Smart Energy markets - Beating the Law of unintended consequences

In the break between Christmas and New Year we will all no doubt be thinking about New Year's resolutions.

Those of us who have a connection with the development of Smart Metering and Smart Grids will also be looking forward to the development programme put in place by the government in its response to the consultation published on the 2nd of Dec on Smart Metering.

By the summer of next year we should see OFGEM complete the "Prospectus" phase of the programme which will deliver:

- The systems requirements for the meters, communications, and information flows
- The commercial and regulatory framework for managing the smart metered market
- The timetable and allocation of roles for roll-out
- Programme plan for phases 2 (Detailed design which we assume also includes procurement) and 3 (Implementation)

Whilst the "Detailed Design" phase is expected to be completed by the summer of 2012, the "Prospectus" phase is expected to deliver in the summer of next year (2010). Time is of the essence.

Increasing inter-dependence and complexity

As implementation rolls-out we will see a communications network built which will stretch from the nuclear power station on land and the wind farm in the North Sea, through the transmission and distribution network, and then all the way through to the freezer in the home and the electric car parked in the street.

Over the same period, and in line with the agreements which are destined to come out post Copenhagen, we will see a much greater share of energy supply being made up of intermittent (wind/solar/wave) power and locally produced power e.g. both in-home micro-generation and local scale CHP (combined heat and power).

The consequence of these two parallel developments (smart metering and changing supply sources) is that a significant proportion of supply (20%+) will be uncertain, and demand will have the potential of being much more flexible.

Most importantly the inter-connectivity of the supply and demand elements of the system will increase significantly making the energy system much more complex and dynamic.

Understanding complex systems

Over the course of my career I have witnessed a growing appreciation that much of the world around us behaves as a complex dynamic system, in which feedback loops and time delays cause the system to behave in unexpected and sometimes counter-intuitive ways.

Luckily there is a whole wealth of theory and practice in modelling these types of systems which can give real insights into how these systems may behave – thus turning the

unexpected into the anticipated. However, my experience to date is that this type of modelling (agent based, discrete event and systems dynamics) is not prevalent in either regulatory or commercial practice in the utilities.

So why should Energy Utilities, Regulators and Governments look to adopting the mathematics of complex dynamic systems to plan for Smart metering roll-out?

The Smart metering world is a much more of complex system

On the supply side…..

We have the issue of wind power where on the coldest day this year 95% of current wind power was also unavailable due to the becalmed weather conditions. The opposite also applies – since if the wind is blowing in the middle of the night we can have a surfeit of cheap electricity with nowhere to go.

On the demand side….

In a world where the immersion heaters in household hot water cylinders are connected to the smart system we could imagine this cheap electricity being used to heat up the water thus saving on higher cost energy consumption later in the day. It is estimated that there may be 120 gWhr of energy storage available through this mechanism.

In a world which has a significant population of electric vehicles we have both a demand source (re-charging the battery) and a supply source (parked vehicle batteries).

With freezers, washing machines, tumble dryers all connected into the grid we can envisage load being shifted to enable consumers to benefit from the lower prices which will prevail outside peak usage times.

Gas fired micro-generation will straddle the gas and electricity market boundary as demand for heat will automatically generate co-produced electricity either for use in the home or for delivery into the grid.

The inter-connectivity of a multiplicity of supply and demand sources all potentially responsive to short term price signals will give rise to an energy market which is much more complex and much more dynamic than today's market.

Complex Dynamic systems can often display unexpected outcomes

In a complex dynamic system we can often see that a small stimulus can create an unexpectedly extreme reaction in another part of the system.

Let me share a couple of thought experiments with you to illustrate the point:

1. Imagine that consumers set their home appliances to switch on when the price of electricity drops below a certain threshold. Also imagine that the price of electricity is just above that threshold. Now a very small increase in wind availability could cause market prices to drop marginally which could then trigger all the appliances to switch themselves on causing a massive increase in demand, causing prices to spike upwards thus triggering switch off thresholds for appliances to switch off – although more of them since the spike is greater than the marginal reduction in price which caused the switch off- this in turn contracts demand and drops the price which then causes a whole additional raft of appliances to switch on. Effectively each swing of the on-off pendulum has an increasing amplitude and the system may well become unstable.

2. Imagine a summer night during which immersion heaters across the country switch on in the middle of the night to take advantage of cheap wind power. They stay on for the time taken to bring the water in the tanks up to the required temperature then automatically switch off. When the morning comes the gas which was scheduled to heat the tanks is not required, and furthermore the gas fired microgeneration does not switch on to heat the water so does not produce the electricity it would normally do. So during the morning peak gas demand is driven down and electricity demand on conventional generation up. In effect we have cheap wind based electricity driving up prices of electricity – both an unintended and counter-intuitive consequence

There will be many, many more consequences of operation of an integrated and inter-connected smart market which cannot be envisaged without having a model which illustrates what can happen – our brains simply cannot handle the feedback loop and time delay logic which defines the operation of these systems.

We need to understand the full implications of one market model over another before we put our frameworks in place or we will be caught out by the "Law of unintended consequences" and may well find ourselves having to change the model post-implementation which could be a very costly affair.

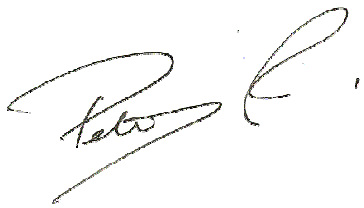
The maths of Complex Dynamic Systems can deliver the required insights

Deploying simulation models of the Smart world based on the maths of Complex Dynamic systems provides us with two benefits which enable us to understand and manage these systems.

1. Being able to explore futures through mathematical simulation enables unexpected consequences to be uncovered and, hence, avoided
2. Being able to trace back exactly why a consequence occurred greatly improves our understanding of the system and hence our ability to manage it

If we are to avoid the unintended consequences which will manifest themselves in the Smart world due to its multiplicity of feed-back loops and time delays we need to deploy the maths of complex dynamic systems to model and understand the new world.

So for all of us involved in creating the Smart Metering world let us make the adoption of the maths of Complex Dynamic Systems a New Year's resolution.



Peter Franklin
Director
Enstra Consulting

12th December 2009

Postscript: Enstra can provide access to leading practitioners in the field of creating simulations of complex dynamic systems using the mathematical formalisms of systems dynamics, discrete event and agent based modelling. If you would like to explore this further please contact me on +44 20 8780 3313, or email me at peter.franklin@enstra.com

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