dynamicDemand
promoting new technology for green energy integration

The potential for reducing carbon emissions by introducing 'dynamic demand control' on the UK electricity grid

Dynamic Demand briefing paper

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Summary

- Dynamic demand control is a low-cost technology that uses electrical appliances to provide balancing services to the electricity grid.
- Such technology has the potential to replace certain back-up generation, increasing the efficiency of the electricity system and reducing greenhouse gas emissions.
- **The potential emissions saving is highly significant in policy terms, equivalent to 25% of the reduction predicted to come from the UK's 10% renewable energy target.**
- The savings are similar to those that would result from the Government achieving its energy efficiency target for public sector buildings.
- The technology could also help facilitate greater use of renewable generation and hence release the potential for further CO_2 savings.

1 Introduction

The United Kingdom has set a domestic goal to reduce carbon dioxide (CO_2) emissions by 20% below 1990 levels by 2010. This paper estimates the contribution to this reduction that could be achieved by a widespread adoption of 'dynamic demand control' techniques on the UK grid.

2 Balancing the grid

Electricity cannot be directly stored. This means, at every second, electricity supply must precisely equal demand. The demand changes continually as many millions of customers switch loads on and off.

To a large extent, the demand for any period of the day can be predicted. This allows generating plant to be scheduled in advance. In the UK, this is done through the electricity market.

2.1 Supply-side balancing

There are continual random fluctuations in demand which cannot be predicted and hence there is a slight difference between the supply and the demand at any particular time. These random imbalances are removed by a service called "response" which involves the use of generators whose output is continuously and automatically adjusted to maintain balance.

There are two kinds of response on the UK system: primary response is very short term (10-30 seconds) and secondary response is longer term (up to 30 minutes). It is the National Grid Company's responsibility to commission adequate response and it does so at a cost of approximately £80m per year [1].

2.2 Emissions due to balancing

The kind of generation used for response is usually fossil fuel powered which produces emissions of between 0.48 and 1.3 tonnes (t) of CO_2 equivalent for every megawatt hour (MWh) generated [2].

In order to provide response, a generator must operate at less than maximum output in order to provide the necessary back-up capacity. This is generally less efficient than running at designed output.

A recent computer simulation of the UK power system found that the total CO_2 emissions associated with providing response are approximately 2.1 million tonnes per year [3]. This is equivalent to 0.6 million tonnes of carbon (MtC).

3 Demand-side balancing

There is a growing market for demand-side techniques to provide balancing services. However this currently comprises only very basic technology whereby specific large loads (e.g. aluminium smelters) are able to switch off when there is excess demand on the grid.

3.1 What is dynamic demand control?

'Dynamic demand control' describes any technology which enables individual loads (e.g. electrical appliances) to contribute essential balancing services to the power grid. Such technologies have the potential to smooth out fluctuations in the demand, and hence reduce the need for fast-reacting back-up.

There is vast potential on the demand side to provide grid-balancing services and to reduce CO_2 emissions associated with back-up generation. In principle, any appliance that operates to a 'duty cycle' (such as industrial or domestic air conditioners, water-heaters, heat-pumps and refrigeration) could be used to provide a constant and reliable grid balancing service at very little cost. Such devices would alter the timing of electricity consumption, in response to the current imbalance on the grid, to provide a service equivalent to traditional response.

Simulation studies carried out by Dynamic Demand indicate that such devices could provide an amount of response almost equal to their combined electricity demand.

The combined demand from all suitable appliances is far in excess of current levels of response. The maximum amount of response currently required on the UK system is 1320MW [4]. Domestic refrigeration alone, for example, has a combined electricity demand of 1900MW [5].

It is clear therefore that the technology has the potential to replace a large proportion, if not all, generator-based response services and avoid their associated CO_2 emissions.

3.2 Emissions reduction

Enabling appliances to deliver dynamic demand control requires the incorporation of a low-cost microcontroller which uses negligible additional energy. They are assumed to entail zero operating costs (though some statistical metering system and signalling system may be required for participation in certain markets). This would enable the technology always to out-compete traditional response (with its unavoidable additional fuel costs).

Demand-side techniques therefore have the potential to remove most if not all of the additional CO_2 emissions from traditional response, a saving of up to 0.6 million tonnes of carbon (MtC) per year.

3.3 Comparison with other policies

To put this in context, the renewables obligation, which is designed to deliver 10% of UK electricity from renewable sources by 2010, is predicted to save around 2.5 MtC per year. This means demand-side response could save as much as 25% of the UK's entire renewable energy policy.

The potential savings are similar to those that would result from the Government achieving its energy efficiency target for public sector buildings.

3.4 Supporting renewables

There has been much debate recently about the potential stability problems that could arise on the power grid if a large amount of randomly variable renewable energy sources are connected. This problem has been crudely characterised by some commentators with statements like: "the lights will go out when the wind stops blowing or the sun stops shining."

The problem of variability has been widely misunderstood and often exaggerated. For example, many commentators ignore the beneficial effects of 'aggregation', where short-term, local fluctuations in wind speed are averaged out across the many sites where windfarms would be located. (The National Grid Company sees no problem arising from variability within current renewable targets.)[6].

However, it is possible that there may be a challenge to overcome in the future. According to simulations conducted by Dynamic Demand (where wind data from 23 sites was aggregated), a large increase in wind power, beyond current targets, is likely significantly to increase the requirement for response.

While it may be possible simply to increase the amount of backup generation, this would lead to increased carbon emissions, partially negating some of the positive effects of renewable generation. Demand-side techniques could be an efficient and cost effective way to meet any additional requirement, and could therefore help the integration of future renewable sources onto the grid.

3.5 Further potential

This paper has concentrated on response. However, another vital balancing service is 'fast reserve' which is the use of standby plant to replace possible lost generation (e.g. due to a failed power generator or lost power line). The provision of fast reserve also entails additional emissions of CO_2.

Simulation studies indicate that dynamic demand control has the potential to defer demand over timescales of an hour or more. It is therefore possible that demand-side techniques could reduce the requirement for reserve.

Although more work needs to be done to assess this technically (and to work out how such a service could be compatible with the current energy market), it would clearly lead to a much greater CO_2 saving than has been estimated in this paper.

4 Making it happen

Whilst there would be many beneficiaries from dynamic demand technologies, nothing will happen until there is a secure financial incentive.

Although in theory the technology could earn money from the services it provides, in practice this money is not yet accessible to those who may wish to invest in the technology. This is because current regulations and institutional policies are mainly geared towards the traditional ways of providing response, namely through large generators.

The not-for-profit company Dynamic Demand was founded to promote new technology to reduce the environmental impact of the electricity system. Its current work is to demonstrate the potential of dynamic demand control, inform key decision-makers of its benefits, and pave the way for a thriving market.

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