Engineer - Install - Maintain

How to reduce CO_2 emissions and the UK's reliance on gas, by installing combined heat and power.

Alan Beech – Clarke Energy Sales Director UK & Ireland

Many, including The Association for Decentralised Energy (ADE), advocate using the marginal carbon-emission factor in carbon emissions methodologies. The ADE has developed an independent dispatch model reflecting the value of Combined Heat and Power (CHP).

Current methodologies for accounting for the carbon emissions of CHP could be more accurate, rather than relying on the average carbon emissions from the grid, which undervalues the carbon benefit of CHP.

To calculate energy and emissions savings from gas CHP, both energy outputs - heat and power - need consideration. It is crucial to assume that a unit of electricity from CHP displaces a unit from the central power station, and a unit of heat displaces a unit raised by boilers to determine its carbon impact. The challenge lies in calculating fuel and emissions savings associated with displaced grid electricity due to diverse central power stations.

Currently, it is assumed a unit of electricity from CHP displaces one from all power stations on the grid (as shown in figure 1), calculated using government historical data.

However, the electricity system's carbon emissions factor varies on a **half-hourly basis**, depending on power plant mixes meeting loads. It means any demand reduction or generation increase displaces not a **hypothetical average power plant**, but the marginal power plant – the last one in merit order; in figure 1, that would be Coal and then Gas. ADE analysis suggests gas CHP mainly displaces other gas power plants, not intermittent renewables or biomass and nuclear generators.

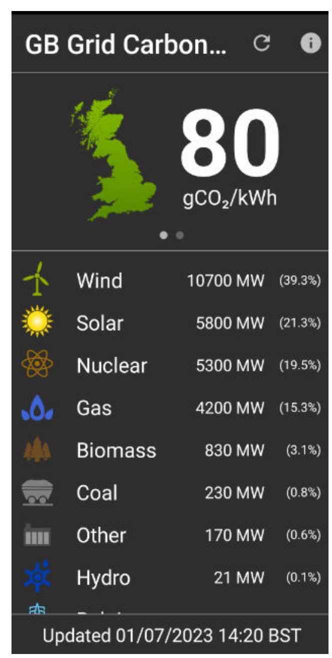

Figure 1 - Grid Carbon Intensity App, 01/07/23

The ADE power dispatch model replicates how the electricity system operates – to minimise overall delivery cost. Suppliers decide which power plant to purchase from, based on marginal operating costs. If the wind is blowing, suppliers prefer electricity from wind farms with nearly zero marginal operating cost before turning to fossil-fuel plants. This determines the merit order – ranking electrical generation sources based on their relative short-run marginal costs.

Therefore, generators at the bottom of the stack are typically wind, hydro, biomass, nuclear, and interconnectors (questionably classed as zero) – which generate at maximum capacity, lowering the average carbon intensity of the grid. In contrast, plants at the top of the stack – coal power stations, open-cycle gas turbines (OCGT), and combined-cycle gas turbines (CCGT) – vary output to meet load variations, pushing the average grid carbon intensity up. The plant with the highest marginal cost over a settlement period is the last one in the merit order, or the 'marginal' plant.

As a result, outside peak demand periods, renewable generating plants supply most of the UK's electricity load, and the carbon content of the grid is very low. At other times, especially during morning and evening peak demands, when outputs from lower running cost plants aren't enough to meet the load, the carbon content is much higher (see figure 2 for a typical low carbon intensity 24-hour period).

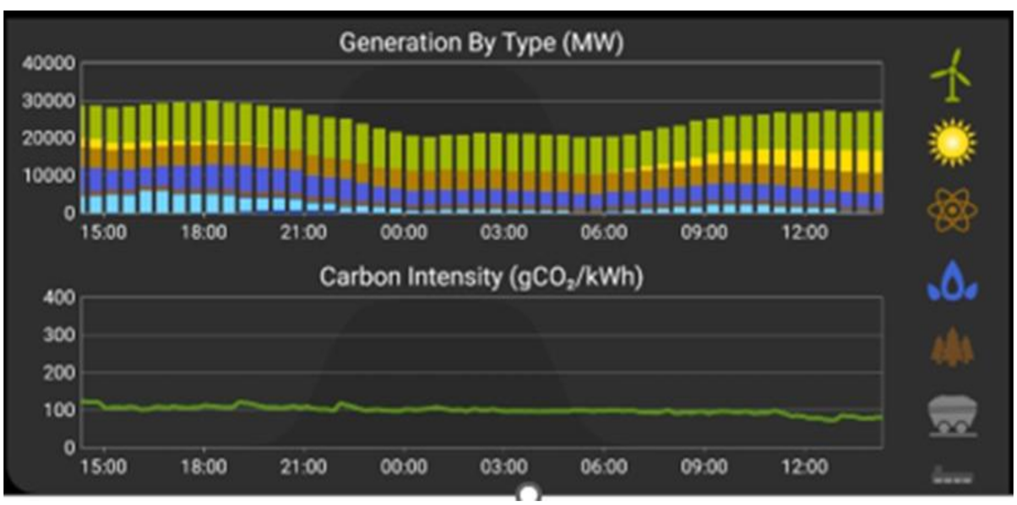

Figure 2. Grid Carbon Intensity App, 01/07/23

Analysis of the relative marginal cost of generators over a typical year (see figure 3 & 4) suggests CHP plants following the merit order produce lower marginal-cost electricity than even the most efficient combined-cycle gas turbines (CCGTs). This is because, by the time electrons reach the point of use, many are lost due to system losses. So, any efficiency gained versus a locally installed generator is lost, and unlike CHP, these GTs do not use their waste heat. By following the merit order, CHP's electrical output will never displace renewables' output. This differentiation is crucial when considering the appropriate quantification of the energy and carbon-emissions savings from CHP and understanding how to define its true carbon-value proposition.

2022's Electricity Generation Mix

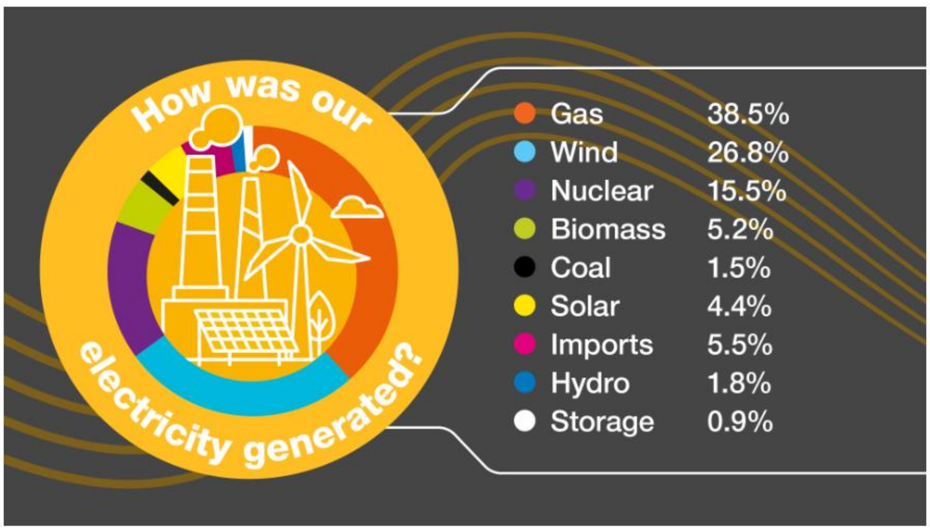

Figure 3. Average Generation stack in 2022, source www.nationalgrideso.com

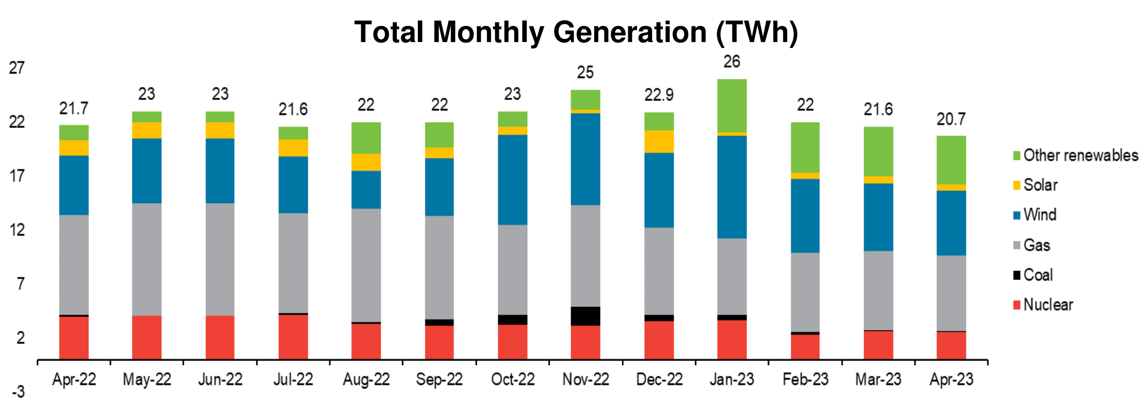

Figure 4. Annual generation stack by month April 22 to April 23

Conclusion

On sites with both heat and power demand, CHP is the go-to solution. When installed, a CHP should be running, delivering optimum efficiency and thereby reducing the UK's overall Scope 1 emissions. It should be prioritised ahead of any individual localised Scope 1 targets. While we continue to use gas in our energy mix, a **CHP's electrical content should be considered at least neutral, and the heat generated as a carbon offset.**

In addition, a CHP will not only save carbon and money but provide resilience to your site should the electrical grid fail and help electrical grid operators alleviate growing electrical system constraints.

Postscript

Also, consider that mains gas is in the process of decarbonisation, with the growing injection of green renewable biomethane and the planned mixing of Hydrogen. Most gas engines have the capability to run on hydrogen blends and can be converted during their operational lifetime to run on 100% hydrogen. Therefore, a CHP should not become a stranded asset but a critical part of our energy infrastructure and the transition into the Net-zero world.

Personal note: I accept this blog may provoke some debate – my probable answer would be, 'it is for each CHP user to decide their actual run times v the real time grid carbon make up in their area (even on a half hourly basis, if they have the appropriate technology e.g., microgrid control), thereby balancing their CO2 & financial ambitions and potentially extending the CHP lifespan.