Creating and managing a demand side response

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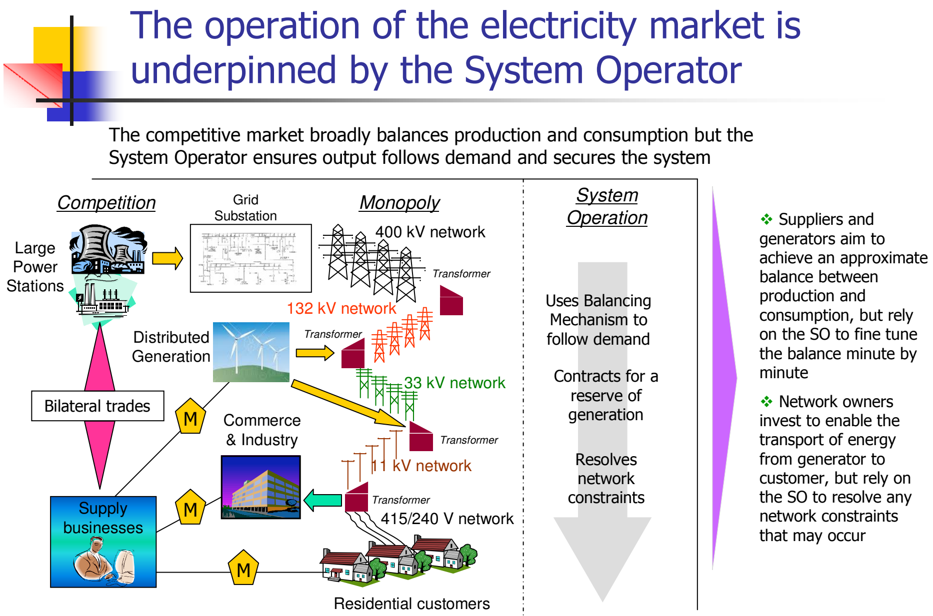
This paper is based on a presentation given in March 2011

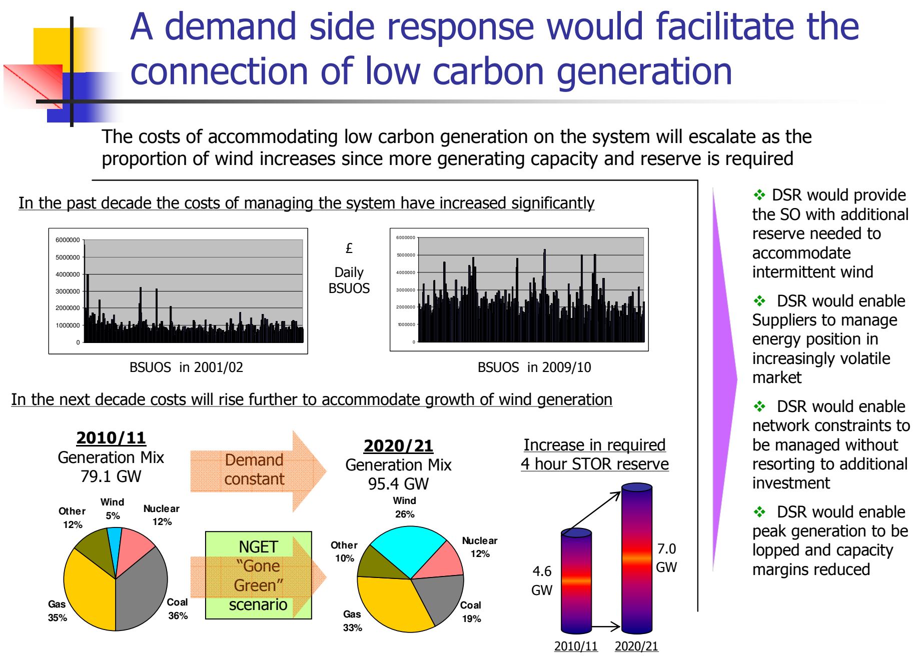


- Smart meters have a capability to alter radically the way we use energy, but to do so their installation must be accompanied by innovative home applications. There would appear to be some way to go before these applications are developed and their commercial potential recognised.

- The structure of the GB electricity market will be familiar to many. On the left of the above diagram are the competitive parts of the supply chain, generation and retailing or supply, and on the right the monopoly components of transmission and distribution.

- The BETTA market arrangements encourage generators and suppliers broadly to balance their production with their forward contracts to supply energy. However, this is by means of what is essentially an accounting relationship. The physical flows of energy from generators to the consumer obey the more fundamental physical laws of Kirchoff and others. Generators and suppliers rely on the system operator to fine tune the balance within the half hour through the use of the balancing mechanism and balancing services

- Network owners invest to ensure the energy can be transported securely but rely on the system operator to resolve instances when the network becomes congested and constraints would otherwise occur. The role in this respect is emphasised under the connect and manage policy now adopted by government to facilitate the connection of low carbon generation, and especially wind generation.



- The costs of accommodating wind generation on the system will increase as a greater generation reserve is needed to manage the intermittency of wind generation and its location long distances from demand. The daily cost of balancing and securing the system (BSUoS in the above diagram) has increased threefold over the past decade whilst the proportion of wind generation has increased from a fraction of a percent to 5 percent. Furthermore the balancing costs have become more uncertain, and the daily peaks more extreme.

- Over the coming decade the situation is likely to become even direr. The National Grid's "Gone Green" scenario forecasts a fivefold increase in wind generation and a 16GW increase in generating capacity, despite a forecast of the consumption of electrical energy that remains virtually constant up until 2020.

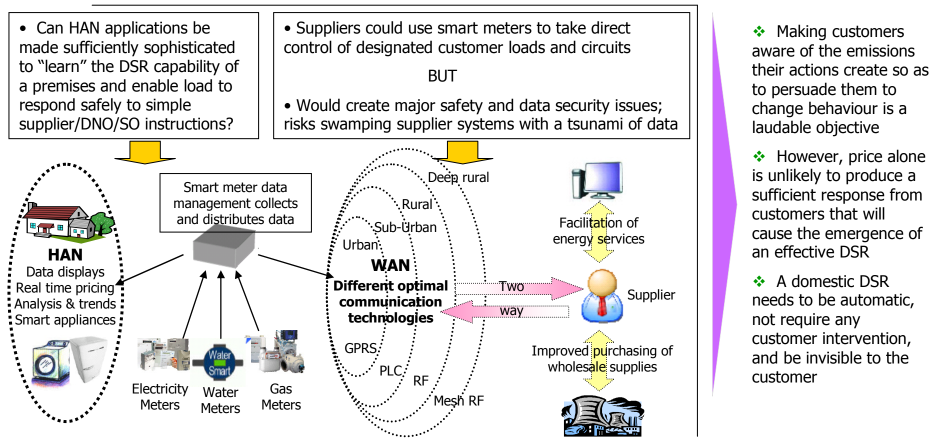
- To manage this shift in the generation mix National Grid as system operator believes it will need to hold more than half as much 4 hour operating reserve as it currently does, which is a further 2.4 GW.

- If a demand side response could be both encouraged and managed it could be used to:

    - Provide the System Operator with an additional source of reserve
    - Enable suppliers to better manage their energy accounts
    - Facilitate the management of network constraints
    - Displace investment in peak generation capacity

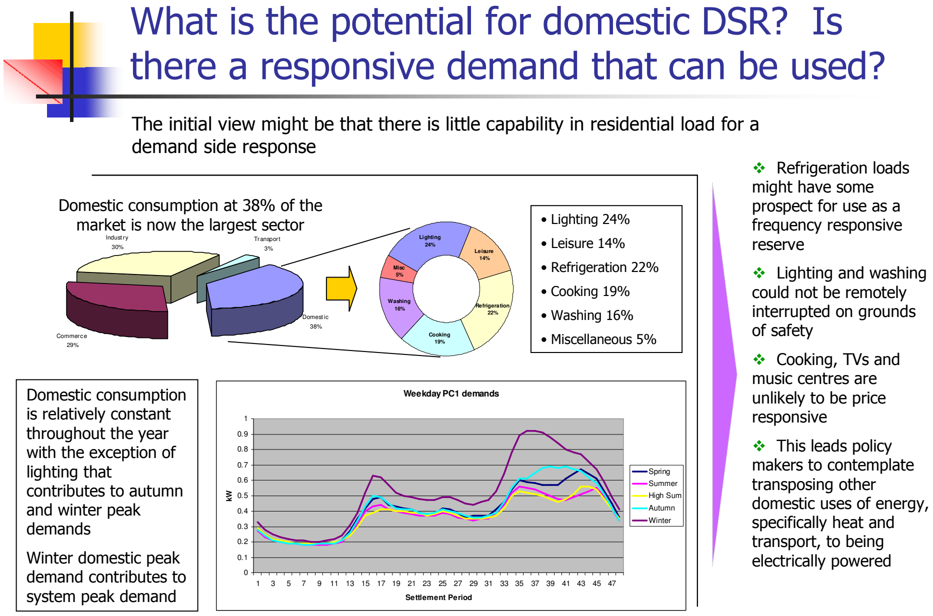
Smart metering is intended to change customer behaviour so as to reduce CO_2 emissions

Expecting a supplier to provide a passive pricing signal that will encourage customers to act differently ignores much of the potential for smart metering



- The analysis supporting the implementation of smart metering was based primarily on the benefits of efficiency and carbon reduction that would result from a change in customer behaviour. This is of itself a highly laudable objective, although the cost benefit analysis sadly omitted any mention of the value that could be garnered from utilising the two way capability of a smart meter to provide a demand side response.
- Clearly suppliers could use the functionality in a smart meter to take direct control of designated loads or circuits, but this would raise significant safety and data security issues and risk swamping a supplier's systems with a tsunami of data.
- Dynamic prices might create a muted response but given the price inelasticity of electricity they are unlikely to be sufficiently sharp or focussed to be useful in the context of managing wind generation intermittency. Expecting a pricing signal alone to encourage a demand side response ignores the potential of the technology encapsulated in smart metering, and would be politically courageous.
- The technology challenge is in the Home Area Network. The question to be addressed is can HAN applications be made sufficiently sophisticated such that the meter can effectively learn the DSR capability of premises and enable the load to respond safely to simple instructions from a supplier, generator or system operator?
- It is the belief of the author that a domestic DSR, and there is no other sufficiently substantive source, should be:

    - Automatic
    - Require no customer intervention, and be
    - Invisible to the customer when required

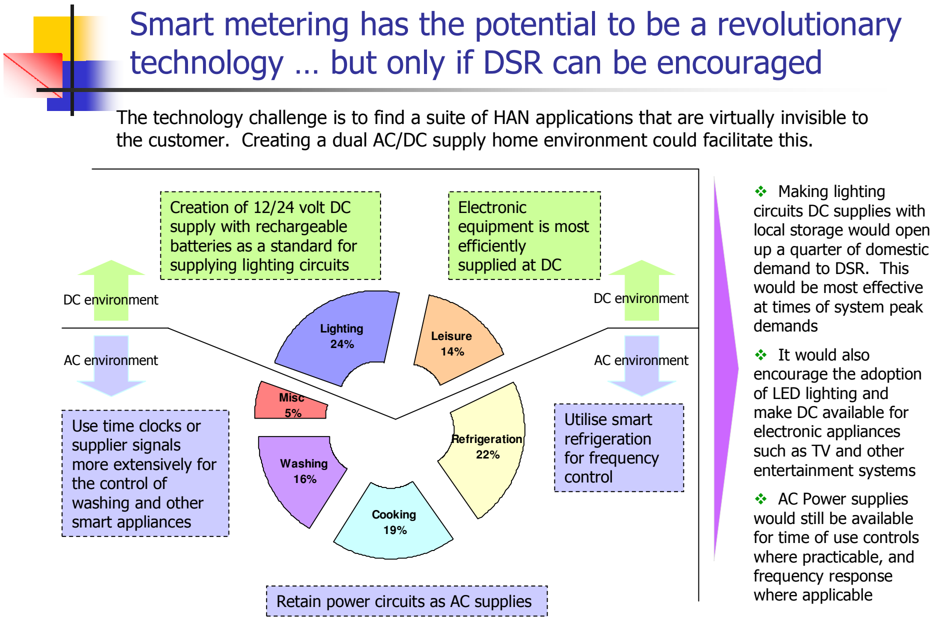


- At first sight the potential for residential DSR appears very little. Surprisingly the consumption of electricity in the average household has remained relatively constant over the past 25 years. The growth in overall domestic electricity consumption has matched the growth in the housing stock. However, the nature of electricity use has changed. The proportion consumed in refrigeration and cooking has decreased but the reduction has been offset by an increase in that used by home electronic equipment and lighting. Together the opposite trends maintain constancy in the average household consumption.

- The graphs at the bottom of the diagram show the average daily consumption pattern for the 20 million or so households in the ubiquitous profile class 1; summer for the bottom two traces, then spring autumn and winter at the top of the chart. The pattern of daily use for much of the year is surprisingly constant. The winter peak after diversity demand is still less than 1kW per household, but if the winter season is ignored then for most of the year the daytime demand is fairly constant at under 0.4kW.

- The prospects for a growth of smart appliances have been much discussed. Refrigeration loads have a prospect as a frequency responsive load (which would satisfy the criteria of automatic anonymity). Washing loads may be subject to time-switch control although there are safety concerns in this regard, but lighting (a quarter of domestic electricity consumption) could not be remotely controlled on grounds of safety.

- The lack of any obvious residential DSR capability leads policy makers to contemplate the transfer of heat (80% of the household energy need) and domestic transport to be electrically powered so as to provide more scope for a responsive electricity demand.



- A suite of HAN applications that can function invisibly to the customer is required to unleash the potential in smart metering as a revolutionary technology that will encourage DSR. One approach to facilitating this would be to amend the IEE wiring regulation such that the wiring standard for domestic premises would became a dual AC/DC supply environment. The DC circuits would be coupled to local battery storage that could be managed through remote signalling utilising the two way communication functionality of the meter.

- Household wiring already separates lighting from power circuits. Making DC the norm for lighting circuits fed from a rechargeable battery would allow a quarter of residential energy consumption to be managed in a manner that was invisible to the customer. This capability would be at its maximum at times of system peak demand which coincides with the maximum lighting load in the home.

- Electronic equipment functions most efficiently when supplied with DC electricity. If brought within the DC environment it would contribute to a third of residential consumption being available for invisible control, as well as making redundant the myriad power transformers currently needed to operate these equipments.

- AC power supplies would continue to service the appliances that account for the other two thirds of domestic electricity consumption, and would be available for frequency response or timed control where appropriate.

- In this manner the smart meter could be used to harvest a DSR capability for the integration of intermittent low carbon generation. DSR would also be available for the management of electricity flows on the transmission and distribution networks thus avoiding the need for future network investment. These benefits would be over and above the efficiency gains that are expected to emerge from any change in customer behaviour.