department for International Development (DFID), the initiative seeks to develop, research and test appropriate sustainable energy solutions, as well as innovative delivery models for energy solutions.

According to UNHCR data at the time of the survey, there were 351,538 refugees and 83,277 households in the whole of Dadaab. Almost all used firewood as their main cooking fuel. The firewood rations distributed by the UNHCR cover only 10% of a household's monthly firewood demand, forcing them to procure the tradition fuel from other sources. MEI concluded '…there is a demonstrated need for a more sustainable source of energy for the refugees…'

Cooking with firewood is often the only option available to refugees

LPG can displace traditional fuels for cooking with significant benefits. Almost 50% of global LPG demand is in the residential sector where it is used mainly as a cooking fuel.

The Global Alliance for Clean Cookstoves (GACC) is a public-private partnership that seeks to save lives, improve livelihoods, empower women, and protect the environment by creating a thriving global market for clean and efficient household cooking solutions. GACC states that '…refugees, internally displaced people, and other crisis-affected populations lack access to clean cookstoves and fuels for cooking. Clean and efficient cooking solutions can help reduce the need for long and often dangerous trips in search of fuel, and improve outcomes in humanitarian settings…'

The increasing use of LPG in households is one of several pathways to meet the objective of universal access to clean cooking and heating solutions by 2030.

This is one of the three pillars of the UN Sustainable Energy for All (SE4All) initiative, along with doubling the global rate of improvement in energy efficiency and doubling the share of renewable energy in the global energy mix.

Refugee camps are temporary structures, often with limited services

In 2012, the WLPGA launched the "Cooking For Life" campaign to communicate the health benefits of switching communities from wood, charcoal, coal, dung and other traditional fuels, and kerosene, to LPG for cooking.

In October 2013, Sustainable Energy for All (SE4All) and the WLPGA announced the goal to transition one billion people from traditional fuels to LPG.

To secure this, they agreed to support a multi-stakeholder partnership that would build on best practices and sustainable business models. The aim was to overcome the multitude of policy, market regulation, business environment and local financing bottlenecks inhibiting the ability of governments and the private sector to meet the need for LPG.

The SAFE Humanitarian Working Group is a consortium of key partners working to meet the energy needs of crisis affected populations around the world. Each agency contributes specific expertise critical to addressing the energy needs for the world's most vulnerable populations. The group is committed to ensuring that relevant stakeholders at all levels take action for energy implementation to achieve large scale impact and long lasting outcomes. It serves as the main coordinating body for energy access in humanitarian settings. The SAFE project mapping contains data on several LPG projects www.safefuelandenergy.org.

LPG is a clean-burning, efficient, versatile and portable fuel. It is a by-product from the refining of crude oil as well as when natural gas is 'wet' and contains liquids, through the production of natural gas.

Communal cooking with LPG

LPG is up to five times more efficient than traditional fuels. It produces less air pollutants than kerosene, wood or coal, about 20% less CO2 than heating oil and 50% less CO2 than coal; it also reduces black carbon emissions.

LPG can be transported in small or large quantities by sea, rail or land. Small quantities with as little as a few kg can be easily carried in cylinders, enabling the LPG to be used in the most remote and rural areas. However there has to be an LPG infrastructure in place to allow that to happen.

LPG has a very good safety record but it is highly flammable and needs to be handled according to good safety practices.

It is hoped that this document will provide stakeholders with some encouragement and ideas to consider LPG as a safe alternative to traditional fuels and kerosene, especially for those people who have been forcibly displaced.

The document is seen as a first step towards securing partnerships between the LPG industry and the organisations involved in managing these humanitarian settings, with the aim of replacing traditional fuels with LPG.

CHAPTER ONE – BACKGROUND

- **The total number of displaced people in the world is equivalent to the population of the UK**
- **Most are burning traditional fuels such as wood, charcoal and kerosene**
- **Transitioning to LPG would bring health, social and environmental benefits**
- **There is an opportunity for the LPG industry to work with the UNHCR and other organisations to achieve this**

1.1 THE NEED FOR THIS DOCUMENT

The purpose of this document is two-fold.

It first seeks to further the argument for LPG as a solution to transition away from traditional fuels for people in humanitarian settings, such as refugee camps and natural disaster areas.

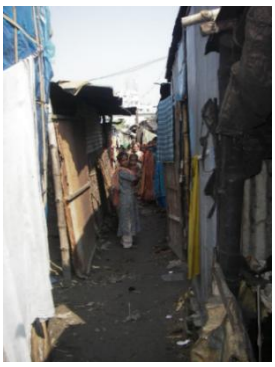
Secondly, it aims to provide an understanding for stakeholders in the LPG industry of the challenges and opportunities for providing LPG into these communities.

As the global organisation representing the LPG industry, the WLPGA is committed to promoting the use of LPG as a clean and healthy alternative to dirty traditional fuels such as firewood, charcoal, coal, animal waste and kerosene.

LPG is recognised as a very versatile and portable form of clean modern energy. Almost half of the global demand for LPG is in the residential sector where it is used as a cooking fuel and for heating homes and water.

Modern energy services are crucial to the well-being of individual health and a country's economic development. According to the International Energy Agency (https://www.iea.org/), 1.2 billion people are without access to electricity and more than 2.7 billion people are without clean cooking facilities. More than 95% of these people are either in sub-Saharan African or developing Asia, and around 80% are in rural areas.

Indoor air pollution kills 4 m people a year



Slum areas in major cities present some of the most challenging living conditions

These people have to rely on traditional fuels as their primary source of heat for cooking. This results in health, economic, social and environmental issues. The use of wood and charcoal is also a major contributor to deforestation and desertification.

Many of these people live in remote rural areas, well away from the modern grid networks of electricity and natural gas, and are also on restricted incomes. Some live in peri-urban areas, on the outskirts of cities, often in slum areas.

An increasing number of the world's population is being forcibly displaced as a result of wars, conflicts or persecution. The UNHCR estimated that over 65 million people, or one person in 113 of the world population, were displaced from their homes by conflict and persecution in 2015. After adding to that number the people impacted by natural disasters such as earthquakes and tsunamis, the figure is daunting.

Although the UNHCR have refugee camps where LPG is already being used (refer chapter 8.1), traditional fuels - such as wood, charcoal and kerosene - are frequently the only forms of energy available. In addition

LPG power generators can be small 1kw units or larger truck mounted ones

to this, when natural disasters suddenly hit inhabited areas, power lines and piped gas networks get damaged and supplies of electricity, water and gas are interrupted.

The portability of LPG, enabling it to reach even the most inaccessible locations, makes it an ideal and proven alternative to traditional fuels.

Its versatility and powerful flame is ideal for cooking, heating and providing light.

When used with gas powered generators, LPG can also provide electricity to the most remote areas.

Two of the challenges of providing LPG to refugee camps and areas hit by natural disasters are cost and availability. These and other issues will be explored in this document. Some examples of how these challenges have been overcome will be described in case studies.

1.2 Who is the Audience for this Document?

There are two main audiences for this document.

The first are organisations who are responsible for, or involved in, managing populations who have been forcibly displaced as a result of wars, conflicts or persecution, and those affected by natural disasters. It is hoped that this audience can learn more about what LPG is, and how it can play a major role in alleviating some of the issues that are associated with energy shortages and the use of traditional fuels. Especially in refugee camps and areas affected by natural disasters.

The second audience for this document are the stakeholders in the LPG industry who may not be fully aware of the scale of the humanitarian problem, and how, for example, refugees are coping with such a basic need as cooking food, heating water, and in some cases providing heat in their rudimentary accommodation.

The document includes some brief details of where the larger refugee camps are, how many people are affected, and what resources they have now.

1.3 General Introduction

Today there are three billion people still without access to modern energy. They rely on traditional fuels such as wood, charcoal and coal. Even animal waste and rice husks. In fact, anything that can generate heat and be burned is a target fuel for these impoverished people.

The more fortunate amongst them will use kerosene. But kerosene is hazardous to have around the home.

Cooking with wood is dirty, dangerous and unhealthy

LPG is a viable, modern alternative in this scenario, due to its ease of handling, cleanliness, energy density, and portability in many cases, allowing it to reach out to these people and transform their lives.

The ease of handling, cleanliness, energy concentration and portability of LPG allows it to reach out to these people and transform their lives.

With LPG, there is no need to spend many hazardous hours a day collecting firewood, especially for the woman and children who are normally tasked with that job.

Using LPG removes the frustration of trying to light a fire with damp fuel on a wet day.

The appalling polluted air inside the kitchen, caused by the burning of these traditional fuels, along with the health risks affecting an entire family, can be stopped.

There is a high risk of fire in the home when cooking with wood

There is no need to sustain the wood fire throughout the day to cook the evening meal because LPG stoves can be turned on and off when required.

Kitchens that use solid fuel require storage areas that must be designed to keep the fuel dry, especially during winter months or monsoon seasons.

Using kerosene brings its own hazards, especially to children as it is often stored in bottles that resemble water or soft drink containers.

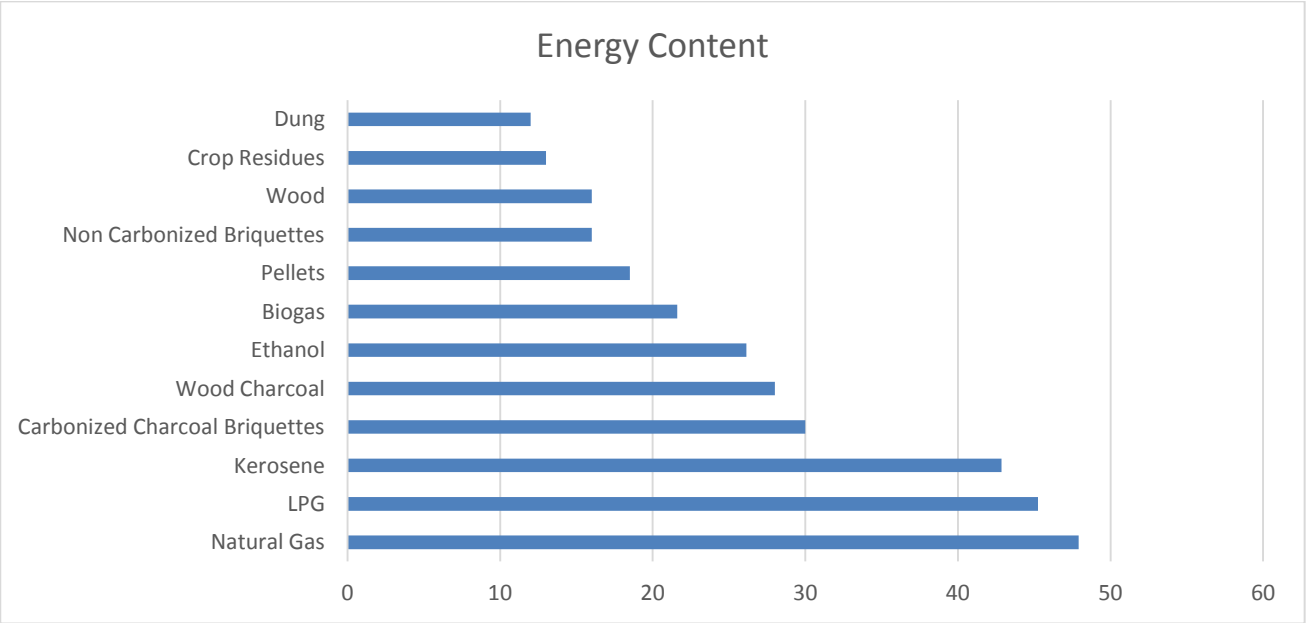
Kerosene is purchased in small quantities, often in soft drink bottles creating a risk of accidental poisoning

It can be mistakenly drunk by children and is one of the most common causes of paediatric poisoning (Lang, et al., 2008). Kerosene is also highly inflammable and poses a serious fire risk when used carelessly.

LPG can still make a compelling case even if there is access to a gas grid or a reliable electric power supply.

LPG has a very hot flame which is easily controlled. It can be used with both woks and simmering pans, and is very clean, both to use and burn.

The versatility of LPG also allows it to be used as an engine fuel in a portable power generator, powering gas refrigerators and heating water.



**Energy content values (Mj/kg) vary depending on factors such a moisture content, % of fuel mixes, types of feedstock, species of wood, carbonization process, etc. This table represents averages based on literature sources cited.*

The table shows some indicative energy values for various types of fuel but LPG would typically always lead when comparing gross energy content. If the relative efficiencies of the stoves are taken into account the gap is wider. An LPG stove can be quickly shut down when not in use. Unlike traditional stoves that often have to be kept alight to sustain the fire.

The pressure required to liquefy LPG is relatively low allowing it to be stored in convenient pressure vessels designed for moderate pressure.

These pressure vessels are generally made of steel but more recently, the use of composite plastics has been used to reduce the weight of the container, resist corrosion, and in some cases allow for the contents to be seen.

For bigger operations LPG can be supplied in larger cylinders, or if the demand warrants it, small bulk tanks.

Larger LPG cylinder storage facility with an automatic changeover device

Large cylinder installations are designed to ensure continued operation even if one of the cylinders becomes empty.

This is done by having a changeover device that detects when one set of cylinders are becoming empty and switching across to the full ones automatically maintaining continuity of supply.

Small bulk tanks are installed when the demand is high and they are accessible by road tanker.

Important properties and hazards of LPG are included in Appendix One.

Many of the traditional fuels have to be frequently mined, collected or gathered by women and children in often dangerous circumstances.

Women carrying wood

The mining of coal has a long history of injuries and deaths associated with bringing it to the surface. The subsequent transportation, storage and combustion of coal creates challenges to human health. Especially when used in old and poorly designed equipment.

Traditionally, the collection of wood is done by women and children. It is a painstaking task that starts early in the morning and can take several hours. As outlined in the GACC's Statistical Snapshot: Access to Improved Cookstoves and Fuels and its impact on Women's Safety in Crises, several organisations, including the GACC, have found that women and children spend up to 5 or 6 hours a day collecting firewood and are being subject to violence.

Woman burning wood

There are other consequences that impact on the social and economic aspects of the family. Very young children are left at home by their mothers with other family members, often the grandparents. Parents take their younger children with them to collect wood, impacting their schooling and education.

When these fuels are burnt they are often used in open stoves that release damaging emissions in the kitchen. This results in respiratory and cardiovascular related infections and diseases.

The use of firewood is also a major risk for burns, especially with children, and a possible cause of homes being destroyed by fire.

In addition to this, it is often the young trees that are taken, undermining the future of the forests.

Children buying charcoal

Charcoal is very dirty and inefficient to manufacture, wasting energy even before it is burnt. It is also a dirty fuel to handle and use, generating a similar type of environment as wood. Because it is relatively light and easy to carry, children are frequently asked to collect the charcoal, making them vulnerable to assault and theft.

LPG is commonly recognised in cylinders but it can also be provided from small bulk tanks

The traditional LPG distribution channel is well established and involves trained and professional people delivering the LPG to the consumer (see Appendix Three).

In the case of a communal kitchen, the demand will be relatively high probably requiring either a small bulk tank or a bank of large cylinders.

LPG is very clean to store and use. A small leak of LPG will disperse, whereas a leak of kerosene does not only emit an odour, but is a great safety hazard.

CHAPTER TWO – LPG – AN EXCEPTIONAL ENERGY

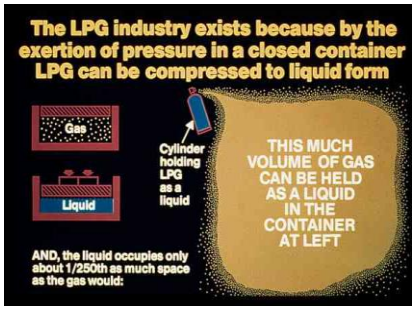
- **LPG is an exceptional energy, providing many benefits when compared to traditional fuels**
- **All indications provide that there will be plentiful supplies for the foreseeable future**
- **LPG is available in most of the countries where there are displaced people**

2.1 WHAT IS LPG?

LPG, or Liquefied Petroleum Gas, is propane, butane or mixtures of the two. Propane and butane are chemically very similar but have different properties, making them suitable for different applications.

LPG is part of the natural gas family

LPG can be easily compressed to a liquid under modest pressure and stored in cylinders. This enables it to be transported and used in remote areas that cannot be reached by natural gas or the electricity grid.



LPG is an extremely powerful energy

When that pressure is released, by operating a cook stove for example, the liquid LPG in the cylinder will produce a vapour or gas. One unit of liquid will produce around 250 units of gas, which demonstrates how powerful LPG is in liquid form.

LPG is easy to light, and its flame can be controlled across a wide range, which is necessary for cooking. The quality of traditional fuels varies greatly depending on the source, composition and condition but LPG has a very consistent composition and quality.

2.2 WHERE DOES IT COME FROM?

LPG is a by-product of the crude oil refining process and can also be extracted from natural gas production. Today there is an increasing amount of LPG being produced from natural gas which underpins its long term availability.

North America and the Middle East are the two largest LPG producing regions but the industry is well equipped with very large gas carriers (VLGC's) to transport LPG to the major demand centres around the world.

The USA is now the world's largest exporter of LPG, larger than any of the Middle Eastern producing countries. This turnaround (the USA was a net importer of LPG just a few years ago) has been driven by the huge discoveries of shale in the USA.

VLGC Lycaste Peace was the first LPG vessel through the Panama canal's new locks in July 2016

The logistical infrastructure is in place to move LPG from the major producing countries to the regions where there are opportunities for developing new LPG markets.

The opening of the new Panama Canal in July 2016, which is large enough to accommodate VLGC's, has opened a gateway from the US to the large growing markets of Asia.

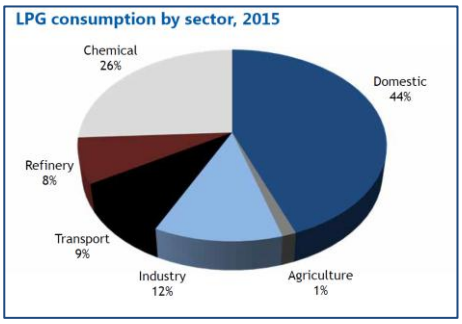
The trade flow map in Appendix Two illustrates that availability is no barrier to transporting LPG to the demand centres of the world.

2.3 HOW DOES IT FIT INTO THE GLOBAL ENERGY PICTURE?

Although LPG is technically a by-product, it plays an important role in the world's energy picture.

Around 285 m tonnes of LPG were consumed in 2015 with almost half being used in the domestic (residential) sector. The second largest sector is the chemical industry where LPG is used as a feedstock for manufacturing plastics. Here it competes with naphtha, one of the derivatives of crude oil.

It is this link with crude oil that has historically driven a correlation between world crude oil and LPG prices.



LPG used in domestic (residential) applications, cooking and heating, is the largest sector (source: WLPGA)

There are hundreds of other applications for LPG in the commercial, industrial, agricultural and transport (auto) sectors. LPG for transport is due to the fact that it is a very good engine fuel, with an octane rating higher than gasoline (petrol). About 10% of all the LPG consumed in the world is used in on road vehicles, as an alternative to diesel and gasoline.

In the context of other energy forms, total LPG consumption is equivalent to 10% of global coal consumption, 11% of natural gas consumption, 42% of nuclear energy consumption, 42% of the world's hydroelectricity consumption and 140% of the world's liquefied natural gas consumption.

2.4 WHERE IS IT USED?

It is estimated that two billion people use LPG in one application or another. From cigarette lighters to cook stoves, the ease in which LPG can be stored, handled and distributed enables the infrastructure to be installed relatively quickly and efficiently.

One of the main drivers of LPG demand is Gross Domestic Product (GDP) and there is a close correlation between GDP and LPG consumption per capita.

The charts in 9.2 show where LPG is being used in the world and the per capita consumption by country. These heat maps provide a good indication of where the infrastructure exists for storing and distributing LPG and where the opportunities are for further development of LPG demand.

LPG is produced in refineries and natural gas production facilities. Where local production is unable to meet country demand, imports supplement the remaining or total supplies needed.

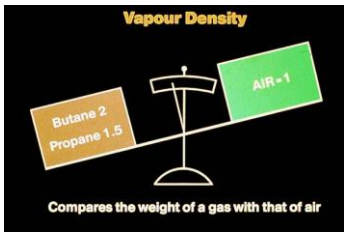
Sea fed LPG imports require land based storage together with facilities to fill cylinders and move the product in bulk.

CHAPTER THREE – KEY PROPERTIES OF LPG

- **LPG is ideally suited for use in refugee camps and areas hit by natural disasters**
- **Apart from cooking it can also be used for heating, transport, power generation and pumping water**
- **LPG is easy to use, although first time users will need some education and basic training**
- **Involvement of all stakeholders in the change process is important**

3.1 DESCRIPTION OF KEY PROPERTIES AND CHARACTERISTICS

LPG becomes liquid at room temperature if moderately compressed and reverts to gas form when the pressure is sufficiently reduced. This gives it a considerable advantage over other fuels because it can be easily transported and stored in the liquid state. Some general properties of LPG are included in Appendix One.



LPG is heavier than air

An important property of LPG is that in vapour form it is heavier than air. If LPG leaks, it will always fall towards the ground rather than dissipate into the air. LPG should therefore never be stored below ground and always be in a well ventilated area.

LPG is portable, enabling it to reach the most inaccessible areas. LPG has a high calorific value presenting an opportunity to provide energy to a number of households at the same time.

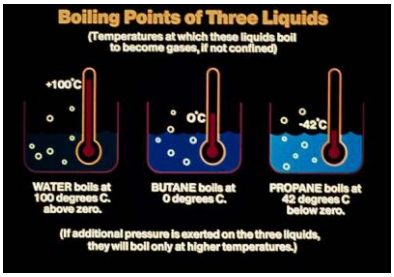
In liquid form LPG is lighter than water. A full domestic LPG cylinder, weighing typically 30kg, will float. This was most evident during the Tsunami in Japan where storage tanks, road tankers and cylinders were seen floating amongst the debris after the tsunami had struck.

Because LPG is lighter than water the cylinders floated after the tsunami in Japan

Storage tanks with other forms of energy such as gasoline (petrol) and diesel were rendered useless after the tsunami. The distribution channel, including storage tanks and road tankers, became contaminated with water and created an environmental danger as the fuel spilled out.

Because LPG is stored under pressure, any leak will disperse without creating an environmental mess. In Japan, after the tsunami, LPG was one of the only forms of energy that was available and useable.

LPG has a much higher heat (calorific) value than traditional fuels such as firewood, charcoal, biomass, kerosene etc. It is also clean burning, creating no particulate matter, has a very low sulphur content and burns very efficiently.



Propane can be used in circumstances where there are very low temperatures

Propane boils at around minus 42 degrees centigrade which makes it more suitable than butane for cold climates. Butane boils at zero degree.

The flame temperature of LPG is very high, making it an ideal cooking fuel. Because it burns within a narrow range, the risk of unintended ignition is reduced.

Liquid LPG has a high co-efficient of volumetric expansion which is why cylinders should never be completely filled. An ullage or space is left in the container to allow liquid LPG to expand when temperature rises. This is especially important in the event of a fire.

Unlike natural gas (methane), which does not liquefy unless compressed at high pressures, LPG can be delivered in small quantities by road tanker.

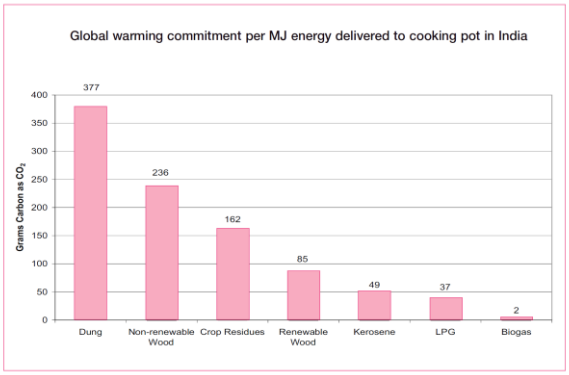
The global warming commitment per mega joule (MJ) of LPG is significantly less than other fuels according to Dr. Kirk Smith et al (refer chart).

Unlike traditional fuels, which are very visible, LPG is a gas. Consumers see the pile of logs deplete but they cannot see the contents of an LPG cylinder deplete with a steel cylinder.

This can be managed with education but it has to be considered when transitioning away from traditional fuels.

The introduction of composite cylinders has allowed consumers to see the level of the contents through the translucent body.

LPG is non-toxic, environmentally friendly and very safe when used properly.



Global warming commitment of different fuels (source: K Smith et al 2000)

3.2 How these impact on the use of LPG

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

LPG containers (cylinders and tanks) should never be overfilled. It can lead to the container being subjected to hydraulic pressure resulting in the pressure relief valve lifting to relieve LPG. This is a hazardous situation that should be avoided.

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

LPG is stored under pressure meaning that any small gaps or pinholes can cause LPG to leak out. Pipes must never be stepped on, or used to hang kitchen equipment and other objects that may create undue force on.

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. Gas valves should be closed immediately once LPG is detected by smell and all ignition sources should be put out.

Soapy water should be used to check for leaks in the piping system. It should be applied on all joints and hoses. The presence of bubbles indicates a source of leak. Naked flames should never be used to search for leaks.

When appliances are disconnected for servicing or removed to clean the area, the connection should be checked for vapour tightness when those appliances are reconnected.

Cooking utensils should match the burners used. A burner where the flame exceeds the base of a pan wastes heat and energy.

Appliance gas valves should always be closed when the appliance is not being used and when LPG is not used for an extended period of time.

When using an appliance without a spark igniter, the lighter or match must be lit before opening the appliance gas valve, to avoid an 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. Ensure there is a 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.

When converting from traditional fuels to LPG a suitable space should be allocated for the 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.

LPG installations should preferably be outdoors. The space required will depend on the size of the installation. Cylinder installations will typically require a smaller footprint than bulk tank installations.

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. The installation 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 to minimise any risks during delivery.

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

LPG appliances do not emit smoke or other toxic fumes that can be hazardous to individual health. They must, however, be placed in a location with sufficient ventilation to disperse the elements of combustion. Such elements consist mainly of carbon dioxide and water vapour. This minimises any risk of the build-up of carbon monoxide and asphyxiating (oxygen deficient) conditions.

There are many types of LPG appliances available that can meet the different needs of the consumer i.e. cook stoves, ovens, water heaters etc. The right appliance should be chosen for consumers to optimize the benefits of switching to LPG.

Only appliances that are certified, and/or meet applicable standards or regulations, should be used. Uncertified appliances may pose a risk.

The LPG appliance chosen must be compatible with the grade of LPG used. The installer must be consulted regarding any adjustments to be made on the appliance.

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

Insufficient air will result in yellow tipping of the flame. Too much air will cause the flame to lift. 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 to get the LPG appliances installed and serviced by an approved installer.

CHAPTER FOUR – A GLOBAL ENERGY

- **LPG supplies are growing by 3-4% a year, with its growth rate presumed to continue**
- **Nearly half the global demand is in the domestic (residential) sector**
- **Many countries still have very low usage levels**
- **International prices are at historically low levels**

4.1 OVERALL SUPPLY AND DEMAND PICTURE

Two of the questions often asked by governments when discussing LPG as an option to their energy policy are 'is there going to be much LPG available in the future?' and 'will it be affordable?'

This chapter tries to address those questions in the context of the opportunity for displacing traditional fuels with LPG into a potential market the size of the United Kingdom.

LPG is a by-product and global demand is driven by supply. Historically, LPG supplies have grown consistently at around 3% to 4% a year. With 2015 volumes at around 285 m metric tonnes (mn t), this adds around 10 mn t of LPG to the global market every year.

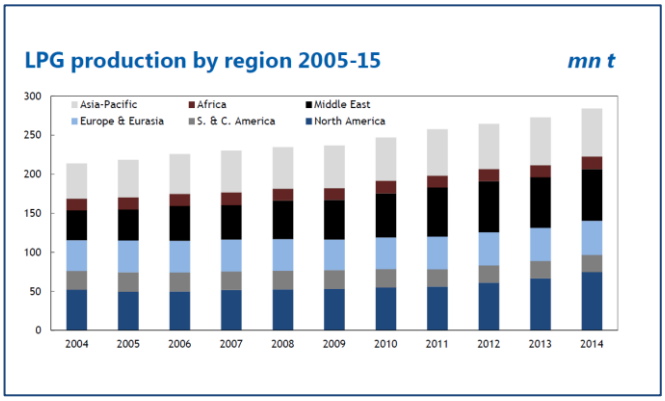
LPG production occurs across the world but the Middle East and the USA and the largest producing regions. The ease at which LPG can be transported allows the product to flow to the markets where the demand lies.

The map shown in Appendix Two illustrates this.

4.2 FUTURE OUTLOOK FOR LPG

With the increasing discoveries of shale related gas in the USA, together with the new natural gas fields continually being discovered around the world, the outlook for LPG has never looked better.

Historically supplies have grown by 3-4% per year and all the forecasts are predicting similar growth over the foreseeable future. There is likely to be more LPG produced from natural gas than crude oil in the future.

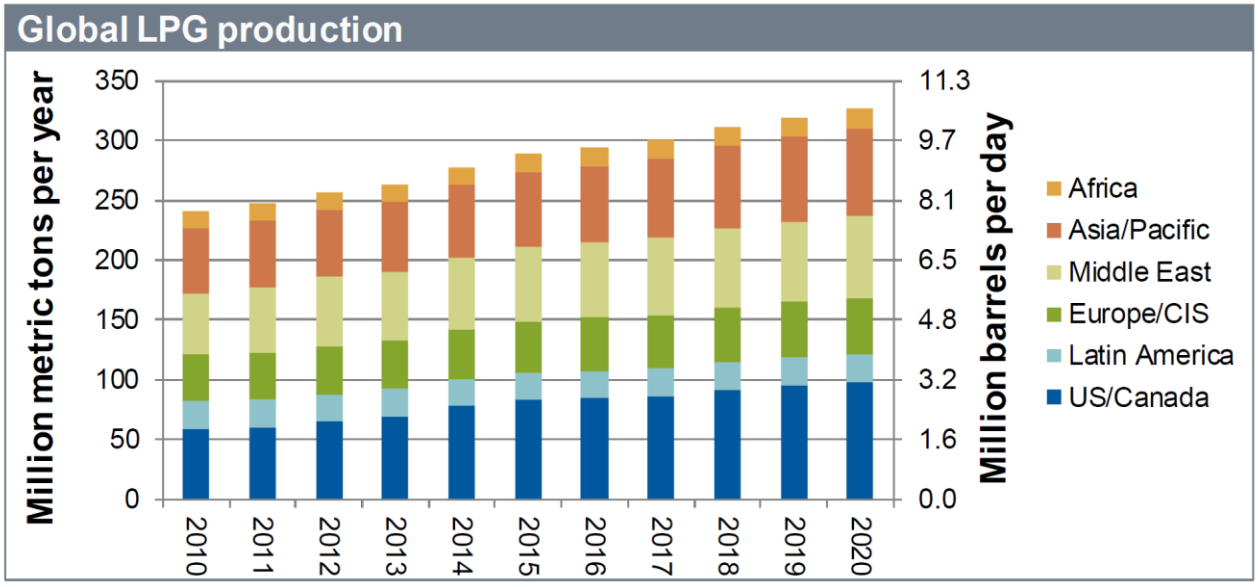


LPG production has grown at around 4% in 2015 across all regions to reach 292mt in 2015 – map courtesy Argus Media (www.argusmedia.com)

This is leading governments to confidently plan LPG into their future energy portfolios. Recent controversies over diesel – with the WHO in 2012 confirming that diesel emissions are a proven group one carcinogen to humans, coupled with the VW emissions scandal – has led governments to act against the use of diesel in urban areas. The mayor of Paris for example wants diesel vehicles removed from the capital's streets by 2020.

This has not only opened up opportunities for LPG as a replacement for diesel, but it is also confirming government's views that LPG is clean.

Against this background of plentiful supplies, coupled with government endorsement, the future for LPG as a clean alternative to traditional fuels looks positive.



Source IHS

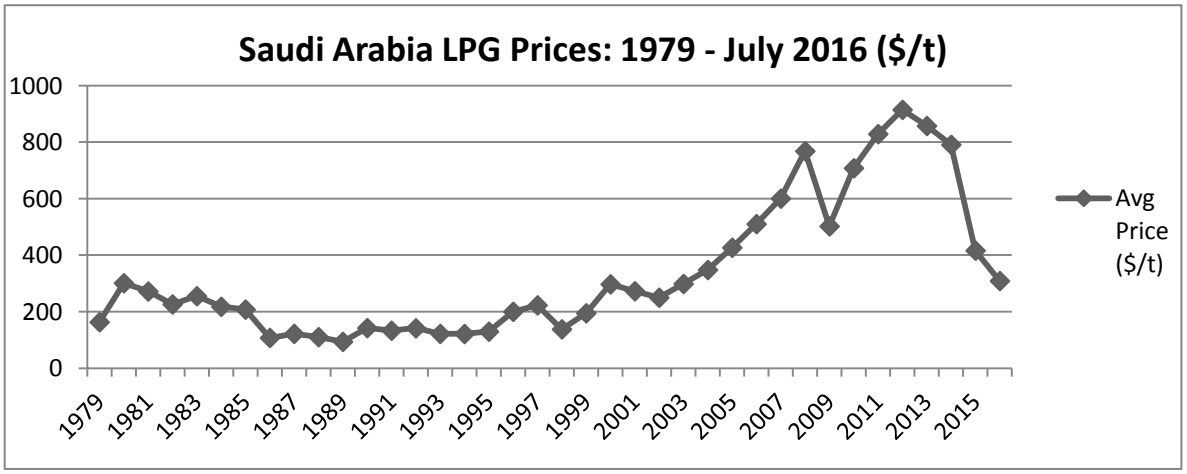
Most of this forecast production is expected to come from the USA, the Middle East and Asia/Pacific regions with the USA likely to remain the world's largest exporting country.

4.3 WHAT DRIVES THE PRICE OF LPG?

The international price of LPG is set on a monthly basis and one of the most common methods has been to use the Saudi Arabia Contract Price (CP). CP is announced at the beginning of each month in US$/metric tonne. The CP is a 'free on board' (FOB) price, meaning that freight, insurance and other costs will be added to determine the final price at the LPG cylinder filling plant.

There are other pricing mechanisms but all have been trending downwards over the last few years to levels not seen since 2000.

The following chart illustrates how CP has changed over the last 30 years.



Three years ago the international price of LPG was around US$1,000/metric tonne (mt), but since then prices have fallen to around US$300/mt.

Predicting prices is very difficult but the expectation is, with the assumption of continued plentiful supplies and stable conditions, that these low prices could continue into the foreseeable future.

Cost has been a barrier for the challenge of transitioning people from traditional fuels to LPG, but the possible continuity of low prices for LPG is good news for the industry.

4.4 How can LPG compete with other forms of energy?

Despite the falling price trends, one of the challenges for LPG is that traditional fuels are often purchased in very small quantities for little outlay, or they may even be obtained at no cost.

Another challenge for LPG is that when consumers purchase it for the first time there is also the initial cost of the equipment – cylinder, hose, regulator and appliance (cook stove). This can be over US$40 depending on the size of the cylinder.

Firewood is sometimes obtained at no cost

Compare this to a primitive wood stove that might consist of three rocks, and a free supply of wood.

The initial cost of the various energy options hides the actual cost of cooking a meal. LPG burns very efficiently and can be turned on, turned down or turned off, very easily. Wood fires are often sustained during the day in order to cook the later meals, wasting energy when not being used.

If the wood or charcoal is wet, traditional fuel stoves are not easy to light and keep alight, but LPG stoves can be easily ignited and turned off. Also, the efficiency of an LPG stove compared to a traditional stove is much higher (ref chart in 1.3).

Despite these advantages, the cost of transitioning from traditional fuels to LPG for most people is beyond their reach. This is due to the upfront cost of the initial equipment coupled with the ongoing refill cost.

There have been several initiatives to break down this entry barrier and two of those, the Community Kitchen and the Darfur project, have been included in Chapter Eight.

Following a pilot programme in Southern China in the 1980's when consumers switched from using coal briquettes to LPG, when consumer spending power reduced, they were reluctant to revert back to coal. Instead they would continue to use LPG, albeit sparingly, by supplementing with other fuels.

CHAPTER FIVE – HUMANITARIAN SITUATIONS

- **There are over 65 million displaced people in the world**
- **The UNHCR has a mandate to support refugees**
- **Organisations such as the Global Alliance for Clean Cookstoves also provide valuable support**
- **Over 85% of refugees are in low and middle income countries that are close to situations of conflict**
- **Many use traditional fuels as their primary energy**
- **Transitioning them away from traditional fuels would alleviate their situation**

According to a 2015 UNHCR study, (https://s3.amazonaws.com/unhcrsharedmedia/2016/2016-06-20-global-trends/2016-06-14-Global-Trends-2015.pdf) a total of 65.3 million people, or one person in 113 of the world population, were displaced – an asylum-seeker, internally displaced or a refugee – from their homes by conflict and persecution in 2015. This compares to 59.5 million just 12 months earlier.

Wars and persecution have driven more people from their homes than at any other time since UNHCR records began. Twenty-four people are displaced every minute.

The UN High Commissioner for Refugees, Filippo Grandi, said "…more people are being displaced by war and persecution, and that's worrying in itself, but the factors that endanger refugees are multiplying too…" "…at sea, a frightening number of refugees and migrants are dying each year; on land, people fleeing war are finding their way blocked by closed borders…"

The total number of displaced people amounts to the population of the United Kingdom. The number includes 40.8 million people who are internally displaced (have been forced to flee their homes but are within the confines of their own countries) and there are 21.3 million refugees.

The report said that forced displacement has been on the rise since at least the mid-1990s in most regions, but over the past five years the rate has increased.

The reasons are threefold:

(i) Conflicts that cause large refugee outflows, like Somalia and Afghanistan – now in their third and fourth decade respectively – are lasting longer.
(ii) New or reignited conflicts and situations of insecurity are occurring more frequently. While todays largest is Syria, wars have broken out over the past five years in South Sudan, Yemen, Burundi, Ukraine and Central African Republic. Thousands more people have fled raging gang and other violence in Central America.
(iii) The rate at which solutions are being found for refugees and internally displaced people has been on a falling trend since the end of the Cold War, leaving a growing number of individuals in limbo.

The study found that three countries produce half the world's refugees. Syria (4.9 million), Afghanistan (2.7 million) and Somalia (1.1 million) together accounted for more than half the refugees under UNHCR's mandate worldwide. Colombia (6.9 million), Syria (6.6 million) and Iraq (4.4 million) had the largest numbers of internally displaced people.

While the spotlight in 2015 was on Europe's challenge to manage more than 1m refugees and migrants who arrived via the Mediterranean, the report shows that the vast majority of the world's refugees were in developing countries in the southern hemisphere.

In all, 86% of the refugees under UNHCR's mandate in 2015 were in low and middle income countries close to situations of conflict. Worldwide, Turkey was the biggest host country, with 2.5 million refugees. With nearly one refugee for every five citizens, Lebanon hosted more refugees compared to its population than any other country.

Children made up 51% of the world's refugees in 2015, according to the data that UNHCR was able to gather. Many were separated from their parents or travelling alone.

UN High Commissioner for Refugees António Guterres said "…we are witnessing a paradigm change, an unchecked slide into an era in which the scale of global forced displacement as well as the response required is now clearly dwarfing anything seen before…"

Since early 2011, the main reason for the acceleration has been the war in Syria, now the world's single-largest driver of displacement. Every day last year an average of 42,500 people became refugees, asylum seekers, or internally displaced, a four-fold increase in just four years.

The UNHCR report details how, in region after region, the number of refugees and internally displaced people is on the rise. In the past five years, at least 15 conflicts have erupted or reignited: eight in Africa (Ivory Coast, Central African Republic, Libya, Mali, northeastern Nigeria, Democratic Republic of Congo, South Sudan and this year in Burundi); three in the Middle East (Syria, Iraq, and Yemen [see Appendix Four]); one in Europe (Ukraine) and three in Asia (Kyrgyzstan, Myanmar and Pakistan).

Areas of conflict over the last 15 years that have been driving the refugee problem

The report notes "…few of these crises have been resolved and most still generate new displacement…" adding that in 2014 only 126,800 refugees were able to return to their home countries, the lowest number in 31 years.

Meanwhile, decades-old instability and conflict in Afghanistan, Somalia and elsewhere means that millions of people remain on the move or – as is increasingly common – stranded for years on the edge of society as long-term internally displaced people or refugees.

One of the most recent and highly visible consequences of the world's conflicts and the terrible suffering they cause has been the dramatic growth in the numbers of refugees seeking safety through dangerous sea journeys, including through the Mediterranean, the Gulf of Aden and Red Sea, and Southeast Asia.

Conflict in Ukraine, a record 219,000 Mediterranean crossings (see Appendix Five), and the large number of Syrian refugees in Turkey brought increased public attention to the world's refugee problem.

In the EU, the biggest volume of asylum applications was in Germany and Sweden. Overall, forced displacement numbers in Europe totalled 6.7 million at the end of the year, compared to 4.4 million at the end of 2013, and with the largest proportion of this being Syrians in Turkey and Ukrainians in the Russian Federation.

Africa's numerous conflicts, including those in the Central African Republic, South Sudan, Somalia, Nigeria, Democratic Republic of Congo and elsewhere, together produced immense forced displacement totals in 2014.

In all, sub-Saharan Africa saw 3.7 million refugees and 11.4 million internally displaced people, 4.5 million of whom were newly displaced in 2014. Ethiopia replaced Kenya as the largest refugee-hosting country in Africa and the fifth largest worldwide.

Asia has been one of the world's major displacement producing regions. The number of refugees and internally displaced people in Asia grew by 31% in 2014 to 9 million people. Continuing displacement was also seen in, and from, Myanmar. Iran and Pakistan remained two of the world's top four refugee hosting countries.

The Americas also saw a rise in forced displacement. The number of Colombian refugees increased from 36,300 to 360,300 over the year, although mainly because of a revision in the numbers of refugees reported by Venezuela. Colombia continued, nonetheless to have one of the world's largest internally displaced populations, reported at 6 million people and with 137,000 Colombians being newly displaced during the year. With more people fleeing gang violence or other forms of persecution in Central America, the United States saw 36,800 more asylum claims than in 2013, representing growth of 44%.

The full Global Trends report with this information and more, and including data on individual countries, demographics, numbers of people returning to their countries, and available estimates of stateless population is available at http://unhcr.org/556725e69.html.

5.1 TYPES OF HUMANITARIAN SETTINGS

The main focus of this document is on the plight of refugees in camps. However, there are similar, challenging situations to be found with populations living in the peri-urban slum areas of major cities in developing countries and those that suffer from natural disasters.

The impact of the tsunami in Japan caused massive devastation

According to the United Nations Office for the Coordination of Humanitarian Affairs (OCHA) nearly 100 million people have been affected by natural disasters.

The common denominator with all these situations is that the people affected by these humanitarian settings all need to cook food to survive. The fuel available to most of them is traditional fuel such as wood, charcoal and kerosene. This might be because of cost, or it might be that traditional fuels are the only form of energy available in the circumstances they are in.

Conditions in some of the world's slums create immense challenges too

The effects of tsunamis can be even more challenging than the situations faced by refugees, with unchecked diseases and wrecked infrastructure. Tsunamis strike with little warning and the consequences can be devastating with power lines and gas mains are severed. The situation is probably not dissimilar to a war zone. Survivors need assistance very quickly and there is little time to plan.

The peri-urban areas of some major cities present their own challenges which are on-going. A lack of proper sanitation due to poor water supplies and no sewage brings health risks to the communities. Illegal power lines create a constant fear of electrocution and fire, with poor housing that exposes the residents to such hazardous elements. In addition to this, there is the need for food and fuel to cook meals.

In slum areas the only fuel is sometimes waste newspapers

Night brings darkness and the absence of electrical power limits any activities unless some other form of artificial light is available. Primitive kerosene

lamps might be the only option but these pose their own threat with the risk of fire from spillages.

Lighting from a kerosene lamp made from string and an old beer can

Some refugee camps have been supplied with solar lanterns which are not only safer but provide light at no cost.

Natural disasters such as tsunamis are fortunately relatively uncommon events, but wreak havoc when they do occur.

Recent events around the world have shined a spotlight on the refugee crisis with so many people suffering the trauma of being forcibly displaced from their homes, especially in Africa and the Middle East.

But the tsunami's that hit Asia on 26 December 2004 and Japan on 11 March 2011, highlight that not all the humanitarian situations are caused by man, and no region is safe. Nature too can devastate a community anywhere.

Conditions are challenging with small children to look after

The impact on the estimated 65 million population having to be forcibly removed from their homes is massive. One of the fundamental objectives for families in this situation is to make sure they can find a way to feed themselves and their families. Finding food, and a means to cook that food, can be a daily challenge.

In tsunami stricken areas this can be an almost impossible task, with lines of communications down and energy supplies severely interrupted or simply washed away.

Unlike refugee numbers it is difficult to obtain accurate data on the slum areas of cities. The challenge of dealing with these people and providing them with the basics of life remain huge in some countries.

The apparent ever growing plight of refugees has been well documented and the scale of the problem appears daunting.

The UNHCR has very good data available on refugee camps and although the information might be disheartening, it presents the opportunity for change. Refugee camps are by nature temporary structures, although some have been in existence for many years and many have also grown with demand. The changing boundaries of dispute might also mean moving populations.

Host governments are clearly not willing to encourage longevity with the camps which makes the supply of sustainable services more of a challenge.

This document is focusing on the supply of energy but there are many additional needs that have to be met.

5.2 What essentials are needed in these situations (water, food, clothing, light, heat etc.)

The UNHCR list a number of needs for the refugee camps that they are administering, and providing energy is just one item on the long list. This document is focused on the opportunities for LPG but they stretch far beyond cooking.

Apart from providing the opportunity for a clean and efficient cooking fuel, the versatility of LPG can also make a big difference to a facility with no heating or main source of electricity.

Electric power also provides light and the opportunity to use refrigeration to improve food hygiene. Gas hot water systems also bring improvements in personal hygiene and in the kitchen.

Removing traditional fuel from the kitchen might be one of the biggest challenges but it will create the largest benefits. The kitchen may be part of the living quarters in a single dwelling or in a central facility.

USAID (2006) reported that more than 80% of refugees may have missed their meals several times, even when food exists, because of the lack of fuel to cook with.

The dynamics of supply and demand for energy services to displaced people are diverse and complex. The situation varies between rural and urban settings. UN agencies and those leading humanitarian responses share differing levels of responsibility with governments and implementing partners depending on the context.

It is difficult to compare services available in upper-middle-income countries such as Jordan, Lebanon or Iran with those in low-income countries such as Burkina Faso or Uganda. The country of origin and former standard of living of the displaced people in question also make a difference. For example, Syrian refugees will use energy equipment differently from that of internally displaced people (IDP's) in the Central African Republic.

Also, the method of payment will differ. The UNHCR encourages a market economy in camps where refugees can buy what they need. The introduction of vouchers within refugee camps has encouraged this market concept.

In Chad, the roofs of refugee huts are traditionally made of straw. Since the closure of the Chad/Central African Republic (CAR) border, commerce has collapsed and refugees do not find enough straw for their cattle on the local market and resort to feeding their animals with the straw from their roofs. The UNHCR distributes plastic sheets to enable a temporary solution.

Although water can be drawn from the ground using hand pumps, in some countries, like Bangladesh for example, the water can be contaminated. By drawing water from deeper sources it is possible to go below the contaminated levels. Hand pumps are unable to recover water at these depths and so electric pumps are used. Pumps driven by LPG power generators can make this achievable.

LPG gas generators, powering electric water pumps can assist with sourcing deeper fresh water supplies

LPG can be supplied to a dwelling either independently or as part of a reticulated system. The fundamentals of providing LPG to a kitchen are set out in the WLPGA Guide for LPG in Commercial Kitchens (http://www.wlpga.org/wp-content/uploads/2015/10/Guide-to-Good-Industry-Practices-for-LPG-in-Commercial-Kitchens.pdf).

Refugees in camps can be supplied with LPG in each home through the use of cylinders or if the circumstances allow, it can be reticulated through a piped network. LPG cylinders can be swapped or exchanged when empty but reticulated supplies will require some form of metering in order to measure the amount used per family.

Reticulated systems might be an option if the facilities and refugee camps appearing to be semi-permanent.

CHAPTER SIX – WHY LPG IS A GOOD OPTION

- **LPG is a proven energy for billions of users**
- **It can easily displace traditional fuels and bring significant benefits**
- **It can reduce indoor air pollution, alleviate the need to collect wood and reduce deforestation**
- **LPG can also enable electricity and water to be provided through small generators and pumps**

6.1 WHY LPG IS SUCH AN EXCEPTIONAL FORM OF ENERGY

The properties of LPG described in Chapter Three enable it to be used in many different applications in the most remote locations, making it a truly exceptional energy.

The WLPGA has launched a dedicated web based library show casing the different applications that LPG can be used on http://lpg-apps.org/.

Residential applications, especially domestic cooking, water and room heating, are the most popular applications for LPG. Its portability, high flame temperature, ease of control and cleanliness – both in storage and in use – make it very suitable for humanitarian setting applications.

An added benefit is the use of LPG as an engine fuel enabling it to be used in gas engines for power generation.

As one of the cleanest conventional fuels available, LPG complements renewable energy sources and technologies, which depend on variable weather conditions. LPG is a natural partner for renewable energy.

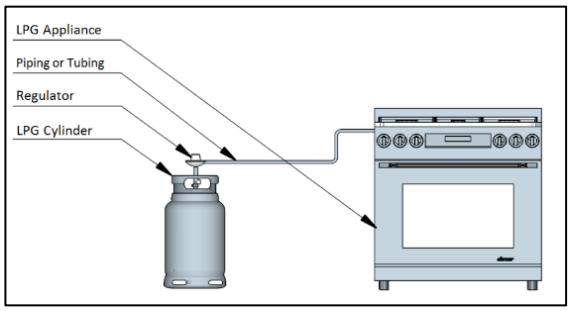
Propane can be used in very cold climates and elevated regions

Where butane cylinders can only be used where temperatures are above freezing, propane boils at minus 42 degrees Centigrade making it very suitable for use in cold climates.

6.2 LPG USE AS A COOKING FUEL, SPACE AND WATER HEATING AND POWER GENERATION

A basic LPG system for domestic cooking consists of the LPG container (cylinder or tank) and valve connector, a regulator, piping or tubing, and an appliance.

The container can be a cylinder(s) or bulk tank(s) depending on the demands of the consumer. The piping or tubing conveys the vapour from the container, through the regulator – which reduces the gas pressure to the appliance – where it is ignited to create the flame for cooking.



A simple LPG system

LPG vapour pressure inside the container fluctuates with changes in temperature – an increase in temperature increases the vapour pressure - which can affect combustion. The purpose of the regulator is to control these fluctuations to ensure a constant pressure at the appliance.

To reduce the cost of the LPG system it is possible to fit the appliance or cook stove directly onto the top of the cylinder. It is important to make sure the base of the cylinder is large enough to ensure stability in use.

LPG lights and small room heaters can also be fitted directly to the cylinder creating a useful and portable package for use in humanitarian settings.

LPG also enables highly efficient decentralised power generation through small self-containing generators and micro-combined heat and power units. For these types of localised power generation units, LPG's carbon footprint is lower than that of diesel and significantly lower than gasoline.

An LPG cook stove and light fitted directly to a 4.5kg cylinder being demonstrated

Its versatility, easy handling, high efficiency, low carbon and clean combustion make it an attractive option for LPG hybrids where LPG exists alongside renewable energy options such as solar and wind.

This is especially true for energy-intensive activities which can be located off the gas-grid such as heating, cooling and power generation.

These potential hybrid appliances include heat pumps, solar energy systems and photovoltaic power generators.

LPG power units can range between the small portable units generating 1kw of electricity to very large 300MW units.

LPG powered water pumps can be used to extract fresh water where there is no power (courtesy: Cavagna)

LPG power generation units sit well alongside grid based systems where they can be used for standby operations in the event of unscheduled power cuts.

A small portable LPG generator, the type that can be used to provide power to a family

Even small LPG cylinders have the capability of producing significant amounts of heat for a period of time and so portable room heaters are often used as stand by units.

LPG has a much higher calorific value than natural gas and so it cannot be used in natural gas systems or appliances. By blending LPG with air however, to dilute the calorific value, a synthetic natural gas (SNG) can be created. SNG is a gas that resembles all the characteristics of natural gas, with the ability to be used in natural appliances.

This allows SNG to be used alongside natural gas networks as a back-up, or a stand-by system in the event of high natural gas tariffs or interruptions in supply. SNG is often used to create demand in an area for natural gas before the natural gas system has entered the area.

A simple synthetic natural (SNG) gas system

In cases where cylinders 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. This is a common method where there are a large number of consumers. For example, in a piped LPG system supplying many thousands of households.

6.3 KEY BENEFITS AS A DOMESTIC/COMMERCIAL ENERGY

Portability, cleanliness and flexibility are the three key words to sum up LPG as a domestic or commercial energy.

The portability of LPG enables it to reach the most remote areas where modern energy would, otherwise, not be possible. Whether that be in areas hit by natural disasters or refugee camps located away from grid and piped energy.

LPG is flexible enough to supply a single dwelling using a small cylinder, up to a multi dwelling community where there are thousands of consumers. The latter would probably be best served using a central storage facility and a piped distribution network.

A single burning cook stove supplied from a 3kg cylinder

Underground storage facility supplying over 7,000 apartments through a piped network

LPG is stored under pressure in containers that range from cigarette lighters containing just a few grams of product, to domestic and commercial cylinders with capacities between 1kg and 50kg.

LPG can also be stored in bulk storage tanks containing several tonnes, as well as sea fed storage vessels and ships containing tens of thousands of tonnes (see 2.2).

CHAPTER SEVEN – TYPICAL LPG DISTRIBUTION CHANNEL

- **LPG infrastructure is in place to deliver to the most remote locations**
- **The portability of LPG makes is extremely accessible even in the most remote locations**
- **LPG has a very long shelf life and can be stored for years without deteriorating**

7.1 HOW LPG WORKS

LPG is easily stored as a liquid under moderate pressure. Once that pressure is released, for example when the valve on an appliance such as a cook stove is opened, the liquid boils releasing the vapour.

The amount of vapour released is equivalent to 250 times the equivalent volume as a liquid. This makes it a very powerful fuel and one where large amounts of energy can be transported easily.

LPG is invisible as a vapour and people using it for the first time need to be trained properly. Unlike some of the fossil fuel alternatives, LPG has a very long shelf life enabling it to be stored for years without fear of degradation.

Training is an essential element of ensuring safety when handling and using LPG. It helps create awareness for the hazards and risks 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 undergo 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 personnel involved.

Training should include regular emergency exercises.

Finally, food safety and sanitation training are vital components of healthy and safe meal preparation. These are preventative practices that are designed to reduce the spread of disease and food borne illnesses.

Details of these training procedures can be found in the various other Guides produced by the WLPGA.

7.2 BASIC COMPONENTS (SUPPLY, STORAGE, HANDLING, DISTRIBUTION, USE)

The basic components needed to supply LPG are very simple and easy to use. In the simplest case, all that is required is the cylinder, valve, regulator, pipework and appliance described earlier. A typical distribution channel is shown in Appendix Three.

Smaller LPG cylinders can be carried home by the consumer

In each case, the cylinders can be transported readily from the centres of supply to the various markets.

The way LPG is transported can be very innovative. Smaller cylinders can be carried home by the consumer. A 4.5kg cylinder when full weighs under 10kg allowing it to be hand carried.

15 kg cylinders being delivered in Ecuador

Larger cylinders are often delivered to the consumer by the retailer using bicycles or rickshaws.

Where LPG is supplied in bulk, road tankers are used to bring product to a bulk storage facility.

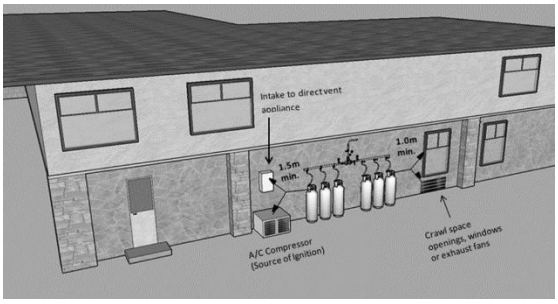
Road tankers are a common method of transporting LPG from terminals to depots, or consumers, even in very cold weather as shown here

Refugee camps are by nature densely populated areas and suitable to be supplied by LPG through a piped network fed from a central bulk storage facility. This type of installation requires significant upfront investment which is generally only justified with a long term supply contract.

Because refugee camps are likely to be temporary structures a piped supply is probably not going to be justified. Similarly, with an LPG supply to an area hit by a natural disaster. It is hoped that both are temporary arrangements, but if a justification exists, then a piped supply might be an option.

There may be cases where it is justified to have a small community facility such as those found in parts of India where villages share a community kitchen (refer chapter eight).

A community arrangement like this removes the entry barrier cost of buying or putting a deposit on LPG equipment, such as the cylinder and cook stove package.



LPG cylinder installation location supplying a number of consumers

The LPG supply could be from a few large cylinders or a small bulk tank.

The choice of supply will often be determined by access conditions. It may be difficult for a vehicle to access some of the areas where the centre of demand is. In cases like this, alternative methods exist to distribute the LPG, such as horse drawn carts or boats.

CHAPTER EIGHT – EXAMPLES AND CASE STUDIES

- **LPG played a major role in Japan in providing vital energy immediately after the 2011 tsunami**
- **LPG has already been introduced successfully in refugee camps in South Sudan**
- **Community kitchens in India using LPG can be a model for their potential use in refugee camps**
- **In New Zealand, LPG was mobilised quickly to provide energy after the earthquakes of 2010**

8.1 EXAMPLES OF HOW LPG HAS ALREADY BEEN USED SUCCESSFULLY IN HUMANITARIAN SETTINGS

JAPAN

On Friday, 11 March 2011, at 2:46pm, a powerful earthquake struck the east coast of Japan some 130km off Miyagi Prefecture in the Pacific Ocean. The earthquake set off a devastating tsunami that sent walls of water washing the coastal area of this north east part of Japan.

The situation was bleak after the Japanese tsunami but LPG played a major role in providing relief in the way of energy for cooking food

Waves up to ten meters rushed onto the shore, engulfing houses, cars and carrying fishing boats and debris away. Even in Tokyo, far from the epicentre, the earthquake struck hard causing the city's skyscrapers to sway.

Despite the fact that Japan is exceptionally well prepared for disaster situations, and that cities are constructed with high level construction codes, almost 16,000 people perished and over 3,000 people are still missing. Over 270,000 homes were destroyed, the roads were rendered impassable, public transportation was utterly devastated and electricity supplies were cut off across a widespread area. Even in Tokyo, the mobile telephone system floundered.

The gas pipeline networks were significantly damaged by the earthquake and tsunami. Refineries and LPG import terminals were also heavily damaged. The petroleum product terminals and LPG terminals on the coast were also hit.

The disaster affected about 160,000 households using LPG. Many cylinders were washed away and local LPG distributors suffered damage to their filling facilities. Subsequently, the supply chain suffered. Over 270,000 households were destroyed.

In Japan LPG importers import and store at their terminals, distribute mostly by using transporters and sell LPG to end users, wholesalers and retailers via their sales networks.

LPG is an extremely efficiently distributed source of energy in Japan. Typically, LPG residential users have two LPG cylinders, one full and one spare. When the full one is empty retailers replace the empty cylinder with a full one.

As a reliable, portable energy, unlike grid-based energy services, LPG played an important role in the historical disaster relief effort in Japan. The tsunami destroyed everything in the affected area, particularly the north east coast. Even outside of the directly affected area by earthquake, infrastructure was damaged.

The electricity supply was cut off in many areas and modern city life, so dependent on electricity, was effectively suspended. Transport suffered enormously; train services were cancelled, petrol stations closed and gasoline (petrol) was in seriously short supply.

Supplies of LPG were affected but recovery was swift. Despite many LPG road tank trucks being lost in the tsunami, with a plentiful stock of LPG at terminals, the industry united to ensure the affected areas had the supplies they needed.

LPG distributors in the area brought in emergency kitchen kits comprising LPG cylinders and cook stoves for food centres that were rapidly set up in temporary shelters, providing life-saving space for evacuees to come together, cook meals and stay warm.

LPG was used to generate electricity by fuelling stand-by gas fired generators at the temporary shelters, to provide lighting and communication services, while the electricity grid system was disrupted.

The city gas companies in the area supplied substitute natural gas (SNG), manufactured by an LPG and air mixture, to their customers who had lost access to the piped gas network. They maintained the portable gas manufacturing facilities using LPG as the disaster prevention equipment.

Refineries that had been hit had sufficient stock of crude oil, but critically not of petrol. Petrol stations suffered short supplies and motorists often had to queue for hours. Autogas (LPG as a transport fuel) drivers, on the other hand, could refuel with no difficulties as LPG facilities continued to operate. Taxis, which in Japan run largely on Autogas, were also available to provide public transport, and transport relief supplies to the temporary shelters.

Over 52,000 temporary evacuee housing units were constructed in the affected region in northern Japan. Approximately 50% of these units were equipped with LPG facilities including heaters, cook stoves and hot water facilities.

In light of the March 2011 disaster, LPG was proven to be resistant to disaster circumstances. There were three key elements of immediate reaction:

(i) A Mutual Assistance Agreement was put in place between Japanese LPG importers to lessen the risks for importers caused by shortage of LPG supply during an emergency. Under this agreement, LPG importers may initiate interaction and discussion with each other to 'borrow' LPG under reasonable conditions and take delivery of LPG at their agreed terminals. Consequently, LPG stock will be kept at each terminal throughout Japan, effectively maintaining a joint, available stock among the Japanese importer community.

(ii) Each local LPG Association, whose members are the local retailers, located in the 47 Japanese prefectures (administrative divisions), including the capital of Tokyo, entered a cooperation agreement with their local government administration to secure supply.

(iii) The Japanese government agreed to release LPG from the national stockpile to cover any shortage of LPG importation caused by the closure of the LPG import terminal which had been blocked by a 91,000GT cargo ship grounded by the power of the tsunami.

The main lesson learned was that to be more effective during great disasters, regional LPG filling plants must be made stronger and communications must be improved. The Japanese government is now nominating around ten LPG filling plants in each prefecture to function as primary facilities to ensure a fully maintained LPG supply to the local population. These filling plants will be equipped with stand-by generators and Autogas vehicles with sufficient fuel to transport LPG cylinders and satellite communication systems to affected areas. These equipped filling plants will serve to further strengthen the LPG supply chain.

The government has also decided to provide four transportable power generation systems, which will be transported to the LPG import terminals to maintain LPG supply, even in the case of ruptured electricity supply to the affected terminals.

Centralised energy distribution networks are more prone to failure during natural disasters. As a decentralised, off grid energy source, LPG is a peerless fuel in times of hardship. LPG can be moved easily to the suffering areas, it effectively and completely supports primary needs of the affected population and fully supports emergency and recovery backup activities and systems. It does so by fuelling temporary kitchens and refugee centres with cooking, boiling water and refrigeration appliances; establishes electric power generators; introduces mobile LPG-Air systems to replace damaged natural gas networks in vital buildings such as hospitals and schools; and provides the opportunities for heating and power systems (combined heat/power systems mCHP). In addition to this, automotive fuel for Autogas vehicles or dual fuelled Autogas vehicles running on LPG, allows to keep them running when other vehicles are forced to stop due to a shortage of fuel.

NORTH DARFUR, SUDAN (SOURCE: GACC)

Between 2002 and 2007, Practical Action (www.practicalaction.org) successfully facilitated a shift from wood and charcoal to LPG in 1,500 households in Kassala State, East Sudan.

Traditional fuels comprise over 80% of the total primary energy supply in Sudan. The majority of this is consumed by households, inefficiently burned over three-stone fires or traditional metal cookstoves. Dependency on charcoal and firewood has caused widespread deforestation throughout Sudan, which has lost over 11% of its forests between 1990 and 2005.

In 2005, Human Rights Watch reported that 82% of the rapes treated by Médecins Sans Frontières (MSF) in West and South Darfur occurred when women left the towns and internally displaced people (IDP's) camps in search of firewood and other supplies.

A 2006 study showed that 80% of IDPs interviewed in North Darfur reported selling food from their World Food Programme rations to buy firewood – negatively impacting their nutritional intake. On average they missed three meals a week when they had food but lacked cooking fuel.

Without a clean fuel alternative, health, protection, and environmental impacts, Sudan's reliance on biomass fuel will only worsen. Addressing this issue in the long term, however, requires an intervention that is both financially and environmentally sustainable.

Drawing on the lessons learned in Kassala, Practical Action partnered with Carbon Clear (http://carbon-clear.com/uk/) in 2008 to apply the project model in El Fashir – the urban capital of North Darfur. As of 2010, the population of El Fashir included 198,391 local residents and 29,645 (IDPs), with a low household income, seldom reaching US$30 per month.

With start-up financing from Carbon Clear, Practical Action established a revolving loan fund that is managed by the Women's Development Association Network (WDAN). Local women who participate in the project receive a loan that covers the upfront costs of the LPG fuel and cooking equipment, which they then pay back in instalments over time.

WDAN's representatives are local community members, which enables them to develop flexible payment plans that meet the specific circumstances of each grantee. As the loans are repaid, the money is invested back into the fund and can be loaned to another woman. The loan fund has "revolved" 20 times in this manner since 2008, enabling long term benefits.

In humanitarian settings, free distribution of products without sufficient training often results in the products being improperly used, broken, or sold – negating their intended benefits.

Recognising this, Practical Action hosts training sessions to educate women about the health and environmental benefits of switching to LPG, to introduce the concept of revolving loans, and to give women the opportunity to provide feedback on their needs.

The three burner table top LPG stove used in the project

Those who are interested can then receive further information and are trained in how to safely handle LPG equipment. These activities ensure that the women are fully engaged and willing to invest their own resources in the loan program.

The LPG equipment distributed to each loan recipient consists of a stove, a gas-filled bottle, and a Kisra (local sorghum chapatti) plate. The majority of the stoves are three-burner table top cookers which are manufactured and assembled in Khartoum. These stoves burn 2-5 times more efficiently than the three stone fires, mud stoves, and metal stoves that families previously used with firewood and charcoal. This results in substantial savings on fuel costs.

On average, women in El-Fashir purchase one sack of charcoal per month at 130 Sudanese Pounds (SDG). Refilling their LPG cylinders once a month costs about 70 SDG. The savings assist the women in paying back their loans on the initial equipment.

India

An initiative that has been used to provide LPG into a rural community where traditional fuels have been used is the community kitchen in India. Although this doesn't describe a humanitarian setting is does provide an interesting example of how to penetrate into a community and displace traditional fuels.

The circumstances surrounding this type of community is not dissimilar to that found in humanitarian settings. There is no modern energy available (the community is off the mains electric grid), there is heavy dependence on traditional fuels, especially firewood, and the disposable income is limited.

The concept of the Community Kitchen was introduced into India fifteen years ago. It was a scheme to enable rural village folk, who had no access to modern energy, to use a central village community facility where LPG was available.

The kitchen had modern facilities (hot water, gas stoves) which were fed from a small LPG facility, which was managed by one of the village heads. Villagers were allowed access to the kitchen in return for a few rupiahs/hr which covered the cost of running the facility and financed any micro loans.

The facility allowed woman to dispense with the chore of collecting wood every day and brought significant environmental (deforestation and climate change) benefits, as well as social, health and economic advantages.

The basis for selection of a village was based on the following parameters:

- The population of the village must be more than 5,000

Community kitchen in a rural part of India

- Less than 50% of the village households have domestic LPG connections

The Oil Marketing Company (OMC) liaises with the head of the village who expressed interest in installing the facility, and agrees for the following:

- To provide a suitable building (covered shed) for housing the facility so that at least 5 people can cook at the same time
- The size of the building should preferably be a minimum of 5m x 2m
- To take overall responsibility for the day to day operations of the facility including fixing & collection of usage charges, maintenance of the kitchen, and safe custody of the equipment provided by the OMCs, etc.

Alternatively, the facility may be operated by the OMC through their Distributor.

The role of the OMC is to provide the necessary LPG facilities such as cylinder manifold, cylinders, stoves and related accessories (pressure regulators, hoses) free of cost, including the cost of the first refill of LPG and the installation charges.

The on-going periodic LPG refills are borne by the operator (head of the village) or the person nominated by him. The head of the village also recovers the usage cost from the consumers (seen here using the facility) on an actual usage basis.

The example of the community kitchen is included in this report because of the scalability into humanitarian settings such as refugee camps and post tsunami conditions.

NEW ZEALAND

Christchurch is the largest city on the South Island of New Zealand and the second largest city in New Zealand. On 4 September 2010, a 7.1 magnitude earthquake hit the city at 4:35am local time. The epicentre was some 40km west of Christchurch, near the town of Darfield at a depth of 10km. The initial quake lasted about 40 seconds and was felt not only widely across the South Island but also in parts of the North Island.

Whilst the earthquake caused significant damage to infrastructure and buildings, there were no direct fatalities, aided by the quake occurring during the night.

There then followed a series of aftershocks, the most severe being of a 6.3 magnitude aftershock a few months later on 22 February of 2011. This second quake struck at a depth of 5km, just 10km south of central Christchurch, and caused the loss of life of 185 people, not to mention massive damage to property and infrastructure that had already been weakened by the initial earthquake.

The overall impact to the LP Gas industry was minor compared to other utilities, and the network was fully operating within ten days.

All of the LPG distributors took immediate action to restore deliveries as quickly as possible. As soon as the news of the scale of the disaster became clear, LPG staff started mobilising to deliver extra supplies of domestic cylinders to the stricken areas.

People were relying on LPG to keep warm, cook food and heat water on their barbeques. Suppliers were overwhelmed with demand and to ensure supply for the first 5-10 days was very challenging. In some cases, people could not access cash, so the gas was supplied at no charge.

One key lesson learned was that normal communication methods cannot be relied on. In times of disaster, traditional communications often fail. One supplier was coordinating neighbourhood deliveries by

announcing it on the local radio stations. Residents were waiting for the trucks when they arrived in the devastated areas.

Access to LPG became critical, as most other infrastructure had been destroyed, severely hampering delivery. Some of the LPG infrastructure was also damaged, including a wharf used for ship unloading. However, LPG can be easily stored. In addition, infrastructure was moved by bringing in extra cylinders, trucks and staff from other areas.

LPG equipment at both the supplier depots and the customer installations were monitored to ensure safety. LPG staff and drivers were kept out of undue risky situations, including entry into unsafe areas.

Suppliers made a special effort to ensure that emergency services in the devastated parts were kept supplied with LPG, to make sure they could feed their teams who were operating around the clock. It was also important to keep in touch with the authorities to assess needs from their perspective.

The continuity of LPG supply to Christchurch and the surrounding areas made a bad situation a little easier. The ability to store LPG, combined with the flexible nature of the LPG infrastructure, made LPG an important form of energy during these emergencies.

8.2 QUOTES FROM STAKEHOLDERS WHERE LPG HAS BEEN USED SUCCESSFULLY

'…without doubt LPG has protected Japan from a situation that could have been much worse following the earthquake and tsunami in 2011. The lessons learned have enabled Japan to be better prepared and through close cooperation with the LPG industry it is in a better position to handle any future disaster that may occur…'

Mr Makoto Arahata, Overseas Business Manager, Japan LP Gas Association

CHAPTER NINE – SOURCING LPG IN AN EMERGENCY

- **Emergency LPG kits are available now and can be mobilised quickly**
- **There is scope for improving some of the emergency kits that exist**
- **LPG supplies can be easily and quickly mobilised**

9.1 TYPICAL EMERGENCY LPG KITS

There are several international charity organisations that provide support to people who suffer as a result of humanitarian situations such as refugees and natural disasters. Rotary International provide Shelter Boxes (https://www.shelterbox.org/), which contain some essential components to assist people who have suffered and require immediate support. The contents of these Shelter Boxes differ depending on the disaster and the climate, but include items such as solar lights, water storage and purification equipment, thermal blankets and cooking utensils. The addition of a small LPG cylinder and stove would provide a valuable supplement.

A Shelter Box provided by Rotary International

Inspired by the role that LPG played in the recovery operations during recent humanitarian emergencies, Repsol LPG and the Repsol Foundation have launched a project to provide LPG Emergency Kits to assist in future crises.

Over 3,000 such kits, which include an LPG stove and eight LPG cartridges, a basic kitchen set and a lamp, have been produced for the express purpose of providing basic cooking, lighting and heating in the immediate aftermath of a natural disaster.

LPG, with its versatile and portable properties is particularly well-suited to providing for such needs when electricity and gas lines have been destroyed, or when displaced persons are unable to return to their homes.

LPG is especially useful in temporary shelters, which require an energy source that can be delivered quickly and efficiently to a large number of people in one location.

Repsol's emergency LPG kit

Over 1,000 of the kits have already been donated to Spain's Emergency Military Unit (UME), which is responsible for assistance in the event of emergencies such as floods, earthquakes, forest fires, and other disasters. The remaining 2,000 kits will be stored at Pinto, an LPG Repsol filling plant, and are available to a variety of organizations including the Red Cross and the Spanish Agency for International Cooperation and Development.

Immediately after the tsunami in Japan in 2011 there was a desperate need for food and energy.

It was possible to mobilise some LPG cylinders and cook stoves and bring them to the affected areas by road very quickly.

LPG cylinders and cook stoves being loaded off a truck to bring much needed energy to the affected areas of Japan after the tsunami

The Japanese government has now recognised the importance of LPG, and its role in alleviating the suffering in the aftermath of a natural disaster. This type of emergency kit is very much part of future planning in the event of a recurring disaster.

9.2 MAP WITH LPG USAGE WORLDWIDE

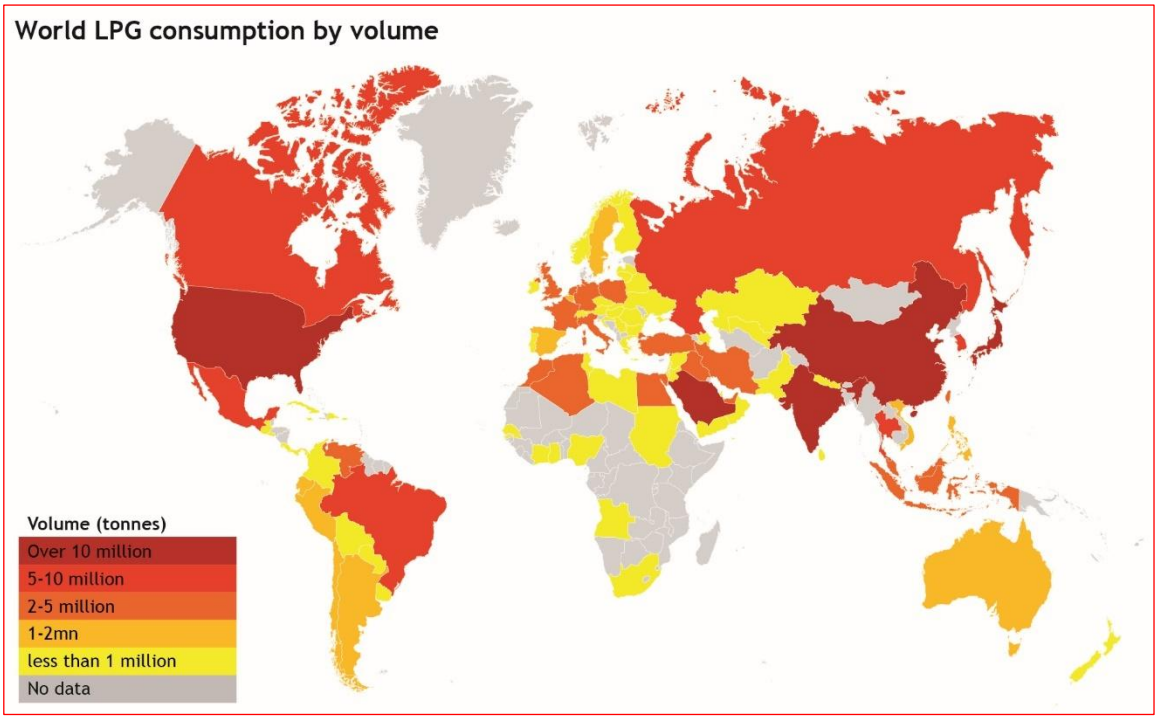
The WLPGA has over 250 members across the world, with many operating in areas of natural disasters, conflict and in countries that are hosting refugee camps. They can all be accessed and contacted through this link (http://www.wlpga.org/wlpga-membership/members/).

There are also many other companies that operate in the LPG business and are able to provide facilities and access to supplies of LPG.

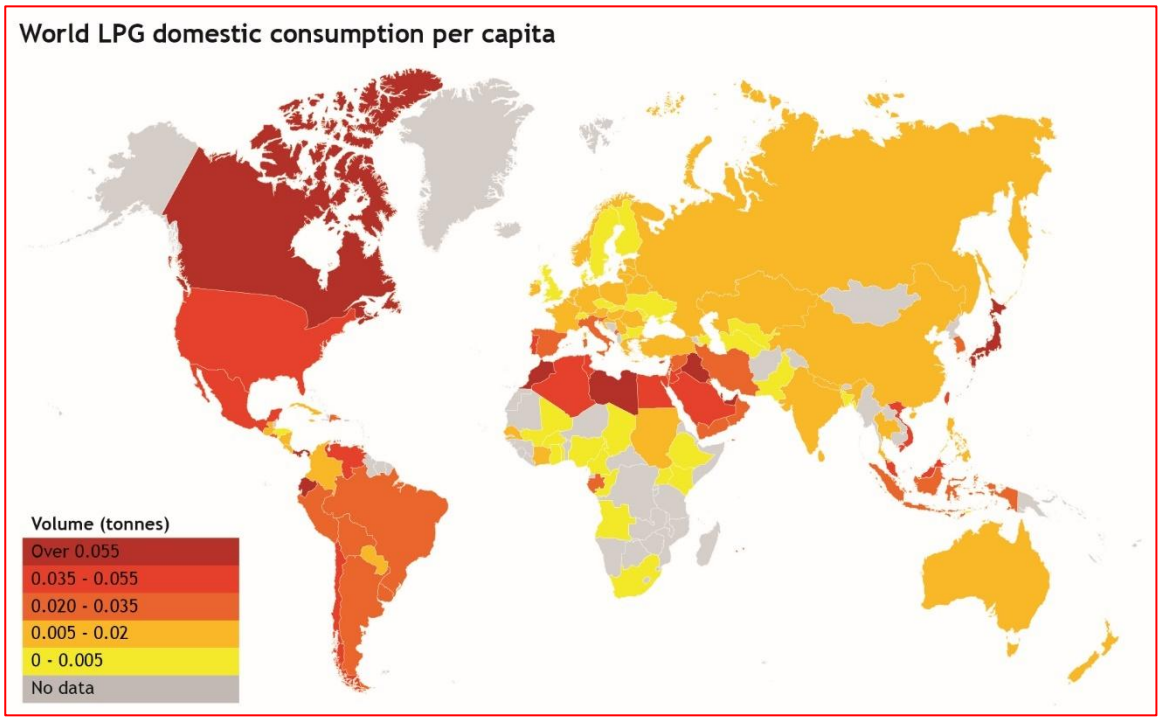
The map below shows where LPG is being used worldwide and it is clear that in some parts of Africa consumption of LPG is particularly low.

If the same map is viewed from a per capita perspective (also below), it highlights where the obvious opportunities are for LPG conversion. Many of the refugee camps are also located in these countries. This also mirrors where there are large consumption levels of traditional fuels.

There are exceptions, with countries such as Turkey and Jordan, where there is very good LPG infrastructure and an ability to rapidly access camps in those countries. With other countries, access to LPG in remote areas is not difficult but will need managing. This illustrates the need for cooperation between the LPG industry, the UNHCR, and other stakeholders if successful access to LPG into the refugee camps in these areas is to happen.



The map shows where LPG is being consumed with the countries marked red the major users. Central and Southern parts of Africa are low users of LPG compared to the north with countries such as Algeria, Morocco, Tunisia and Egypt consuming large quantities [map courtesy of Argus media – www.argusmedia.com]



Map shows where there are low levels of LPG consumption per capita indicating opportunities for development. The areas mirror where most of the refugee camps are located [map courtesy - www.argusmedia.com]

CHAPTER TEN – HOW TO USE LPG SAFELY

- **LPG has a very safe track record**
- **Users who are new to LPG require education and training**
- **There is a wealth of material available to enable education and training**

10.1 KEY SAFETY MESSAGES

Training is an essential component to ensure the safe handling and use of LPG. It helps create awareness for the hazards and risk associated with LPG and minimises bad practices that may lead to an incident.

All personnel involved with handling LPG should undergo training, operators and maintenance people, kitchen staff and security guards. Training should be the responsibility of the LPG supplier.

Training should cover topics such as LPG product knowledge, relevant procedures and emergency actions. People involved in the supply of LPG should cover the following topics:

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

Consumers in India using LPG for the first time being shown how to use it safely

The amount of training for each person will depend on his/her level of involvement with LPG.

Consumers using LPG for the first time should also be briefed on how to use LPG safely. The use of simple safety leaflets using pictures can overcome any issue of literacy.

Examples of an LPG consumer leaflet in Sri Lanka

Organisations such as the HSE in the UK have publications that focus on the safe use of LPG (http://www.hse.gov.uk/gas/lpg/index.htm). The UK LPGA also has information available (http://www.uklpg.org/advice-and-information/camping-safely/). Other organisations with information of the safe use of LPG include the include the New Zealand LPGA (http://www.lpga.co.nz/infoSafety.php), and the South African LPG Association (http://www.lpgas.co.za/safety/using%20lpg/).

10.2 EMERGENCY RESPONSE

Mention is made here of some basic points to consider in preparing for an emergency.

The primary objective in emergency response is to prevent harm to people. Being prepared on how to handle emergency situations can minimise the risk of minor incidents becoming major incidents.

For a refugee camp where there might be LPG storage areas, an emergency team should be organized and the roles and responsibilities of everyone should be clearly defined. Any emergency procedures should be documented in clear and concise languages with a copy posted near the LPG storage site, where it is easy to read. Diagrams are useful for these procedures.

In an emergency the situation should be assessed and the appropriate response taken.

If a serious incident occurs everyone should be evacuated and made safe. Fire and emergency services should be called for assistance.

When handling a leak of LPG without a fire, personnel should be kept upwind of the leak. Remove any ignition sources downwind of the leak. Do not switch on or off any electrical switch which might cause a spark.

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 it is safe to do so. Clearly mark the cylinder as defective and alert the supplier.

Regular emergency exercises 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 exercises should involve local fire service.

APPENDIX ONE – GENERAL PROPERTIES OF LPG

The following is a summary of some of the important properties of LPG.

LPG - Comprises Commercial Propane and Commercial Butane, and mixtures thereof. They are hydrocarbon gases that can be changed into a liquid and changed back into a gas by the simple application and release of pressure

Density – LPG vapour is heavier than air and tends to gather at 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 came 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 should be obvious. Uncontrolled ignition of LPG can cause serious fires or explosions (i.e. if ignited within a confined space). A fire 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.

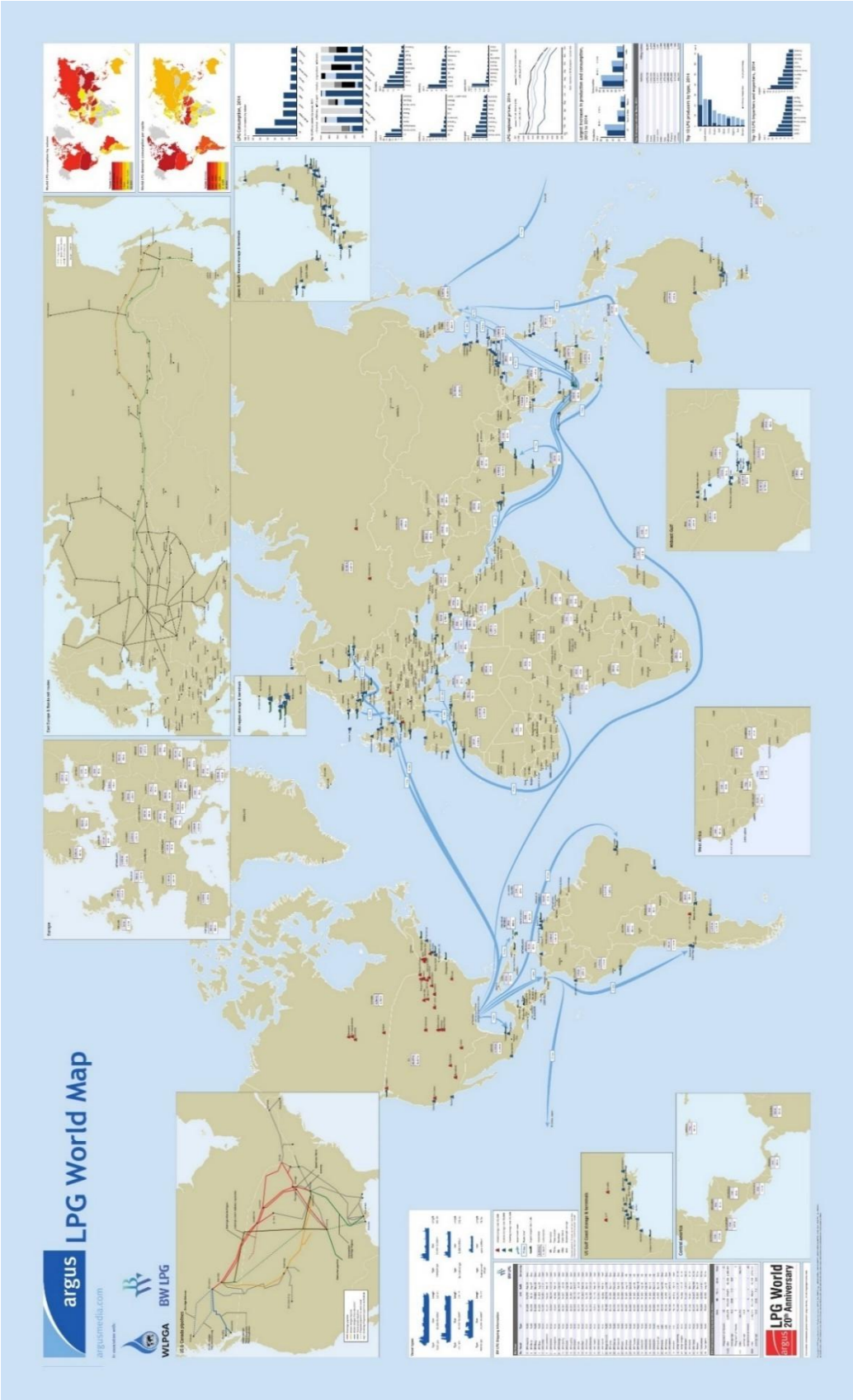
Liquid Expansion – LPG liquid has a high coefficient of expansion. Tanks, cylinders, pipelines and equipment must be protected against the high pressure resulting from liquid expansion with temperature rise.

The table overleaf shows some typical physical properties of LPG. As LPG is a by-product, these values are approximate and indicative only.

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 ^{o}C		Minus 42	Zero
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
	BTUu/ft^3 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 TWO – LPG TRADE FLOW MAP

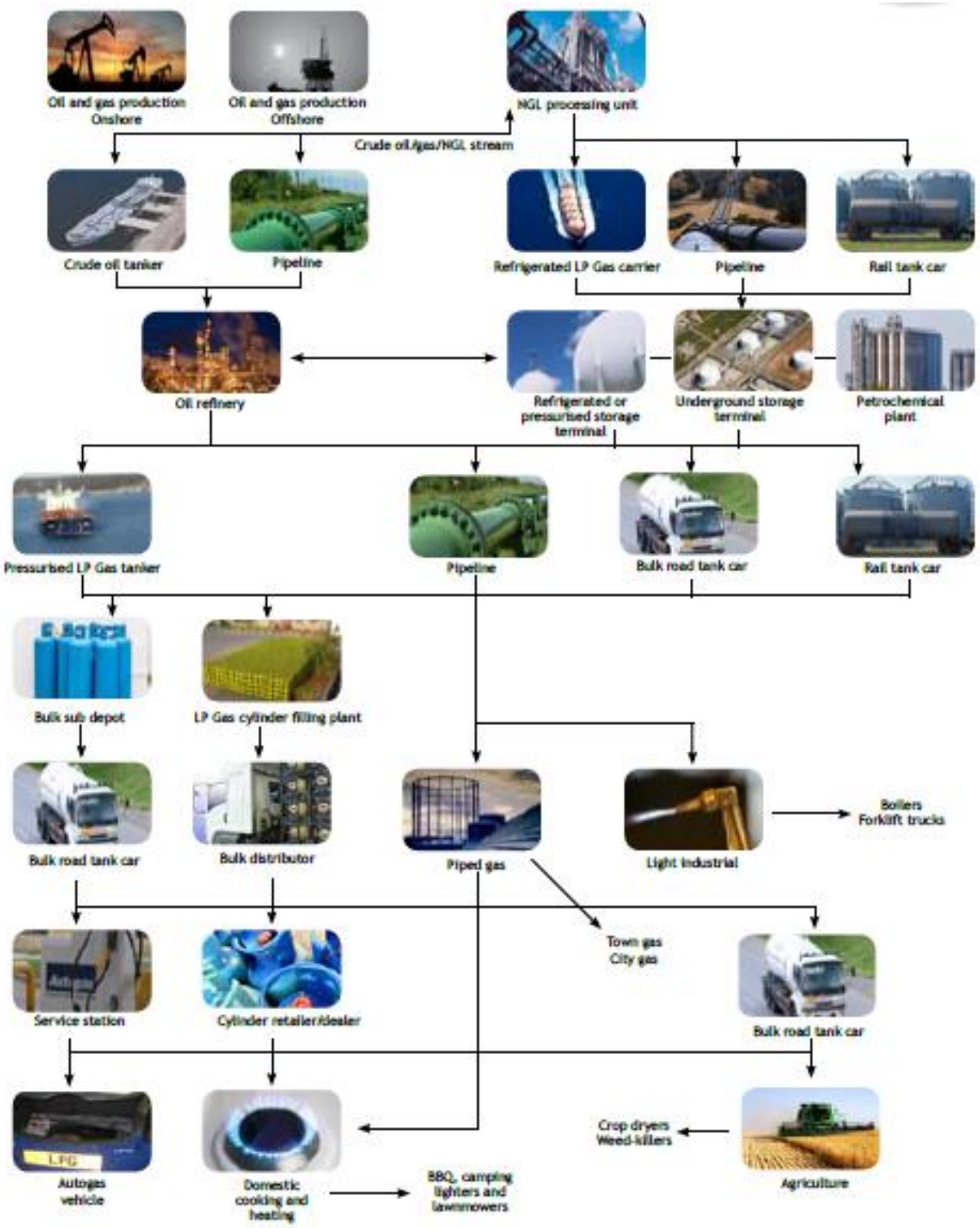
LPG TRADE FLOW MAP (COURTESY ARGUS MEDIA)



The arrows show the general direction of trade flows, from the producing countries to the centres of demand, by sea and land

APPENDIX THREE – TYPICAL LPG DISTRIBUTION CHANNEL

(COURTESY ARGUS MEDIA – WWW.ARGUSMEDIA.COM)



APPENDIX FOUR – REFUGEE FLOWS FROM YEMEN

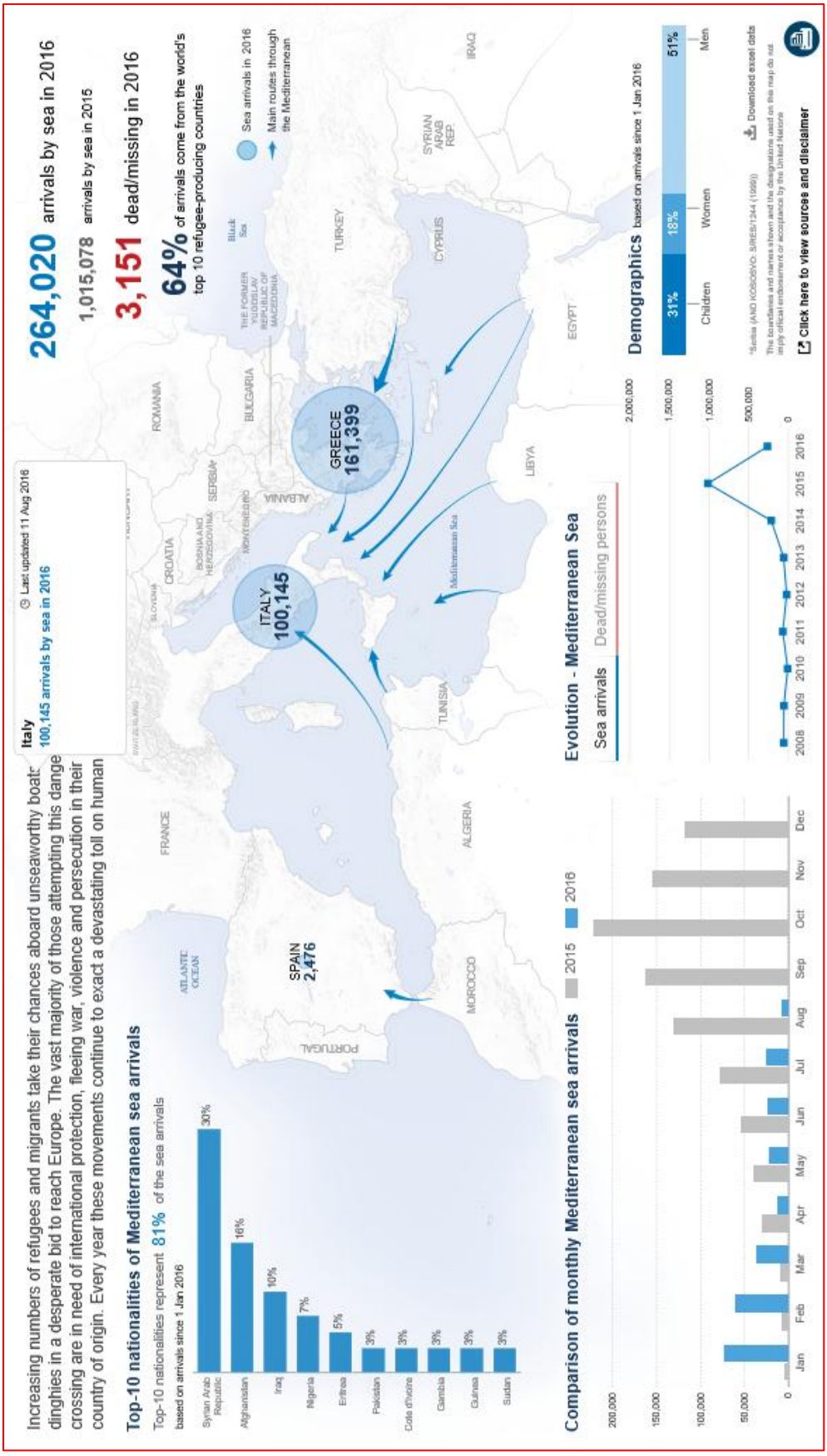
The following map has been included to illustrate the impact of one crisis in one country and the neighbouring countries that are affected by it.

An illustrative map showing typical refugee movements from a conflict area. In this case refuges from Yemen seek refuge in several neighbouring countries, many of which are already struggling to cope with their own populations

Additional maps could be included for many other countries and a similar pattern would emerge. Events causing forced displacement of populations in one country impact not only on its neighbours, but on surrounding countries within in the region.

APPENDIX FIVE – REFUGEE FLOWS IN THE MEDITERRANEAN

The following chart has been provided by UNHCR and demonstrates the refugee flows, and the scale of numbers, in the Mediterranean. It is shown here to illustrate the enormity of the situation and the impact on the receiving countries.



References

http://actu.epfl.ch/news/smart-energy-to-power-refugee-camps/

http://www.unhcr.org/4a1d2f422.html

https://www.chathamhouse.org/sites/files/chathamhouse/publications/research/2016-05-19-mei-energy-situation-dadaab-refugee-camps-okello-final.pdf

https://www.chathamhouse.org/sites/files/chathamhouse/publications/research/20151117HeatLightPowerRefugeesMEILahnGrafham.pdf

https://www.euractiv.com/section/global-europe/news/refugee-camps-energy-bills-over-2bn-due-to-neglected-energy-efficiency/

http://www.theguardian.com/world/2015/ nov/02/winter-is-coming-the-new-crisis-for-refugees-in-europe

http://www.wolframalpha.com/input/?i=refugees

http://www.hrpub.org/download/20131215/EEE3-14501159.pdf

http://www.unhcr.org/406c368f2.pdf

http://catalog.cleancookstoves.org/test-results

http://www.jseejournal.com/JSEE%202013/JSEE%204(3)/9.%20Biogas%20as%20a%20Sustainable%20Alternative%20pp.%20120

http://www.mdpi.com/1996-1073/8/9/9565/htm

http://biofuel.org.uk/solid-biofuels.html

http://www.wlpga.org/

http://www.cleancookstoves.org/

http://www.safefuelandenergy.org/

http://caritas.ge/

http://www.unocha.org/

http://www.practicalaction.org/

http://carbon-clear.com/uk/

https://www.chathamhouse.org/

http://www.energy4impact.org/

http://www.who.int

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