The Wholesale Price of Gas.

This is extremely complex. A client of mine has been trying to explain it to me, after he saw an assumption I had made that he knew to be wrong.

He kindly proof read every change I made, but it got too complex for me to explain, which is why I have edited his emails together here.

I have corrected a few spelling mistakes and I have tried to hide his identity. I have added some definitions and added question marks in parenthesis (?) if I think he may have made a typo.

Otherwise, this is exactly what he wrote.

Reading your article on heat pumps and deep bore holes. I worked in the energy industry for quite a few years and while at XXX I used to control the within day balancing aspect for ZZZ power station. What the current rationale for heat pumps completely misses is that the CoP needs to be at least 2 to start off with.... because the marginal electricity is from gas. You need more electricity, 2 units of gas is burnt to deliver 1 unit of electricity. Then that 1 unit of electricity needs at least CoP of 2 to deliver the same heat energy as the gas that went into the CCGT to create the electricity. That's all excluding losses and part loading inefficiencies overnight. Ah, you may say, but when the UK has lots of wind power..... yes, we will still be marginally interconnected to gas fired generation in Europe.... so from a true net energy perspective if heat pumps that can't achieve way above CoP2 they are completely irrational. But that bit of detail undermines the apparent green philosophy.... then....

CoP =Coefficient of Performance

CCGT = Combined Cycle Gas Turbine, which means the gas is burnt to turn the first turbine then the hot gases are used to turn a second turbine.

For a CCGT that has an efficiency of say 50% at full load that efficiency may drop to 47% at say 60% loading. The way in which the market prices the overnight electricity is actually based on the reduction "cost" of that 3% efficiency loss. It's not clear at first how this is worked out, however it is how the balancing market works and as a result how the overnight "turn down" period is calculated from a marginal price perspective.

Lets say that we have a 300MW CCGT power station and gas is 10p/kWh and at full load our electricity then costs 20p/kWh. Simple 50% efficiency.

Overnight say the power station turns down to 240MW and the efficiency is then 47% for the 240MW. We have then lost 3% on 240MW. This 3% needs to be factored in to the price reduction required for the 60MW in order for it to break even, which pulls the price down below 20p.

Daytime the cost to generate 300MW at 10p/kWh gas would be £60,000 per hour

Overnight the 240MW is then costing 21.28p/kWh to generate due to the lower efficiency or £51,064 per hour.

At 50% efficiency I would need to buy back 60MW at 20p/kWh or £12,000 per hour and then recover the £3,064 per hour efficiency loss on the 240MW. The 60MW would then need to be bought back at a price of 14.9p/kWh just to break even. This is why the overnight price is lower and is a very misunderstood pricing mechanism. It's how the market works and how so very often nobody really understands it. Because it can't be explained easily, it is usually just not covered at all.

"Coal fired power stations take hours to get up to speed and hours to stop." - they do take a few hours to warm up and take more notice from the control room to get going, which is where they are given an effective standby notice / payment to make them warm so that if they are needed they can start up within 30 minutes to an hour. They can shut down whenever, but they can't just fire up again immediately (unlike a CCGT - jet engine). The CGCT power stations are just like the jet engine on an aeroplane, just bigger and fixed to the ground with a steam recovery boiler on the back... hence the "combined cycle".

I have never seen any written explanation that really shows how the market pricing interacts with the actual dispatch and market price that is then set. Initially I had one argument with one of our traders at the time as they were not pricing correctly and making a loss overnight, which took me a week to get them to see and understand the mechanism properly. So, if a trader can't understand the basics of their own business, getting a general readership to understand the mechanism properly may well be a little too in depth and lose your audience.

It's also more complex as the interaction works over a period of time and it is an interplay between forward hedging of generation and shorter term optimisation. Part of the characteristic is defined by the maintenance schedule for the power station as they can't just switch on and off every day as there is a maintenance implication/impact for each hot/cold cycle. For example, a power station may have a maintenance period of say 4,200 hours over a maximum 200 days. Each stop/start may take away say 8 hours of running time from that 4,200 hours and is also limited to X starts as part of a maintenance contract. So, another variable that comes into play is if you switch off a power station for a weekend (low demand) that switch off also needs to factor in say start-up cost, missed opportunity cost (8x running hours) and risk the unit does not start properly (missed generation output that needs to be bought back). Start-up cost includes all the gas you burn to warm the unit up before actually starting it generating (net generation output).

I'd be happy to explain what I know, although for a general web page it may lose readers very quickly.

Whilst at XXX I had the DTI come in for an explanation as to how carbon pricing in the electricity market worked and why at the stroke of midnight on the day the scheme started the electricity price would be fully factored in - 100% guaranteed. I was a bit stunned that they did not understand how the existing mechanism worked (they did not think electricity would factor in carbon pricing so quickly or at the level it would), more so that it was only a month or two before it all went live.... i.e. they had committed to a scheme and mechanism they had no idea how it actually worked in the real world ??? How does that happen ???

"If you generated all the electricity in Scotland, the voltage in Scotland would have to be too high to use in Scotland if the voltage would still be sufficient by the time the energy reached London." - incorrect - the voltage level all around the grid is virtually the same, it's the phase angle that differs

Electricity transmission system at the pylon level can adjust the voltage (via transformers and reactive power) so they can move the power around (within certain limits) so the voltage is not really what constrains power transmission. Generally, it's either the physical line capacity, the

contingency rating (what if power station X stops) or another technical issue. Like the pull on a spider's web, not all threads need to be as strong, but some of them are just in case another breaks to prevent the whole web collapsing.

In Australia one of the lines between Snowy (Hydro generation area) and Victoria had wind speed and temperature in as factors that determined the constraint level... if it got too hot it would sag too much under contingency conditions...

Now if you say frequency / phase angle that is different as well.

Imagine a long round rod of rubber say 5m long - this is for a virtual single transmission line imaginary scenario

At one end is John 'O'Groats and the other Lands End.

Now spin the rod at 3,000rpm (1 revolution per second or 50Hz)

Then any generator putting power into the rod will try and accelerate it (apply a slight twist in one direction)

Then any loads will try and slow the rod down (applying a slight twist in opposite direction)

The relative twist between each point is then effectively a time variation - which creates a voltage phase angle difference which results in the transfer of energy

If the twist is too much the rod will break (circuit breaker on a transmission line will switch off)

If a generator or load suddenly detaches, the rod vibrates in that area for a few milliseconds.

Detach a generator - the whole rod slows down

Attach too much generation - the rod spins too fast

AGC (Automatic generation control) via frequency response is what controls the speed in real time. Scheduling by national grid is to provide the balance so that real time automated balancing can occur.

" It will almost all come from gas." - the variable marginal power may well be from gas. The balance is nuclear, interconnector flows from Europe, biomass (drax) and maybe even coal in the winter and could be higher than UK gas.

The UK wind strategy (say 50GW) only works if the wind generation is dispersed around the size of a typical blocking high pressure system in winter, i.e. about 1000 miles. So, an interesting aspect is the UK wind strategy is a tell tale sign that our system can't work if we are not even more integrated into Europe from a power perspective, so it is really saying we are committing to high integration with Europe and their power system.