An Operational Lifetime Assessment of the Carbon Performance of Gas Fired CHP led District Heating

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1. Context: Why this is an important issue

2. Gas CHP Today: Energy and Carbon

3. The Future: A changing picture over time

4. Reality: Approximations of a more complex system
Context

Why the carbon performance of Gas CHP engines is important
UK gas and electricity demand throughout the year

32% of all of the UK’s CO₂ emissions 562 MtCO₂e

Heat supply vectors

Number of UK Homes [Thousands]

- Gas
- Solid fuel
- Electric
- Oil
- Other

Year:
- 1970
- 1975
- 1980
- 1985
- 1990
- 1995
- 2000
- 2005
- 2010
In all locations and building types, drive down demand as early as possible through thermal efficiency, smart meters and heading controls.

Potential for low carbon heat networks in denser urban areas where limited space for heat pumps and storage to help with grid balancing may be a major barrier to building level renewables.

Suburban areas transform later. High efficiency condensing boilers should remain a useful transitional technology into the 2030s, but will be gradually squeezed out as penetration of low carbon heat networks and building level solutions increases.

High heat pump penetration faces fewer barriers in buildings that are not closely clustered, starting with buildings off the gas grid which are more likely to be using relatively expensive, high carbon forms of heating such as heating oil.

Recreated from “The Future of Heating: Meeting the Challenge” Decc-2013
Chapter 3: Heat and Cooling for Buildings
Gas CHP Today
Typical CHP system energy flows
The Model CHP system

Gas INPUT

Losses 20%

CHP Engine

40% Electricity

40% CHP Heat

Boiler Heat

70% Thermal store

30%

Top-up boilers

Electricity EXPORTED

Electrical losses

Development

Heat Delivered

Transmission Losses

Energy Centre

Electricity

40% 40%

20%
The relationship between grid carbon, the CHP efficiency, and emission factor of heat.
The Future

A changing picture over time
Trajectory for the decarbonisation of the UK electricity grid and associated impact on CHP
Impact of grid decarbonisation on annual CO₂ savings, for a CHP engine installed in 2015
Lifetime assessment of CHP carbon savings

Average annual emissions savings over a 15 year lifetime [%]

BETA ON SAP 2012 3-YEAR AVERAGE FACTOR
Lifetime assessment of CHP carbon savings

Average annual emissions savings over a 15 year lifetime [%]

BASED ON SAP 2012 15-YEAR AVERAGE FACTOR
BASED ON SAP 2012 3-YEAR AVERAGE FACTOR
Lifetime assessment of CHP carbon savings

Average annual emissions savings over a 15 year lifetime [%]

- BASED ON DECC FACTORS (Green Book guidance: Grid average) [17]
- BASED ON SAP 2012 15-YEAR AVERAGE FACTOR
- BASED ON SAP 2012 3-YEAR AVERAGE FACTOR
Reality

Approximations of a more complex system
1. Short term: displacement of marginal plant;

a) Grid average emissions factors for footprinting

b) Marginal emissions factors for changes in supply/demand

Emissions factor of a gas fired CCGT?

\[
\frac{CF_{gas}}{\eta \times (1-l_t)} = \frac{216}{0.47 \times (1-0.08)}
\]

=500 gCO2/kWh
What goes offline when a CHP comes online?

Modelling the impacts of additional Gas CHP capacity in the GB electricity market, LCP report for DECC
2. Long-term: displacement or deferral of deployment of other generation assets
3. Daily and seasonal CHP operational patterns

“The change in electricity consumption is assumed to be constant throughout the day and year (i.e. no differentiation is made between peak and non-peak. Figures are an average for each year)”

-DECC 2014: Valuation of energy use and greenhouse gas (GHG) emissions- Background documentation
4. Geographical variations in marginal plant

Local variations in marginal plant

Scotland
- Coal: 48%
- Gas: 32%
- Nuclear: 17%
- Wind: 10%
- Hydro: 3%
- Other: 1%

North England
- Coal: 48%
- Gas: 32%
- Nuclear: 17%
- Wind: 10%
- Hydro: 6%
- Other: 3%

South England
- Coal: 20%
- Gas: 10%
- Nuclear: 23%
- Wind: 30%
- Hydro: 17%
- Other: 12%
Conclusions
Conclusions

1. Designers use a simplification of the UK’s energy system, to make technology selection choices.

2. CO₂ savings are eroded as the electricity grid decarbonises, which dictates the transition away from the use of gas CHP engines.

3. The carbon intensity of marginal generation provides a more representative measure of the impact of CHP.

4. Determining the marginal figures relies on a range of complex factors.
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Thank You