Hydrogen Fuelled CCGTs: The Back Up to Wind Power

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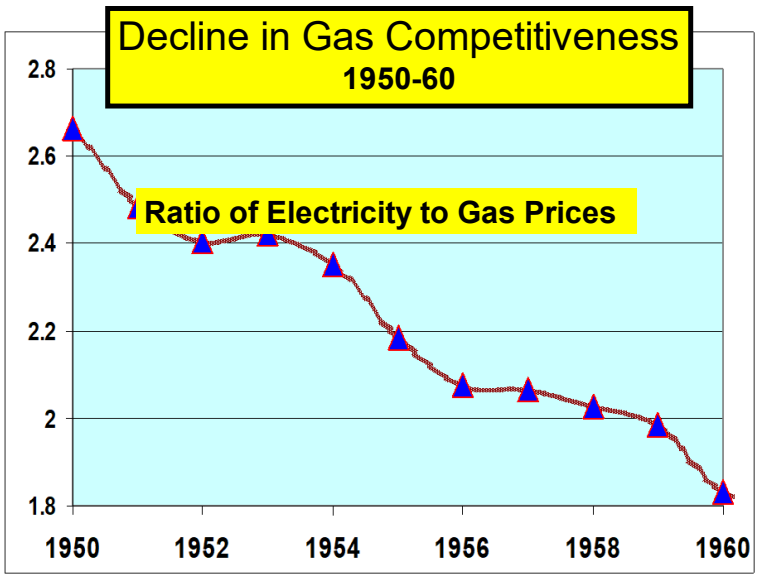
This article falls into two parts. The first emphasises that the cost of renewable hydrogen will limit its use in the domestic sector for home heating. As such, hydrogen's almost certain use will be as a fuel for CCGTs that provide back up for wind energy. The second part of the article is a critical assessment of a recent ESO-National Grid paper which looked at the kind of backup for wind that would be in place in 2035.

In the opinion of this author, the ESO paper makes a major mistake in thinking that much of the back up will come from imports and the so-called V2G power. This is where power from electrical cars flows back into the grid. If I am right, it follows that there will have to be much greater reliance on CCGTs fuelled by hydrogen and carbon capture type CCGTs running on natural gas.Fred, why not hydrogen or ammonia engines running in cities? Over 6 Gw already in the UK

Any Gaseous Fuel Must be Significantly Cheaper than Electricity

In stating these views, where although graduating as a metallurgist I come from a lifetime of involvement in the technical side of the energy business. I spent thirty years in British Gas, where when I joined it in 1966, it was beginning to emerge from a long postwar period of decline. It was ceasing to competitive with electricity. What saved it from extinction was the introduction of steam reforming, a much cheaper process than making town gas from coal. The link goes to a fuller paper on the subject, but quite obviously complete salvation for British Gas came with the introduction of North Sea Gas.

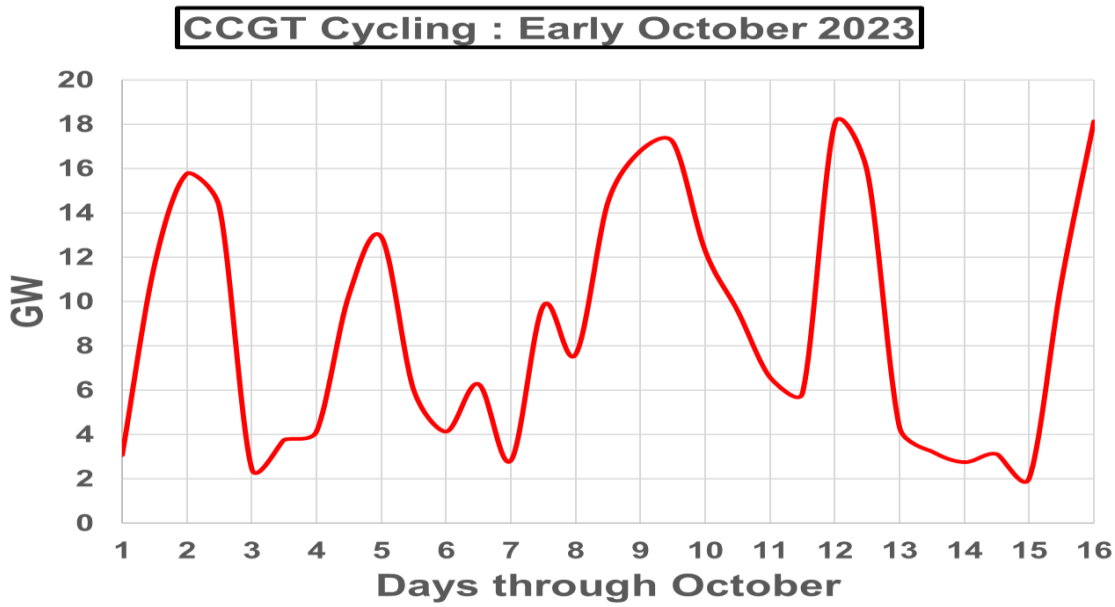
https://fredstarr.com/wp-content/uploads/Steam-Reforming-at-British-Gas-and-Hydrogen-PART-1.pdf



The actual price ratio between electricity and gas fell for domestic users fell to 1.8/1 by 1960. Stream reforming improved the ratio, but cheap North Sea Gas finished off the big plans for an all electric future. Presently the ratio is about 4/1. However, as some slides in the presentation emphasise, the profits that British Gas made from North Sea Gas, enabled this nationalised (monopoly) concern to pay for the conversion of town gas burners to natural gas. This isn't the case now with a fragmented industry and with no margin between the buying and selling price for gas. I estimate the conversion cost will be around £2000 for every household.

The CCGT Story and the Impact of Wind

Against the strong advice of British Gas, and the apparently unlimited reserves of gas, the newly privatised electricity companies were allowed to use this fuel in CCGTs. CCGT electricity is so cheap, it has not only killed off coal fuelled steam plants but the nuclear sector too. With the decline of its rivals, by 2015 as much natural gas was being used in the CCGT as the domestic sector.

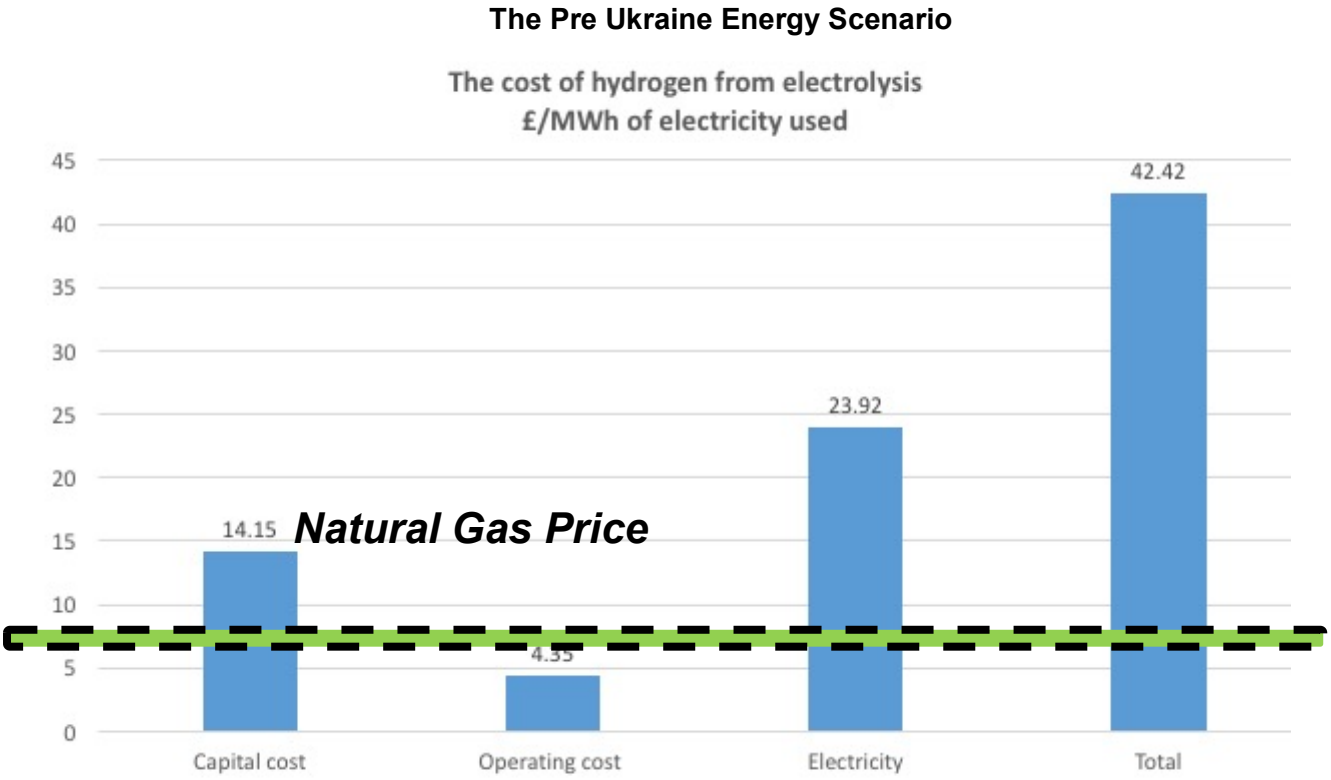


Along with these changes, there has been the rise of wind and solar power. Now having a massive impact, sometimes accounting for up to 60% of the demand. CCGTs have to compensate. One slide using outputs from the CCGT fleet for the first fifteen days in October 2023, immediately before the conference, shows outputs varying from 2GW to 18GW over one day.

Can Hydrogen Make a Comeback?

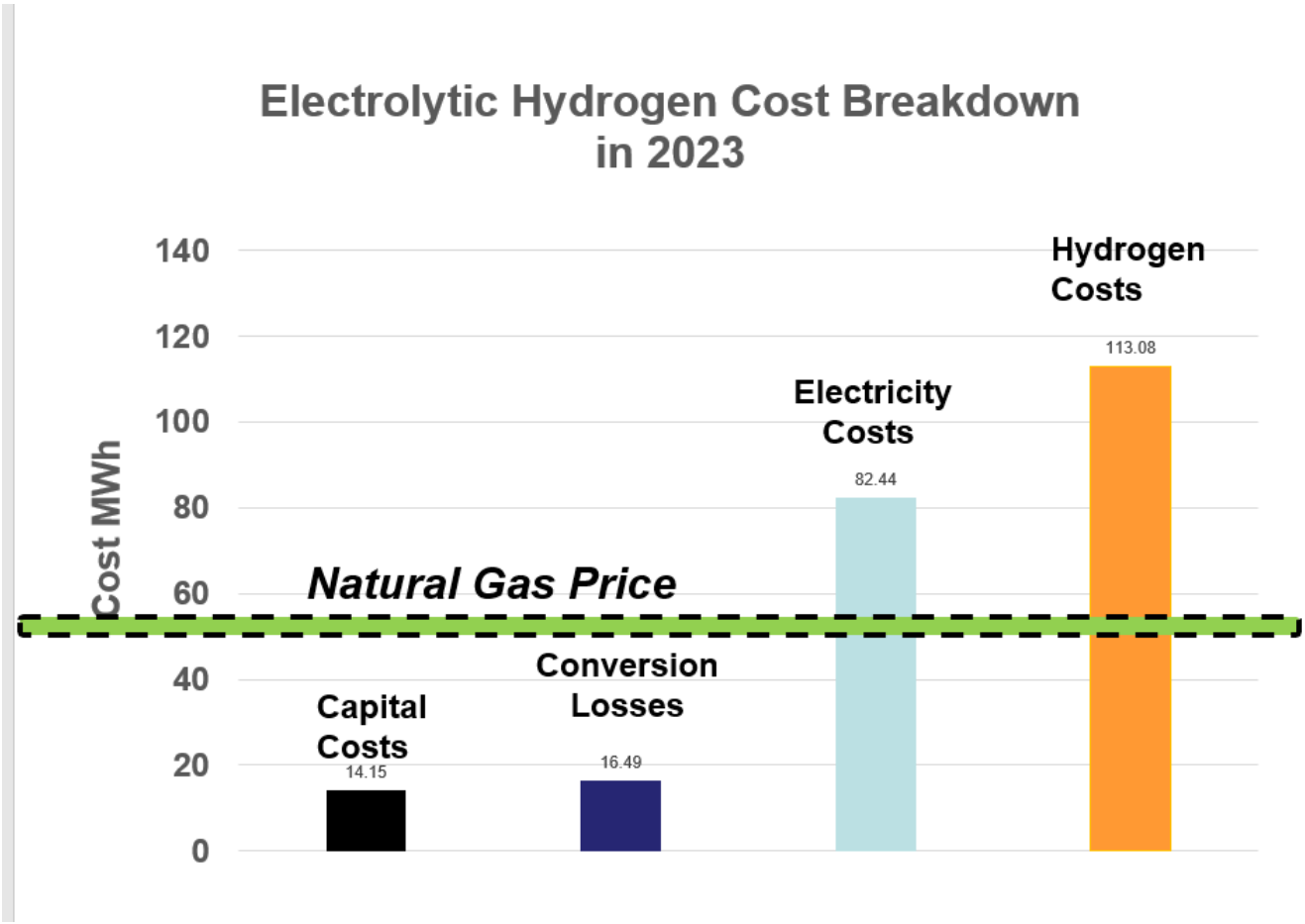
It all depends on costs. The first slide in this section shows replica gas lamps in Fitzroy Street, Central London. These are of the "simple burning flame" type that used town gas, as made in 1820. They were cheaper than candles, the gas containing 50% hydrogen…….Worries about the explosive risk of hydrogen are overstated. Natural gas is just as dangerous.

The issue for hydrogen is how does the cost, in energy terms compare with electricity, if the hydrogen is made by electrolysis, using electricity from wind farms. And, just as important, how would electrolytic hydrogen compare with the wholesale price of natural gas?



The slide above was made in 2020, before the Invasion of the Ukraine, when gas prices were less than £9/MWh. The slide shows how the cost of hydrogen stacks up, in terms of the capital cost of the electrolysis plant, operating costs/conversion losses and the wholesale cost of electricity. The prediction was that **off peak** electricity would be available at £23.92/MWh, giving a hydrogen price of £42.42/MWh. This was almost five times the then natural gas price, and was significantly more than the price of electricity at that time.

I brought this story up to the present, as far as I could. See the following slide. The problem is that post-Ukraine gas and electricity prices are continually moving around. The only certain factor is that because CCGTs are fuelled with gas, hence when the price of gas goes up, so does that of electricity. Even though much of the electricity comes from wind, solar, nuclear and biomass. It's the stupid system we now have, for pricing, which was originally intended to help nuclear and has now been converted to assist off shore wind.



On this basis I assumed an electricity price 0f £82.44/MWh. This resulted in a hydrogen cost of £113.08/ MWh. Gas is presently selling at about £50-55/MWh. Therefore, on the one hand, the price ratio between electricity and gas is now just above two to one. Which is not good news for the gas sector. Particularly as consumers are already squealing about energy prices. **The impact of hydrogen in doubling the wholesale cost of gas will mean a further turning away from gas.** The domestic sector looks doomed.

Best Market for Hydrogen

Obviously, a hydrogen fuelled CCGT cannot compete with wind or electricity. Hydrogen's best option seems to be as a back up to wind and solar. What it will be doing is competing with nuclear, natural gas fuelled CCGT with carbon capture, and the standard natural gas fuelled CCGT. I don't think ammonia fuelled CCGTs are worth considering in a 2035 scenario. It will be even more expensive than hydrogen. Accordingly reviewing each of these prospects.

- **Nuclear:** A high cost option, only really suitable for constant output operation. Not a big source of electricity
- **Renewable Hydrogen:** A high cost fuel, but which can be stored in pipelines, disused gas fields and salt cavities. No CO_2emissions. **Its greatest advantage is that it allows stop/start and cyclic operation of CCGTS.**
- **Natural Gas CCGTs with Carbon Capture:** Possibly low fuel/ energy costs. But CO_2 must be captured and stored. The "carbon capture" equipment needed for this will preclude

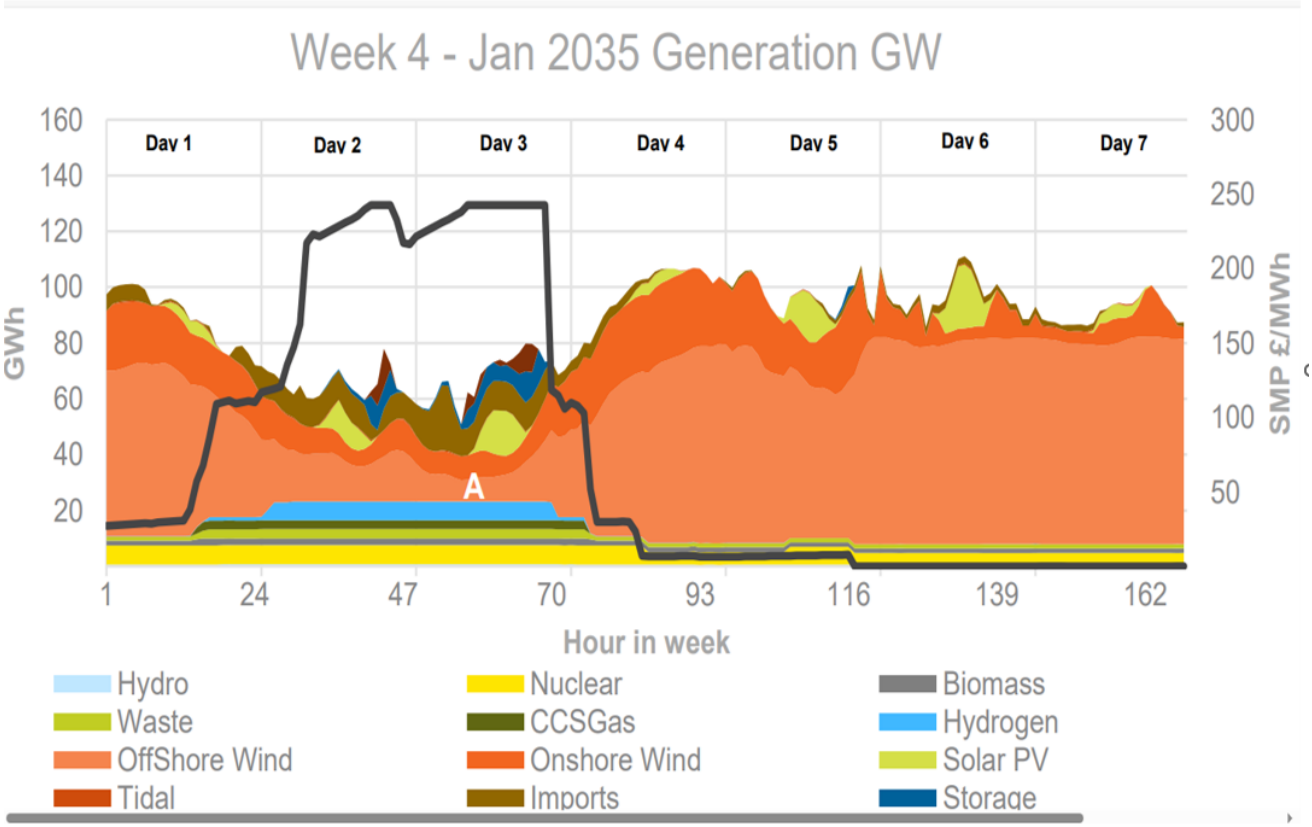
stop/start operation. These units will have to operate as near constant output/ based load plants

- **Unabated CCGTs:** These are CCGTs running on natural gas, but because of the CO_2 issue, will only be operated at periods of dire necessity.

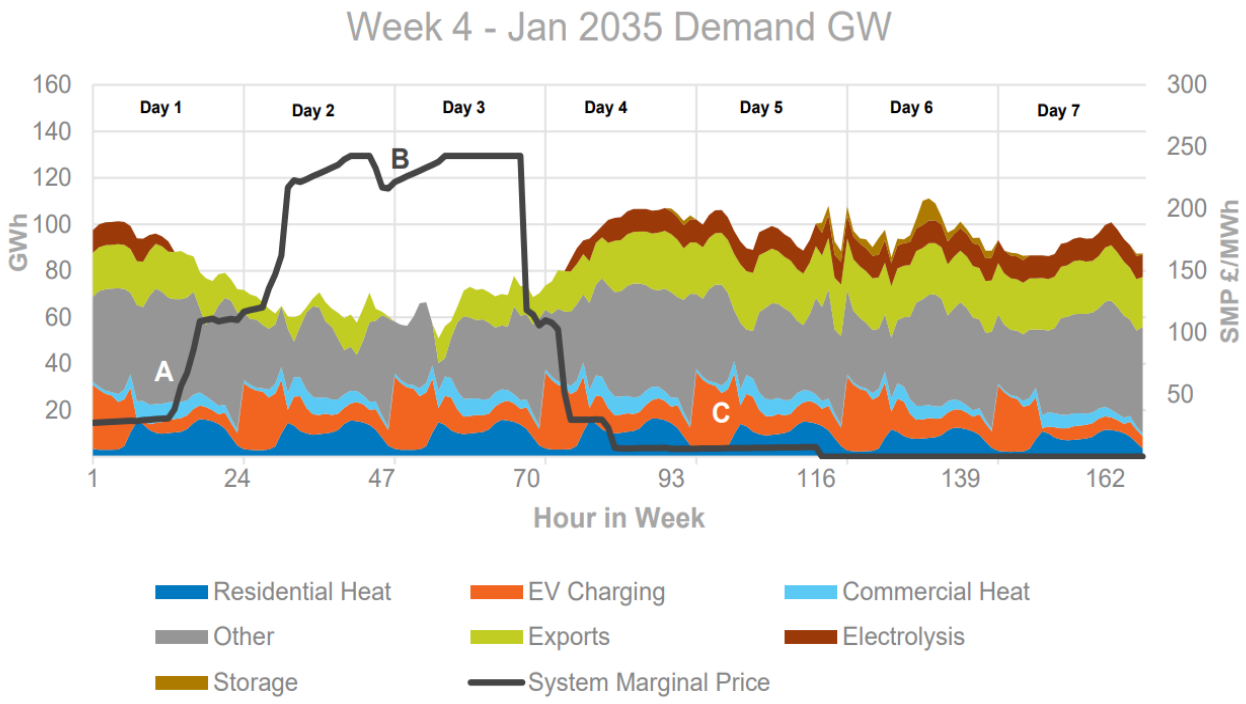
The ESO-National Grid Article download (nationalgrideso.com)

This is an attempt to forecast what type of backup for wind will be available during a cold week in January in 2035. The back up is driven by price, the level of which is shown by the black line. The price per MWh is shown on the right hand side of the graph. **Please note that this is in excess of the baseline electricity price during this part of the year.**

Estimates by National Grid of Future Sources of Power



The perception is that most of the electricity in 2035 come from offshore and onshore wind, implying a toral capacity of between 120-140 GW. But during Week 4 in January 2035, from about 12 hours until about 80 hours, wind falls to about 40 GW. Although it fluctuates, the average British power demand is in the 60 to 70 GW range. Hence the backup needs to supply about 30 GW, ideally using sources that do not emit CO_2.



The price will determine the order in which what backup comes on line. Nuclear in this scenario is regarded as being cheapest, and is really not a backup but really a base load generator. However, in the week-long simulation, nuclear seems to show that nuclear will continue to suffer from the unwanted hiccups in losing output that we are familiar with. None happen during the critical period. Good fortune, indeed.

Solar too (in greenish-yellow) is also not back up, but always comes on when the sun shines.

For actually meeting back up needs, as the lowest cost, are biomass and waste. Both are shown to have some potential in varying output from day to day and run throughout the week. It isn't made clear that they could if needed, respond much more quickly than that.

We now come to natural gas CCGTs with carbon capture (in dark green) and hydrogen (blue). Both only run during the most critical period at apparently constant output. Hydrogen is assessed as being more expensive than carbon capture natural gas.

The next three genuine back ups in terms of cost are; imported electricity, battery power banks and, finally V2G. That is using the power from the batteries in electric cars to support the grid. In a 2035 time frame I am extremely doubtful about this. The graph suggests that about 10-15 GW will be coming from this source. A rough calculation suggests it would require half a million car owners to bother to couple up, deliberately, to help prevent blackouts. Or, alternatively, the technology to be available for the National Grid to take extra power when it was needed from any car that was hitched up to an electric vehicle charging post.

The idea, too, that we can rely on imported power is also daft. To put it mildly. At the same time as wind dropping in Britain it will also be low across much of Europe. With each country scrabbling for back up power from somewhere. There will be none for export.

Better Prospects for Carbon Capture CCGT

Equally derisory is the idea that carbon capture CCGTs will run for a short time to compensate for the shortfalls in wind energy. This is a high cost facility that only makes sense if used to full capacity. Carbon capture involves the actual CO_2 absorption equipment on each CCGT. In addition, there will be new pipeline compressors and new compressor/high pressure pumps for off shore facilities. Extra money will be required if new pipelines and off shore rigs are necessary. Then there is also the actual operation of the absorption equipment. Equipment like this is not suitable for a stop-start scenario. It is designed for steady state operation.

Given these facts, it seems likely that carbon capture CCGTs will be running at a constant load for all of the winter and probably for much of the autumn and spring. There should be no fears about outlandish prices for natural gas, negating this hypothesis. By 2035, Europe, Japan and, hopefully, the USA will have switched over to renewables, depressing the market for natural gas.

Even Better for Renewable Hydrogen

On this view, nuclear and carbon capture CCGTs become base load suppliers. Biomass and waste have some facility for meeting short term changes in in demand. This leaves the field to renewable hydrogen, using this to fuel CGGTs.

A hydrogen fuelled CCGT, unlike the operation a carbon capture CCGT is not constrained or dominated by the CO_2 absorption unit. It can be started up and shut down and operated at part load, just as well present day “unabated CCGTs” using natural gas.

Hydrogen has downsides, of course. It will need salt cavity or pipeline storage. Whether storage in North Sea or Morecambe Bay disused gas reservoirs is a moot point. It will be costly. But my own feeling is that the cost of electricity from new nuclear, Carbon Capture CCGTs and hydrogen CCGTs will come out fairly closely. Hydrogen CCGTs, however have much greater ability to respond to the vagaries of wind and solar energy.

Fred Starr: 17th Nov 2023