

## LP GAS + RENEWABLES THE PERFECT HYBRID COMBINATION

An inside look at efficient LP Gas hybrid systems



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## 1. Foreword from the WLPGA

Ever seen or heard of a Toyota Prius? If so, then already you know something about hybrids – appliances powered by a combination of fossil and alternative energy. Development is fast and furious, and it even includes a Hyundai Elantra and a Kia Cerato, both LP Gas hybrid automobiles.

In heating and power generation, the other two most energy-intensive sectors, hybrids are moving rapidly forward. Several technologies use our product, LP Gas. To give these hybrids a higher profile, the World LP Gas Association (WLPGA) decided to publish this white paper. In the following pages, we sketch out the market expectations for hybrids, the advantages of LP Gas as a hybrid co-fuel, and we look in detail at four areas where LP Gas hybrids – already – are achieving commercial success.

### **What is a LP Gas hybrid?**

It is an application which combines LP Gas and renewable energies to form efficient, clean heating and power systems, where LP Gas is used as a primary, secondary or back up fuel.

### **Who should read this white paper?**

Technical and commercial experts in the LP Gas industry and policy-makers. Feel free to use it as you like, to ask questions and to give us feedback. We see this as one of the first words on the subject, surely not the last.

### **Who wrote this white paper?**

A ‘Hybrids Working Group’ within WLPGA’s Global Technology Network, together with help from business partners who produce hybrid-equipment. This is part of the Network’s ongoing mission to promote new technologies and innovation.

As Chairman of that working group, I should like to thank its members

- Armando Viçoso – WLPGA
- Greg Kerr – Propane Education & Research Council
- Ignacio Leiva - REPSOL
- Marcelo Cesar Palmieri - Ultragaz
- Paul Ladner - UGI

as well as other supportive staff and members of the WLPGA.

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## 2. Summary: LP Gas – co-fuel of choice for hybrids

Renewables are on the rise. Alternative energy will power the future. But reaching that brave new, non-fossil-fuelled world is a huge endeavour. Pushing the ‘reset’ button on global energy supplies will entail massive changes in how we work and live involving massive investment as well. All this will take time: a fossil-fuel-free world would at earliest arrive in several decades. Until then, fossil fuels will still be essential. More essential than ever, actually, because they will keep things running while alternatives grow into their new role.

One obvious way to make the renewable-energy transition is via hybridisation. Hybrids share the energy load between alternative and fossil fuels, thereby building a bridge to the future.

Hybrids’ future looks very bright. They are expected to ride the wave of renewables, which already are attracting annual, global investment of more than \$200 billion and they are commercial today. Hybrids are most obvious in road transport and power generation, and they are gaining ever more traction in heating and cooling: these sectors are the largest contributors to greenhouse gas emissions.

According to various studies done across the industry, it is understood that LP Gas has very little impact on the environment so is natural gas. Is LP Gas a petroleum product?

The answer is partly yes from the source of it. However, LP Gas should be considered as “gaseous energy”. The Japanese government admitted this concept in 2009. Since then the Japanese official statistics have independently described LP Gas, separately from petroleum.

Therefore, LP Gas is proving to be a hybrid co-fuel of choice. Thanks to its versatility, easy handling, high efficiency, low carbon and clean burning, appliance developers are devoting great attention to LP Gas hybrids, especially for applications located off the gas-grid, in heating, cooling and power generation. According to analysis by the Hybrids Working Group of the World LP Gas Association, LP Gas hybrids hold particular promise in three areas:

- **Heat pumps:** LP Gas has a strong future in two parts of this burgeoning renewable. First, it can provide the supplemental energy boost that conventional (compression) heat-pumps typically need in colder climates. Second, it can directly fire sorption heat-pumps, which are increasingly attractive for heating and for cooling as well.
- **Solar heating:** in regions with sufficient sunny weather, domestic water heating – a traditional workhorse application for LPG – can be hybridised to include solar power. In principle, it can be as simple as adding a water tank to the roof of a building that uses solar energy to heat the water.

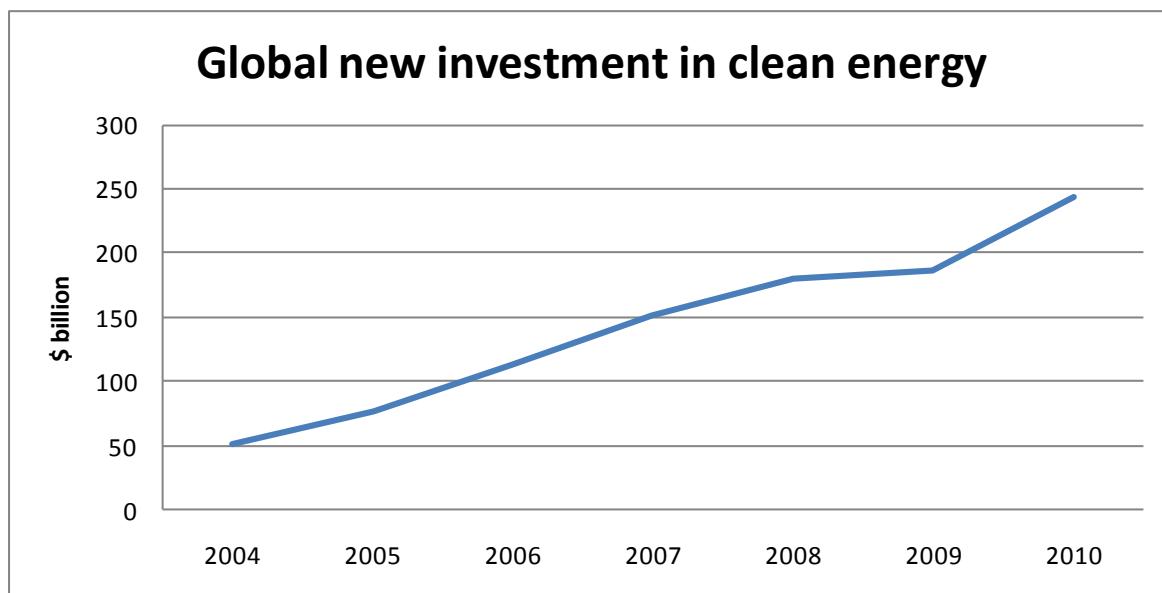
- **Photovoltaic power generation:** while PV is a prime choice for electrifying off-power-grid users such as homes, telecom relays and pipelines, it still needs a back-up for non-sunny hours. LP Gas generators are an ideal supplemental solution.

This report elaborates on the above, covering the markets, the environmental impacts, the technologies and the economics.

### 3. Hybrids – here they come!

The race to renewables has begun (Figure 1). But it starts from a very small base, well under 5% of all energy consumption, so fossil fuels are far from forgotten. Indeed, they offer the bridge to the world's new energy future, not least through hybridisation: combining alternative and fossil fuels in one appliance.

Figure 1: Spending on renewables is soaring<sup>1</sup>



In the three areas where LP Gas is most promising as a hybrid co-fuel – heat pumps, photovoltaic power generation and solar heating – installation, investment and market share are poised for a rapid climb.

#### 3.1 A race to renewables

Faced with the twin challenges of global warming and energy security, countries around the world are looking to displace fossil energy with alternatives: biofuels, geothermal, solar, waves and wind.

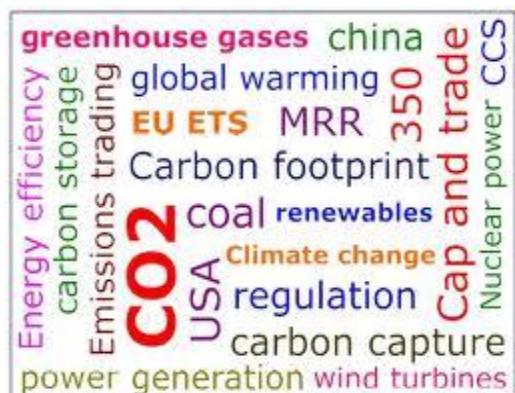
As a consequence, governments have thrown their renewables policies into high gear. Today nearly half of the world's countries, twice as many as five years ago, have renewables targets. In 2010 alone, entirely new targets were adopted in South Africa, Guatemala and India, while existing targets were raised in countries such as Finland, Germany, Spain and Taiwan.

Most of these are aimed at a horizon of 2020, and nearly all have a goal for renewable electricity (typically 10-30%).

<sup>1</sup> Source: Bloomberg New Energy Finance

Many also have goals for road transport, and some have them for heating. A prominent renewables target is the European Union's 20% of final energy by 2020. Others include Brazil's 75% of electricity by 2030, China's 15% of final energy by 2020, India's 20 gigawatts of solar by 2022 and Kenya's 4 gigawatts of geothermal by 2030.

When compared to existing penetration, these goals appear truly daunting. So-called 'new' renewables – which exclude traditional biomass and large-scale hydropower<sup>2</sup> – supply only 2.5% of today's global energy. On the other hand, powerful growth has already started: over the past five years, 'new' renewables consumption has climbed some 25%.

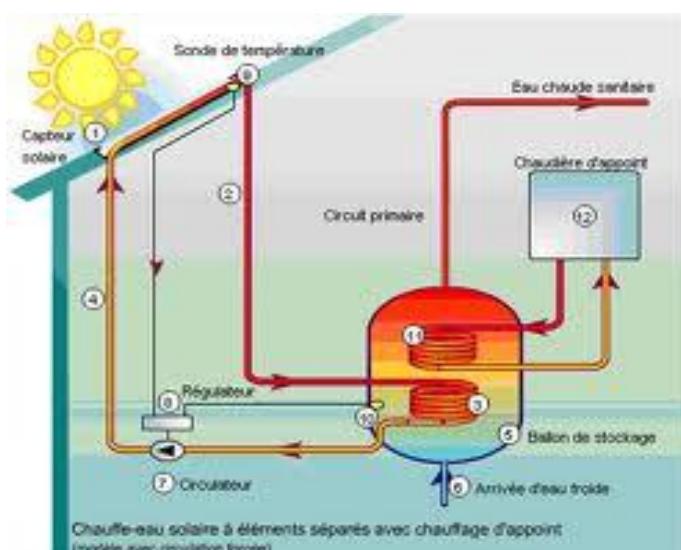


That growth is expected to continue, even accelerate. According to one of the more authoritative energy forecasters, BP, consumption of renewables will rise at an annualised 8.2% in the coming two decades, hitting some 6% of the world total energy by 2030. Meanwhile, total energy use will climb at only one-fifth of that rate, 1.7%. According to BP, renewables will account for 18% of the 2010-2030 growth in energy – a rate similar to that shown by nuclear power in its heyday of the 1970s-80s.

Funding this calls for a tidal wave of investment. The current annual spend is topping \$200 billion, some 4-5 times the level of 2004 (Figure 1). One authoritative study predicts that by 2020, annual outlays will triple.

### 3.2 LP Gas Hybrids – a bridge to the future

All this action in alternatives does not mean that fossil fuels are finished. Far from it – they will continue as the world's main power source, well into the future. They will keep economies and lives moving, as renewables gain technological and economic maturity. And they will play back-up when the wind will not blow and the sun will not shine.



Hybrids – a combination of fossil and renewable fuels – are a sort of halfway house, an initial step toward renewables. Already they can be seen in transport, in cars fuelled by biofuel mixtures or batteries and gasoline, in ships powered by bunker fuels plus wind sails or kites. Power plants have adopted biomass co-firing.

In this new, growing realm of hybrids, LP Gas is expected to play a key role. Three areas are seen as particularly promising commercially: two in heating, heat pumps and solar heating; and one in power generation, as a backup to photovoltaic electricity.

<sup>2</sup> These supply, respectively, 10% and 3.4% of global energy. However, for multiple reasons, neither is a primary target of renewables policies.

### 3.2.1 Demand warms up for Heat Pumps

They work similarly to a refrigerator – moving ambient heat from the inside to the outside of a container, or vice versa. The container needs not be just a box, but an entire building. In the residential sector, heat pumps already are well-known, heating and sometimes cooling 80 million homes<sup>3</sup>, some 5% of the world's total. Leading user markets are China, France, Germany, Sweden and the United States (US).

Heat pump sales bode to be robust. If governments adopt the climate change policies recommended by the International Energy Agency (IEA) and the Intergovernmental Panel on Climate Change (IPCC)<sup>4</sup>, then IEA expects installations to climb to 350 million by 2050, which would hike capacity at a 5% annualised clip, rising from today's 740 GWth to nearly 5,000 GWth. Highest growth, says the IEA, will come in hot-water heating and in reversible systems (heating in winter, cooling in summer). Regionally, the biggest uptake is foreseen in developed (OECD) countries, the former Soviet Union and China.

### 3.2.2 Getting warmer – Solar water heating

Of all renewables, this surely is the simplest. As the name suggests, so-called solar thermal consists of using sunlight to heat water. Indeed, it is the same mechanism by which most global warming is created. At 185 GWth, solar thermal has about one-quarter the global capacity of heat pumps, serving about half as many homes, i.e. 40 million. Regionally, China leads by far with two-thirds market share; Germany and Turkey run second and third, each with only 5%.

Solar water heating is economically viable today specifically in sunnier areas and even more in those without access to the gas grid that use electricity. As the technology matures (and it is more involved than just sticking a tank on the roof), installation costs are expected to fall by about two-thirds by 2030. This, plus government incentives, lead to an IEA Blue Map projection of 8% annualised growth, or 3.7 GWth capacity by 2050. As with PV power, the forecast assumes considerable growth acceleration in the 2020s, when prices are expected to be much more competitive.



### 3.2.3 Shining brighter – Photo-voltaic power

If you use a pocket calculator, you have probably seen the silvery-black panels of photovoltaic (PV) systems that convert sunlight into direct-current electricity. Increasingly, they power entire homes and businesses; over the past two decades, they have colonised rooftops and remote masts in countries such as Germany, Spain and Japan. From an almost negligible presence in 1990, world capacity grew at an annualised rate of nearly 40% to a current level of some 40 GW.

<sup>3</sup> Author's note: the actual figure cited is 800 million, but this appears to be a slipped decimal place. So too, for the 350 million in the next paragraph, which is cited by the IEA at 3.5 billion.

<sup>4</sup> The IEA's 'Blue Map' scenario assumes that by 2050, greenhouse gas emissions would be half what they were in 2005. This is roughly equivalent to the IPCC's '450 ppm' scenario. Both are predicated on the idea that they could and should limit global temperature increases to 2-2.4° C.

PV power will likely continue to boom, especially if installation costs continue to fall. Thanks to a steep learning curve, prices of PV electricity have tumbled in recent years, making them competitive today in some off-grid applications. Governments and investors are funding further development, which according to the IEA should allow commercial parity with conventional power plants (in sunnier areas with relatively expensive electricity costs) sometime in the 2020s.

Under the IEA's Blue Map scenario – which assumes such cost reductions coupled with government incentives – PV capacity will rise to 3,000 GW by 2050, which is roughly equivalent to adding some 150 conventional generating stations every year. As a proportion of global power generation, PV's share would soar from around 0.1% today to 11% in 2050. Residential is expected to predominate with some 40% market share, followed by utilities at 33%, then commercial and off-grid splitting the rest.

## 4. Which co-fuel to choose?

For hybrid developers, LP Gas is proving to be a co-fuel of choice in off-grid locations. This is not surprising, given the fuel's ability to perform highly and burn cleanly.

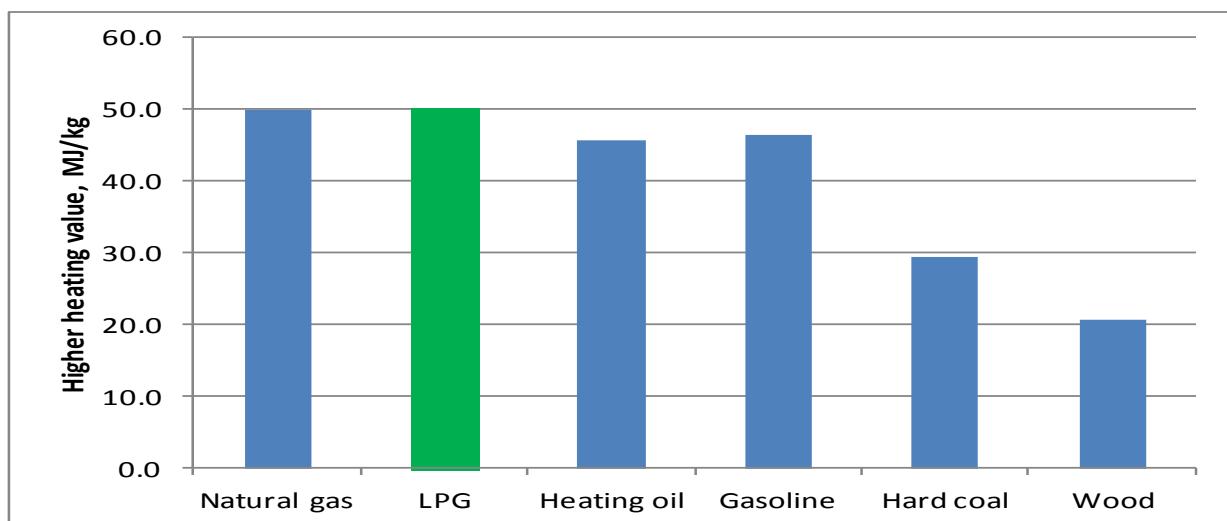
### 4.1 LP Gas: high performance

For nearly a century LP Gas has been a commercial fuel, so suppliers and designers are well-informed on how to use it safely and effectively. They find three reasons why it stands out as an energy source for heating, transport and power generation.

**Easy handling:** LP Gas can be bought nearly everywhere and taken almost anywhere. Because it is stored and transported as a liquid<sup>5</sup>, it takes up comparable space to other liquid fuels. It can be burned safely indoors, i.e. the fumes are less harmful. And if it does leak, LP Gas dissipates into the surrounding atmosphere, without leaving a puddle leaching into the earth.

**High efficiency:** this not only saves storage and transport space, but it also boosts efficiency. LP Gas's higher heating value – energy per weight ratio – is about 10% higher than heating oil or gasoline, and roughly equal to that of natural gas. This is about 50% higher than typical hard coal, and more than twice as high as dried wood (Figure 2).

**Figure 2: Heating values of LP Gas versus competitor fuels**



<sup>5</sup> Hence the LP in LP Gas, which stands for liquefied petroleum.

**High turndown ratio:** in most boiler and water-heating systems, natural gas and LP Gas have considerably higher turndown ratios than do competing fuel-oil or electric systems. This improves their operating efficiencies at reduced loads.

**Versatility:** LP Gas can be used on its own or as a hybrid across the full complement of applications, from transport and power generation to agricultural, industrial, commercial and domestic heating.

## 4.2 LP Gas: low carbon and clean-burning

Compared to other fossil fuels and most biofuels, LP Gas is relatively low carbon. It also is low on black carbon emissions and associated particles – more commonly known as soot.

### 4.2.1 Conventional greenhouse-gas emissions

In heating and cooking, which consume over 80% of LP Gas sold as fuel<sup>6</sup>, LP Gas is about 20% lower-carbon than heating oil. That is, it emits about 20% less greenhouse gases per unit of energy delivered.

With electric resistance heating, the comparison varies by location. Depending on the carbon intensity of local power generation, either LP Gas or electricity can be lower-carbon. Global totals are not available, but clearly there are significant regions where each is superior. For example, LP Gas is lower-carbon in countries such as China, Germany, the United Kingdom UK and the US, but electric resistance is lower-carbon in countries such as Austria, Brazil, France, Sweden and Switzerland. In some countries, for instance the Netherlands and the UK, LP Gas heating has been shown to be about equal in carbon intensity to conventional heat pumps.

In transport and power generation, LP Gas's carbon footprint is about equal to that diesel or light fuel oil (which in most markets are the same product). Why the difference to heating applications? Probably two reasons explain it: 1) diesel (compression) engines generally are more efficient than spark-ignition ones; and 2) LP Gas engines have seen far less development funding and attention, and surely are less technically mature than diesels.

### 4.2.2 Black carbon

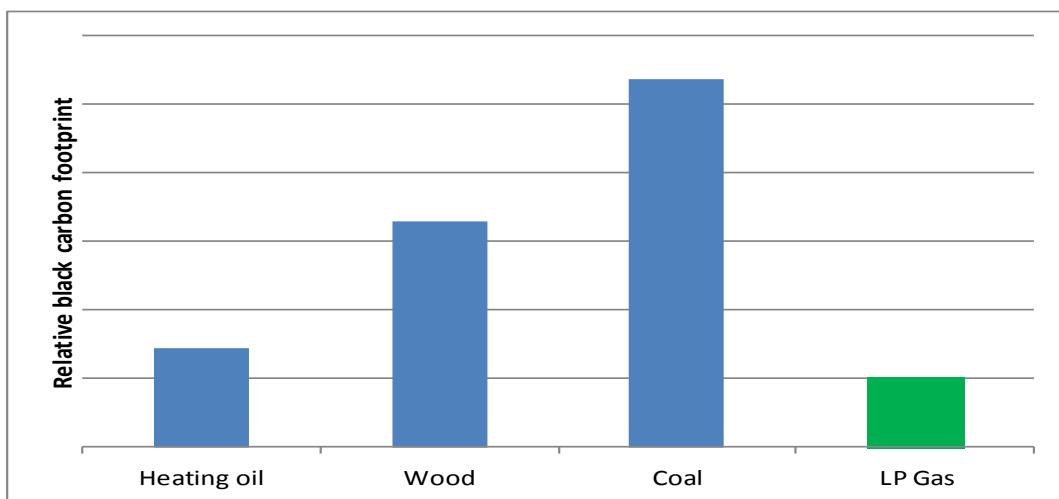
The above comparisons (see 0) are somewhat incomplete and inaccurate, because they exclude black carbon – commonly known as soot. Scientists agree that black carbon causes about 15% of global warming, particularly in sensitive arctic regions. However, regulators chose not to include it in the Kyoto Protocol<sup>7</sup>, and it is not yet included in other climate-change rules.

Including black carbon raises the carbon footprint of dirtier fuels such as coal, diesel and wood dramatically (Figure 3).

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<sup>6</sup> According to the WPGA Statistical Review 2008

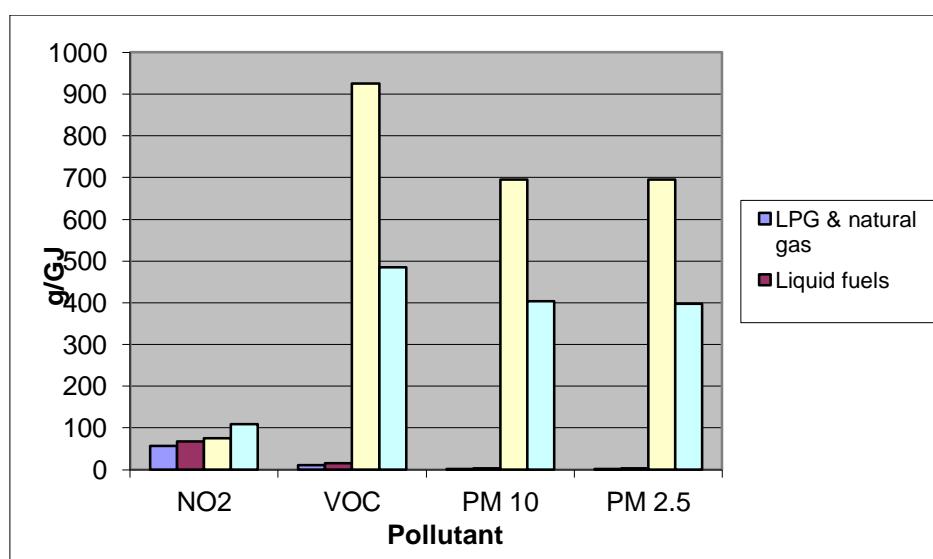
<sup>7</sup> The 1997 UN Treaty for combating climate change

**Figure 3: Relative black carbon footprints by fuel<sup>8</sup>, relative scale**

If it were included in carbon comparisons, LP Gas's advantage over fuel oil (see 0) clearly would increase.

#### 4.2.3 Other emissions

Although carbon wins the most media attention, other air pollution than greenhouse gases, particularly in urban areas, cause health hazards. In heating or cooking, on all three priority pollutants, hydrocarbons (HC), nitrous oxides (NOx) and particle matter (PM), as well as on carbon monoxide (CO), toxics and heavy metals, LP Gas's emissions are significantly lower than those of liquid fuels (heating oil and residual oil) and dramatically lower than those of solid fuels (coal and wood) (Figure 4).

**Figure 4: Local-air-quality emissions of LP Gas versus competing fuels**

<sup>8</sup> Relative GW20 footprints for each fuel, each for a specific application (automotive, heating, cooking and heating, respectively), are compared with and without BC. All the 'without BC' footprints are set at 100%, while the 'with BC' footprints are expressed as a proportion of that. Absolute footprint comparisons between different fuels are not possible from these data.

## 5. LP Gas hybrids

The LP Gas industry has already developed a number of commercial hybrids for heating and power generation. Some examples include:

- The US's Propane Education and Research Council's initiative in distributed power generation.
- The Japan LP Gas Association, especially since the nuclear catastrophe in Fukushima, has been active in developing LP Gas heat pumps as well as micro-combined heat and power generation combined with solar PV.
- The New Zealand/Australian Associations have been active in promoting hybrid heat pumps for domestic hot water and hybrids for power generation.



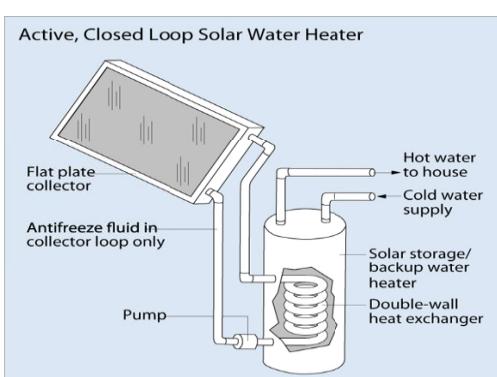
Key developers and manufacturers of appliances have also committed themselves to working closely with LP Gas suppliers to create hybrids in this sector.

According to analysis by the Hybrids Working Group of the World LP Gas Association, three areas are seen as particularly promising commercially for LP Gas hybrids. Two are in heating: **heat pumps** and **solar (water) heating**. The third is in **power generation**, as a backup to photovoltaic electricity. So let's look at these in more detail: the technologies, efficiencies, emissions and economics.

### 5.1 Hybrids in heating

Sunshine supplement – that is the role of LP Gas in two of these applications. Conventional heat pumps and solar water heaters sometimes need that extra boost of warmth that a LP Gas fired supplemental boiler can supply. LP Gas's other role is to hybridise a renewable energy that is well-proven but little known to the general public: sorption heat pumps, which are increasingly attractive for not just heating, but cooling as well.

#### 5.1.1 How they work



Heat pumps and solar thermal systems capture energy from the outside environment and use that to supply indoor heat and sometimes cooling. Heat pumps work similarly to ordinary refrigerators, using latent heat to transfer warmth from a source to a sink.

Heat is pumped from outdoors to indoors (or vice versa); sources and sinks include earth, air and water<sup>9</sup>. In any case, a refrigerant is cycled between two heat-exchangers: in one coil it is condensed to release heat; in the other it is evaporated to absorb heat.

<sup>9</sup> Earth is only an outdoor source or sink. Air can be indoor or outdoor, source or sink. Outdoors, water can be a source or sink, and it also can be a sink indoors – in a hydronic circuit for radiators or underfloor heating.

Heat pumps can be designed to run both ways, i.e. to heat and to cool an indoor area; perhaps about half actually do, while the rest are designed to run in only one direction, usually for heating. Most heat pumps use a compressor and expansion valve, respectively, to condense and evaporate the refrigerant. Compressors usually are powered by electricity, but natural gas or LP Gas powered units are also available.

Highly innovated gas heat pumps under the unified brand name “GHPxAIR” became available this year from Japanese manufacturers. The performance of “GHPxAIR” is rated about 5.5 based on APF (annual performance factor).



Sorption heat pumps use that eponymous principle, rather than mechanical force, to drive the condensation-evaporation cycle. The refrigerant is condensed by absorption (to water) or adsorption (to a solid, usually a zeolite), and evaporated by heat. An excellent heat source here is LP Gas.

Solar thermal systems use sunlight to heat, usually hot water. In very mild climates, solar systems can be direct: hot water supply runs directly through the sunshine-collector. In climates where water freezes, more commonly

chosen are ‘indirect’ systems, where a non-freezing heat-transfer liquid runs on one circuit through the collector and surrenders that by heat exchange in a separate second circuit for hot water.



### 5.1.2 Many variations – including LP Gas

In practice, heat pumps and solar thermal systems show a wide variety of detail. Heat pumps, for instance, can transfer energy from air to air, air to water (radiators), water to water and so on. ‘Combi’ systems combine space and water heating from one system. Solar systems use a range of collector types, from flat plates, basically insulated boxes, to evacuated tubes.

None of these approaches is experimental; all are proven many times over and commercially available from numerous vendors. At the same time, performance can vary significantly – generally more so than with conventional heating systems – depending on site-specific design features, installer skilfulness and operator practices. Compared to conventional heating, these alternate technologies are less mature; therefore offer more room for improvement, if for no other reason than they have less overall experience.

In any case, both heat pumps and solar thermal systems are capable of supplying significant load coverage at high efficiency and affordable investment for a long period (Table 1).

**Table 1: Heat pumps and solar thermal – performance in a typical single-family home<sup>10</sup>**

Type of heating	Lifetime	Typical size	Efficiency <sup>11</sup>	Installation cost	Load coverage
Heat pump	15-30 years	2-20 kWth	200-600%	200-1,400 US\$/kWth	70-100% of all heating
Solar thermal water heaters	20-30 years	2-10 kWth	100%	1,200-2,100 US\$/kWth	40-100% of water heating

Because most heat pumps and all solar systems rely on low-grade, ambient heat, many systems need a back-up heat source for unfavourable weather conditions. An auxiliary LP Gas boiler can plug the gap in colder weather. This is the basic hybrid principle: using a conventional fossil fuel to back up an alternate energy. The exception here is a sorption heat pump. In its case, the renewable is the heat pump itself<sup>12</sup>. It never needs backup heat, because it is powered in the first place by higher-grade energy – say, LP Gas.

### 5.1.3 Hybrid solutions and savings

Potential configurations for hybrids are numerous, which means that they can be adapted to local climates, technologies, regulations and cost structures. In a typical North American forced-air heating installation, for example, a heat pump can be supplemented by an LP Gas furnace in series or in parallel, to heat space only or to heat both space and water. That can be combined further with a solar thermal unit for water heating. A sorption heat pump can supply both space and hot-water heating, and it also can be designed to chill water and cool the building interior.

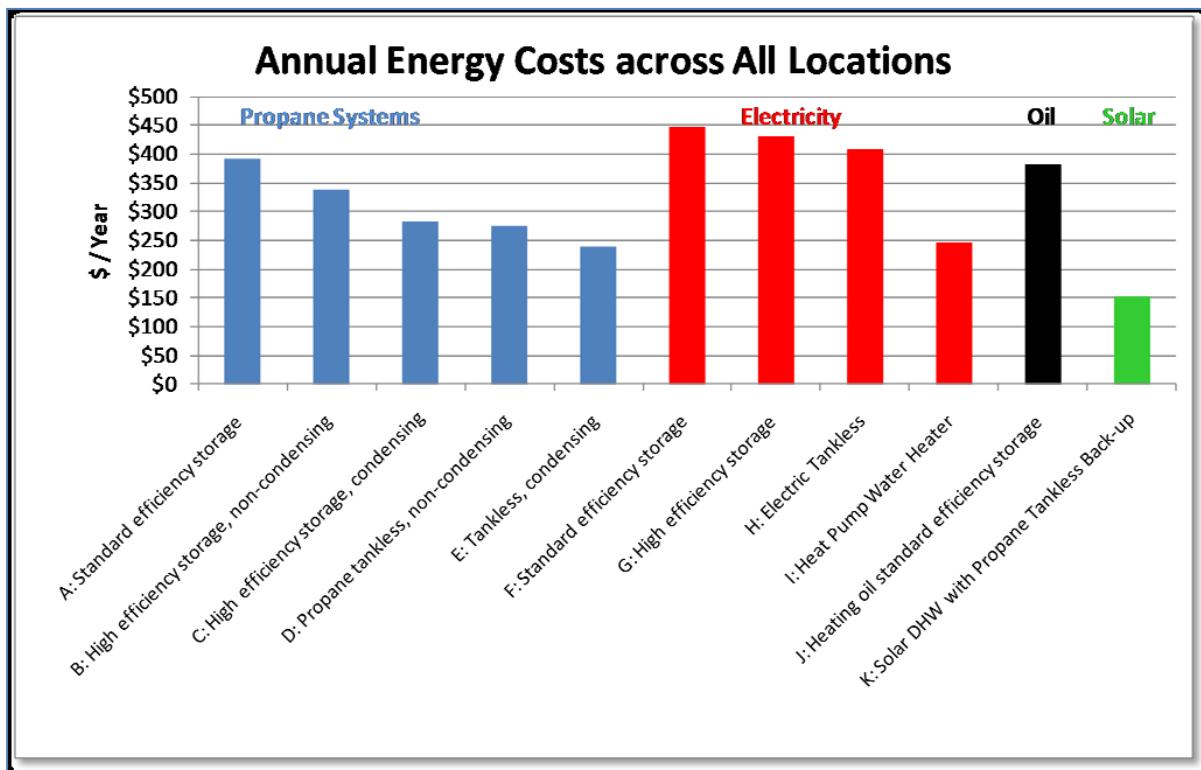
The operating costs of a hybrid can be considerably lower than that of a conventional heating system. A recent study compared in 10 US locations domestic water heating (DHW) from 11 types of systems. One of its findings was that solar thermal backed up by LP Gas is about 40% cheaper in annual energy costs than any of the other options (Figure 5).

<sup>10</sup> Global ranges are shown; data are primarily from the IEA.

<sup>11</sup> Input energy to drive system (either electrical or thermal) divided by output thermal energy. For heat pumps, this is often defined as a seasonal performance factor (SPF); for solar thermal, it is the solar energy factor (SEF).

<sup>12</sup> Heat pumps are generally considered to be renewables, in that the ambient heat they pump is renewable. Under the European Union's Renewable Energy Directive, gas-engine and gas-sorption heat pumps with efficiency (coefficient of performance) of greater than approximately 115% are classified as renewable.

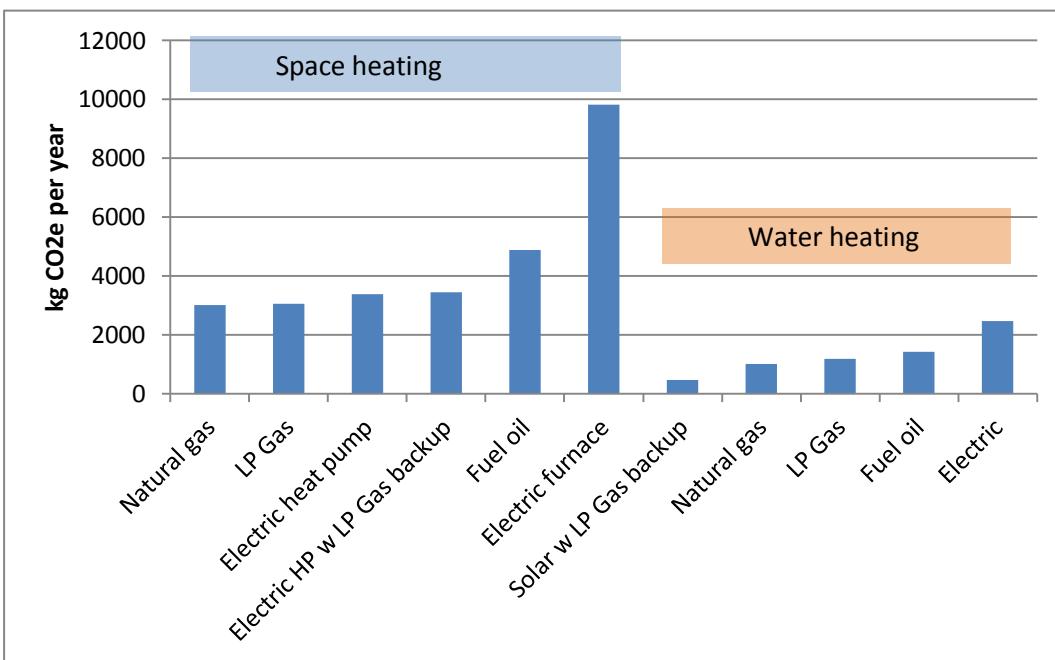
**Figure 5: Annual water-heating costs, Solar-LP Gas hybrid comes in lowest**



#### 5.1.4 Emissions

Compared to conventional heating systems, hybrids can offer considerable reductions in emissions. A comparison for the US in space and water heating shows this clearly (Figure 6).

**Figure 6: Heating footprints with hybrids can be lower than conventional fuels**



In space heating, using an electric heat pump-LP Gas hybrid generates a much lower carbon footprint than a fuel oil or an electric furnace. In water heating, the solar-LP Gas hybrid is considerably lower-carbon than all of the conventional options.



## 5.2 Hybrids in power generation

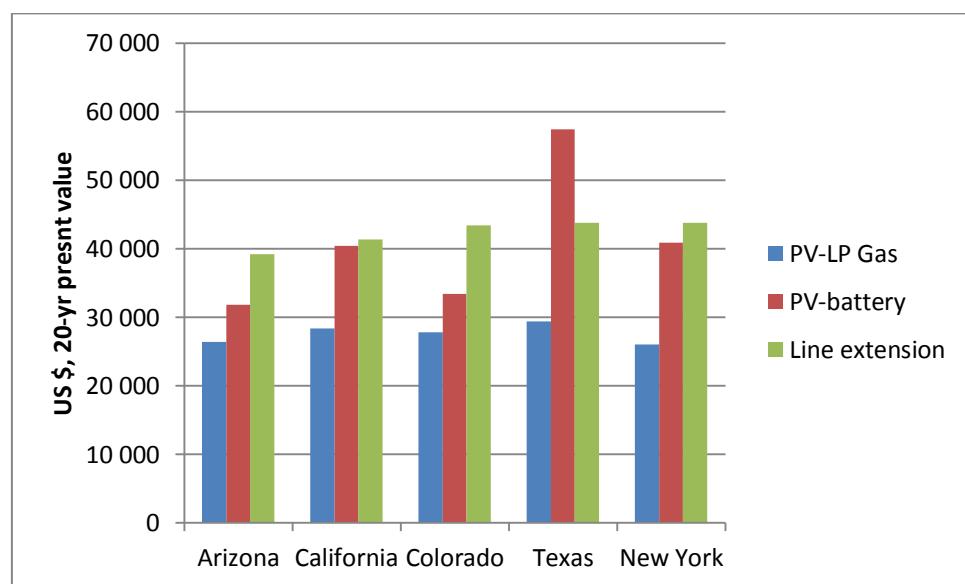
Sunshine supplement – once again, this is the role of LP Gas in another hybrid sector, power generation. Photovoltaic (PV) power is not yet economically viable (without subsidy) in the electricity grid, but in some remote locations – serving back-country houses, telecoms relays, pipelines, boats and recreational vehicles – it is competitive already.

PV also offers considerable reductions in emissions. While the lowest carbon footprints of conventional power generation are around, that of PV is an order-of-magnitude lower, in the range of 30-60 g CO<sub>2</sub>e/kWh.

PV cells produce electricity from light. Photons of light strike the semiconductors in a PV cell (often called a solar cell), and these release electrons, which are bundled together into direct current electricity. Current efficiencies of commercial installation, i.e. the amount of light energy converted to power, are around 5-15%, while experimental units are reaching yields of nearly 40%. Clever as this is, PV still needs a back-up for non-sunny hours, if continuous electrical service is to be provided. Solutions include: extending the grid connection to the remote site, or using a hybrid, either a PV-battery or a PV-generator.

For users more than about 1.5 km from the grid, line extensions from the grid to a single user are rarely considered by electric utilities, and they are not cost-competitive with hybrids. According to the study, PV-LP Gas hybrids in a range of US locations are consistently cheaper<sup>13</sup> (Figure 7) than either PV-battery hybrids or line extensions.

**Figure 7: For remote power generation, PV-LP Gas hybrids are the cheapest alternative**



<sup>13</sup> Total cost for investment and operating for 20 years, net present value in US dollars.

## 6. Examples of LP Gas hybrids

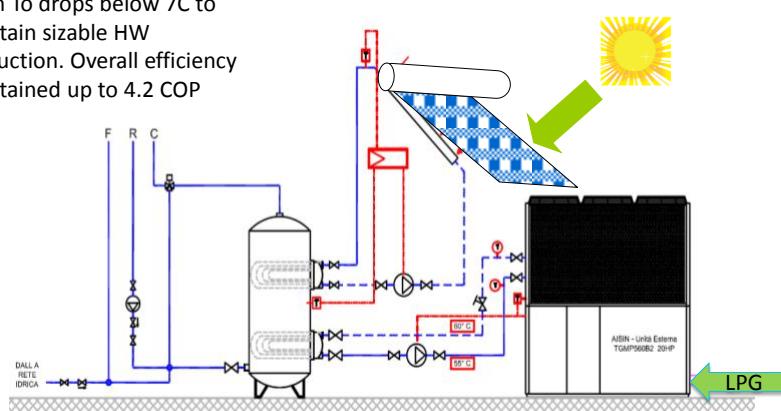
### LPG Hybrid heat pump - Compact module

- Combines an efficient condensing boiler and a powerful AHP in a single unit
- Selects the most efficient operating mode depending on temperature
- COP up to 3.5
- Also cost savings and reduced CO<sub>2</sub> emissions
- 2 parts to be assembled and plug & play
- Fits to existing systems
- No cooling certificate needed
- Max heat output: from 14 to 24 Kw



### LPG Hybrid heat pump - Standard GHP + Solar kit

Integration of a solar panel when T<sub>o</sub> drops below 7°C to maintain sizable HW production. Overall efficiency maintained up to 4.2 COP

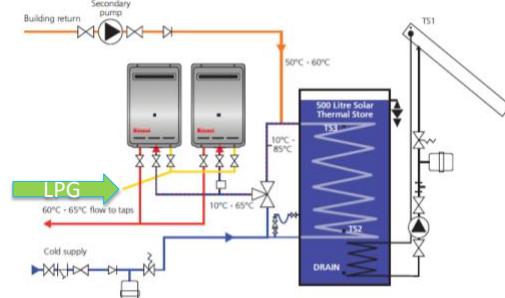


## LPG + Solar

- Compact designed module, floor or wall mounted, including high condensing boiler integrated within a solar module and efficient control system
- Low Nox (Class 5) and CO<sub>2</sub> emissions
- Low energy consumption compare to standard system (-60% DHW & -30% H)
- High efficiency
- Plug and play
- From 14 to 30Kw.



## LPG Hybrid Hot Water Systems



- A Rinnai LPG condensing Water Heater emits 35mg/Kwh Nox vs an oil boiler in the UK which emits ca. 364mg/ Kwh Nox
- In the UK, LPG emits 50% less CO<sub>2</sub> than electricity coal based. This improves up to 70% when LPG is combined with Solar as here.

Rinnai Water Heaters accept temperatures of 65°C at the cold water inlet making them the ideal solution for solar, heat pump or any other renewable water heating project

## Renewable Energy: Solar Energy

J-LPGAS  
Japan LP Gas Association

Application	Solar Energy
➤ Condensing Boiler  CO2 reduction: abt.300kg/year	Solar Collector 
➤ CHP  CO2 reduction: abt.2.8mt/year	Photovoltaic power generation 
➤ Fuel cell  CO2 reduction: abt.3.8mt/year	Excess electricity can be sold back to "grid"

## LP Gas hybrid power generator

- Commercially available generator, can be supplied as backup to PV power for remote residences
- Continuous capacity of 6 kW and load 240 V
- LP Gas fuelled V-twin overhead valve engine that operates at 2,600 rpm
- 3-year, 2000-hour limited warranty for off-grid hybrid applications
- Completed 5,000-hour testing regimen for output and noise levels



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