Future Power Systems 21 - The Smart Customer

Overview

From Future Power Systems (FPS) articles 18 and 19 we can see that there are a number of different trading and tariff mechanisms which can be employed on the utility to customer interface to enable participation. From article 20 we see that there will be different pricing profiles on similar day types due to changes in availability of renewable generation.

The customer interface has to be carefully managed to avoid overreaction, the spectre of 'uncertainty' and major changes to energy bills. The last two conditions can cause serious adverse reactions from the customers.

The main thing the customer, the industry and the community wants to see out of the Smart Enterprise is 'value'; to put together the infrastructure from two way premises communications device (meter+) through aggregator/disseminator mechanisms to supplier trading/back office and distribution/transmission/system operator systems is quite a large and expensive undertaking.

A number of recent attempts to introduce (or rather impose) Smart metering in the USA have encountered severe adverse reactions from the customers.

In summary, we are making the biggest change to the retail electricity market 'philosophy' in nearly 130years of electricity supply. Goodbye to 'pay me 10p/10cts/10Eurcents/1Rupee.... per unit and you can use what you like when you like'. In the new world, time and day both matter.

In Great Britain we have had @100000 half hour (hhr) meters installed, at customer premises with maximum demand in excess of 100kW and at smaller sites voluntarily. This covers @half the GB demand and some of the sites also have generation installed. There seems to be a lot of potential to engage these customers in early Smart Activity. We have a project proposal for analysis/assessment/demonstration for storage/smoothing/communication on a site by site basis, but it is too 'wide' to fit into any single EU FP7 or Intelligent Energy Europe call theme (as we found in discussion with the Energy commissioners rep). The hhr customers are now obliged (Apr 2010) to improve their Carbon performance under the GB Carbon Reduction Commitment.

However, although that hhr metering is provided, managed and collected by the suppliers, it was installed to enable hhr based wholesale Settlement (1998 project). I'm not sure if supplier back office customer charging systems have been upgraded. It may be that suppliers just use either a 'back office front end' to summate the hhr readings or employ integrating registers within the meter which are also collected automatically with the hhr data.

Initial Customer Dialogue

It seems that a simple dialogue with the customer is needed before Smart systems are deployed, especially to avoid some of the adverse reactions which have been encountered.

An initial approach could be a set of 'what-if' walk through time-sequence dialogues, in a relaxed manner, to get the customer thinking about what they (or rather their control systems) might wish to do when faced with sequences of rising and falling tariff prices on a daily basis. This needs to encompass preset time of day, real time only time of use and predictive time of use pricing to get a comprehensive view of the likely activity from each method. Such dialogue would also reveal the nature of likely changes to demand behaviour (albeit automatically controlled) by demand type (lighting, white goods, cooking etc), which is important when determining the requirements for data exchange, premises controls and for configuring the new utility demand forecasting system. Note that, where there is extensive penetration of varying output renewable generation on a system at any levels, the tariff profile will not necessarily follow the customer demand profile. We also need to explore the opportunities for 'trading' (power-time blocks at a set price) and ancillary service mechanisms.

The customer engagement exercise needs to be iterative in that the utility side evaluates the impact of blocks of likely customer response to a tariff or trade, in terms of fossil output demand change, to get a better view of what prices should be offered. i.e Customer reaction curves.

As part of such dialogue it is also helpful to try and explain the reasons behind price movements in the walk through exercise (price spikes due to use of inefficient plant for short periods) to try and engender the necessary level of enthusiasm for the new world of 'customer participation'; albeit managed automatically by intelligent premises control.

Developing the dialogue and price issues

The actual Customer Engagement exercise needs to carry a lot of 'suggestion' to get things moving; as has been said elsewhere ‘the average person thinks about his/her home energy costs in real time (or even at any time between billing) about as often as they consider thumb tacks (drawing pins) and phytoplankton’.

We don’t have any accurate rates at this stage and certainly no fixed ‘script’. The way that dynamic retail market prices will be set is dependent on the reaction expected and the revenue requirements of the suppliers. So, within the unique framework of Electricity Delivery, the price should be set at a level at which the market will react to give the most efficient use of production and transport while the retail suppliers and wholesale generators still make a reasonable profit.

Raw marginal prices must not be used for the dynamic retail tariff (Wholesale marginal with Use of System added) or violent reactions will result (see next). Use of marginal price indicators (station heat cost) in the Generation-Fuel modelling field shows where damping is required to produce the correct result.

However the shape of the marginal prices from the wholesale market and from the operator matching and ancillary services mechanisms carries the 'message' of what the main generation is costing; and emitting if you apply Carbon pricing. This is probably the basis for the retail market signals.

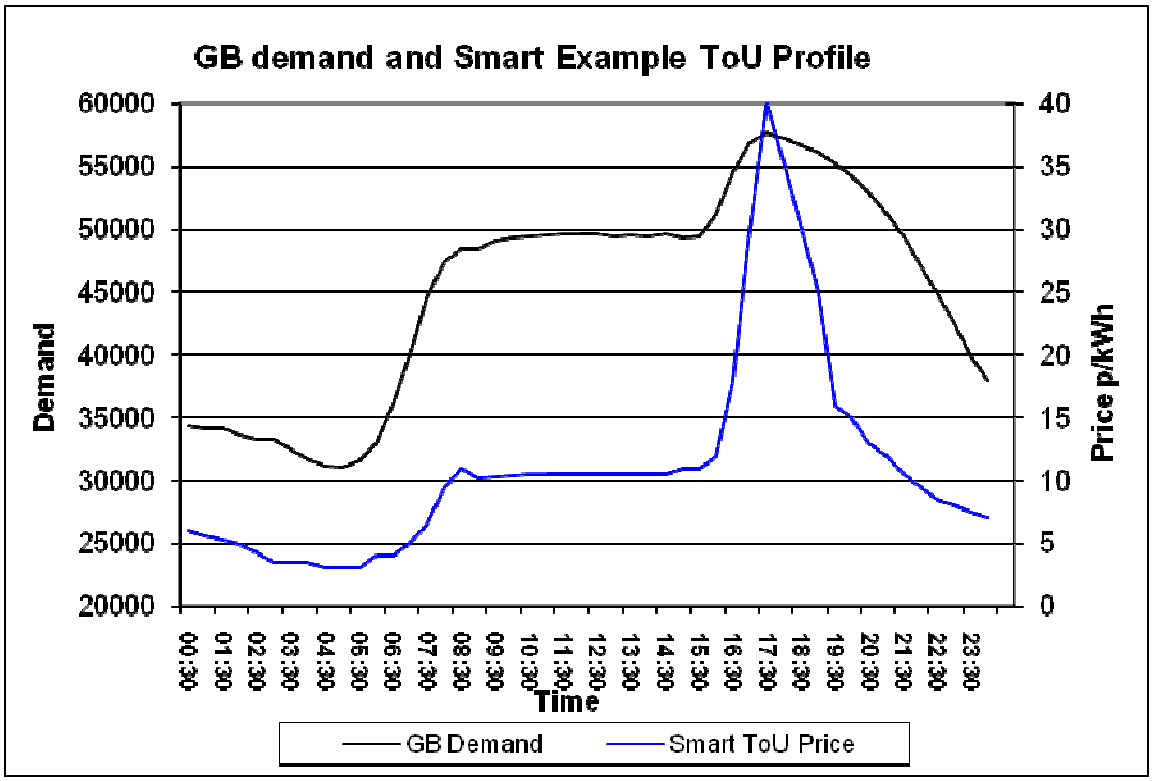
Use of System Charging - Wires and Services

In FPS 5,10 and 16 we looked at wires and services are charged at wholesale level; a fixed annual levy based on Peak demand to cover the cost of the infrastructure. This is difficult to apportion correctly in the retail market, due to lack of Peak Power metering and limitations of Supplier back office systems. The charge is evenly spread over all customers, either as a Standing charge or a p/kWh charge.

When Smart meters go in and the supplier's back office systems are changed, the functionality will be in place to allow the annual Use of System charges (£/kW) to be correctly apportioned by individual customer Peak usage, whenever it occurs. The Smart meters can identify Power level while coupled HAN systems should be able to manage Power Import/Export against UoS pricing. That should give 'smoothing' of the demand profile by avoiding simultaneous operation of large appliances. It also means that infrastructure and reinforcement is more correctly charged to users with large Peak demands.

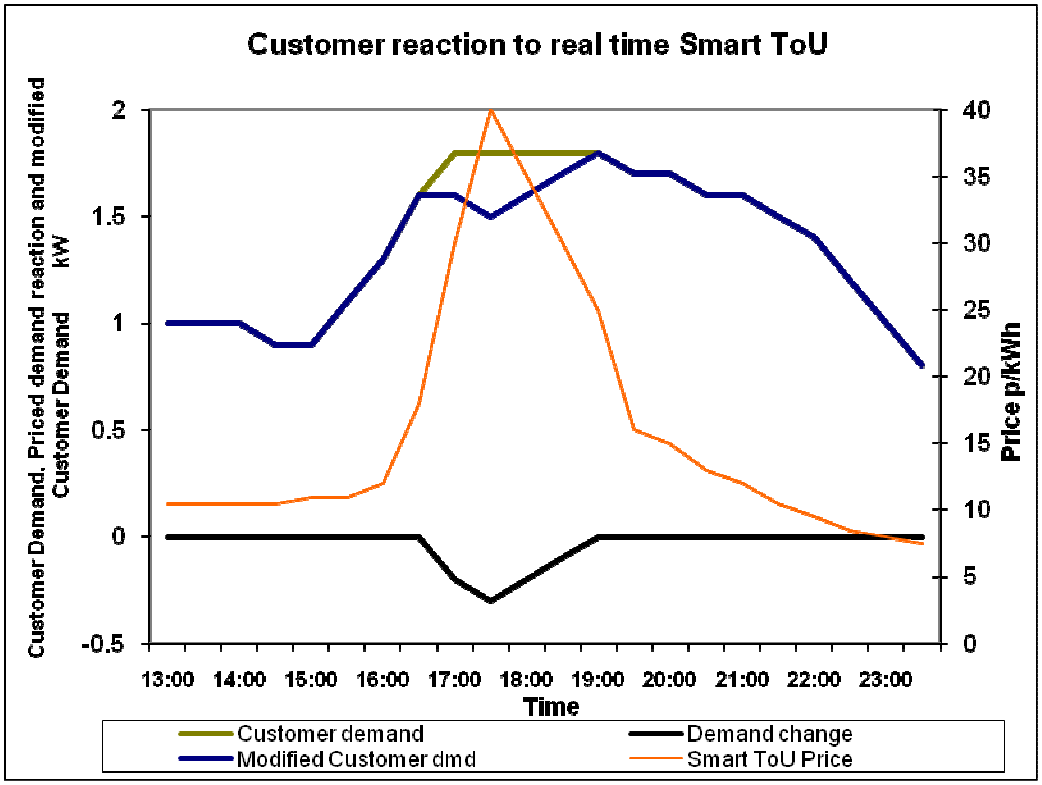
An Example of Customer Engagement

Let's take a basic domestic scenario with the above Time of use (ToU) profile. Remember that a lot of Smart meters are only configured for Real Time ToU and the customer only sees one value at a time.



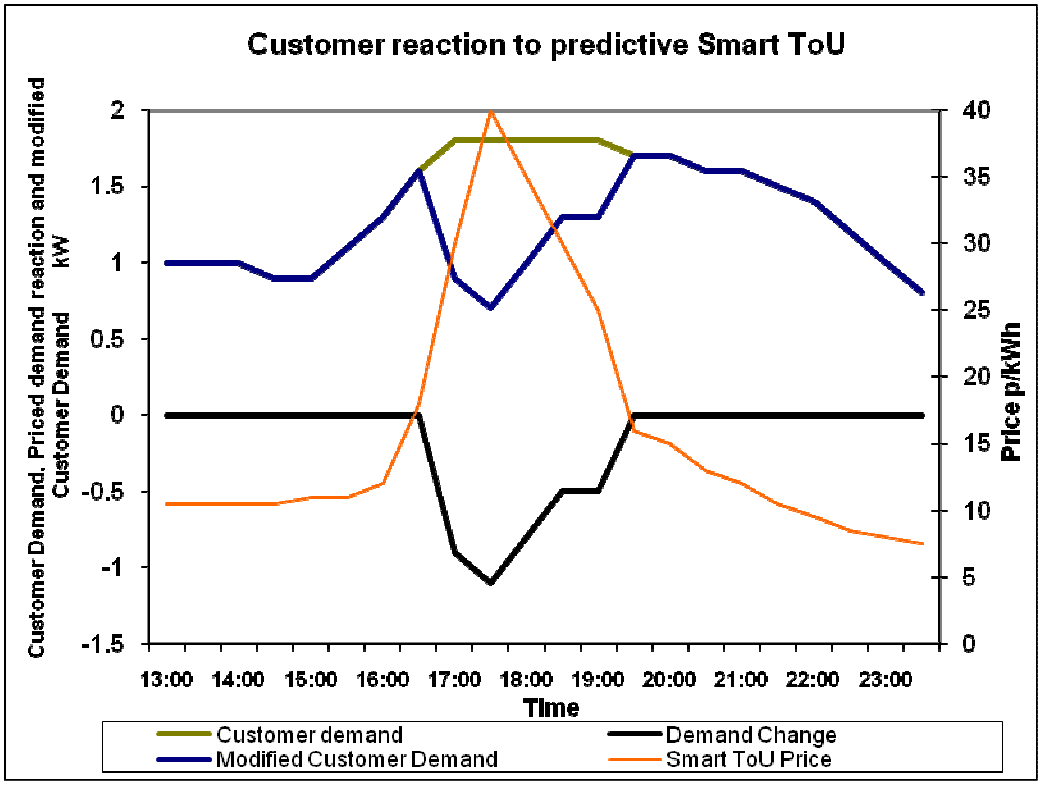
We start at 1500hrs on a weekday afternoon at the current GB marginal rate (@11p/kWh - which could actually be 'low')!! You ask the customer what they intend to do with their appliances over the next few hours; that's where you need the 'suggestions' – just got back in from collecting the kids, when will you start cooking, have you laundry to do, turn on the TV and of course you'll be putting on the lights in an hour or less. We then walk through the next five or six half hours in sequence with a price profile of say 11-11-12-18p/kWh (1500 1530 1600 1630) to see how they might change their electricity use at each time. I suggest they might have started the washing machine around 1530 and started cooking (electric stove) just before 1700.

In GB the sharp Daily Peak occurs in half hour ending 1730. So, for 1700 we jack the price up to 30p/kWh and then to 40p/kWh at 1730; deliberately contentious to get a reaction and would not be done in practice. Too late to stop cooking, or to 'interrupt' the laundry without having to reheat the machine…. However, we might get some reaction.



So, this scenario shows the 'Real Time ToU' tariff in action which is all that a lot of existing Smart meters appear to be designed to display.

We now turn time back to 1500rs and say 'what if I told you, or rather your Home Automation Network (HAN), at this time that the price profile was **going** to be to 10-12-15-20-40'; this is predictive ToU. The customer reaction would probably be to delay or advance dinner, leave the washing till later and even, possibly, turn all the lights but one off and sit in that room reading a story to the Kids!! That would probably produce a more violent result....



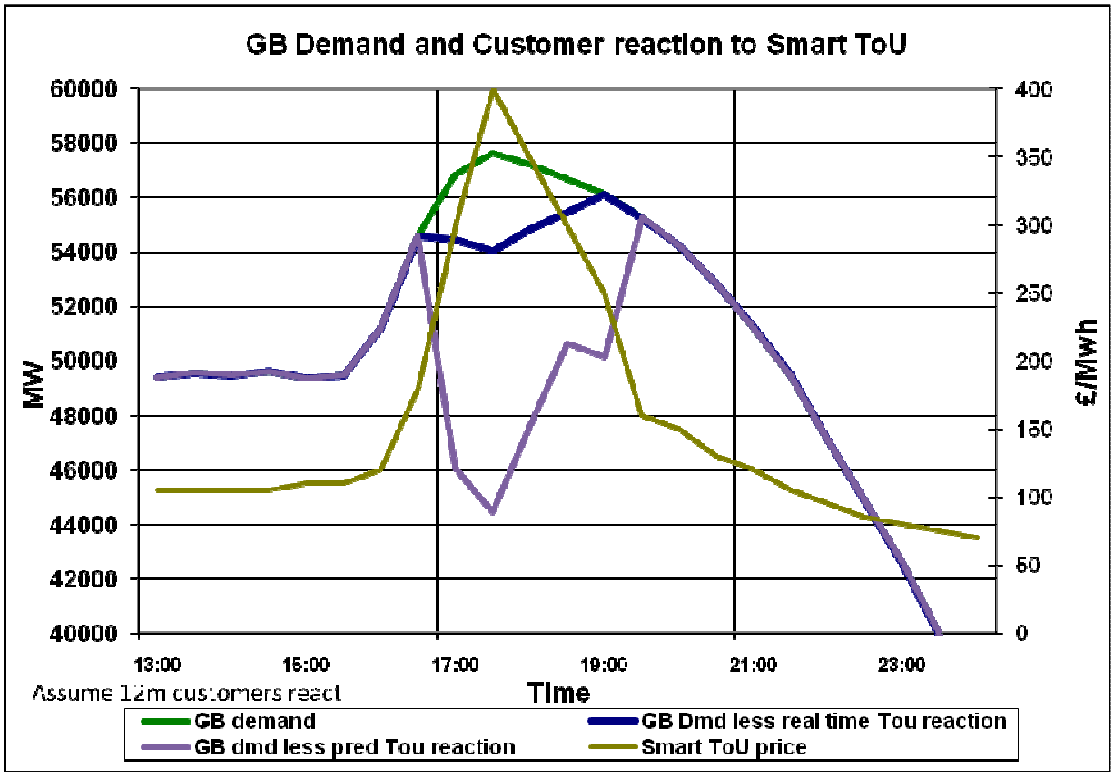
This exercise has been run through with a couple of GB electricity supplier energy efficiency departments; responsible for defining their company's smart meter system. The message that immediately came clear, as you can see above, is that predictive TOU would be much more useful in terms of the level of customer participation. This just reflects the fact that prediction is always vital anyway in all aspects of Power system matching and secure operation.

The ability to send predictive overlapping prices (firm and non-firm time periods) obviously has a considerable impact on meter design.

Extending the dialogue and a look at Impact

The next bit is to explain to the customer 'why the 40p/kWh', why prices vary and also why on the following day the peak price may only be 20p/kWh. Using the GB 'green future' model, the wind didn't blow on the first day but does on the second….. What we can also introduce is the idea that customer can make some income if their HAN is set to interrupt the fridge, freezer and other short duration non-time critical demand to provide reserve. If they have microgeneration installed, the addition of storage may look attractive; also gives them backup for mains failure. What we also need to do is to explain what customer actions are doing in terms of reducing fossil output and improving efficiency. That can be a bit tricky in GB (unbundled utility structure) as we have the extra wholesale energy trading market between the Generating Units and the Suppliers.

And… the '40p' value as a single half hour 'spike' is impracticable and excessive (see my comments above re marginal pricing). It was just included to get the customer thinking about the issue. If we actually sent that price profile out in practice to all customers we would turn the Daily Peak into a massive trough!!



However, if we set a higher price profile right across the high demand period, but without the violent spike at the peak, we would probably 'flatten' the Peak period demand which would reduce short and inefficient runs on main fossil fired plant ...

Artificial Intelligence (AI) in the utility Aggregator/Disseminator mechanisms is important to support the new utility forecasting models. The premises HAN/BMIS/Industrial control needs AI to help the customer tell it what it needs to do so that it can be set up then 'left alone' most of the time??. It would then just produce an alarm when there is a situation it can't handle and it needs some customer input??

What we have also done is to split the Use of System Charge from the Energy charge. The UoS is a simple Power levy based on the customer's Peak Power demand. The HAN can monitor this and warn when the level for the current charging period (could be monthly or quarterly or annually with new metering in place) is going to be exceeded in real time.
This should cause quite a change in behaviour to avoid simultaneous operation of large Non time critical appliances (Laundry, Electric Vehicle charging etc).

Customer Engagement Feedback

The other important thing that needs to come out of the customer dialogue process is a sense of what concerns the customer with all this and how the supplier might deal with those issues. The obvious issue will be whether bills will rise with dynamic pricing, even though such rises might actually be caused by other factors such as normal fuel price movement and/or carbon pricing and other environmental charges. One obvious protective approach at the outset is to apply dynamic price capping or, in the extreme, to set up a standard preset tariff in parallel and allow bills to be based on that if cheaper.

The customer dialogue must be done 'up front' before the system is commissioned; it forms part of the design process for the Smart enterprise of a particular Power system. Power systems can be configured very differently in different areas.

The dialogue needs to be both iterative and interactive with knowledge exchange both ways; that's how we get the Smart Enterprise accepted.

The main thing we need is a flexible design for the two-way Customer premises Smart device and Customer-Utility data framework, (through the aggregator/disseminators to and from the Utility front office systems). For example we could cater for everything up to overlapping predictive ToU tariffs and ‘trading’ of import/export variation blocks for market and ancillary services functions. The latter is already being done experimentally.

And, all this has a considerable impact on meter design and the data framework standards.

Introducing Smart metering - staged parallel tariffs

The main thing the customer is going to be concerned about with the Smart Enterprise is what is going to happen to their bills. To smooth the introduction, new tariff structures should be introduced in stages. At each stage the existing and new tariffs are run in parallel for a time, until both utility and customer have confidence with the behaviour and benefits of the new tariff.

Smart Tariff Introduction Stages 1 to m – Preset Time Period tariffs.

Customer premises Smart devices are installed with half hour Automatic Meter recording, which to be communicated back to utility back office systems, which in turn can handle half hourly prices by customer location for invoicing. There should also be the ability to link the metering and tariff rates to simple electricity monitoring systems within customer premises.

Start with the customers' existing simple one or two daily rate tariff. In parallel, set up a structure with some basic time of day, day of week and possibly seasonal variation patterns.

At the end of each billing period (month or quarter), each customer's electricity charges are calculated on both the original simple daily one/two rate tariff and on the new time varying rates. We allow the customer to pay the lesser of the bills but also ensure that some analysis of their energy use on the new period based tariff is available to them.

Each time the simple tariff would have changed due to normal commercial factors (wholesale electricity price movements, use of system charge changes, introduction of climate levies etc), then calculate the customer bills on both tariff systems as at that change date. Then apply the rate change functions to both tariffs in parallel.

This exercise encourages customers to change behaviour, in response to the period tariff, but still allows them the 'safety net' of their original tariff. It allows the utility to evaluate customer reaction (vital for forecasting in the Smart world) and to gain experience in resetting the period rates if there is serious divergence between invoices calculated on the two tariff systems.

Over time, we would hope to see customer reaction which would give improvements in electricity generation and thus make the period tariff more effective. Also, the customer would hopefully become more comfortable with the preset period tariff and the old simple tariff could be dropped…

Smart Tariff Introduction Stages 1 to m - Preset tariff progression

We then move on by gradually introducing new tariffs with more preset Period of Day, Day of Week, Week of Month, Month of Season and Season of Year rates. The actual data needn't end up encompassing all these options but each change should be aimed on at better getting the 'time' message across to the customer. In each case we keep the previous tariff available in parallel and allow the customer to pay the lower charge.

As we move on, the actual time period structure will depend on the pricing patterns from the generation side. I'm sure there will be nearly as many variants as there are interconnected AC Power Systems in the world.

Here is one example of the progression…

Period of day; say one value for Peak, one for Plateau and one for Trough.

By Day of Week - One set of Peak, Plateau and Trough values for Weekdays, another set for Saturdays and another for Sundays/Bank Holidays .

By Season – One set of Weekday/Saturday/Sunday values for each of Winter, Spring (before and after clock change), Summer, and Autumn (again before and after clock change).

The clock changes (daylight savings time changeover) are important in GB because the demand shapes undergo fundamental change at those times.

So, we are further encouraging customers to change behaviour, in response to each period tariff, but still allowing them the 'safety net' of their previous tariff. This progression again allows the utility to evaluate evolving customer reaction (vital for forecasting in the Smart world) and to gain further experience in setting and adjusting the period rates.

Smart Tariff Stages m to n Dynamic Time of Use Tariff (progress to full Smart)

This time, we gradually introduce Dynamic ToU pricing in parallel with the preset period tariff. Perhaps we just start with Critical Peak pricing (with alarms) and move on from there.

Once again bills are calculated in parallel (this time preset price vs ToU) and the customer pays the lower value. It will probably take some time for the ToU framework to be accepted and managed, especially where price variations between days can be caused by big changes in output from renewables on the generation side. Again, there could be as many different variants as there are interconnected AC Power Systems!!.

One other important thing to remember. Each time you make a change to the customer side, from the installation of new meters through the staged introduction of new tariffs, only do one thing at a time. If, for instance, a major increase in the tariff basis is required (say for the addition of a Carbon pricing mechanism, then do not do that at the same time as you install Smart meters or the customer will associate the consequential bill increases with the meter and not the underlying rate change. Unravelling the objections can cause a lot of extra work for the utility and will delay the effective rollout of the Smart system.

Smart Tariff - split out Use of System

Above, I outlined how the 'infrastructure charge' element could be correctly applied and apportioned and the possible benefits. If this Peak Power based charge were to be split out from the Energy charges, it would send a clear message that high demands are inefficient. In advance of Smart metering, simple monitors which show real time Power consumption are already being deployed (sometimes for free) in the retail sector in GB. So, the customer is already being made aware of their Power consumption in real time and, with Smart metering, this can be used as a vehicle to influence better use of the system. Coupled with the Smart (Distribution-Transmission) Grid, which should be able to increase circuit load factors and limit damage, we can make better use of the existing assets and defer reinforcement.

Splitting UoS and Energy charges is another logical step in the Smart Customer strategy. However, it does change the tariff relationship dramatically. Having said that, in GB we are making the customer aware of their real time Power usage up front by making simple Energy monitors available (sometimes free). The logical progression seems to be to show separately the costs of Power and Energy delivery.

Conclusion

This is just the tip of the iceberg as regards Customer engagement scenarios and the industry. We have the weekday and seasonal effects to demonstrate and also the commercial and industrial sectors to consider; would you turn everything off in the office and go home early in the winter??.

It is the demand less renewables output, less Nuclear and other inflexible output plus/minus Interconnector flows and plus/minus storage which determines the output requirements from flexible fossil plant from which in turn we derive the Smart price profile. That profile of fossil plant requirement can change significantly from day to day where you have a lot of variable output renewables installed (such as GB Big Wind).

There is also of course the concept of trading kW 'blocks' across time with the customer (see FPS 18 & 19), where the resultant customer action can be proved and therefore charged/credited. This usually requires submission of predictive electricity

use profiles from the customer side. What we would be doing is putting a framework in the retail market which is similar to what GB Generators have to do in the Wholesale Balancing (should be called Matching) mechanism. Larger customers should be suitable for this activity, which can also extend to ancillary services provision

Storage is a crucial factor in the new Electricity system with lots of renewables; how that storage is 'positioned', at customer premises or Utility level, is important to how the Smart system will develop.

And, there will be nearly as many plant-demand scenarios and thus different requirements for Smart configurations, as there are Interconnected AC Power Systems in the world!!

For all this to work, the intelligent Customer-Utility Interface (CUI - 'meter' is too restrictive a term) needs to be flexible. In addition there are different ideas on premises metering granularity (15 minute, hhr, etc) and we've noted that 'appliance level' monitoring and control may be necessary. Over time, we would expect the suppliers and distributors (with the SO, TO and the Generators behind them) to develop their customer interface techniques. Different methodologies will be appropriate on different Power systems and even between supplier and distributor companies on the same system; especially where different suppliers target different customer groups.

To enable a creative progression, we need a flexible Standards 'framework' for data content, not just rigid standards, to ensure that the CUI and upstream processing can have new data structures defined as we develop the methodologies for customer participation.

The salient points and a few more ideas looking at the above debate...

1) The change from fixed preset single or two rate daily tariff to ToU has a major impact. Try going in stages via more preset rates (time of day, day of week, season etc).

2) Put up a safety net at each progression with the old and next tariff in parallel. Allow the customer to pay the cheaper at each billing point but try and help them see where behavioural change would make the new tariff more advantageous.

3) Predictive ToU, being sequences of firm then non-firm prices updated at regular intervals, would seem to be more effective in getting useful Customer reaction. This however has a big impact on Meter design and upstream processing. Make the meter (Customer Interface) unit flexible as regards data content.

4) Get the data together for customer reaction vs price (Site Import/export change) from the interface; quite a complex function which varies depending on preceeding

profiles of price level and activity. Use the Smart interface to get intelligence on appliance action.

5) Don't try using raw marginal prices (10x at peak etc) as a tariff signal to a large part of the customer demand base or you will throw the load curve all over the place. That will result in inefficient operation of generation.

Set the price to get the customer reaction to remove just the high price generation.

(P.S I have experience in the area of marginal price signals in getting the big Iterative Generation-Fuel models to converge).

6) What we are aiming to do is to 'flatten the fossils'; i.e. reduce running periods for this plant but also make sure that the remaining fossil plant runs up and down at max rate and is then loaded flat out when on the bars (FPS20). That requirement shape will not necessarily follow the demand curve, especially where large amounts of variable output renewables (e.g. Big Wind) are installed.

7) All the Customer controls need to be automatic; we need good HAN, BMIS and Industrial Control mechanisms with suitable AI to help the customer set up the strategy logic.

8) There is also of course the concept of supplier or operator trading kW 'blocks' across time with the customer, where the resultant customer action can be proved and therefore charged/credited.

9) The intelligent Customer-Utility Interface (CUI - 'meter' is too restrictive a term), needs to be a flexible unit within a flexible Standards 'framework' for data content. This will ensure that new data structures can be incorporated as we develop the methodologies for customer participation. I believe this is the message coming out of the consultation by the GB Regulator (OFGEM). This approach also of course allows 'interoperability' in that the same meter can be used by different suppliers with different tariff and customer trading structures. Thus, if the customer changes supplier the 'interface unit' (meter+++) does not need to be changed.

10) One size will most definitely not fit all. Different solutions will be appropriate on different Power systems and for different customer groups.

11) Don't try making too many changes at once. If, for instance, you increase the electricity price (rate) basis while installing smart meters, the customer will target the new meter as the reason for any bill increases whereas it is in fact the underlying price (rate) increase which is responsible.

12) There is only so much demand you can 'shift' on a particular day. On a GB Winter Weekday the trough can be 65% of the peak demand (due to off peak electrical heating in some areas). There could be more potential gains from weekday to weekend and cross seasonal movements but the latter especially require large amounts of storage. Longer period 'shifts' are even more important when there are

large penetrations of variable output renewables (Big Wind Again) which exhibit multi-day patterns.

13) The installation of Smart metering across the retail sector, coupled with the changes to Supplier back office systems should allow Transmission, Distribution and Balancing Services Use of System charges to be correctly apportioned as an annual levy based on customer Peak power demand and not as an Energy type charge. This would encourage customers to limit simultaneous use of heavy appliances (e.g. dryer + Electric Vehicle charging) and thus stabilise system loadings which in turn avoids major reinforcement and keeps the Use of System charge levels down.