Gas: the right choice for heating in Europe

The report has been prepared by a taskforce comprising members of Eurogas, Marcogaz and GERG.

Avenue de Cortenbergh 172
1000 Brussels
Belgium
+32 2 894 48 48
eurogas@eurogas.org
www.eurogas.org

Avenue Palmerston 4
1000 Brussels
Belgium
+32 2 237 11 11
marcogaz@marcogaz.org
www.marcogaz.org

Avenue Palmerston 4
1000 Brussels
Belgium
+32 2 230 80 17
robertjudd@gerg.eu
www.gerg.eu

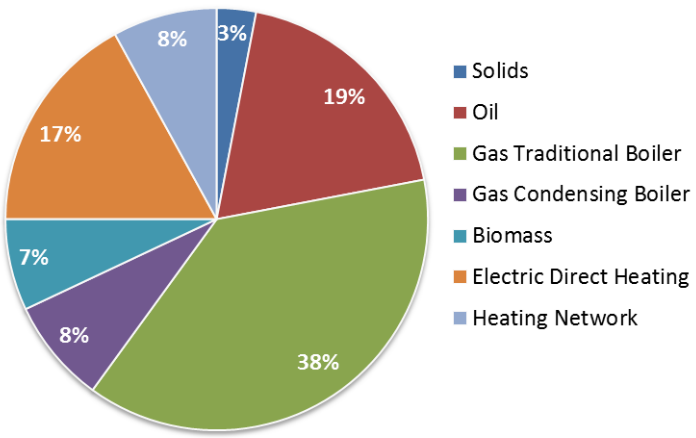
Heating: the EU's most important energy consumer

Heating our homes, businesses and public buildings accounts for almost one third (27% heating) of Europe's final energy consumption. A further 2% is dedicated to keeping our buildings cool, through air conditioning. Space heating accounts for approximately 70% of a building's energy needs and the heating of hot water 15% or so, meaning about 85% of the energy needs of buildings is used for heating.
Heat is generated through the use of appliances such as boilers, combined heat and power (CHP) and heat pumps, which convert an input energy (such as gas) into thermal energy (such as hot water).

Gas is still the No.1 consumer choice

The majority of heating appliances currently used are gas-fuelled, with a market share of just over 45%. The amount of oil and petroleum-fuelled appliances is also significant at just under 20% of the market share. Electricity comes a close third in providing heat for our private and public spaces with around 17%, while the remainder is taken up by heating networks, biomass and coal.

Figure 1: EU27 Household heating systems by market share



Source: EU Roadmap 2050, 2010 scenario

Consumer choice for heating and cooling varies considerably across the European Union and is largely driven by different climates, available fuel types and national policy.

Policy for heating and cooling is evolving

Now is a perfect opportunity to assess the continued role of gas in the heating and cooling residential and commercial sectors, given that the European Union is currently preparing a climate and energy policy to 2030, as well as reviewing applicable legislation.

Current legislation

The European Commission is currently reviewing legislation regulating the heating and cooling sector as part of its climate and energy policy to 2030. Current legislation includes:

- Energy Labelling Directive – rates the various heating and cooling appliances for their energy efficiency, including combined systems such as a gas condensing boiler + solar panel.

- EcoDesign Directive sets minimum performance levels (including efficiency and emissions limits) for energy-using appliances and minimum requirements for products affecting energy consumed (e.g. windows, insulation, shower heads, taps…).

- Energy Efficiency Directive outlines initiatives for Member States to follow in order to meet the non-binding objective to achieve 20% savings in primary energy consumption by 2020, in comparison with the 2007 projected primary energy consumption for 2020.

- Energy Performance of Buildings Directive sets out the minimum energy performance levels for existing buildings undergoing major renovation; stipulates that new builds must consume nearly-zero energy from 2021 (public buildings from 2019); and sets out a certification guideline for energy performance including rules for inspecting heating and air-conditioning systems.

A challenge in implementing policy in this sector is the large number of stakeholders involved, as shown in the table below.

Area	Stakeholder
Technology	▪ Manufacturers ▪ Smart equipment providers
Service Providers	▪ Engineers ▪ Architects ▪ Energy service providers ▪ Appliance vendors ▪ Installers / Project developers / Agents ▪ Energy suppliers
Infrastructure	▪ Biomass / Oil provider ▪ Gas DSO ▪ Electricity DSO
Policy Makers	▪ Standardisation bodies ▪ Regulator ▪ Municipalities ▪ EU & National legislative authorities

This makes policy measures for the heating and cooling sectors more complex, as they often have to reach many of these participants and missing one group can result in the measure not working.

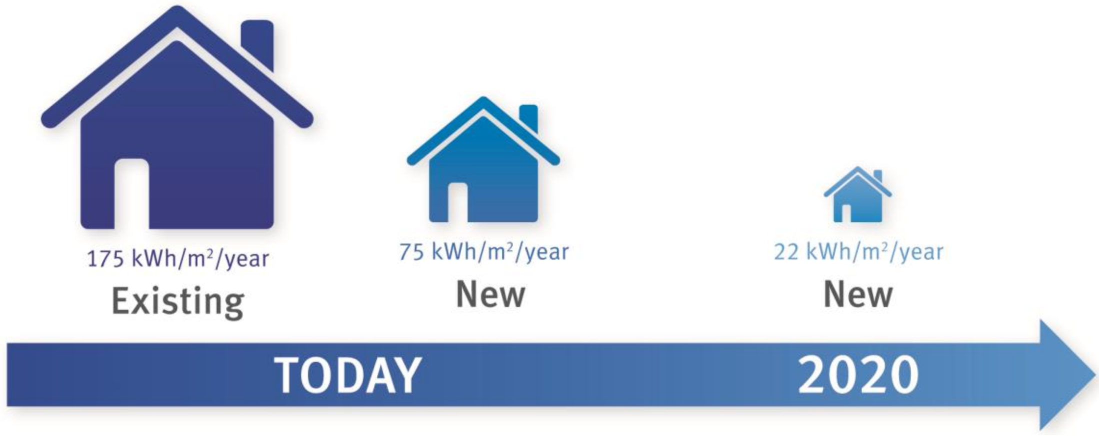
Changing needs

Consumer energy demand has been decreasing considerably over a long period of time due to improved building standards and the application of legislation.

Case Study: Denmark

Denmark is a case in point. Current energy demand for typical 100 m^2 existing building is approximately 175 kilowatt hour per square metres (kWh/m^2) per year. For new builds, because of planned insulation regulations, demand is expected to fall to 22 kWh/m^2 per year by 2020, a drop of almost 90%.

Figure 2: Changing household heating needs, Denmark



Source: Danish Gas Technology Centre, based on a 100 m^2 building

However, heating existing buildings still takes a sizeable chunk of the overall EU boilers market. In 2012, for example, an estimated 80% share of the boiler market went on replacing existing boilers, while only 20% was to install appliances in new buildings. This is an important consideration when making policy choices, as the effect of change from the replacement market is greater than that of the new build market.

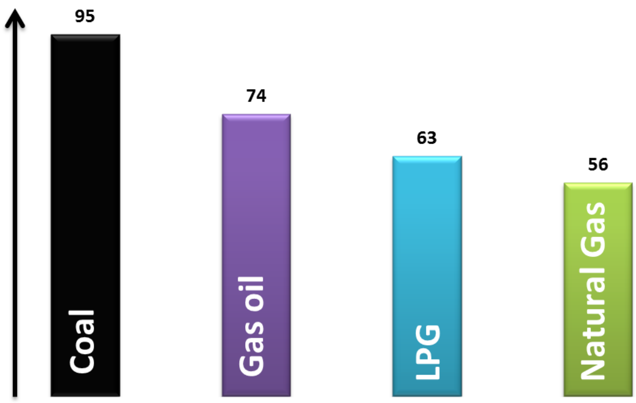
Gas is currently the fuel of choice in the EU for heating homes and businesses. It could remain the fuel of choice even when demand drops due to energy efficiency measures. Read on and see why…

Using the right energies for heating and cooling

Gas is clean

Using the most clean, secure choice of energy is crucial to reducing greenhouse gas (GHG) emissions. Gas is cleaner than other fuels commonly used for heating and cooling because it emits the least amount of carbon dioxide (CO_2) when compared with gasoil, coal or LPG. This means that using an equally efficient boiler, the natural gas option would produce the least CO_2.

Figure 3: Carbon intensity of common heating fuels, kg CO_2/GJ

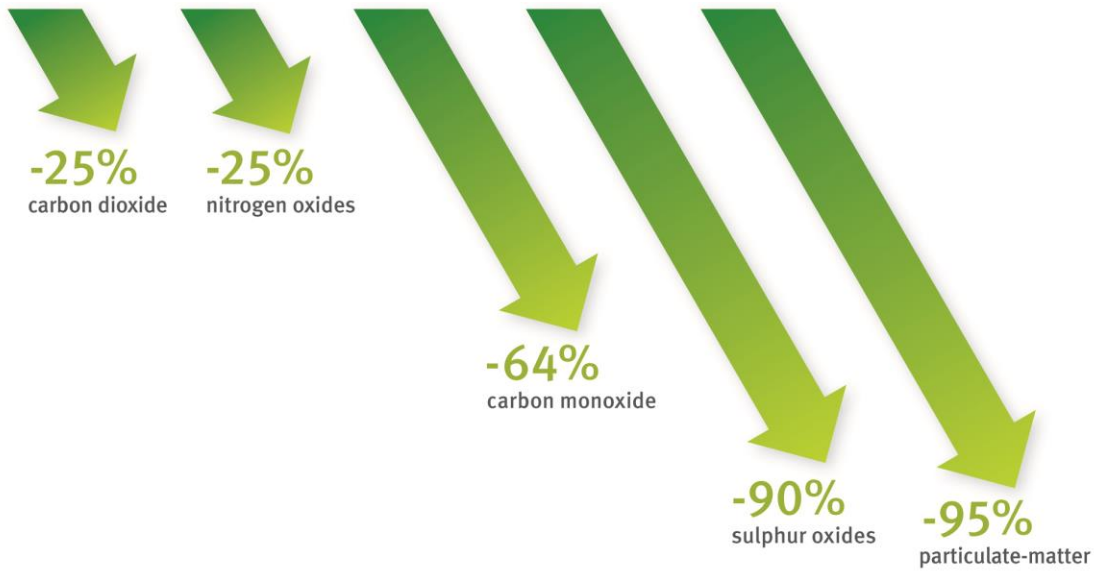


Source: IPCC guidelines

Case Study: Spain

According to a recent study carried out on behalf of the Spanish national association for gas, Sedigas, 50.2 terawatt hour (TWh) of gasoil used for heating could be replaced by natural gas in Spain, the equivalent of approximately 2 million customers. By making this switch to gas, pollutants could be considerably reduced, according to the report.

Figure 4: Estimated emission reductions by switching gasoil to gas in heating in Spain



Source: Based on data from Sedigas, Spanish Gas Association

Gas is green

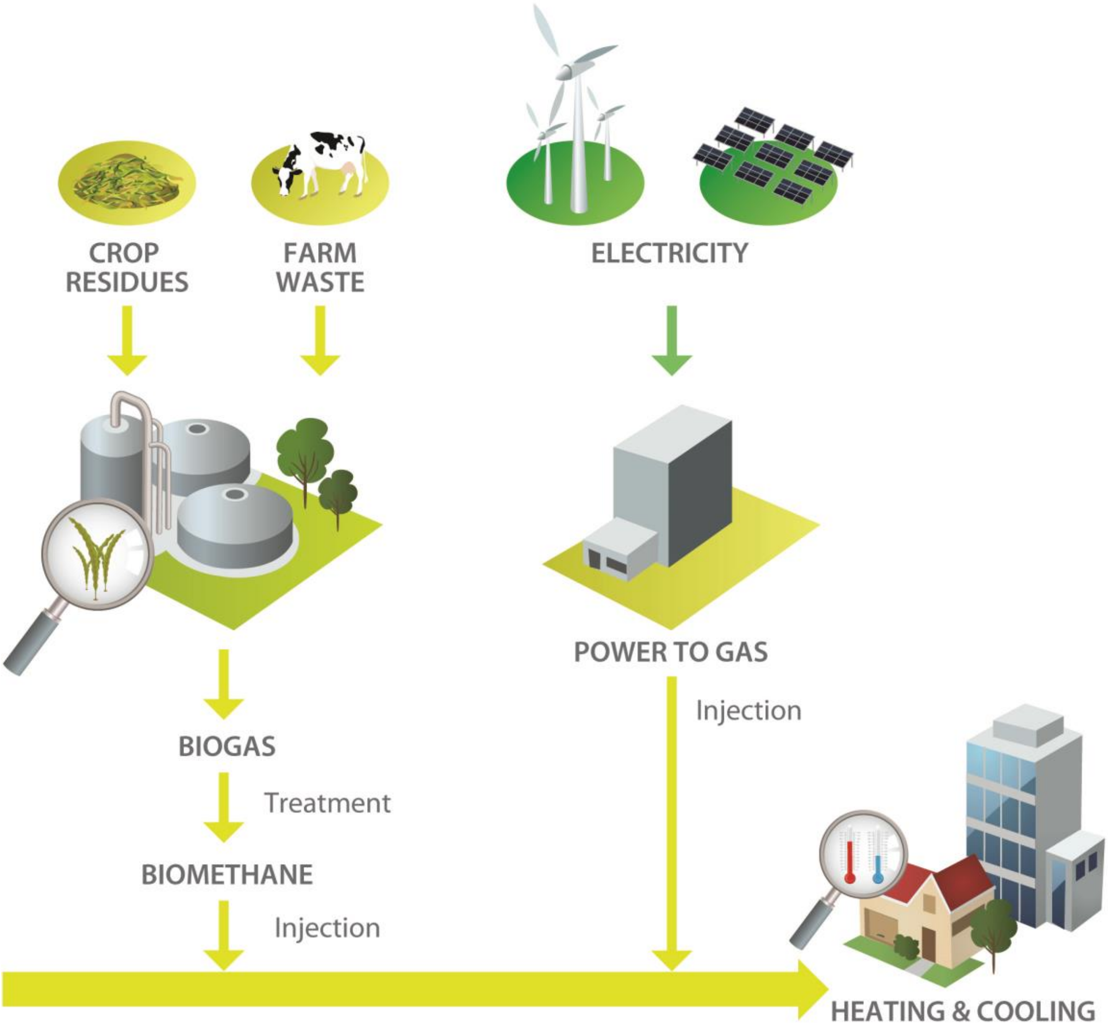
Green gas in the form of biogas or renewable gas is a carbon-neutral energy for tomorrow's heating portfolio.

Biogas is produced from anaerobic decomposition of waste or organic materials. Second and third generation biogases are emerging which do not compete with food-crops for supply as some first generation biogases do. This carbon-neutral, 100% renewable gas, once upgraded to reach the same quality as natural gas to become biomethane can be pumped directly into the existing gas grid and used in existing gas appliances. A total of 11 million tonnes of oil equivalent (mtoe) biogas is currently produced in the 27 Member States of the European Union.[1] Potential production is estimated to stand at around 42 mtoe. The Eurogas *Statistical Report* 2013 put primary consumption of gas for EU27 in 2013 at 390mtoe, so biogas could provide up to 10% of this demand. Biogas represents a chance to introduce direct consumption of zero emissions renewable gas in homes and businesses without any changes to the connecting infrastructure and appliances in place.

Renewable gas is also created via the conversion of electricity to gas using a process called electrolysis. Power-to-gas facilities that convert electricity, including surplus renewable electricity into "renewable" gas are emerging throughout Europe. The gas produced in this way can then also be used for heating and cooling as well as used by other sectors. The gas created is in the form of hydrogen and can be injected straight into the gas grid or through a process of methanisation be converted into methane before being injected. The gas grid has the capacity to transfer significantly more energy than the electricity grid so using this emerging technology would again not require any additional investment in infrastructure. Power-to-gas plants are currently operating in France (1), Italy (1) and Germany (4), with more planned throughout Europe.

[1] "The Biomethane Guide for Decision Makers", Green Gas Grids Report, September 2013.

Figure 5: Production of renewable gas



Source: Eurogas 2014

Gas: an ideal partner for renewables

Gas based appliances (boilers, heat pumps, hybrids and micro-combined heat and power (mCHP)) can act as an ideal partner working alongside renewable energy such as solar to produce heat. All of these appliances can operate also with renewable gas (either on its own or as a mixture with natural gas) and can be combined with renewable sources of energy. Using mCHP and hybrids also allows gas and electricity to work together. By accommodating such a wide variety of appliances and partnerships with renewable energies, gas offers an appropriate flexible solution for all consumer circumstances. For homes in warmer climates heating via solar energy alone may be possible.

Figure 6: Heating technologies and partnerships available

Energy	Means of Heat Creation	Potential Partners					
		*Bio-methane	Solar	Biomass	Air	Water	Electric
Gas	Condensing Boiler	✔	✔	✔			
	Heat Pump	✔	✔		✔	✔	
	Micro CHP	✔	✔				✔
	Hybrid	✔	✔		✔	✔	✔
Oil	Condensing Boiler		✔	✔			
	Hybrid		✔		✔	✔	✔
Solar	Solar Panel						
Solid Fuel (Coal, Pellets, Woodchips)	Boiler		✔	✔			
Electric	Heat Pump		✔		✔	✔	
	Radiators		✔				
	Electric Boiler		✔				

Source: Eurogas 2014

Recent studies confirm that combining a high-efficiency gas condensing boiler or a gas hybrid system together with solar PV-panels and state-of-the-art insulation is in many cases a very cost-efficient solution for building nearly-zero energy buildings in accordance with the Energy Performance of Buildings Directive.

The gas grid is fit for purpose

We cannot simply replace the heating load met by gas by switching to electricity. The gas grid can transfer significantly more than the amount of energy to that of the electricity grid. Any change to policy favouring electrification would need to consider the cost and environmental impact of increasing the electricity infrastructure. The gas grid is designed to accommodate the peak energy requirements that heating requires.

Case Study: Germany

Take, for example, one of the coldest days of the year in Germany 14 January 2013. Using a standard load profile for a German household[2], which consumes 15,000 kWh of gas per annum and uses a gas-condensing boiler and consumes additionally 3,000 kWh of electricity per annum, would have resulted in the consumption of the following energy on that day:

- just under 100 kWh of gas, for space heating and hot water; and
- approximately 10 kWh of electricity, for lighting and electrical appliances.

If that same household had used electricity **instead** of gas for their heating and hot water, the occupants would have used:

- **10 X** increase in electricity if direct electric heating was used;
- **4 X** increase in electricity if the latest state-of-the-art electric heat pumps were used;
- **8 X** increase in electricity if using electric storage heaters were used.

Switching the gas heating load to the electricity system would require mutiple times the electrical grid currently in place. The gas grid, which of course is underground, provides a secure, sustainable source of energy with the capability to accommodate the peaks and troughs of energy demand that heating systems require in the winter and that cooling systems require in the summer.

[2] Based on load profiles provided by Thüga.

Converting energy to heat in an efficient way

Using more efficient technologies to convert the input energies into heat reduces the energy requirement and reduces the greenhouse gas emissions.

Gas allows us to capture the easy wins

Appliances using gas and oil combined make up 65% of the market share for heating systems. These systems will use boiler technology that can be divided into two different technologies: the traditional boiler and the condensing boiler. Although both are water heaters, condensing boilers are more efficient than traditional boilers.

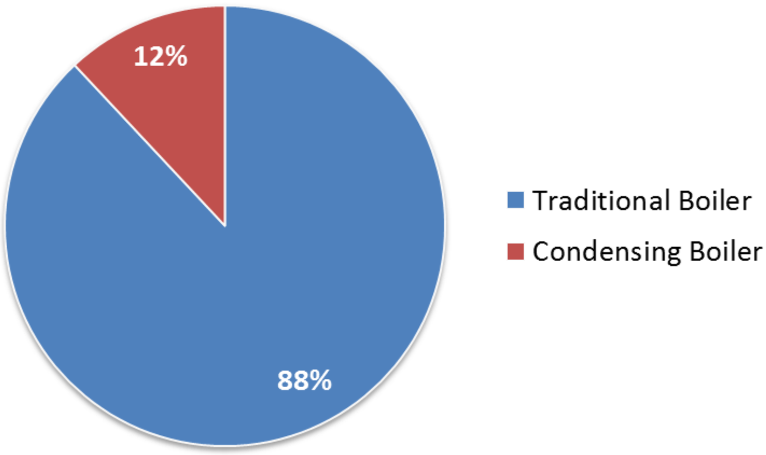
A traditional **gas boiler** burns gas and the hot gases produced are passed through a heat exchanger where much of their heat is transferred to water, thus raising the water's temperature.

A **gas-condensing boiler** includes an additional step where it captures the waste heat in the flue gases, which is used to pre-heat the cold water entering the boiler, hence improving the overall energy efficiency.

An **oil-condensing boiler** is essentially the same technology as a gas one, except using oil as the fuel source. Unlike gas, oil is usually stored on site.

Over 85% of the existing gas and oil boilers are the older less efficient variety. Switching now to gas-condensing boilers would be one quick way to reduce GHG emissions, improve energy efficiency and cut the utility bills of consumers. Under the EcoDesign Directive, consumers will no longer be able to buy traditional boilers after 2015.

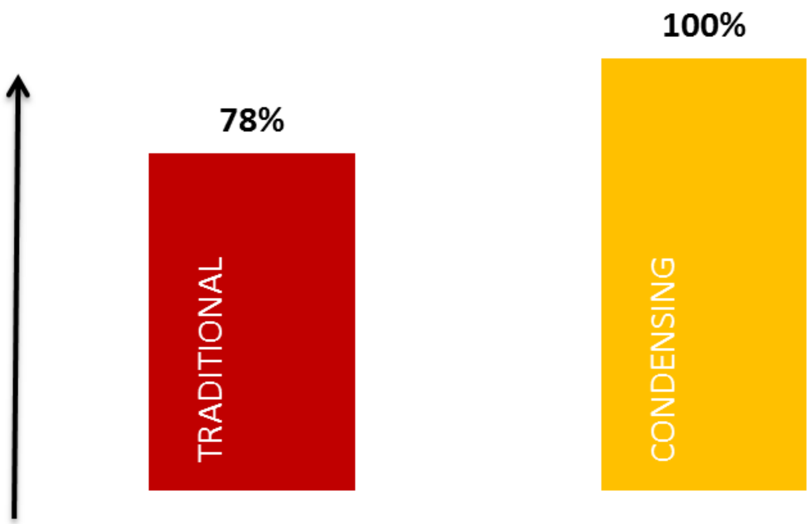
Figure 7: Europe's gas boiler share by traditional and condensing



Source: EU Roadmap 2050

The differences in the efficiency of these boilers are significant, as shown in Figure 8 below.

Figure 8: Comparison of boiler types by efficiency



Source: Burgeap Report to Eurogas, May 2014

Note: lower calorific value, excluding generation and distribution losses.

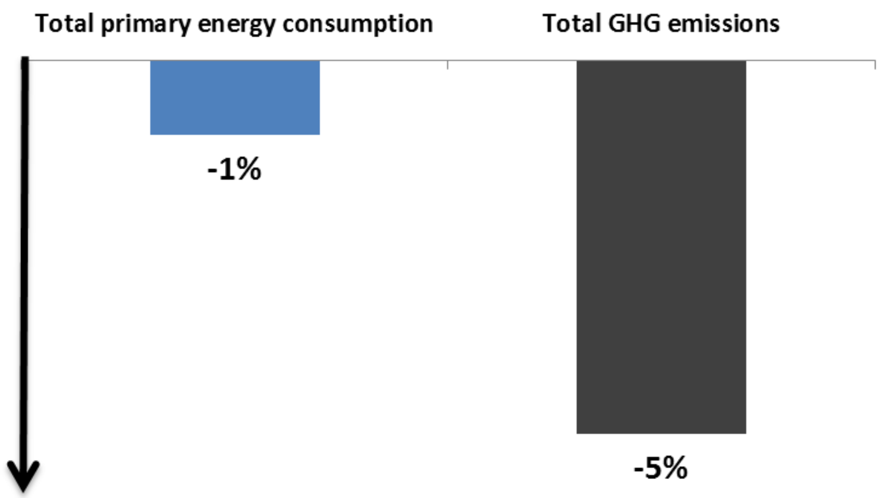
Eurogas asked BURGEAP a specialist in modelling energy systems, to assess the impact of different scenarios of heating technology in the housing and commercial sectors on energy consumption and GHG emissions in the European Union.

In the first scenario, half of the existing oil boilers in Europe were replaced by gas condensing boilers.

Scenario 1: Replacement of 50% of oil traditional boilers by gas condensing boilers

There is a large share of oil boilers in the market, which are nearly all traditional rather than condensing. A complete switch of these to gas condensing boilers is unlikely as the gas network is not available at all homes. Therefore, only 50% were assumed to switch in this scenario.

Figure 9: Replacing oil traditional boilers with gas condensing boilers for year 2010 in the housing and commercial sectors



Source: Burgeap Report to Eurogas, May 2014

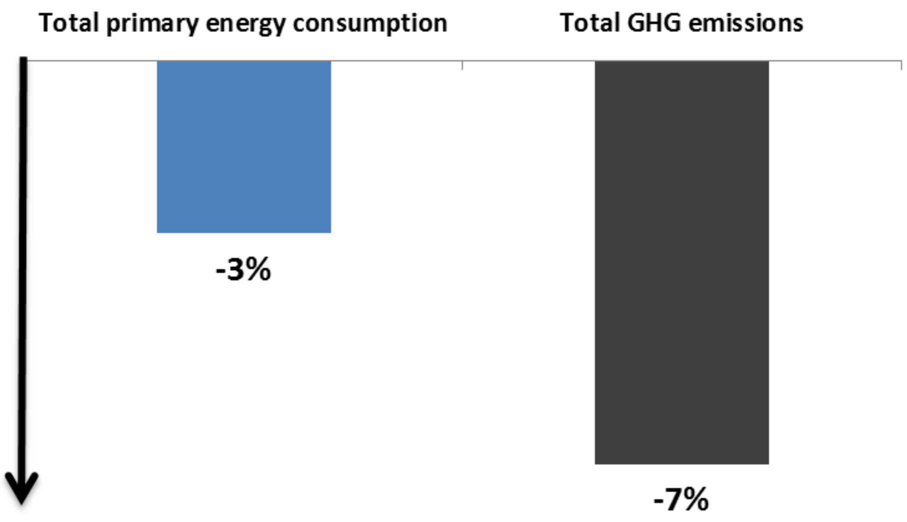
The results of the analysis showed a 1% reduction in the total primary energy consumption in 2010 and a 5% reduction in GHG emissions, for the housing and commercial sectors.

In the second scenario, the gas boiler fleet that are traditional were replaced with gas condensing boilers.

Scenario 2: All gas traditional boilers are replaced by gas condensing boilers

The majority of gas boilers being used today are the less efficient traditional boiler. This scenario looks at the savings that would be achieved were these boilers switched to gas condensing boilers.

Figure 10: Replacing gas traditional boilers with gas condensing boilers for year 2010 in housing and commercial sectors



Source: Burgeap Report to Eurogas, May 2014

Case Study: Netherlands

Dutch gas trading company, GasTerra, estimates that Dutch gas homes have become 50% more efficient in terms of gas use since 1980 with 23% of this attributed to the replacement of traditional boilers by modern condensing boilers. Contrary to many other markets the gas condensing boiler is already the prevailing boiler in the Netherlands.

New gas technology for more efficient heating

Using energy-efficent appliances will save on energy, reduce GHG emissions into the atmosphere and cost the consumer less. There are several technologies which can be considered:

A **gas-heat pump** combines condensing technology with environmental energy extracted heat from low temperature sources (air, water, ground) and upgrades it to a higher temperature and releases it where it is required for space and water heating. Heat pumps can also be operated in a reverse mode for cooling purposes.

An **electric heat pump** works on the same principle but using electricity rather than gas as the main energy input.

A **combined heat and power** unit is a system that produces both heat and electricity for the user. This single process of combined heat and power production provides synergy that improves efficiency. The co-generation process, which is often for larger industrial-type use, is also now available on a small-scale for residential and commercial usage.

Large CHP plants are often commonly used for district heating. **District heating** is a system for distributing heat generated in a centralised location for residential and commercial heating requirements via pipes with hot water.

A **fuel cell** is a device with a similar effect, using chemical energy from gas and converting it into heat and electricity through a chemical reaction with oxygen or another oxidizing agent.

A **gas hybrid** is the combination of a gas condensing boiler and an electric heat pump. Electric heat pumps efficiency worsens as the outdoor temperature becomes colder, as there is less heat available from the air, ground or ground water. During periods of lower temperatures, the gas condensing boiler provides the heat. It will not only result in a better overall efficiency of the system, but will also reduce the load on the electrical grid in a period of very high electricity demand.

The options for **cooling** are limited to gas or electric based appliances. Given the limited options for cooling, the availability of gas technologies provide competition to electricity appliances, whilst also offering the consumer greater choice.

Some key features of gas appliances

There are factors other than efficiency and GHG emissions that should be considered when comparing different technologies.

NOx emissions – gas based appliances are amongst the lowest emitters of NOx emissions. They emit significantly less NOx than oil and biomass appliances. They also compare favourably to electrical based appliances, with the extent varying on the source of the electricity.

Source: Energinet DK, Technology data for energy plants

Costs – One of the big advantages of gas appliances is the competitiveness of the technologies cost wise. A review of different technologies carried out by Delta Energy and Environmental showed gas boilers having the lowest upfront cost of all of the common heating options available. In terms of annual running costs, the same report showed that the gas boiler, gas heat pump and micro-CHP as being the most competitive. Delta concludes that under their base case assumptions that “gas appliances have substantially stronger customer economics than alternative technologies”.

Source: Delta energy and environmental, 2050 Pathways for Domestic Heat

Gas products for heating and cooling are among the best performing appliances on the market in terms of ease of use, affordability, emissions, efficiency and performance. Tested over a number of criteria gas based appliances are consistently strong and well-rounded.

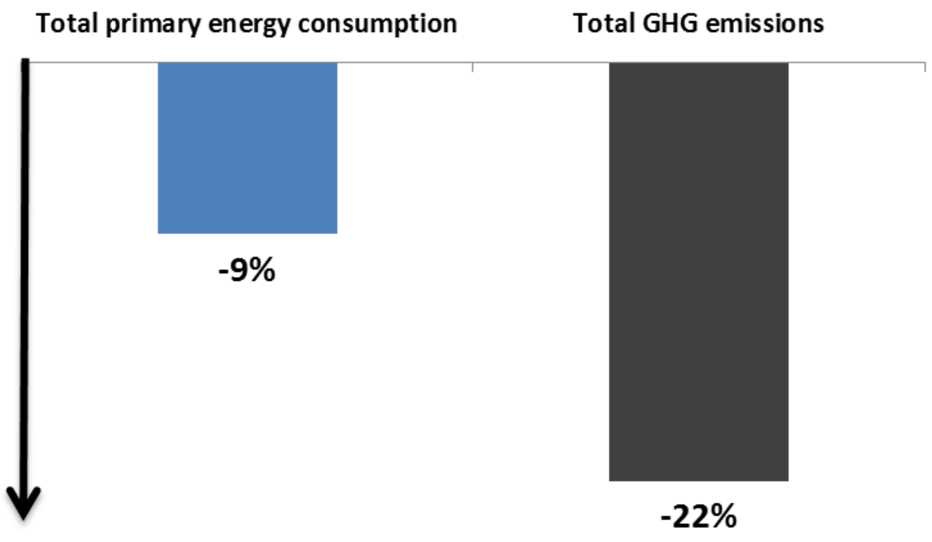
While the conversion to the gas condensing boiler offers a cost effective path for swift considerable energy savings and GHG reductions, in some cases other technologies may be more appropiate. Using some of these newer based technologies allows for even greater savings in energy and reductions in GHG emissions.

In the third scenario analysed, the gas boiler fleet that are traditional were replaced with gas heat pumps.

Scenario 3: All gas traditional boilers are replaced by gas heat pumps

It should be noted that that not all consumers could use heat pumps, as those in city dwellings for example may not be able to install them. They are also more expensive to purchase than a gas condenisng boiler.

Figure 11: Replacing gas traditional boilers with gas-heat pumps for year 2010 in housing and commercial sectors



Source: Burgeap Report to Eurogas, May 2014

Finally, in the fourth scenario, the gas boiler fleet that are traditional were replaced by gas micro combined heat and power (CHP). While similarly to gas heat pumps this may not be possible for all consumers, the analysis is intended to show the different impacts of these technologies.

Scenario 4 : All traditional gas boilers are replaced by micro combined heat and power (CHP) gas.

In this scenario, the efficiency considered for micro CHP is 70% for heating and 12% for power production (based on actual Rankine cycle technologies efficiency*).* The 12% represents the primary energy consumption and in final energy consumption terms would mean a 30% efficiency.

The analysis for this scenario showed one key result: a **reduction in the primary energy consumption of 5%** for the housing and commercial sectors. This is because while the gas used for heating is the equivalent amount, the production of electricity by the mCHP means less electricity is needed to be delivered to the property.

These scenarios show the extent of both energy savings and greenhouse reductions that can be achieved by using gas appliances.

Policy Recommendations

- Employ policies that are technology and fuel neutral in order to be cost efficient and innovation-friendly.
- Promote new technologies as an essential tool for reaching EU targets.
- Take into account in making policy choices that the effect of changes from the replacement market is greater than that of the new build.
- Ensure a stable regulatory and legal framework to encourage investment in modernisation measures.
- Provide financial incentives for consumers to replace existing heating and cooling systems for systems that are easy to implement, efficient, effective and affordable in order to allow for competition to evolve and greater consumer choice.
- Promote consumer choice of heating and cooling technology and inform them about new choices available such as gas heat pumps and not only electric heat pumps. The creation of a tool to allow consumers to choose their heating and cooling application based on their individual circumstances, such as costs, needs and accommodation would be very useful. The gas industry is willing to play its part in providing such a tool.
- Amend the Energy Labelling Directive so that all technologies using biomethane are rewarded.
- Create a framework for the dissemination of relevant information in a technology neutral way to the many stakeholders involved such as architects, appliance vendors and installers, in order to allow them to assist consumers in making the right choices. Provide them with guidelines to ensure policy measures work in practice. Again, the gas industry is willing to cooperate to provide this.

The gas industry is ready to cooperate to help achieve the significant consumer benefits set out in this report.

Appendix

Definition of units used in this report

- All efficiencies in this report are expressed in Lower Calorific Value. It means that all efficiencies are net efficiencies.
- Unless stated otherwise, efficiencies are yearly average efficiencies for final energy. Analysis carried out includes generation, distribution, regulation and emission losses.
- All the results presented are yearly results.

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