An ALDES Briefing Note 50p

Green, Cheap, Electricity?

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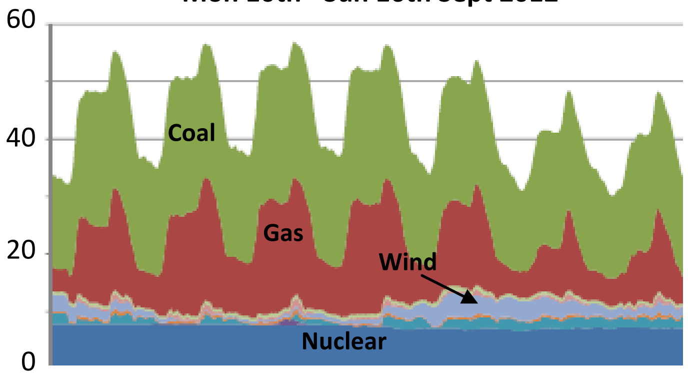
Reducing bills and increasing renewables?

A key issue with electricity is matching supply and demand at all times. Demand varies by season, time of day, weather, and incidentals like breaks in popular TV programmes. Demand varies by a factor of up to about three. Clearly, if we could better match demand to supply, we could also reduce bills because we would not need so many power stations or so much distribution capacity.

A new factor is now complicating the equation. Whereas gas and, to a lesser extent, coal and nuclear power stations can be turned on and off as needed, an increasing amount of our electricity now comes from intermittent sources, such as wind and solar. The more of them we can use the better. However, already the national grid operator is, occasionally, asking wind farm operators to switch turbines off and are paying them *not* to generate what is potentially valuable renewable electricity.

One way to increase demand when it is low, or intermittent sources are high (and vice versa) is to give consumers a financial incentive: charge them less when there is plenty of electricity available and more as demand rises, especially when it risks exceeding total grid capacity. In other words charge consumers on a real-time tariff basis. The goal is to achieve cheaper, greener, electricity.

Fig 1: GB Electricity Demand and Generation (GW)
Mon 10th - Sun 16th Sept 2012



Taken from a DECC Electricity Statistics Division Special Feature, Mar 2014, "Seasonal Variations in Electricity Demand" by Claire Gavin

Matching supply and demand

There are 6 ways supply can balance demand:

1) Simply build a large number of fast-reacting gas fired power stations (see Fig 1) This is largely what occurs at present. It is neither cheap nor green.

2) Use pumped storage. Water is pumped from a low reservoir to a much higher one when electricity demand is low so that it can flow back through a turbine to generate electricity whenever demand risks exceeding supply. There are only 2 sites of significant size in the UK, one at Dinorwig in Wales capable of generating 1800 Megawatts (MW) of electricity for 5 hours, the other at Ben Cruachan in Scotland capable of 400 MW for 18 hours. These are small compared to an average UK demand of around 40 Gigawatts (40,000 MW) and are generally used to cover peaks in demand or the breakdown of a major power station. Unlike mountainous countries such as Norway there are few other suitable sites in the UK.

3) Install batteries. This is expensive. Thousands of batteries would be needed as the largest battery in the world, used in Alaska, will only supply 27 MW for 15 minutes. In the future, however, if the number of electric cars and plug in hybrids increases to the millions their cumulative battery capacity might offer a partial solution.

4) Store electricity chemically. Surplus electricity can be used to produce hydrogen by electrolysis, or methane, both of which can be mixed with gas in the gas mains, or later be burnt to

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generate electricity. There is a great deal of interest in electrolysis, and some very small installations are up and running (see ALDES Briefing Note "Hydrogen: the clean fuel") but storing large volumes of hydrogen remains technically challenging.

5) Connect to grids of different countries. The UK currently has interconnector cables with France, Holland, Northern Ireland and Eire. Weather varies across a wide area and demand patterns vary between countries so this helps smooth both supply and demand. Transmission losses need not be high if high voltage DC (direct current) cables are used. Currently, the capacity of the cables is fairly small (2000 MW to France, 1000 MW to Holland and 500 MW each to Northern Ireland and Eire).

6) Managing demand using financial incentives. Some demand shifting is currently done by negotiation with big customers who accept 'interruptible' tariffs whereby, in exchange for a lower rate, they shut down processes or switch to in-house supplies if grid demand nears capacity. It is also done by householders adopting Economy 7 or similar tariffs, mainly to heat storage heaters and hot water tanks (and sometimes run appliances like washing machines) overnight.

But, we can go further with financial incentives. This Briefing Note indicates how.

Real-time tariff basics

The National Grid balances supply and demand by running a market in which generators bid to supply electricity in half-hour slots. Bids are accepted in order of increasing price until they total enough to meet expected demand in an hour's time. The price of the last accepted bid is paid to all and is known as the spot price. More intermittent generation will, of course, increase price volatility. Low demand coinciding with windy weather would make the price low. When high demand coincides with calm weather there is a risk of demand exceeding supply.

Forecasts of demand a few hours and days ahead are getting better, as are the forecasts of output from wind turbines and solar panels. The timing of many different activities, for example dishwashing, could be shifted in response to price. If domestic and business consumers were offered low real time tariffs when spot prices were low and faced high tariffs when spot prices were high, demand would be smoothed and average bills should reduce for everyone because fewer power stations need be built, and existing stations would be used more efficiently.

Real time tariffs in practice

The unit currently forecasting grid demand would also need to forecast the spot price hours and days ahead. This is the kind of exercise carried out by the train companies. Extremely competitive fares are offered at off peak times and some very expensive fares at rush hours. The aim is to carry all the passengers who wish to travel at the least operating cost. Experience of how electricity consumers react to different tariffs would be gained, over time, from observing patterns of demand as the numbers of consumers using real time tariffs grows.

The first imperative however is to install smart meters. These are already being installed, with the intention that all households will have them by 2020. Typically they display the amount of electricity being used in kilowatts and/or price, plus various bits of summary information. It is estimated that a 2% reduction of electricity will occur simply because consumers will see where their money is going, and react. Smart metering will also allow companies to read meters remotely, eliminating the need for readers to go house to house. Smart meters can record consumption every half hour for later remote reading.

It is currently possible to operate appliances of all sorts remotely via a 'phone app so control could be devolved, by agreement, to the electricity supplier. A trial is underway in the Isle of Wight and, in America, consumers can already buy freezers and refrigerators which the supplier can switch off for 15 minutes or so, or TVs that can be dimmed, or air conditioning that can be allowed to increase by 1 or 2 degrees to trim peak loads, all in exchange for discounted prices.

It is technically possible to supply real time tariff prices via a signal embedded in the electricity itself, direct to an appliance via the internet, or via a 'phone app. If the smart meter was linked to an alarm which signalled times of very high real time tariffs - as could occur with very high grid demand, a shortage of supply, or an emergency when the grid was close to failure - the consumer could switch non-essential lighting off, stop activities such as ironing or mowing the lawn, and postpone others, such as cooking or dishwashing, to save money.

Devolving power from the centre is very much part of Liberal Democrat philosophy. Real-time tariffs would provide manufacturers with the incentive to design smarter products, and open the door to the creativity of all.

The next step is to broadcast real time tariff forecasts for hours and days ahead. The notion of shifting demand is not new: many householders with solar panels do this when they can. Of course the easier it is to 'keep an eye on' the forecast tariffs, for example using display units (perhaps enhanced by 'traffic light' colour coding), the greater the 'take up' will be. Cookers and bread makers for example already provide for delayed starts and, given incentives, manufacturers could easily extend the range.

This would give consumers substantial opportunities to change their daily electricity use and benefit from low prices. Again a trial has already been undertaken. Throughout 2014 over 1000 homes in London received text messages giving 3 different tariff rates in the 24 hours ahead: 4p, 12p and 67p/kWh. The saving over the year averaged £21 as consumers planned their electricity use better, but one family saved £148! 4 out 5 in the trial thought real time tariffs should be available though around a quarter of homes were unable to save, and it would have cost them up to £40 more had it not been a trial.

It must be conceded that not everyone will be able to take advantage of real time tariffs and it is proposed take up be voluntary, not mandatory.

The third, but most important, step is to develop smart products that can 'think' for themselves. Smart electronic control in a dishwasher, for example, would know how much electricity each different cycle needed and for how long. The householder would switch the machine on and merely key in the time the cycle must be completed by. The machine, linked to predicted real time tariff information, would work out when the cheapest electricity was offered and switch itself on at the appropriate time. Most important of all are smart products with high consumption, such as plug-in hybrid and electric cars, and hot water and storage heaters using battery sensors in the first case and smart thermostats in the second. Indeed the latter might only need consumers to pre-set times and maximum tank temperatures on a seasonal basis. At times of excess supply, electricity would be virtually free. If the extra cost of a smart product was £30 but the annual savings £15, there would be a rapid take up of these new devices.

Furthermore, outside the home, industry could install hydrolysis units using cheap electricity to produce hydrogen from water and supermarkets, for example, could optimise the electricity they needed for their freezers.

Setting real time tariffs

The tariff should be based on the actual spot price of the generated electricity plus a charge to cover the cost of conveying the electricity from generator to house. However, spot prices are only fixed for 30 minutes one hour ahead so forecast tariffs further ahead could be higher or lower than the tariff actually charged. The closer they are, the more confidence consumers will have relying on the forecasts and accepting the real time outcomes but there may be a need for safeguards in the early years as experience is gained. A price cap might be sensible.

Limitations

Electricity demand can be shifted a few hours and, to a certain extent, from weekday to weekend, but there is no real possibility at present that it can be shifted from winter to summer or even more than a few days.

This means that, without long-term storage, the maximum amount of wind, solar (and wave or tidal) will still be limited to little more than the lowest demand, over a few days, in the year (probably around summer weekends) unless we are prepared to pay to have the surplus frequently switched off. Having said that, the maximum amount of wind and solar that can be accommodated will always be greater with demand shifting than without.

Possible savings

How much individual consumers might save is obviously speculative at this stage and will depend ultimately on how the costs of supplying electricity come down. If the total generating capacity could be safely reduced by, say, 5000 MW, and if one assumes power generation costs around £2M/MW, the capital saving would be £10 billion (bn). Assuming this sum is amortised at 10%/year, this equates to £1 bn/year, or roughly £40/household.

In addition, further savings would arise because the cheaper power stations would be used more (and more efficiently because they would not be switched on and off so much) which might amount to £50-100/household.

Political action

It is possible that individual companies will choose to offer electricity paid for on a real time basis as the number of homes with smart meters grows. It is possible too that manufacturers will see a market opportunity and begin to offer smart products. It is more likely, however, that both will await a government commitment to real time tariff use and support for financial incentives to ensure a rapid take up within a set time. There are no technical obstacles. There is no reason why electricity suppliers should not be required to offer real time tariffs as a matter of urgency.

Similarly, because we believe the potential savings will be much more than the costs, manufacturers should get on with agreeing technical standards (preferably across the EU) and refine the necessary electronics for smart products. We believe particularly that smart battery sensors should be introduced into electric and hybrid cars as soon as possible. Government should, of course, be prepared to subsidize developments where necessary.

Conclusion

It will take some years to see the impact of using real time tariffs but the concept of shifting electricity demand is not new. As has been noted, many households already do this with Economy 7 meters where at night they pay around 40% of the day time price. All that is proposed here is to take advantage of the rapid advance in modern communications and computer technology to save more money and reduce carbon dioxide emissions.