LPG and Electricity Demand-Side Management

A study on behalf of the World LP Gas Association

WLPGA

The World LP Gas Association

The World LP Gas Association was established in 1987 in Dublin, Ireland, under the initial name of The World LPG Forum.

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

The World LP Gas Association exists to provide representation of LP Gas use through leadership of the industry worldwide.

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Contents

Executive Summary

This paper looks at the current and potential role of Liquefied petroleum gas (LPG) in electricity demand-side management (DSM) programmes, with a particular focus on the advanced, industrialised countries. DSM refers to the activities of electricity utilities aimed at encouraging their customers to reduce their electricity consumption and/or modify their pattern of electricity usage as a way of lowering the overall cost of providing electricity service and ensuring reliable service. DSM includes measures to improve energy efficiency on a permanent basis, tariff designs that encourage consumers to shift their consumption from peak to off-peak periods on a permanent basis, permanent reductions in load through switching to alternative forms of energy and short-term demand response (DR).

LPG, derived either as a by-product from crude oil refining or from natural gas or oil production, is a highly versatile and clean energy source that can be used in a wide range of applications, from water and space heating, to cooking and to use as an alternative transport fuel. LPG can, in principle, contribute to DSM through fuel switching. Switching to LPG may be on a permanent basis, i.e. aimed at shedding load along the load-duration curve, or can occur as part of a DR programme, whereby LPG is used as a back-up fuel (for example, for an on-site generator) to replace electricity from the grid. In most countries, there is considerable scope for such switching as electricity use generally exceeds that of LPG in most end-use sectors and uses. DSM programmes can specifically target LPG or may leave the electricity consumer to decide which fuel to switch to.

Despite the potentially significant societal benefits of switching from electricity to LPG, there have in practice been very few cases of utilities specifically targeting LPG in their DSM programmes, either in industrialised countries or emerging economies. Some US utilities have, in the past, included measures to promote LPG use for cooking and space heating as components of their DSM programmes. The most important explicit pro-LPG DSM programmes in recent years were those implemented by Eskom, the South African national electricity utility, in 2006. Nonetheless, though not always specifically targeted by DSM programmes, LPG has, in many cases, played a significant role in meeting programme objectives by providing a permanent or temporary alternative fuel to electricity, especially in the household sector. On the assumption that LPG, if it were not used, would be replaced with electricity in exact proportion to its current share in total residential energy use, we calculate that, in the OECD as a whole, an additional 486 Terrawatt hours (TWh), or 17%, of electricity would be consumed in that sector, requiring an additional 307 GW of capacity (Table 3). That is equivalent to 600 standard gas-fired power stations of 500 MW each.

The fact that so few DSM programmes to date have involved explicit measures to encourage switching to LPG implies that utilities and other stakeholders are not always aware of the potentially significant mutual benefits that could be obtained. There is a strong case for national LPG associations, LPG distributors and other stakeholders to investigate the scope for developing LPG-DSM initiatives at the national level. Detailed feasibility studies would need to be carried out to verify and quantify their potential, to demonstrate the benefits to all stakeholders and to draw up a detailed proposal for designing and implementing appropriate programmes. In principal, the potential is likely to be greatest in markets where electricity use for cooking is particularly high, peak demand is rising rapidly, a large amount of intermittent renewables-based generating capacity needs to be integrated into the system, and time-of-day tariffs are not in place.

Chapter One

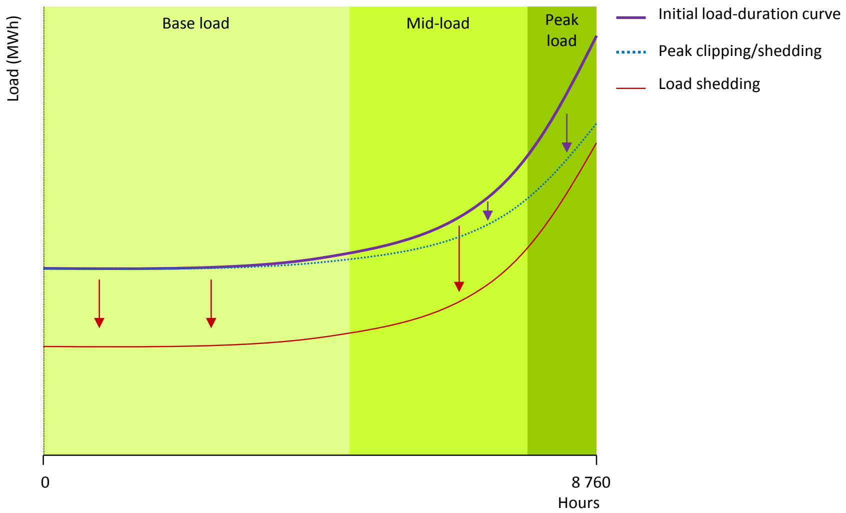
What is Demand-Side Management?

Finding ways of holding down electricity costs has become an urgent priority in many parts of the world amid growing concerns about the impact of rising energy costs on economic and industrial competitiveness and living standards. Demand-side management (DSM) in the electricity sector is one approach to achieving that goal. And LPG, as an alternative to electricity in a wide range of energy end-use applications, has a role to play in DSM programmes in many cases.

DSM refers to the activities of electricity utilities aimed at encouraging their customers to reduce their electricity consumption and/or modify their pattern of electricity usage as a way of lowering the overall cost of providing electricity service and ensuring reliable service. In many countries, electricity utilities are faced with rising costs of new generating, transmission and distribution capacity, either to replace ageing assets or to meet growth in demand. Building, maintaining and operating capacity to meet peak demand is particularly costly – often between two and four times the cost of base-load supply – because the generating and network capacity dedicated to meeting peak load is used only for limited periods. The capital cost associated with this capacity normally represents a large proportion of the total cost of supplying electricity at peak. DSM is the responsibility of the utility that physically provides electricity services and does not cover energy and load-shape changes arising from the normal operation of the marketplace or from government-mandated energy-efficiency standards.

DSM programmes are generally drawn up within the framework of integrated resource planning – a public planning process in which the costs and benefits of both demand- and supply-side resources for meeting electricity demand are evaluated to develop the least-cost mix of options. They must always be tailored to local conditions. Crucially, the utility must define clearly how it wishes to modify the projected load profile for the period in question. The goal may be to shift the load-duration curve, which plots load in each hour of the year sequentially from the lowest to the highest level, uniformly down in response to a lack of base-load capacity – an action referred to as load shedding (Figure 1). Alternatively, the utility may aim to lower demand during peak periods only (peak clipping or shedding).

Figure 1: DSM and the annual load-duration curve



Note: The load-duration curve plots load in each hour of the year sequentially from the lowest to the highest level.
Source: Menecon Consulting analysis.

1. The Rationale for DSM

The rationale for DSM rests on economic inefficiencies in the way electricity is priced and supplied. In practice, consumers' choices of fuel to meet their different energy needs rarely correspond to the most economically efficient fuel mix in aggregate for the economy as a whole. This is because of inefficient pricing, taxation and subsidy policies, or because of market failure. For example, the cost of supplying power at peak hours or during the peak season is not normally reflected in tariffs for household customers for practical reasons: it is costly to install meters to measure consumption on an hourly or even daily basis and to implement corresponding billing systems. Furthermore, energy consumers and suppliers may not be aware of the most efficient means of meeting or providing a given energy service. Households may opt to heat water or their homes with electricity as it is the simplest option involving the lowest upfront investment in equipment, not knowing that alternative fuels like LPG or natural gas may work out cheaper when the full costs of the fuel and equipment are taken into account. DSM is effectively a way of correcting these types of market distortions and overcoming market failures, bringing a number of benefits to consumers, the utility and to society as a whole (Table 1).

Table 1: Benefits of DSM

Customer benefits	Utility benefits	Societal benefits
Electricity demands are met	Lower cost of service & higher profits	Conservation of energy resources
Reduced price for supply	Reduced capital needs	Less local & regional pollution
Improved service quality & reliability	Improved customer service	Reduced greenhouse-gas emissions
Improved lifestyle & productivity	Improved operating efficiency & flexibility	Increased social welfare through boost to employment & income

Source: Adapted from IIEC (2006).

DSM programmes have often proven to be cost-effective, which is why they are common across the developed world and are gaining ground in the emerging economies. A recent study found that DSM expenditures in the United States between 1992 and 2006 produced a 0.9% reduction in electricity consumption over that time period and a 1.8% saving over the longer term, translating to a cost saving of roughly 5 cents per kWh saved (Arimura *et al.*, 2012). It also found that the impact of DSM is still effective even 15 years later because of the lasting effect on consumers' energy consumption behaviour; the effects of DSM spending can be small initially, but increase continuously to a peak several years later.

2. Types of DSM Measures

DSM can include a wide range of actions designed to encourage consumers to modify their level and pattern of electricity usage. DSM is usually understood to include four distinct components:

- Measures to improve energy efficiency on a permanent basis.
- Tariff designs that encourage consumers to change their behaviour so as shift their consumption from peak to off-peak periods on a permanent basis.
- Permanent reductions in load through switching to alternative forms of energy.
- Short-term demand response (DR).

Energy efficiency and fuel switching are designed to shed load during all hours of the year in intervals ranging from seasons to years and focus on end-use energy solutions. In practice, the majority of DSM energy-efficiency programmes target lighting, refrigeration and air conditioning, where the scope for curbing electricity consumption is greatest. Drastic reductions in electricity needs in all sectors can be achieved by replacing traditional incandescent light bulbs (which are still in widespread use despite bans on their sale in most industrialised countries) with compact fluorescent light bulbs (CFLs) and high-efficiency fluorescents, which are typically four to five times more energy efficient.

In most cases, the higher initial cost of buying more efficient light bulbs and lighting systems is quickly compensated by reduced electricity purchases: payback periods can be as low as one or two years. The scope for efficiency gains in refrigeration and air conditioning can also be very large. Many utilities promote the use of efficient lighting and other electrical equipment through information or awareness campaigns, which can be highly cost-effective. In some cases, subsidies to the equipment itself are also provided.

Utility-sponsored energy audits of large commercial and industrial consumers, involving a detailed assessment of current electricity usage and the identification of energy-saving options, are also used to help consumers eliminate wasteful and inefficient practices.

Box 1: Demand response (DR) comes of age

DR can be the responsibility of the utility in charge of the network and generating capacity, or private DR providers. In the commercial and industrial sectors, utilities can sign interruptible contracts, which permit the utility to cut off supply at times of peak load in exchange for a lower tariff the rest of the time. In the household sector, some utilities offer differentiated tariffs, which allow the utility (at short notice) to apply an exceptionally high tariff during short periods when load is particularly high in return for a low tariff during the rest of the year. [1]

DR is increasingly being offered by private companies, mostly offshoots of technology firms, which use computing power and algorithms to efficiently allocate demand reductions; they sign up customers, who are paid for switching off their electric appliances equipment on request, and sell these load savings on the hourly wholesale market at the prevailing price. In some cases, the DR provider negotiates in real time with the consumer; in others, a consumer may agree in advance to the utility turning off a device or set of devices remotely. The load savings are sometimes referred to as a "virtual" power plant. DR markets have developed most in North America, but are starting to take off in Europe and elsewhere. For example, in South Africa, where the electricity system is struggling to meet peak load, an American firm, Comverge, has set up a market in which end users can sell electricity that they chose not to consume.

The attractiveness of DR is increasing with advances in information and communication technology, and the rapid growth in intermittent renewable power, especially in Europe. Maintaining the ability to quickly ramp up supply from other generating plant in response to a sudden dip in output from wind turbines when the wind drops or from solar plants when the sun goes in, or when load suddenly surges due to a cold snap, can be expensive; encouraging consumers to cut their load at such times can be cheaper.

A common approach to managing the load curve involves introducing ***peak and off-peak tariffs***, usually corresponding to day and night, to encourage consumers to modify their consumption behaviour so as to lower peak load. Differentiated tariffs, which may include mid- or shoulder peak periods, require special time-of-day meters and billing systems. They are becoming increasingly common in industrialised countries. For example, more than half of all households in the Nordic electricity market, covering Scandinavian countries, have hourly meters. DSM programmes involving ***fuel switching*** on a permanent basis are much less common, but have been used in some cases where artificially low electricity prices encourage the uneconomic use of electricity in applications that are much better suited to other fuels.

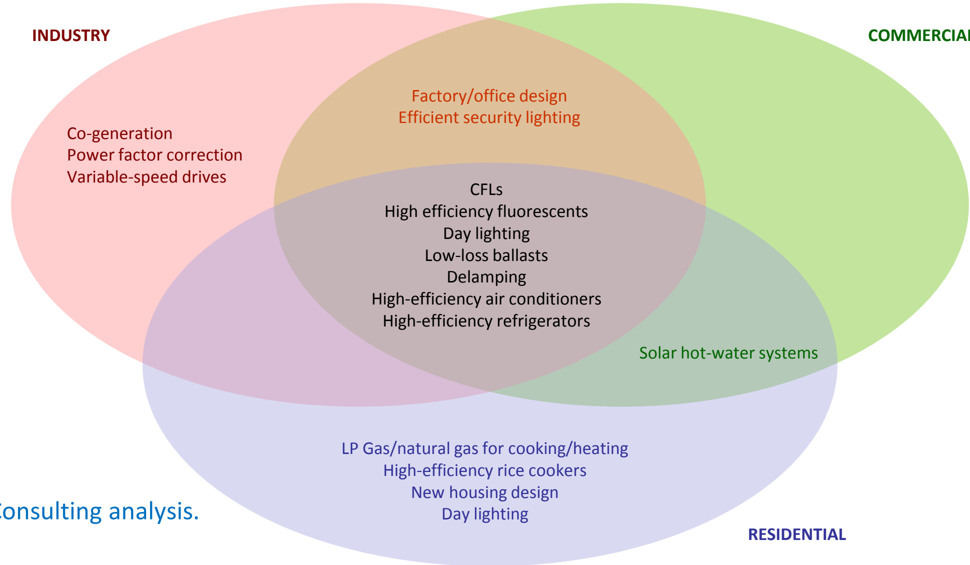
Demand Response (DR) is a term used for DSM programmes designed to encourage or oblige electricity consumers to make short-term reductions in their consumption in real time during peak periods in response to a price signal from the hourly market or a trigger from the operator of the electricity network. The motivation for demand response can be purely economic (i.e. a way of keeping costs down at peak) or technical (i.e. a means of ensuring that the stability of the system is maintained at times when load approaches the level of available capacity). Load reductions involve either energy conservation or fuel switching.

[1] In France, for example, Electricité de France has for many years offered a "tempo" tariff for residential customers, which allows the utility to impose a red rate roughly ten times higher than normal for at most 22 days a year and an intermediate white tariff for 43 days. Customers are alerted through the meter when these rates are about to be applied, to allow them to switch to an alternative, cheaper form of heating or to conserve electricity. A low tariff is applied the rest of the year. Special metering and billings systems have to be put in place for customers who sign up for this tariff. See https://particuliers.edf.com/offres-d-energie/electricite-47378.html for more details.

DR actions generally last between one and four hours and typically involve energy conservation, such as turning off or dimming banks of lighting, turning down the level of air conditioning or shutting down a manufacturing process. Alternatively, on-site generating plant might be used to displace load drawn from the grid (temporary fuel switching). Interest in DR has been growing in recent years (Box1, above).

DSM programmes can cover all end-use sectors and a range of energy applications, some of which cut across sectors (Figure 2). They can be implemented with the assistance of third parties such as DR providers and energy services companies, which offer a broad range of energy solutions such as the design and implementation of energy-savings projects, retrofitting, financing and risk management.

Figure 2: Main electricity DSM technological options by sector



Source: Menecon Consulting analysis.

3. The Changing Nature of DSM

The structure and ownership of the electricity-supply industry and the existence of competition in wholesale and retail supply affect the way DSM works in practice (Crossley, 2013). A privately owned utility will generally not undertake DSM unless is it remunerated financially in some way, usually through its tariffs; the regulatory authorities need to incorporate the cost of DSM programmes into the regulated asset base of the utility to which an appropriate return on investment is applied. In the case of a publicly owned utility, a commitment to DSM can be incorporated into its strategic mission and business plan.

DSM has been in widespread use around the world since the 1970s, but changes in industry structure, ownership and regulation, including increased private participation and the introduction of competition in wholesale and/or retail supply, are changing the way it is applied in many cases. Most of the advanced economies and a growing number of emerging economies have seen an increase in private ownership and/or the introduction of a degree of competition in the electricity sector in recent years. Traditionally, DSM was used by utilities with exclusive rights to supply a particular geographic area. This remains the case in many countries and regions that have yet to restructure their electricity sectors and introduce competition.

Where competition has been introduced, the role of DSM is changing as a single utility is no longer responsible for planning investment and managing demand across the entire market. But the regulatory framework can be designed in such a way as to ensure that DSM, as a market-based offer, is adequately remunerated to provide an incentive to competing utilities to propose demand-side as well as supply-side solutions to an impending shortfall in capacity. For example, DR is increasingly offered by private companies, aggregating real-time load reductions negotiated in advance with a set of end users, usually large industrial or commercial businesses. Utilities are increasingly using DSM to enhance the quality of customer service, combining the benefits of lower cost of supply with better performance of electric equipment and appliances as well as improved reliability. Among the different types of DSM, attention is increasingly being focused on DR, as utilities seek to minimise the cost of meeting increased load and integrated variable renewables.

Chapter Two

LPG in the Industrialised Economies

LPG (otherwise known as LPG) is the abbreviated name for liquefied petroleum gas – the generic name for mixtures of light hydrocarbons, predominantly propane and butane, that change from a gaseous to liquid state when compressed at moderate pressure or chilled. LPG is derived either as a by-product from crude oil refining or from natural gas or oil production. With both processes, LPG must be separated out or removed from the oil product or natural gas streams. LPG is generally liquefied for bulk storage and transportation, because its density is much higher as a liquid. This requires pressurised vessels. LPG is normally refrigerated for shipment by sea and storage of large volumes at receiving terminals. LPG has a high-energy content on a per tonne basis (in a liquid state) compared to traditional fuels and most other oil products and burns readily in the presence of air giving off a hot flame.

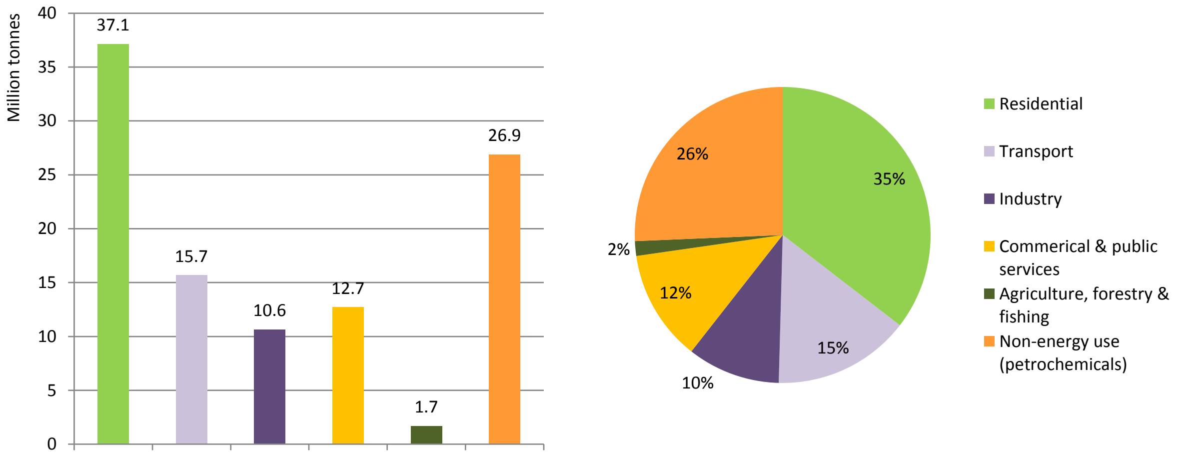
LPG is a highly versatile energy source which can be used in a wide range of applications, from water and space heating, to cooking and to use as an alternative transport fuel. The main energy applications in each sector are as follows:

- *Residential sector:* LPG is well suited for cooking, and space and water heating. In some developing countries, it is also used for lighting where electricity is not available. In developed countries, it may be used for outdoor activities such as barbecues and camping.
- *Agriculture:* LPG is used to increase the production and the quality of farm products through weed flaming, crop harvesting and crop drying. It is also used to heat breeding houses for pigs and poultry and power farm equipment such as irrigation pump engines.
- *Commercial sector:* Applications include commercial cooking (restaurants and small and large-scale catering), and water and space heating in offices and other commercial premises.
- *Industry:* LPG is used in a wide range of industrial processes and activities, notably where a high degree of precision and flexibility in process temperatures – as well as a strong flame – are required. Common applications include heat treatment furnaces, direct firing of ceramic kilns, glass working, textile and paper processing, and paint drying. LPG can also be used as back-up fuel for electricity generators, including hybrid renewable energy systems in remote locations.
- *Transport:* LPG is increasingly used as a low-emission alternative to gasoline and diesel for taxis, buses and private cars.

LPG is also used in the petrochemical industry, as an alternative feedstock to ethane, naphtha and middle distillates in the production of ethylene, the main bulk petrochemical intermediate product used in the manufacturing of a wide range of plastics and specialist chemicals. The other main non-energy uses of LPG are as an aerosol propellant and refrigerant.

In the industrialised countries that make up the Organisation for Economic Co-operation and Development (OECD), final energy use of LPG amounted to 105 million tonnes in 2011 (Figure 3). The residential sector was by far the biggest user, accounting for close to half of all the LPG used for energy. Residential LPG use is highest in regions and areas where it is not economic to supply natural gas, because of the distance from and, therefore, high cost of linking up with the pipeline network (remote towns and villages) or because of low density of population (rural areas).

Figure 3: Final energy consumption of LPG in OECD countries, 2012



Source: Menecon Consulting analysis; International Energy Agency online databases (http://data.iea.org/ieastore/default.asp).

LPG is one of several fuels that can be used in providing a range of energy service in each sector. The principal factor in determining consumers' choice of fuel is price, but other considerations can be important. In practice, LPG has a number of practical and environmental advantages over other fuels. The physical properties of LPG enable significant amounts of energy to be transported easily as a liquid under moderate pressure in specially designed bottles. This portability makes it particularly suitable for applications in remote locations that cannot economically be supplied with natural gas via a pipeline network. Its high calorific value in liquid form reduces transportation costs and makes it easier to handle than other oil-based fuels, wood and coal. For example, a 13-kilogramme bottle provides around 180 kWh of energy; 25 kg of coal and 91 kg of wood would be needed for the same amount of energy. In use, LPG shares similar advantages as natural gas and electricity. Because it is a clean-burning fuel, it can be used in direct contact with food with no risk of contamination, unlike kerosene or traditional fuels, as well as fragile articles such as ceramics.

The environmental benefits of switching to LPG from traditional fuels and most other fossil fuels can be considerable. It produces virtually no soot (particulate matter) and, relative to most other non-renewable fuels, low emissions of carbon monoxide, unburned hydrocarbons and nitrogen oxides (NOx) – the principal precursors of ozone, which produces smog. There are negligible emissions of toxic gases that can cause serious health problems if breathed in close to the point of combustion, which makes LPG highly suitable as a household cooking fuel. Because LPG is transported and stored in sealed cylinders, there are virtually no evaporative emissions; even if it is released accidentally, LPG usually evaporates quickly and disperses into the atmosphere with little risk of igniting unless trapped in a confined space. This is a significant advantage compared to kerosene, a popular household fuel in many countries and one of the principal causes of destruction of property and deaths by fire in urban areas. Fuel-cycle emissions of CO_2 are also lower than most other fossil fuels and traditional fuels used in unsustainable ways (WLPGA, 2005).

Chapter Three

How LPG contributes to DSM

LPG can, in principle, contribute to DSM through fuel switching, i.e. by displacing electricity use in applications, notably cooking and heating, in instances where it is the more economic fuel. Switching to LPG may be on a permanent basis, i.e. aimed at shedding load along the load-duration curve or just at peak, or can occur as part of a DR programme, whereby LPG is used as a back-up fuel (for example, for an on-site generator) to replace electricity from the grid. In most countries, there is considerable scope for such switching as electricity use generally exceeds that of LPG in most end-use applications.[2] DSM programmes can specifically target LPG or may encourage switching away from electricity, leaving the consumer to decide which fuel to switch to.

LPG competes against electricity, as well as several other fuels (primarily natural gas, distillate/heating oil and coal), in all energy end-use sectors, but mainly in the residential/commercial and industrial sectors in most countries; for now, electricity is generally uncompetitive against LPG for transport. In the residential and commercial sectors, LPG and electricity compete mainly in the provision of energy for cooking, space heating and water heating. In the industrial sector, they compete mainly for space heating and process heat. LPG also competes against grid-based electricity in the provision of electricity services through the possibility of using LPG to co-generate heat and power on-site. There are advantages and disadvantages of switching from electricity to LPG in each of these applications (Table 2).

1. Cooking/Space and Water Heating

As LPG is used primarily for household cooking in most countries, the main role that LPG can play in DSM is to reduce peak load by encouraging switching from electricity to LPG as a cooking fuel. LPG is extremely well-suited to this use, having a number of practical and environmental advantages over other fuels, including electricity. Many households and professional chefs prefer cooking with LPG on stoves because of the instant heat and controllability that the fuel provides. Electricity is also a clean and practical form of energy for cooking, but is usually a lot more expensive due to the large energy losses incurred in transforming primary energy into power and the high cost of distributing power to households and commercial premises. Modern electrical induction hobs can provide similar heat controllability to LPG stoves, but are expensive and fragile, making them less suitable for commercial kitchens. The main disadvantage in using LPG compared with electricity is the inconvenience of having to replace the cylinder or to arrange for the bulk fuel-storage tank to be refilled when empty.

Table 2: Pros and cons for consumer of switching from grid-based electricity to LPG

Sector	Application	Advantages	Disadvantages
Residential/commercial	Cooking	Cost of fuel and stove; instant heat and instant 'on/off' controllability (premium cooking fuel)	Inconvenience of replacing empty cylinders; cylinder storage space
	Space/water heating	Cost of fuel; comfort; practicality	Inconvenience of arranging delivery of fuel; cost of buying and maintaining fuel tank; aesthetics/storage space

[2] Data on fuel consumption according to the type of use (cooking, heating, appliances etc.) are not collected systematically in any country, but some survey data is available in some countries.

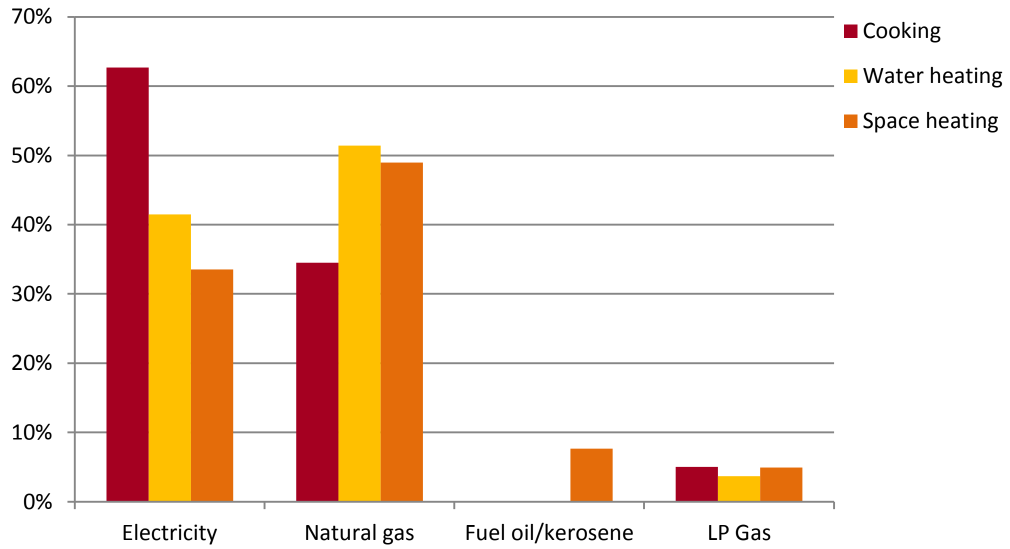
			if tank not underground
Industrial	Space heating/process heat	Cost of fuel; can be a better source of process heat; clean and practical; low maintenance costs.	Inconvenience of arranging delivery of fuel; cost of buying and maintaining fuel tank; storage space
	On-site (co-)generation	Cost compared with grid power & potent alternative generating options; clean & practical	Ditto

Source: Menecon Consulting analysis.

Using electricity for cooking is generally more common in the industrialised countries than in emerging economies, mainly because electricity is more affordable (because of higher incomes). Often electricity is used in ovens while natural gas or LPG is used for stove cooking. Where natural gas is available, it is usually preferred to LPG for reasons of cost and convenience. In the United States, for example, more households cook with electricity than any other fuel (Figure 4). In areas not served by the natural gas grid, LPG is sometimes preferred to electricity largely for reasons of cost. In developing countries, most households cook with LPG, kerosene, charcoal or traditional fuels, such as wood, agricultural residues and animal waste, but electricity accounts for a significant share of cooking energy consumption in some cases, either because electricity is relatively cheap (usually because it is subsidised) or because richer households prefer the convenience of cooking with sophisticated induction hobs and/or electric ovens.

For space and water heating, electricity is less often used than for cooking, but is still more often used than LPG in many cases, especially in the industrialised countries. For example, around one-third of US households use electricity for space heating, while only around 10% use LPG (almost half use natural gas). In France, a mere 2% of households use LPG for space heating and 3.6% for water heating, compared with 35% and 46% that use electricity 44% and 38% that use natural gas (Ademe, 2013).

Figure 4: Household fuel use by application and fuel in the United States (share of households)



Source: Menecon Consulting analysis based on EIA data from 2009 residential energy consumption survey (available at www.eia.gov/consumption/residential/data/2009/#undefined) .

Encouraging households to switch from electricity to LPG for cooking and water and space heating could be a cost-effective DSM programme in certain cases – especially when the goal is to permanently shed peak load – potentially bringing significant practical and financial benefits to both consumers and the utility, as well as broader environmental and social benefits. In countries where electricity is widely used by households for cooking, consumption is concentrated in the evening (typically between 18.00 and 21.00) and in the morning (between 07.00 and 10.00) – often the peak daily periods (during the winter and in countries where air conditioning is not widely used).

Pro-LPG residential DSM programmes are likely to be most cost-effective where electricity prices do not fully reflect the cost of electricity supply and where are exist barriers to the distribution and take-up of LPG. In some advanced economies, residential electricity tariffs are cross-subsidised, i.e. they do not fully reflect the cost of supply, with the shortfall being recovered through higher tariffs for business customers.[3] In addition, electricity tariffs are often set on the basis of the average cost of supplying power throughout the day, as meters and billing systems do not always allow for differentiated tariffs according to the time of day or year. As a result, consumers pay less than the full cost of electricity supply at peak hours, but may pay more than the full cost at other times of the day. By reducing peak load, pro-LPG DSM programmes can bring about large cost savings to the utility, especially if it avoids the need to build new capacity; LPG can be stored and so the cost of supply is not affected by when it is used. Consumers would also benefit if the cost saving is passed on to them through lower tariffs.

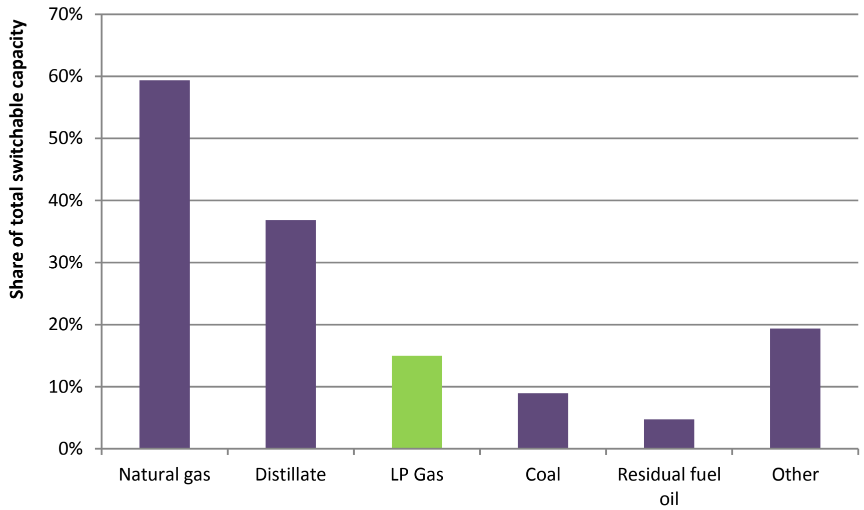
Even where electricity tariffs reflect the true cost at peak, households may not be aware of the financial and practical benefits of switching to LPG because of a lack of information. In particular, many consumers are unaware of the higher thermal efficiency of LPG in stoves compared to electricity and fail to take that factor into account when comparing prices. Some consumers may also hold the false impression that cooking with LPG is less safe than electricity. DSM programmes can help address these financial and information barriers to switching.

2. Industrial Applications

LPG and electricity compete in providing direct process heat in industry, for example in cutting, welding, powering machinery, water heating, de-frosting, shrink-wrapping and kilns or furnaces, as well as for space and water heating. LPG can also be used as a fuel for on-site co-generation of heat and power, competing with grid-supplied electricity. A pro-LPG DSM programme can help to shed load along the load-duration curve and/or at peak, on a permanent or temporary basis. The use of electricity in industry generally varies less throughout the day and year, so any permanent switch to LPG would largely involve load-shedding rather than peak-shedding. However, temporary switching as a demand-response measure could play a role in reducing peak load.

Detailed information is available on short-term switching potential in industry in the United States, thanks to periodic surveys carried out by the US Energy Information Administration.[4] The latest survey in 2012, based on data for 2010, shows that only 2.4% of the electricity consumed in manufacturing can be replaced at short notice by alternative fuel; LPG accounts for 18% of the back-up fuels available. Switching potential is greatest in the chemicals sector (Figure 5). Just under 18% of the electricity consumed by industry is generated on-site, of which LPG accounts for about 5%.[5]

Figure 5: Short-term switchable capacity from electricity in manufacturing industry by fuel in the United States



[3] Mexico, for example, continues to under-charge for electricity supplies to the household sector (Komive *et al.*, 2009). Similarly, regulated prices to small consumers incorporate a subsidised network tariff in Spain (IEA, 2009).
[4] The data can be downloaded from www.eia.gov/consumption/manufacturing/data/2010/#r1
[5] Based on EIA data, available at http://www.eia.gov/electricity/data.cfm#consumption.

Source: Menecon Consulting analysis based on EIA data from 2012 manufacturing energy consumption survey (available at www.eia.gov/consumption/manufacturing/data/2010/#r1) .

3. Experience of Targeted Pro-LPG DSM Programmes in Industrialised Countries

Despite the potentially significant societal benefits of switching from electricity to LPG, there have in practice been very few cases of utilities specifically targeting LPG in their DSM programmes, either in industrialised countries or emerging economies. Some US utilities have, in the past, included measures to promote LPG use for cooking and space heating as components of their DSM programmes. In India, the operator of the port at Paradip in northeast India introduced an electricity DSM programme in 2005 involving the introduction of LPG to replace electricity for cooking because of growing demand and financial losses; the programme reduced annual electricity use by around 7 gigawatt hours (GWh) and peak demand by 3.2 megawatts (MW), yielding savings in electricity costs of 15 million rupees and a payback period of little more than a year (IIEC, 2005). The most important explicit pro-LPG DSM programmes in recent years were those implemented by Eskom, the national electricity utility in South Africa, in 2006 (Box 2).

Box 2: Eskom's LPG-DSM programmes

Two pro-LPG DSM programmes implemented in 2006 by Eskom, South Africa's national electricity utility, illustrate how LPG can contribute to a more economically efficient mix of household energy. Eskom's programmes formed part of a broader emergency DSM plan to quickly curb demand in the Cape region in response to the forced closure in early 2006 of a local nuclear reactor because of technical problems, which resulted in a shortage of capacity. As a result, Eskom was obliged to shed load in the Western Cape, mainly in the vicinity of Cape Town, resulting in widespread blackouts. The emergency plan, which aimed to reduce daily peak electricity by 400 MW, or about 10%, by the middle of the year, consisted of seven components, including measures to encourage more efficient electricity use, conservation and switching to LPG for cooking and heating. This was the first time that Eskom had included fuel switching in its DSM activities.

The two LPG programmes – the Hob, Stove and Heater Programme and the Double Plate Programme – successfully contributed to the achievement of Eskom's target on time (Mohlakoana and Annecke, 2009). Both programmes involved financial incentives for households to trade in their existing electric appliances for equivalent, new LPG versions. Switching to LPG had contributed an estimated 30 MW of the actual 400 MW reduction in peak load in the Cape region by the end of July, and up to 40 MW by the end of the year. Most of the peak demand savings are thought to have been sustained, as few people have switched back to using electricity for cooking. Of the two LPG programmes, the Double Plate Programme, targeted at poor households, contributed most to the reduction in load. The programmes were very cost-effective. We estimate that the cost per kW of load saved as a result of these programmes was around R1 250 per kW of peak load saved, compared with the cost of building new coal-fired generating capacity of about R10 000/kW.

4. The Implicit Role of LPG in DSM

Although not always specifically targeted by DSM programmes, LPG has, in many cases, played a significant role in meeting programme objectives by providing a permanent or temporary alternative fuel to electricity, especially in the household sector. Precise data on the extent to which this has happened outside of explicit pro-LPG DSM programmes are not available, as utilities normally just measure the impact of a DSM on electricity load rather than exactly how it came about. What is clear is that residential use of LPG, in particular, helps to relieve electricity load, especially during morning and evening peak periods as LPG is used heavily for cooking.

An analysis of residential energy use in OECD Member states provides an indication of the savings in electricity and power-generating capacity that are made thanks to the use of LPG. On the assumption that LPG, if it were not used, would be replaced with electricity in exact proportion to its current share in total residential energy use, we calculate that, in the OECD as a whole, an additional 486 Terrawatt hours (TWh), or 17%, of electricity would be consumed in that sector, requiring an additional 307 gigawatts (GW) of capacity (Table 3). This is equivalent to 600 standard gas-fired power stations of 500 MW each.

Table 3: Impact of LPG use in the residential sector on electricity demand and generating capacity in OECD countries, 2012

	Share of residential energy use		Electricity saved by using LPG (GWh)	Generating capacity saved	
	Electricity	LPG		GW	% of actual capacity
Australia	50.9%	2.6%	3 153	2.0	5.1%
Austria	22.9%	0.5%	370	0.2	2.1%
Belgium	22.2%	1.2%	1 048	0.7	5.3%
Canada	41.5%	1.3%	4 847	3.0	3.2%
Chile	14.7%	15.3%	10 588	9.4	104.3%
Czech Republic	20.8%	0.1%	51	0.0	0.4%
Denmark	19.6%	0.4%	204	0.1	2.0%
Estonia	17.3%	0.3%	38	0.0	2.0%
Finland	35.3%	0.0%	0	0.0	0.0%
France	32.4%	2.5%	12 252	7.9	7.7%
Germany	20.5%	1.3%	8 432	8.8	6.2%
Greece	32.5%	0.3%	204	0.1	1.1%
Hungary	17.8%	1.9%	1 137	0.7	10.7%
Iceland	16.2%	0.2%	13	0.0	1.5%
Ireland	25.9%	1.0%	307	0.2	3.8%
Israel	45.8%	20.1%	7 567	5.1	43.9%
Italy	19.1%	3.9%	14 027	10.9	20.2%
Japan	52.6%	10.0%	54 487	29.6	19.0%
Korea	27.1%	2.8%	6 637	7.9	10.4%
Luxembourg	16.9%	0.0%	0	0.0	0.0%
Mexico	25.1%	36.3%	76 284	58.4	144.6%
Netherlands	20.9%	0.2%	281	0.2	1.1%
New Zealand	74.9%	4.6%	782	0.4	6.1%
Norway	78.8%	0.3%	153	0.1	0.4%
Poland	12.4%	2.8%	6 388	5.5	22.6%
Portugal	40.9%	17.2%	5 417	3.6	42.0%
Slovak Republic	19.7%	0.5%	128	0.1	2.7%
Slovenia	23.0%	3.0%	409	0.3	12.9%
Spain	41.7%	7.7%	13 938	8.0	18.6%
Sweden	45.2%	0.0%	0	0.0	0.0%
Switzerland	26.5%	0.0%	0	0.0	0.0%
Turkey	18.7%	3.4%	8 291	6.8	18.3%
United Kingdom	24.9%	0.8%	3 794	1.9	3.3%
United States	46.5%	8.3%	244 760	139.3	17.8%
OECD Total	**36.1%**	**6.0%**	**485 987**	**307.3**	**16.6%**

Notes: Electricity demand and capacity savings are based on the assumption that the load factor for LPG is the same as for electricity and that electricity displaces LPG in the same proportion as its current share of conusmption.
Source: Menecon Consulting analysis; International Energy Agency online databases (http://data.iea.org/ieastore/default.asp).

The savings are particularly big in those countries where LPG accounts for a large share of total consumption, notably Chile, Israel, Mexico and Portugal, where LPG meets more than 10% of total residential energy consumption needs. In percentage terms, the power-generation capacity savings are biggest in Mexico, where capacity would need to increase by almost one-and-a-half times were LPG not used to meet residential energy needs. These results are likely to understate the actual savings that are achieved, as it is assumed that the seasonal and daily demand profiles are the same on average for electricity and LPG; in reality, the use of LPG is likely to be more concentrated at peak periods than electricity, which would increase the need for capacity at peak.

Chapter Four

Lessons Learned and Implications for Future DSM Activities

LPG will continue to play a role in DSM programmes around the world by displacing electricity use in end-use applications where LPG is the more economically efficient fuel, particularly in the residential sector. The limited practical experience of DSM programmes that have specifically targeted LPG use suggests that, where market conditions are right, such programmes could be applied successfully in other parts of the world, including in the advanced economies. For this to happen, the programme must be of mutual benefit and interest to all stakeholders: the utility, the consumer and the LPG distributors.

For utilities, the critical success factors are how electricity is used, the adequacy of electricity-supply capacity to meet current and future demand, and the regulatory and policy framework. LPG can only replace electricity at peak on a significant scale if the latter is already widely used for cooking or heating. The economic case for encouraging fuel switching is strongest where electricity is subsidised for social reasons, or where time-of-day tariffs are not applied such that the price paid for electricity used for cooking during peak times falls short of the true cost of supply. Electricity pricing also affects the prospects for the adequacy of electricity supply capacity to meet demand. Very often, the result of under-pricing to household is that the utility's average revenue per kWh is insufficient to cover the cost of building new capacity at peak. In this case, the utility has no financial incentive to build additional capacity and may, in any case, not be able to finance such investment out of its own funds. Several advanced economies are already faced with an urgent need to expand or replace obsolete peak capacity or expand DR, in part because of the increasing importance of intermittent renewables-based generating technologies, such as wind and solar power. The regulatory and policy framework also affects the incentives for utilities to undertake DSM in general. A private utility, under an obligation to its shareholders to maximise profits in the long term, will only consider DSM if the regulatory regime rewards it financially for cutting electricity consumption through DSM rather than simply expanding supply capacity. In other words, the utility must be able to see an opportunity to increase profits by reducing sales.

The effectiveness of a pro-LPG DSM programme, explicit or implicit, hinges on the willingness of consumers to switch from electricity to LPG. The critical factors are relative prices, convenience and attitudes to cooking with LPG. Many well-off households and commercial establishments prefer LPG because of its practical attributes. Others may prefer to cook with electricity, especially where they can afford high-quality, efficient appliances – notably induction stoves. Where households rely heavily on electricity, it is sometimes because the price is competitive with that of LPG. In order to persuade households to switch to LPG, it may be necessary to provide a financial incentive, either by lowering the cost of the cooking or heating appliance, by raising the price of electricity (including through a tax), by lowering the price of the LPG (possibly by lowering the tax on the fuel) or by some combination of the three. To encourage switching to LPG, consumers also have to be confident that the fuel is safe. In areas where LPG is widely used, this is rarely a concern. But a negative public perception of the safety aspects of using LPG can be a deterrent to switching in communities with no tradition of widespread LPG use.

LPG distributors must also be willing and able to expand supply rapidly enough to meet the higher demand that would result from switching from electricity. This, in turn, depends on the attractiveness of investing in the required infrastructure. LPG distributors need to be confident that the market will be large enough to justify "lumpy" investments in large-scale facilities, including import terminals, storage, bottling plants and road/rail tankers. The regulatory and policy framework for LPG distribution – including any price or margin controls – and the overall business and investment climate also affect the attractiveness of expanding LPG supply infrastructure.

The fact that so few DSM programmes to date have involved explicit measures to encourage switching to LPG suggests that utilities and other stakeholders are not always aware of the potentially significant mutual benefits that could be obtained. There is a strong case for national LPG associations, LPG distributors and other stakeholders to investigate the scope for developing LPG-DSM initiatives at the national level. Detailed feasibility studies would need to be carried out to verify and quantify their potential, to demonstrate the benefits to all stakeholders and to draw up a detailed proposal for designing and implementing appropriate programmes. In principal, the potential is likely to be greatest in markets where electricity use for cooking is particularly high, peak demand is rising rapidly, a large amount of intermittent renewables-based generating capacity needs to be integrated into the system, and time-of-day tariffs are not in place.

Appendix One

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