

The Green Deal for Smarter Electricity Markets

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The Challenge

The UK has relatively new energy infrastructure challenges to tackle: grid variability caused by the growth in offshore wind and solar PV generation; grid congestion caused by growing loads (heat pumps and electric vehicles); and ageing generation and grid infrastructures. In Denmark, where renewables supply around 30% of electricity, negative pricing is already being used to regulate over-supply on the grid, resulting in the politically undesirable situation where consumers are actually paid to take this renewable energy at some times of the day.

The need to match electricity demand with supply is not new. Night time tariff schemes such as Economy 7 became popular in the 1960s and 1970s when they were introduced to encourage consumers to use excess electricity produced by nuclear and coal fired power stations, which unlike modern gas fired plant, were relatively inflexible and operated overnight. Customers were encouraged to invest in crudely controlled storage heaters to take advantage of cheap night time electricity. Remarkably, around 1 in 5 UK homes still have these heaters installed, testament to the effectiveness of strong price signals in encouraging consumer engagement.

PassivSystems consider that integrated-thinking is crucial to the success of smarter markets and that the Government's unprecedented Green Deal scheme provides an excellent opportunity to lay the foundations for future plans.

Energy Storage as a Solution

There is growing consensus that energy storage is the key to managing grid variability, although a number of options exist for locating this storage on the grid. For example it could be constructed on site by a wind farm operator; at the substation by the distribution network operator; or at the point of consumption. In reality a combination of options is likely.

Investment in storage at the point of consumption will be attractive to those in the electricity supply chain if capital investments are made by consumers. Flexible tariffs and other incentives could allow home owners to reap the benefits of taking electricity when supplies are cheap and plentiful, and release the stored energy when supplies are expensive and in short supply. This store of energy, held as electricity or heat, could be topped up, not just by grid supplies but also from PV generated electricity where installed. Hence, electricity made during the day can be used at night, thereby also helping distribution network operators with their export constraints.

A paradox is that such potentially useful storage is being removed progressively from our

homes through the switch to gas combination boilers. PassivSystems estimates that the useful energy storage capacity that is lost to the infrastructure system is more than 60 GWh - at the very time the nation needs more storage.

Our homes need to be re-engineered for the low carbon economy. To enable this to happen on a large scale, consumers need to be incentivised. Green Deal could be this mechanism by including energy storage and grid flexible electrical devices as retrofit options for homes. Action needs to be taken now in order to lay the foundations for an affordable future energy system.

Unlocking Value

The distributed costs associated with renewable energy could provide a significant source of value for innovative solutions which provide flexible demand.

- Flattening the load curve and reducing peak power flow reduces the cost of transmission, while matching load to generation reduces the cost of standby power plants.
- Storing grid-supplied renewable electricity such as that from North Sea wind farms will guarantee better utilisation and help avoid political fallout from turning off wind turbines or paying people to use energy as per Denmark.
- At a security and quality of supply level, the cost of maintaining spinning reserves to meet the shortfall caused by variability of renewables is high. Sinclair Knight Merz (SKM) acting for BERR predict for the year 2020¹ that the costs of balancing an electricity system without demand reduction and with 40% renewables could reach £7.2/MWh, compared with £1.7/MWh for a 'conventional' system.
- DNOs traditionally have little business relationship with consumers and therefore have limited opportunities to engage with them as 'prosumers' in an active electricity system. Consumer propositions may be constructed that enable DNOs to become active participants in a dynamic electricity system. DNOs could then begin to leverage these new relationships (possibly directly, or through third party aggregation businesses) allowing visibility and influence over demand profiles for the benefit of network security, quality of supply and overall cost-reduction.
- Value could be released from higher distribution asset utilisation through local balancing downstream of the 'last transformer'. DNOs also face a problem from increasing levels of local embedded generation in regard to managing voltage to statutory requirements. The problem is made worse by the fact that small embedded generators are non-dispatchable, in that the DNO cannot command them remotely to balance system load and if co-located, they are likely to operate simultaneously, thus offering little diversity of supply.
- Aggregation of individual household demand could make this possible and generate financial benefits for consumers.

¹ Sinclair Knight Merz (2008) *Growth scenarios for UK Renewables Generation and implications for future developments and operation of electricity networks*. BERR, From: www.skmconsulting.com

Energy efficiency measures have in the past been funded through the consumer bill. Network operators face a major challenge in reinforcing the grid, just to keep pace with the growth in consumer electronics. If the costs of balancing and reinforcing the grid could be monetised and a mitigation value assigned, then this value could be shared with consumers as an incentive for investing in storage equipment and intelligent controls, working on their behalf and in conjunction with dynamic tariffs. Consumers will not look for the same ROI as the supply side.

In PassivSystems view, we have an opportunity for Government to set the new parameters, requirements for conformance and accreditation for a new smarter market, such that households can make their capital investments in the knowledge that suppliers are obligated to offer a guaranteed and long term discounted tariff in exchange for demand reduction capacity.

Financing of consumer investment is the missing piece of the jigsaw. Green Deal could be a suitable mechanism to fund the purchase by consumers of modern energy storage equipment and smart controls such as we are developing at PassivSystems.

How the Mechanism Could Operate

The Green Deal can lay the foundations for a future smart grid by ensuring the energy storage capacity of the domestic stock is reinforced and expanded while energy efficiency is improved.

There are three key energy services where flexibility in demand can be developed:

- Space heating which accounts for 66% of household energy use;
- Domestic hot water which accounts for 17% of household energy use;
- Electricity use².

A home engineered for a smart future could:

- **Maintain comfort without using energy**

A new generation of (true) storage heaters may now be used for central heating or to heat domestic water which will provide cost-effective, carbon-free heating and hot water when wind energy is plentiful. Electricity storage is also becoming an option with advances in battery design driven by the vehicle market. The same energy stores could be used to improve dramatically the operational performance of heat pumps, either by topping up as an inlet heat feed or instead to power them when the grid constraint is in place.

The average heat loss rate of the UK housing stock is 254W/°C, meaning that 5kW of power is required to maintain internal temperature at an internal set point of 20°C at 0°C external temperature. If this power was provided by a heat pump this would represent a significant addition to the electricity load of the home, approximately 2kW.

² Cambridge Architectural Research (2011), *Great Britain's housing energy fact file*, DECC. From: www.carltd.com

If heating were electrified, a combination of reduced output and cold weather would therefore have a significant adverse effect on security of supply. Being able to dispatch this load without affecting thermal comfort would provide significant capacity. An electrified heating system needs to find flexibilities similar to those currently provided by gas. A solution currently under investigation by PassivSystems integrates a thermal buffer with the heat pump installation. This would complement improvements in building thermal performance enabled by the Green Deal.

- **Store enough hot water for 1 day's demand**

A study by the Energy Saving Trust (EST)³ found that households used a daily average of nearly 5 kWh of energy for domestic hot water, a quantity of energy that may be stored in a single standard 120 litre tank. Government could help put hot water storage back in homes through integrated solutions.

- **Provide electricity demand flexibility with minimum disruption to consumers**

Based on the typical demand profile, 1.5 kWh of storage would be required to shave the evening peak between 5 and 11pm. Overnight charging would hold household demand almost steady for 24 hours a day. Alternatively about 3.8 kWh would be required to take the home completely off-grid during the afternoon peak. In a home with sufficient PV capacity installed to cover 10 kWh of daily electricity demand, approximately 2.5 kWh of storage would be required to avoid electricity export.

The financial viability of options would be highly contingent on battery costs and electricity price trends. Also, with a growing dependence on renewable energy, constraints may happen at different times each day and not at fixed times as they do now.

However we believe the Golden Rule of savings being greater than costs could eventually be satisfied by energy storage. Therefore financing flexible energy demand and smarter markets should be considered under the Green Deal, with carbon saving benefits being created in the generation sector and the home playing a part in balancing aggregated demand.

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³ Energy Saving Trust (2008), *Measurement of Domestic Hot Water Consumption in Dwellings*