Future Power Systems 20

The Smart Enterprise, its Objective and Forecasting.

Overview

Each AC Power System is always in perfect balance (Kirchoff's law). The wires have no storage and the product moves through them at the speed of light from every electrical alternator and other generation mechanism through every socket to every demand.

What the System Operators have to do is continuously match (NOT just balance) Generation to Demand within close limits or the frequency will move instantaneously until it has increased or dumped enough Generation or Demand..... To achieve an adequate match the operators need forward estimates of Generation and Demand separately, accurate at all lead timescales, together with the relevant data for controllable 'entities' and the ability to instruct same...... Data is either acquired by submission or forecasting/prediction.

So, in electricity production and supply, everything affects everything else instantaneously; thus all elements must be modelled together.

We always have had 'Smart' monitoring and control of Generation and Transmission, while Distribution and Supply have been provided and secured on a passive basis; distribution being sized for 'top down delivery at max demand'. However, we now have to bring more extensive monitoring and management into distribution (Smart Grid) and finally to enable the participation of the 'Smart' customer (Smart Meters to HAN/BMIS/Industrial Control systems). The overall solution should be described as the 'Smart Enterprise'

The main thing the customer, the industry and the community wants to see out of the Smart Enterprise is 'value'.

It is vital that the Smart data system is defined and configured to assist efficient operation of the whole power system, keeping costs down, assisting the accommodation of variable output unpredictable renewables and possibly more inflexible thermal plant, while reducing the fuel burn and emissions from fossil fired plant. This means making the residual power requirement profile from fossil plant predictable and stable (smooth), to minimise the number of such units running and ensure that they are at full load when on the bars so that they operate at maximum efficiency. Causing fossil plant to run part loaded and with frequent output changes to cover uncertainty all gives inefficient burn which costs more in fuel and emissions per kWh.

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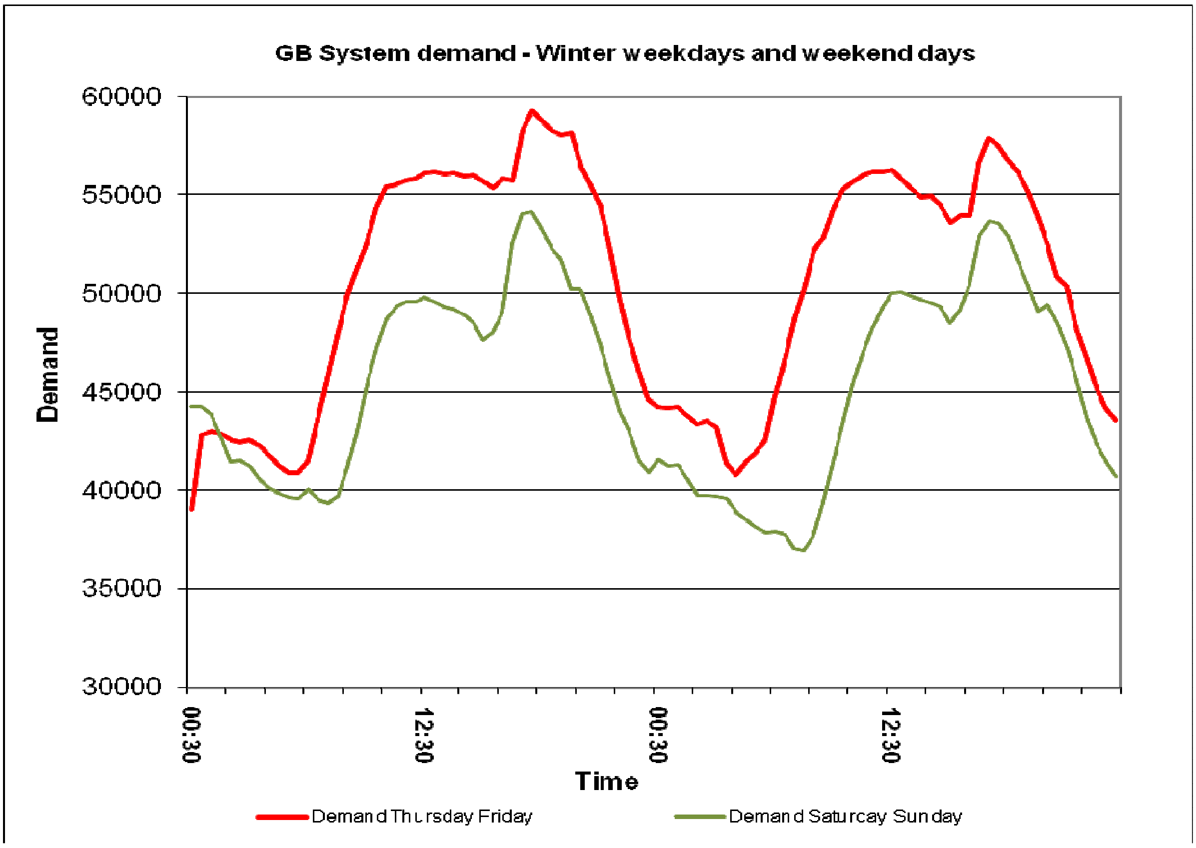
Distributed Energy Resources - participation

We have the following Distributed Premises Resource Elements.

- Demand - in three types
    - Time Critical
    - Non Time Critical
    - Unnecessary!!!
- Generation
- Storage

Although the customers are becoming more environmentally aware, the main driver has to be to add value by reduction in their bills. Obviously reducing the 'Unnecessary' demand is a primary requirement which monitoring and automation can assist with. As regards moving non-time critical demand and output from controllable embedded generation and storage, this depends on the way Preset time period and later, Time of Use pricing will vary over the period across which the kW can be shifted. There is also a limit to the amount of Export/Import which can be moved in a day; there is more scope for weekday to weekend transfers but that is more onerous to manage at both customer and utility level.



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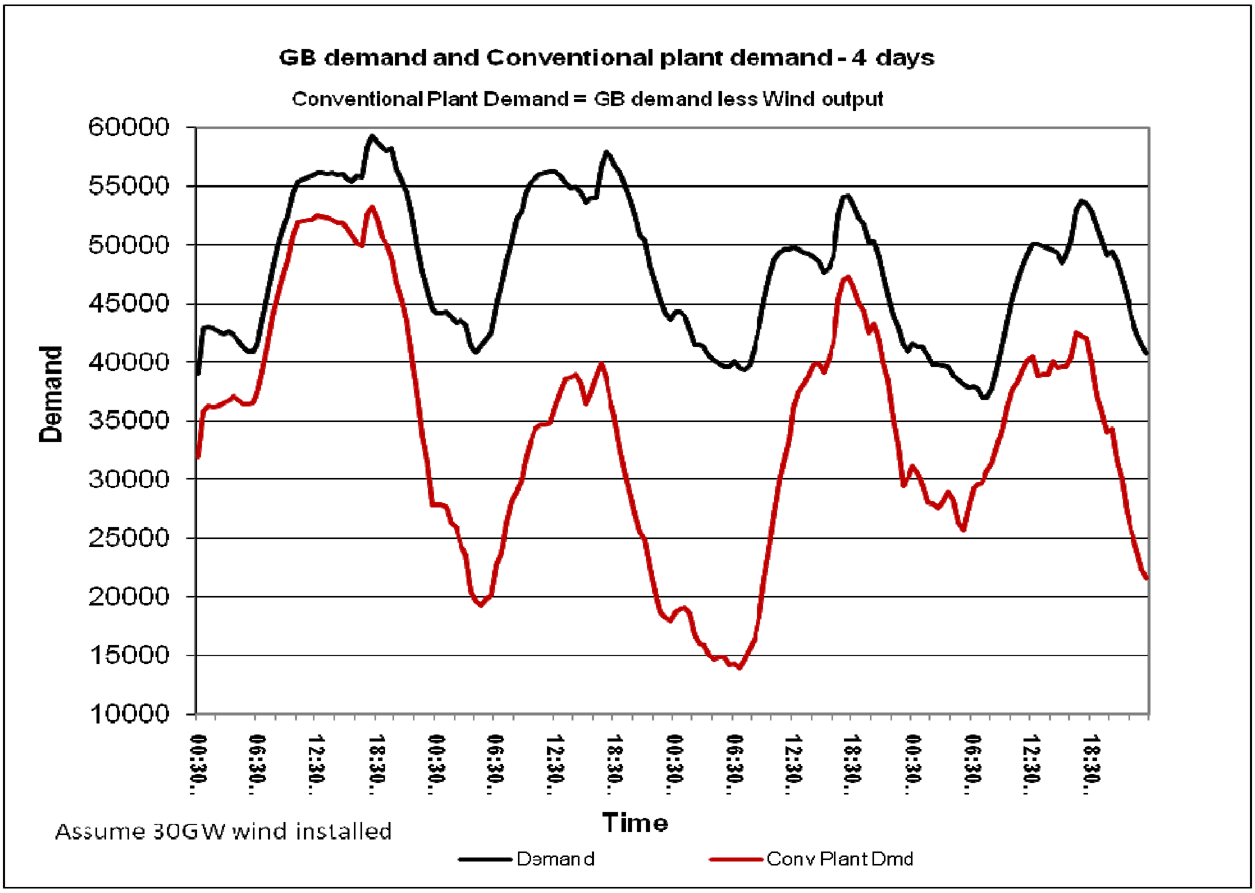
The time shift requirement does not just simply follow the total customer demand profile. The net fossil Generation requirement curve, being total demand less output from renewables+nuclear+hydro, will determine the shape of the price curve. With major penetration of renewables with variable outputs across time, there will be times when that net fossil requirement profile will deviate seriously from the shape of the customer demand curve.



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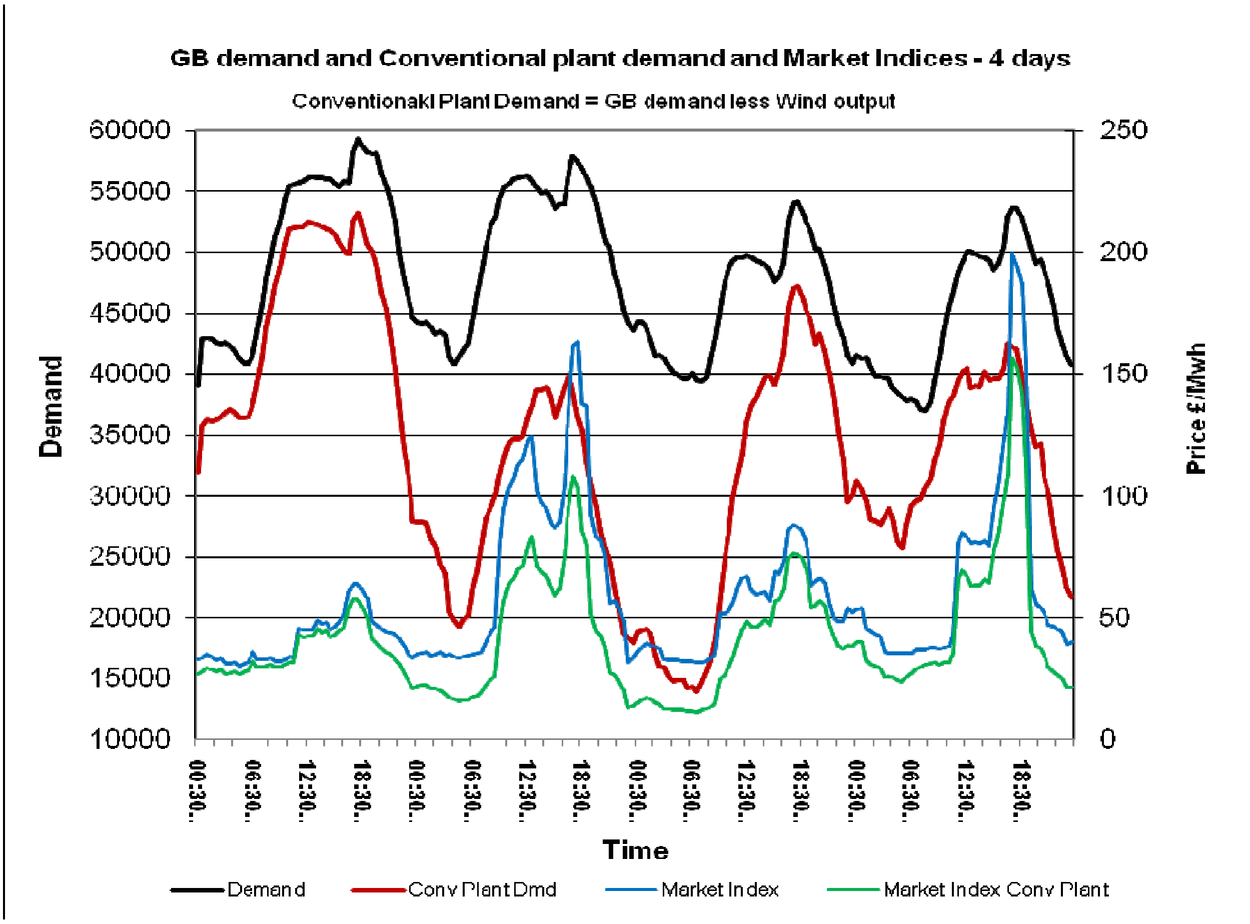
The marginal market index prices are already volatile vs the demand shape and the big changes in fossil output from day to day will cause further variations.



Now, with embedded Generation and Storage added to the Distributed Resources mix, at any level from customer premises to distribution connected and also adding transmission connected storage, we have a lot of capability to shift demand.

As we start to put more demand into the overnight period, and possibly add other major demand such as Electric Vehicles, the day-night tariff differentials will reduce and so will the customer benefit from further 'shifting' action.

What we must also remember is that the management of DER resources must be automatic. After all the main priorities of the three supply sectors are:-

- Making Widgets (Industrial)
- Buying and Selling Stuff and Providing services (Commercial)
- Getting on with life (Domestic)

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Utility Demand Forecasting requirements

The system operator has to match the total system demand to total generation, dispatching down to a minute by minute basis and supported by fast ancillary services to meet short term mismatches.

If there is a wholesale market in place, the suppliers and generators trade down to gate closure and then submit their traded profiles to settlement and the planned generation unit outputs to the operator, who then starts the matching process from that basis.

For efficient operation it is vital that the system operator, and the suppliers in a wholesale market, have accurate forecasts of demand.

The conventional Forecasting method

Now, as the system is in perfect balance, the easiest way to measure the total customer demand (generation requirement) is simple; you just add up all the generating unit outputs, subtract pumped storage pumping and add (import) or subtract (export) interconnection transfers. In the current electricity delivery framework you can then use analysis of historical total demand vs weather at cardinal points (peaks and troughs) by day type (weekdays with day of week weighting, saturdays, sundays and bank holidays) by season (summer and winter) to give a base demand profile and weather related demand variation equations for each point.

For forecasting you can then determine a base demand from the base profile and apply forecast cardinal point weather through the same equations to give a new forecast customer demand. You then profile the result, add planned pumping and interconnection transfers and thus determine what generation is needed to match the resulting requirement on a minute by minute through to half hourly basis. This supports everything from real time dispatch (with real time metering summation to give the start point) through to scheduling, commitment and planning timescales.

Using historic supply point demands, you can then ratio the forecast total to give demand by geographical area and, using the forecast scheduled and instructed generation in that area, ensure that transmission is secure. This can all be regarded as the 'Top down' method.

The suppliers also use historic demand records as a basis for forecasting.

However, the method assumes the demand side is passive, does not carry large amounts of embedded variable generation or storage which does not have specific metering and that customer behaviour is similar on each successive day type at each time.

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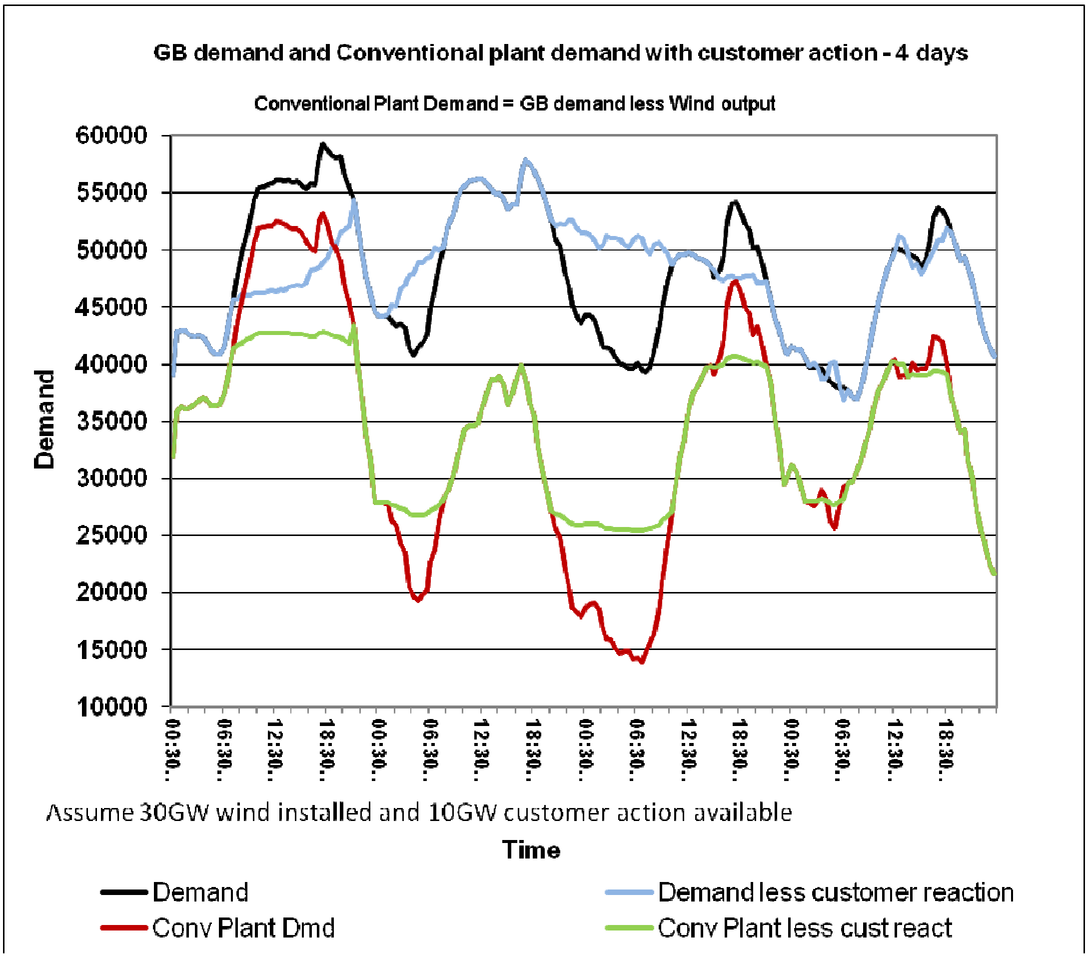
The Smart Enterprise - impact on forecasting

In the brave new world we have active demand shifting either directly or by using embedded storage and generation. The requirement for demand shifting will be influenced by both demand level and the power plant mix. So, returning to our example above of what happens to conventional plant demand with Big Wind.

Suppose for the moment that we can come up with a mechanism which will allow us to signal the customer to shift some demand from times when fossil plant output is high to when it is lower..... The result could look like this.



Now, there are obviously myriad issues to asking the customer to behave in this way; the energy movement is probably unbalanced and the ability to move appliance loads could be questionable. On top of that the wind output predictions are not reliably predictable in advance so giving the customer 'certainty' about when an appliance will be most economic to run will not be easy.

But, if in principle, we wish to modify customer behaviour to reduce fossil plant output. And we need big actions to countermatch Big Wind

Just look at what happens to the main demand curve; the blue line; it is virtually unrecognisable!!

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Thus, with already volatile margin prices and increasing penetrations of variable output renewable generation, both transmission and distribution connected, the level and timing of demand shifting activity will be different from day to day. That means that the metered recorded demands will vary from day to day outside of the normal weather parameters and the old fashioned top down forecasting models will become useless.

So, we need a new approach. As the customer is now active, a bottom up technique using data from the new smart systems with aggregation at the appropriate levels seems appropriate. The main issue is to keep demand and generation separately metered and also storage so that charge and discharge energy can be correctly accounted. We then need predictions of what the customer resources will do….

The main problem will be determining customer demand shift effects (customer reaction) and behaviour of embedded generation. As it is likely that customers will have automatic systems to monitor prices and then control the resources in their premises, we need to get predictive information from those sources. It looks like there is a lot of work to do on the data framework.