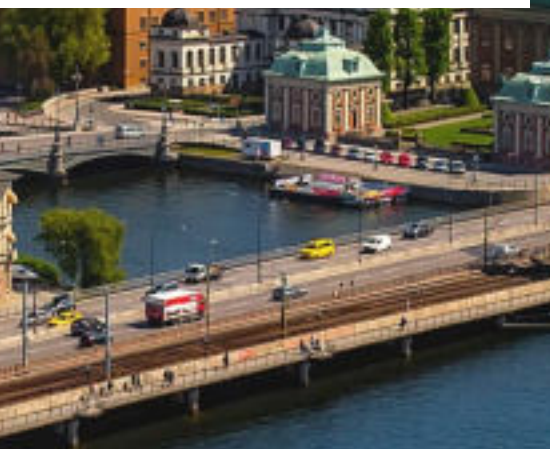
457,000 tonnes of oil was consumed by the industrial sector in 2017

The top three largest consumers of oil in the industrial sector:

- Paper, pulp & printing
- Mining & quarrying
- Iron & steel



SWEDEN

Case study: industrial heating
#BeyondTheGasGrid

In the Swedish industrial sector, manufacturing processes require the largest share of energy to operate. Over the past few years, the consumption of energy has started to decrease, but fuel-switching is still required in the most energy-intensive industries. This case study analyses the monetary and health impact of a typical mining and quarrying site that switches from using a fire-tube steam boiler fuelled by gas oil to a fire-tube boiler fuelled by LPG.

LPG annual CO2 savings: 15% BioLPG annual CO2 savings: 78%
76% NOx emissions savings
96% Lifetime PM emissions savings
€383,730 Annual energy bill savings
Capital cost payback = < 2 years

From 2030 onwards, it is assumed that the industrial boiler is fuelled by bioLPG.

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SWEDEN

Case study: industrial heating
#BeyondTheGasGrid

Alternative technology options available:

The table below compares how alternative technology options compare to an existing fire-tube boiler that is fueled by oil. The different heating systems include a fire-tube fueled by LPG, a water-tube boiler fueled by coal and a biomass-fueled CHP system.

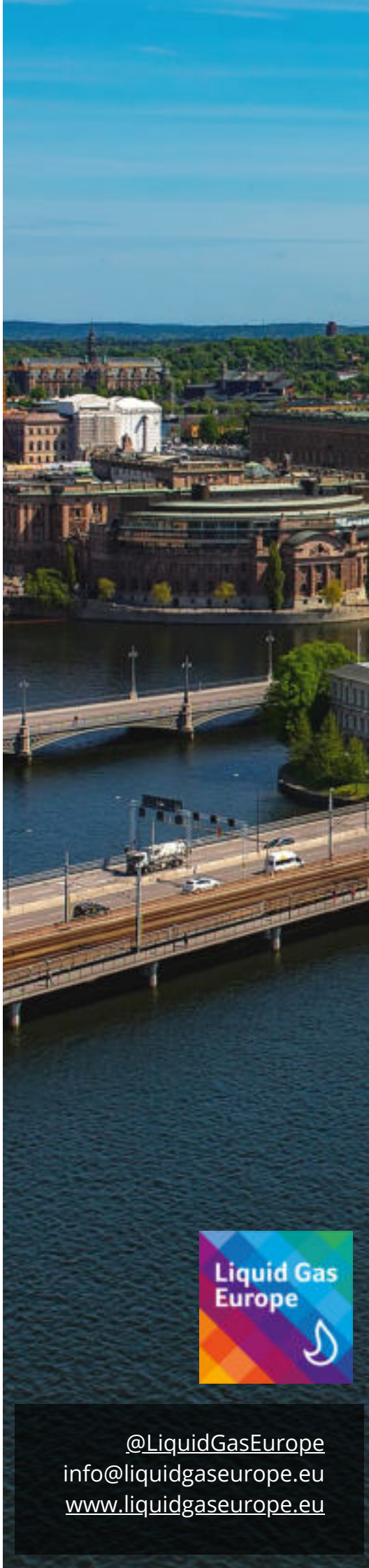
performs worse than existing oil-fueled fire tube boiler

performs better than existing oil-fueled fire tube boiler

Technology Options	Upfront cost*	Running cost	Lifetime CO_2 reduction	Lifetime air pollution reduction
Fire-tube boiler: *(LPG fuelled)*	Same	Lower than oil-fuelled system, assuming efficiency improvements are achieved	Lower than existing oil-fired system (up to 20% if using LPG, up to 80% if using bioLPG)	Substantially lower than existing oil-fuelled system (more than 70%)
Water-tube boiler: *Coal-fuelled*	1-2 times more expensive than an oil-fuelled system	Substantially lower than oil-fuelled system. Price of industrial coal is extremely cheap	Substantially higher than oil-fuelled system. Coal has a relatively higher carbon intensity (up to 50%)	Lower NOx emissions (up to 40%) but higher PM emissions (up to 300%)
Back pressure CHP: *(fuelled by wood pellets)*	3- 4 times more expensive than oil-fuelled system	Substantially lower than oil-fuelled system. Price of wood pellets is low	Substantially lower than current oil-fuelled system (more than 90%)	Lower NOx emissions (up to 20%) but higher PM emissions (up to 100%)

**Upfront cost differences are case-specific; in this case the upfront cost for a heating system is modelled for an energy demand of ~25,000MWh/annual.*

Sources: PwC, European Commission, Fraunhofer, US Department of Energy, Covenant of Mayors, European Commission Oil Bulletin and Argus Media



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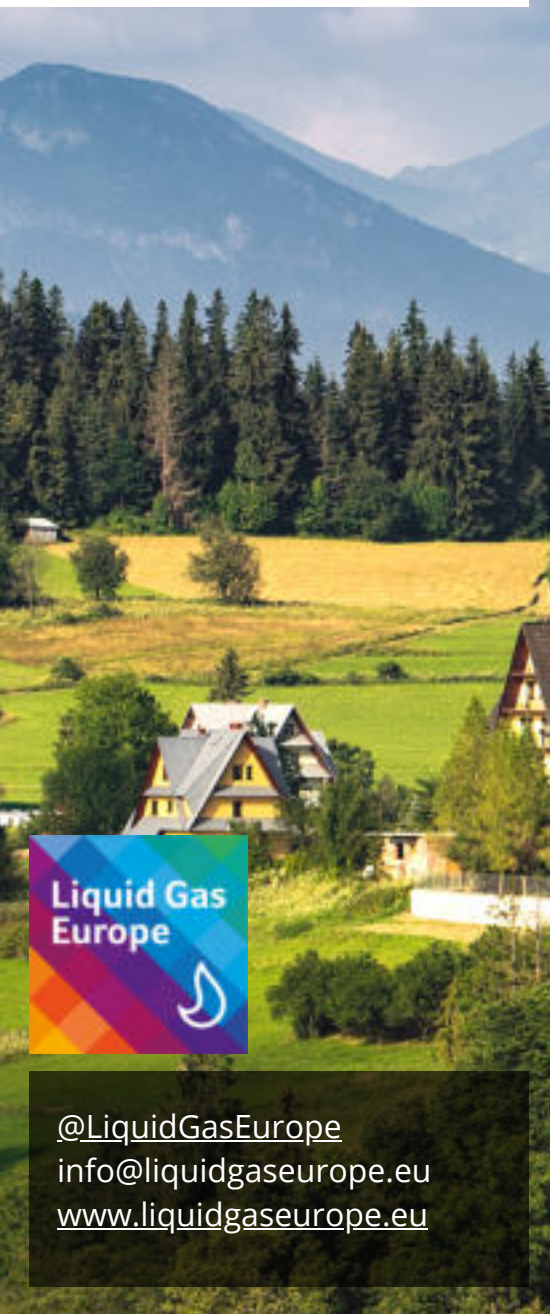
80% of Poland's electricity generation comes from coal

Coal is the largest source of energy in the residential sector, around 30%

3.5 million homes are fitted with coal-fired boilers

70% of single-family homes are heated by coal



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POLAND

Case study: residential heating
#BeyondTheGasGrid

70% of single-family homes in Poland are heated with coal, which represents around 3.5 million coal-fired boilers. The vast majority of these homes (about 3 million) are heated by manual-fed coal boilers that are technologically outdated, inefficient and responsible for high carbon emissions and air pollution.

This analysis considers a typical detached, single-family house in Poland that uses an old coal boiler and estimates the fuel bill and emission savings if the house retrofitted external wall insulation and switched to a new LPG boiler.

LPG annual CO2 savings: 86%
BioLPG annual CO2 savings: 96%

89% NOx emissions savings

99% Lifetime PM emissions savings

€374 Annual energy bill savings

Capital cost payback = 2.6 years

From 2030 onwards, it is assumed that the boiler is fuelled by bioLPG.

POLAND

Case study: residential heating
#BeyondTheGasGrid

Alternative technology options available:

The table below compares how alternative technology options compare to an existing coal boiler. The different heating systems include a new LPG boiler, an air source heat pump and a biomass boiler.

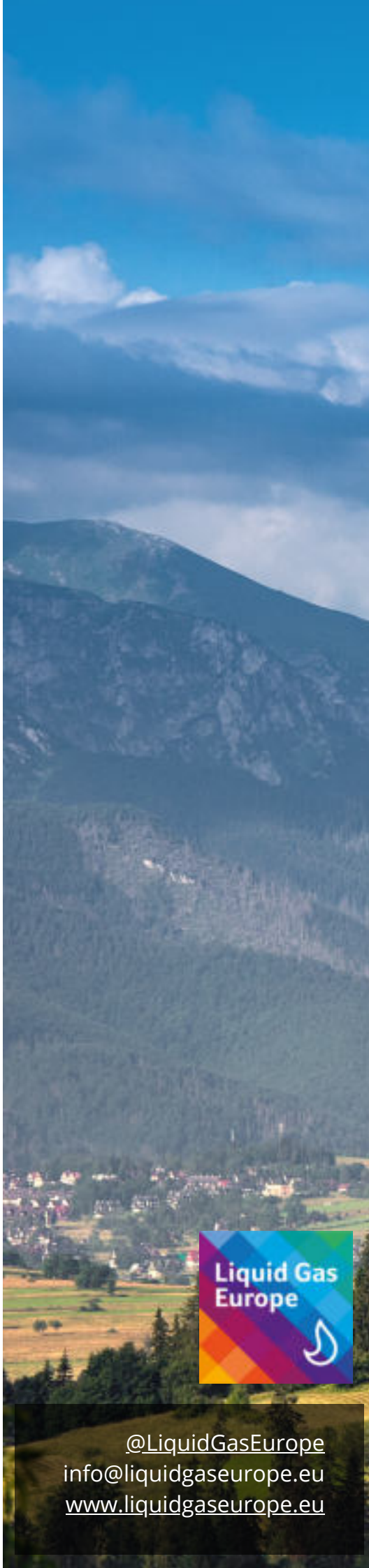
performs worse than old coal boiler

performs better than old coal boiler

Technology Options	Upfront cost*	Running cost	Lifetime CO_2 reduction	Lifetime air pollution reduction
LPG boiler: *New, condensing* + **Thermal insulation**	Lower than coal boiler	Lower than coal boiler. Thermal insulation reduces energy demand, lowering running cost	Substantially lower than coal boiler (80% - 90% dependent on using LPG or bioLPG)	Substantially lower than current coal boiler (up to 99%)
Air Source Heat Pump + **Thermal insulation**	4-5 times more expensive than current coal boiler	Substantially lower, assuming relatively higher operating efficiency of the ASHP is achieved	Substantially lower than current coal boiler (up to 80%)	Substantially lower than current coal boiler (up to 99%)
Biomass boiler: *New, automatic (Pellets or log fuelled)* + **Thermal insulation**	6-7 times more expensive than current coal boiler	Substantially lower, largely drive by a relatively low price for wood pellets/logs	Substantially lower than current coal boiler (more than 90%)	Lower than coal boiler (30% to 90% - pellets provide the largest PM reduction)

**Upfront cost differences are case-specific; in this case the upfront cost for a heating system is modelled for an energy demand of 18,000kWh/annual.*

Sources: Fraunhofer, Eurostat, Covenant of Mayors, VHK, European Environment Agency, European Commission, European Pellet Council, Novatek Polska, Statistics Poland, Institute of Environmental Economics, TABULA Webtool and Covenant of Mayors.



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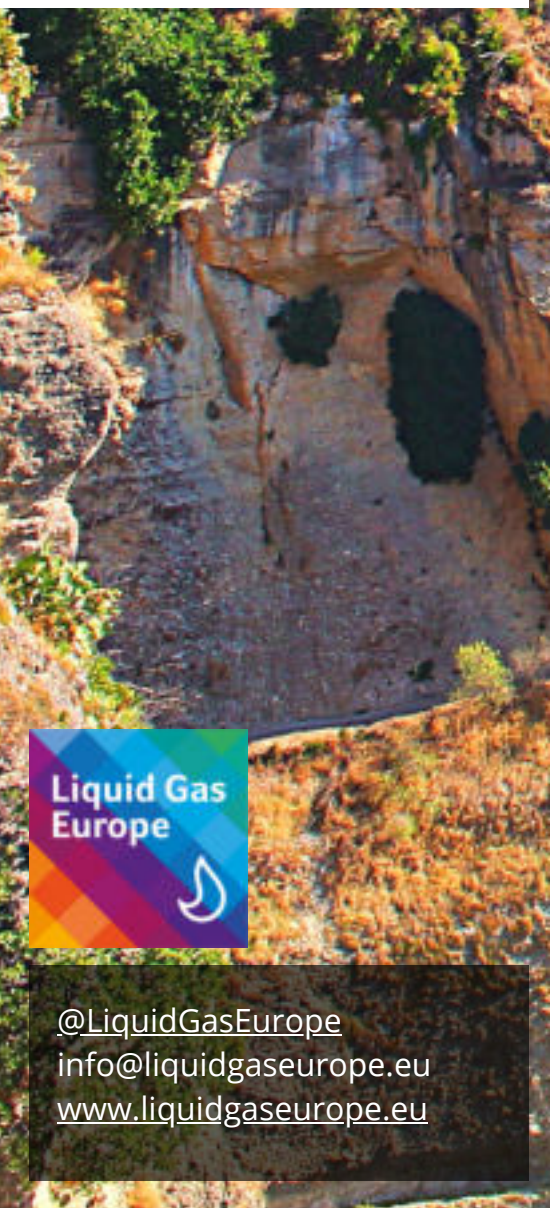
31% dwellings in Spain are single-family homes

Spain has the 5th highest residential electricity prices in Europe (H2 2018)

27% of single-family homes in Mediterranean Spain use heating oil

41% of energy consumption in Mediterranean Spain is attributed to space heating



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SPAIN

Case study: residential heating
#BeyondTheGasGrid

There are 25.2 million dwellings in Spain, with around one-third being single-family homes.
Their energy consumption is dominated by petroleum products (35%) and renewable heating (34.5%), followed by natural gas (25%) and electric heating (6%).
This analysis takes a typical single-family home in Mediterranean Spain and quantifies the impact of switching from an old oil boiler to a hybrid combination of a solar thermal system and a new LPG boiler.

LPG annual CO2 savings: 43%
BioLPG annual CO2 savings: 85%

51% NOx emissions savings

47% Lifetime PM emissions savings

€120 Annual energy bill savings

Capital cost payback = 20+ years

From 2030 onwards, it is assumed that the boiler is fuelled by bioLPG.

SPAIN

Case study: residential heating
#BeyondTheGasGrid

Alternative technology options available:

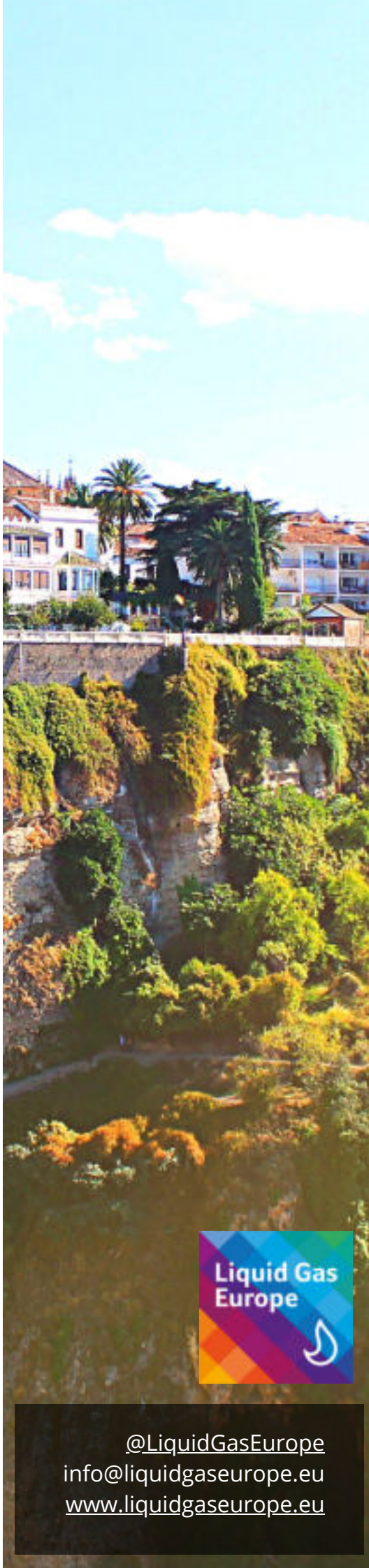
The table below compares how alternative technology options compare to an existing oil boiler. The different heating systems include a new solar thermal system with an LPG boiler, an air source heat pump and a biomass boiler.

performs worse than old oil boiler

performs better than old oil boiler

Technology Options	Upfront cost*	Running cost	Lifetime CO_2 reduction	Lifetime air pollution reduction
Hybrid system: *LPG boiler + solar thermal*	More expensive than old oil boiler	Lower than oil boiler, assuming that solar thermal system can meet hot water demand	Lower than current oil boiler (more than 40% using LPG, up to 90% using bioLPG)	Lower than current oil boiler (40% - 50%)
Air Source Heat Pump	4-5 times more expensive than an oil boiler	Higher fuel bill than oil boiler - electricity price is high in Spain	Substantially lower than current oil boiler (up to 60%)	Substantially lower than current oil boiler (up to 99% lower)
Biomass boiler: *New, automatic (pellet or log fuelled)*	7-8 times more expensive than an oil boiler	Lower than oil boiler	Substantially lower than current oil boiler (more than 90%)	Both NOx and PM emissions higher than oil boiler (more than 100%)

**Upfront cost differences are case-specific; in this case the upfront cost for a heating system is modelled for an energy demand of 9,000kWh/annual. The hybrid system is more expensive because the solar thermal system has a high upfront cost. Desk-based research found that the specific cost of a solar thermal (FPC) system is around €1,500-2,000/kW (including installation). Sources: Fraunhofer, Eurostat, Covenant of Mayors, VHK, European Environment Agency, European Commission, European Pellet Council, Statista, TABULA Webtool, Secretaria de Estado de Infrastructuras, Transporte y Vivienda, SECH Project (SPAHOUSEC), Eco Solar Spain and Instituto para la Diversificacion y Ahorro de la Energia (IDAE)*



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ITALY

Case study: industrial heating
#BeyondTheGasGrid

390,000 manufacturing enterprises in Italy

10% share of oil energy consumption in manufacturing

The top three oil-consuming industrial sectors consume 46% of the final industrial energy consumption

Italy represents 26% of EU-27's steam boiler production

Manufacturing accounts for 16% of Italy's economy, and oil represents 10% of energy consumption in the industrial sector. The sectors that consume the most oil are non-metallic minerals, machinery, and the chemical & petrochemical sector.

This analysis considers the monetary and health impact of a machinery manufacturer switching from a fire-tube steam boiler that is fuelled by oil to a fire-tube boiled fuelled by LPG.

LPG annual CO2 savings: 15%
BioLPG annual CO2 savings: 78%

76% NOx emissions savings

96% Lifetime PM emissions savings

€374,880 Annual energy bill savings

Capital cost payback = < 2 years

From 2030 onwards, it is assumed that the industrial boiler is fuelled by bioLPG.

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ITALY

Case study: industrial heating
#BeyondTheGasGrid

Alternative technology options available:

The table below compares how alternative technology options compare to an existing fire-tube boiler that is fueled by oil. These range from a fire-tube boiler fuelled by LPG, a water-tube boiler fuelled by coal and a biomass-fuelled CHP system.

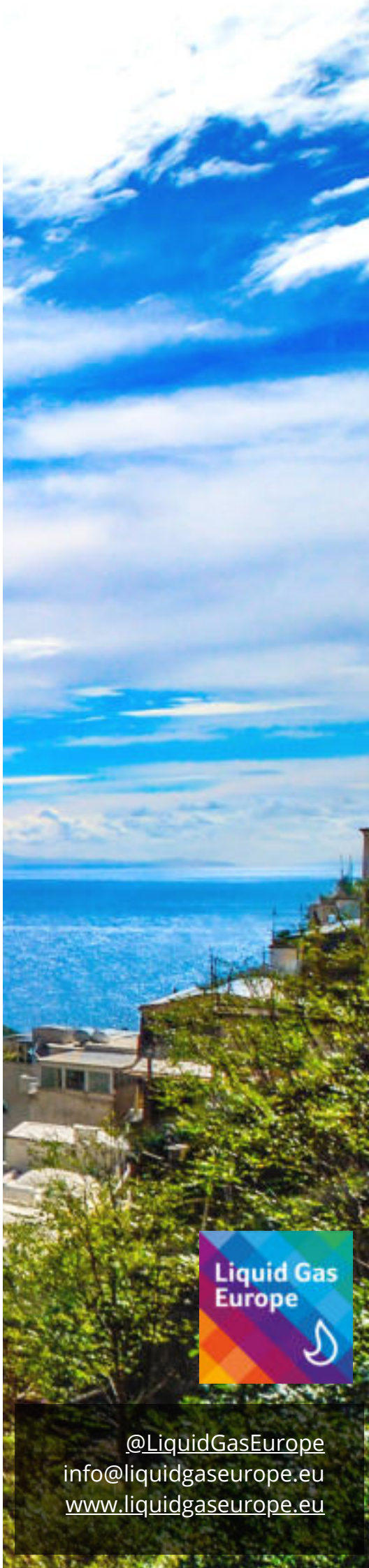
performs worse than existing oil-fired fire tube boiler

performs better than existing oil-fired fire tube boiler

Technology Options	Upfront cost*	Running cost	Lifetime CO_2 reduction	Lifetime air pollution reduction
Fire-tube boiler: *(LPG fuelled)*	Same	Lower than oil-fuelled system, assuming efficiency improvements are achieved	Lower than existing oil-fired system (15% if LPG used, up to 80% if bioLPG used)	Substantially lower than existing oil-fired system (more than 70%)
Water-tube boiler: *Coal-fuelled*	1-2 times more expensive than an oil-fuelled system	Substantially lower than oil-fuelled system. Price of industrial coal is very cheap	Considerably higher than oil-fired system. Coal has a relatively higher carbon intensity (up to 50%)	Lower NOx emissions (up to 40%) but higher PM emissions (up to 300%)
Back-pressure CHP: *(fuelled by wood pellets)*	3-4 times more expensive than oil-fuelled system	Substantially lower than oil-fuelled system. Price of pellets/logs is low	Substantially lower than current oil-fired system (more than 90%)	Lower NOx emissions (up to 30%) but higher PM emissions (up to 100%)

**Upfront cost differences are case-specific; in this case the upfront cost for a heating system is modelled for an energy demand of ~25,000MWh/annual.*

Sources: PwC, European Commission, Fraunhofer, US Department of Energy, Covenant of Mayors, European Commission Oil Bulletin and Argus Media



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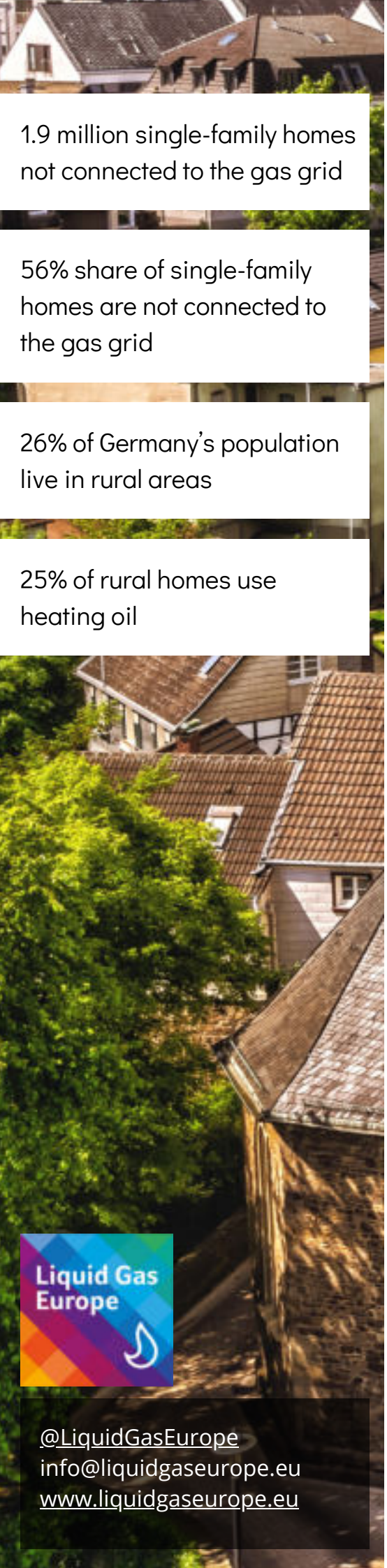


1.9 million single-family homes not connected to the gas grid

56% share of single-family homes are not connected to the gas grid

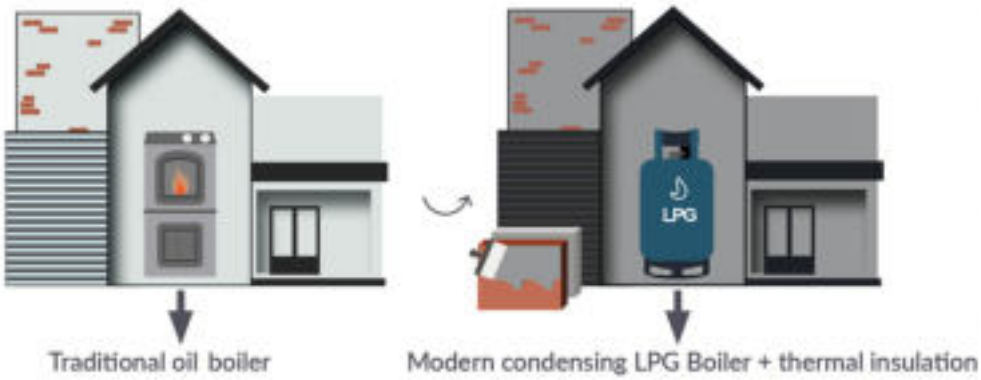
26% of Germany's population live in rural areas

25% of rural homes use heating oil

GERMANY

Case study: residential heating
#BeyondTheGasGrid

There are around 1.9 million single-family homes not connected to the gas grid in Germany.
This analysis takes a typical large detached single-family home in Germany and estimates the health and cost impact of switching from an old conventional oil boiler to a modern condensing LPG boiler. As well as changing heating systems, the household also chooses to retrofit its thermal insulation.



LPG annual CO2 savings: 63%
BioLPG annual CO2 savings: 90%

68% NOx emissions savings

66% Lifetime PM emissions savings

€933 Annual energy bill savings

Capital cost payback = 8.4 years

From 2030 onwards, it is assumed that the boiler is fuelled by bioLPG.

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GERMANY

Case study: residential heating
#BeyondTheGasGrid

Alternative technology options available:

The table below compares how alternative technology options compare to an existing oil boiler. The different heating systems include a new LPG boiler, an air source heat pump and a biomass boiler.

performs worse than old oil boiler

performs better than old oil boiler

Technology Options	Upfront cost*	Running cost	Lifetime CO_2 reduction	Lifetime air pollution reduction
LPG boiler: *New, condensing* + **Thermal insulation**	Similar to oil boiler	Substantially lower than oil boiler assuming that efficiency improvements are achieved (new boiler and thermal insulation)	Considerably lower than current oil boiler (over 60% using LPG, up to 90% using bioLPG)	Markedly lower than current oil boiler (60-80%)
Air Source Heat Pump + **Thermal insulation**	7-8 times more expensive than an oil boiler	Lower than oil boiler due to higher operating efficiency and thermal insulation	Lower than current oil boiler. Relatively high carbon-intensive energy mix (up to 70%)	Substantially lower than current oil boiler (up to 99%)
Biomass boiler: *New, automatic Pellet or log fuelled* + **Thermal insulation**	Up to 10 times more expensive than an oil boiler	Slightly lower than oil boiler	Substantially lower than current oil boiler (more than 90%)	PM emissions higher irrespective of wood type (more than 1000%) NOx emissions lower than oil (up to 60%)

**Upfront cost differences are case-specific; in this case the upfront cost for a heating system is modelled for an energy demand of ~20,000kWh/annual.*

Sources: Fraunhofer ISI, Building Research Establishment (BRE), European Environment Agency (EEA), VHK, Building Performance Institute Europe (BPIE), TABULA Webtool, European Commission Oil Bulletin, Eurostat, Covenant of Mayors EC, European Pellet Council, Building Research Establishment (BRE) and Deutsche Energie-Agentur (DENA)

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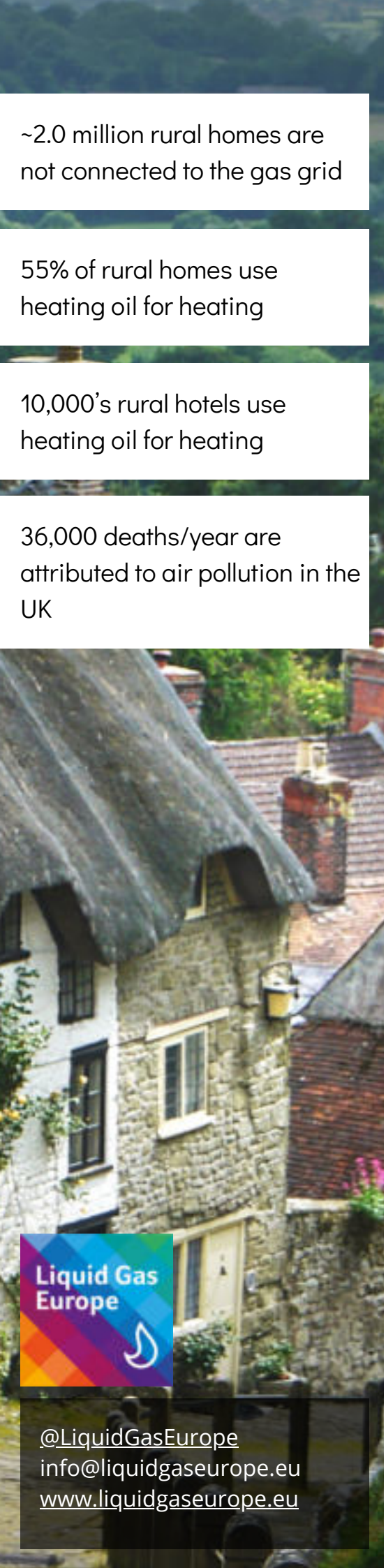

~2.0 million rural homes are not connected to the gas grid

55% of rural homes use heating oil for heating

10,000's rural hotels use heating oil for heating

36,000 deaths/year are attributed to air pollution in the UK

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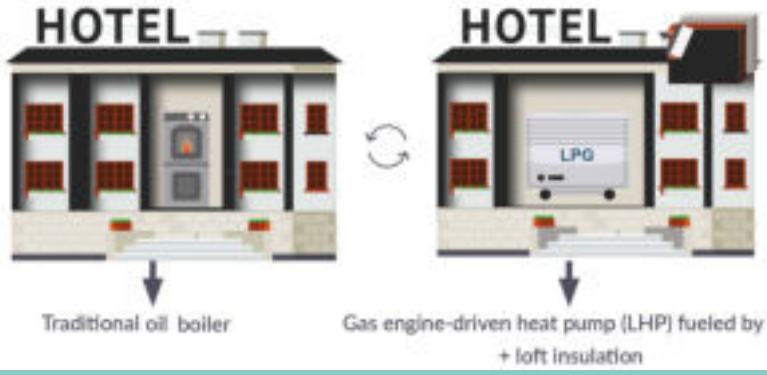
UNITED KINGDOM

Case study: residential heating
#BeyondTheGasGrid

In England's rural areas, heating oil is typically used to heat homes and hotels. Using it produces high levels of greenhouse gas emissions and significantly worsens air quality. Many rural hotels are typically very energy inefficient with a low level of thermal insulation.

This analysis considers the monetary and health benefits of a rural hotel (built before 1918) switching from using an old oil boiler to a new condensing LPG boiler .The hotel also installs loft insulation to increase the energy efficiency of the hotel.



LPG annual CO2 savings: 35%
BioLPG annual CO2 savings: 82%

56% NOx emissions savings

85% Lifetime PM emissions savings

€819 Annual energy bill savings

Capital cost payback = 6 years

From 2030 onwards, it is assumed that the boiler is fuelled by bioLPG.

UNITED KINGDOM

Case study: residential heating
#BeyondTheGasGrid

Alternative technology options available:

The table below compares how alternative technology options compare to an existing oil boiler. The different heating systems include a new LPG boiler, an air source heat pump and a biomass boiler.

performs worse than old oil boiler

performs better than old oil boiler

Technology Options	Upfront cost*	Running cost	Lifetime CO_2 reduction	Lifetime air pollution reduction
LPG boiler: *New, condensing*	Similar to oil boiler	Slightly lower than oil boiler assuming that efficiency improvements are achieved	Lower than current oil boiler (up to 40% using LPG, up to 90% using bioLPG)	Substantially lower than current oil boiler (up to 60%)
Air Source Heat Pump	4-5 times more expensive than an oil boiler	Lower than oil boiler due to efficiency improvements	Substantially lower than current oil boiler (more than 90%)	Substantially lower than current oil boiler (up to 99%)
Biomass boiler: *New, automatic (Pellet or log fuelled)*	7-8 times more expensive than an oil boiler	Potentially higher than oil. Dependent on wood type (pellet or logs).	Substantially lower than current oil boiler (more than 90%)	Substantially higher than current oil boiler. PM emissions are higher irrespective of wood type (more than 1000%)

**Upfront cost differences are case-specific; in this case the upfront cost for a heating system is modelled for an energy demand of 100MWh/annual.*

Sources: UK Business, Energy and Industrial Strategy (BEIS), Fraunhofer ISI, Building Research Establishment (BRE), European Environment Agency (EEA), VHK, Standard Assessment Procedure (SAP) and Liquid Gas UK.

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