SETTLEMENT ISSUES FOR ADVANCED METERING WITH RETAIL COMPETIITON

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ABSTRACT

Participants in competitive electricity markets need to share a distribution infrastructure. Metering systems cannot allocate all costs with precision, and current allocation assumptions and systems do not reward consumption behaviours that support ambient renewables and demand side participation, both critical to a low carbon Electricity Supply Industry.
An alternative approach – FlowCost metering – does offer rewards for tuning consumption to available generation, and supports a competitive electricity retail market. Its adoption will need electricity retailers to develop sophisticated price setting systems, and settlement systems between players will need to migrate to new residual allocation assumptions that are acceptable to all parties.

INTRODUCTION

The shared nature of electricity distribution infrastructure, along with the non discrete nature of consumption, means that assumptions have to be made about efficient and fair tariffs and allocation of charges to individual customers. Current approaches to this settlement are explored under Tariffs and Settlements.

A key purpose of tariffs is to influence behaviour in ways that can optimise the system and its benefits as a whole. The paper explains in Behavioural Incentives how current approaches do not encouraged the behaviours desirable for anticipated future electricity systems. In particular we explain the need for demand to be rewarded for adjusting the timing of consumption to match available ambient generation.

In Smart Grids and Smart metering the paper explores approaches to implement appropriate incentives or controls, exploring the constraint of metering and their implications. A “top down” approach demands very capable communications and data processing systems.

The Flowcost Approach explains how many of these issues are avoided by meters measuring cost and by appliances minimising their cost by optimising the timing of their consumption. A vision of market based participation by smart demand appliances is presented, and some aspects of the sophisticated trading that electricity retailers can bring to their participation are explored.

Settlement Issues sums up the paper, discussing how participants and settlements might migrate to a flowcost approach. Assumptions about the allocation of some costs remain necessary, and need care, but do not appear to present new or insuperable barriers to the approach proposed.

TARIFFS AND SETTLEMENTS

A broad principle of economic systems is that prices and consumption discovered by competing suppliers in a market will maximise the welfare of the players in the system. Wholesale markets are often bilateral, with prices negotiated between players or via an exchange. Retail markets are generally more efficient with a smaller number of retailers making markets that present prices to large numbers of consumers. Retailers compete both in the wholesale markets, and in the retail markets, where they set prices that consumers accept or shop elsewhere.

Underlying the theory of markets is the well substantiated assumption that competition leads to prices that are related to costs, in particular marginal costs [1, 2] and that this maximises the welfare (or well-being) delivered to society as a whole.

Electricity presents complications over this base model. Firstly consumption is continuous and non discrete. It is sold at a rate, without precision as to volume. So if charges are to be based on consumption (which is assumed to be fair) then it needs to be continuously metered. Secondly, electricity is carried over a shared distribution infrastructure, so neither electricity retailers nor consumers have full control over its use, and have to share costs and losses. Thirdly, electricity as such cannot be stored, so there have to be mechanisms to continuously adjust the balance between supply and consumption, and these have to be paid for. See for example [3].

<u>Current Approaches</u>

The current approaches to tariffs and settlements are based on a wholesale settlement period of the order of an hour - in some locations it is 15 minutes or half an hour, and the settlement price is fixed for that period. The consumption or generation of large participants is metered for this period, and settlement is based the total consumption over the period.

Retail metering is based on longer periods, often a month of more, with the consumption over the longer period (a quarter or month) being accumulated between readings. Meters may include different accumulators for different tariffs, usually by time of day (e.g. off-peak) and sometimes by season, but the meter readings do not distinguish consumption in different wholesale periods. Nor are meter readings synchronised.

This means that the consumption which an electricity retailer has sold in a wholesale period cannot be measured directly. So their liability in the wholesale market is determined by a **deemed** consumption, related to the total metered flows over the entire system, and a set of assumptions about the proportion of the total that the retailer's customers are deemed to have consumed. In the UK (see [4]) these are derived from statistically determined profiles with every meter being allocated to a particular profile. As longer period meter readings become available, the deemed consumption and so settlement is adjusted accordingly.

This leaves the electricity retailer exposed to a number of trading risks. They have to purchase generation in the wholesale market to match their best estimate of their customers expected total consumption in each period. While much of the purchased electricity can be with "block" contracts, covering many periods, they will need to fine tune their position in each period in the face of highly variable prices. If their deemed consumption varies from their purchases, they will be exposed to costs related to their imbalance, incurred by the system operator in keeping the system as a whole balanced, and allocated according to agreed assumptions and rules to the various electricity retailers.

BEHAVIOUR INCENTIVES

Current schemes offer restricted opportunities for domestic consumers or appliances to benefit from modifying their behaviour in ways that move consumption from periods where the wholesale price is high to those where it is low. Their only opportunity is to be aware of the "off-peak" tariff periods, and plan that their appliances and other loads will, as far as possible, consume during these periods.

Neither do electricity retailers have opportunities to fine tune demand to match their purchases. Their control is over their purchases of generation, and trading advantage from longer term forecasting, not over their deemed consumption. Generators, on the other hand, can adjust output at short notice, and so can gain from short term trading with the system operator, who has responsibility for balancing the system as a whole, and can contract for changes within the each settlement period. In the UK, electricity retailers are generally associated with generators so that both parties can hedge their risks with each other, and much of their wholesale trading is internal. Independent electricity retailers have only limited niche markets.

Current schemes has proved reasonably satisfactory in newly competitive markets where generation is central and despatchable and the aggregate load changes in reasonably predictable ways (time, weather, day of week, season, etc.) Competitive retail markets have operated, and consumers have been offered choice. However, the relationship between domestic tariffs and wholesale costs is not transparent, and tariff and price changes remain politically sensitive.

Systems expected to absorb increasing proportions renewable generation where output is dependent upon ambient conditions (wind, wave, solar etc.) fare less well. As well as being variable, ambient generation also varies in how far ahead output can be forecast. Tidal output is predictable over astronomical timescales. Wind, wave and solar are predictable for 24 – 48 hours ahead, particularly if the supply is diverse, and one hour ahead can be fairly precise, although still subject to uncertainty in some circumstances. Imprecision in forecasting adds risks that need to be managed by rapid trading.

Looking ahead to high penetrations of such ambient generation, it is clear that the demand side will need to participate in the trading and balancing. If we can harness it, there are many existing and potential uses of electricity where the time of consumption can be varied to match supply. Many appliances, such as dishwashers and laundry machines have flexibility, within deadlines, as to when they consume. If hot water is heated by electricity, this can be stored for many hours with small loss, and there is the substantial potential for electricity to feed an electric vehicle transport fleet, which may have storage for several days of normal use.

SMART GRIDS AND SMART METERING

One approach to greater demand participation is to centralise control of the distributed resources. That is, to connect the various devices and appliances to a shared hierarchical control system which can then arbitrate between the various demands and match the total consumption to available generation? In the case of domestic users, for example, various discounted tariffs are offered to compensate for the reduction in the end users autonomy and giving the central system the right to control consumption. The customer accepts the risk of postponement or denial of use by the utility in return for a discount.

Although useful for some specific services, such as peak chopping, such schemes are not popular, and are meeting resistance from consumers. How can a remote utility really take into account the needs and interests of so many consumers and so many kinds of appliances and devices?

In addition, they impose substantial communications overheads. A rapid, two way, secure communications channel needs to be established between the centralised control system and every participating consumer premises and appliance. This is needed both to control the appliances, and to collect consumption information that can be used in the settlement. While internet services are a clear candidate for this, there are some difficult technical and cost allocation processes still to be defined and agreed between many parties.

Another approach is to rollout metering to match the shorter periods of the wholesale markets. Then the consumption of each consumer in each wholesale price period can be accurately metered. An electricity retailer can then offer price incentives to consumers to shift consumption to lower price periods, and so avoid exposure to aberrant wholesale price periods.

Three problems with this approach remain: The volume of readings, tariff boundaries and scheduling.

Volume of readings

Much larger number of readings to be passed from the consumer premises to the central settlement system. A single monthly reading converts into some 730 hourly readings, with associated increases in billing and settlement computation burdens. The increase in the value of the electricity is essentially unchanged, so the value of reach reading transaction is reduced almost proportionately.

It is also far from clear that (say) hourly readings are the most appropriate. In electricity systems crises that arise need to be addressed within seconds. If, for example, a generation plant fails, then a sound market price would reflect the change in the balance between supply and generation within a minute or two. This would reward reserve generation that is able to come on quickly and demand that reduces to avoid the unexpected high price. This suggests that periods substantially shorter than the wholesale settlement periods would enable prices to more closely reflect the state of the electricity system. Yet, with current metering approaches, any shortening of the period also substantially increases the communications and processing burden. The choice of period becomes a fraught compromise between communications costs and desirable trading.

Tariff Boundaries

Risks arise at tariff boundaries. If large numbers of systems simultaneously see a significant change in the cost of consumption (or the price paid for generation), then they may well react similarly within a very short time. Such shocks to an electricity system present very significant reliability risks. Within UCTE, variations in the system frequency are greater just after the hour than at other times [5], and it is perhaps no coincidence that the big UCTE disturbance in November 2006 arose shortly after the hourly rescheduling. [6] The ideal is to have a continuously variable price so with no discontinuities. It seems likely that a granularity of some 10 seconds would be adequate for foreseeable needs.

Scheduling

Optimising the consumption of devices generally requires planning. If a dishwasher is to minimise the cost of a wash, for example, it can best do so if it can see the price it will expect to pay over the time ahead. In this way it can schedule its various sub-tasks to meet a set deadline, minimise their cost and avoid wasteful or harmful interruptions – some sub-tasks may carry significant penalties if interrupted. If it is charging the battery of a vehicle, the scheduling is less critical, but the cost benefits of optimisation greater.

THE FLOWCOST APPROACH

The Flowcost approach aims to resolve the conflicting needs of an ideal tariff: **Predictability**, so devices can plan; **Flexibility** in the light of changed electricity system circumstances; and **Continuous variability**, so no risky shocks can arise.

Expected Future Price Curve

The concept is for electricity retailers to broadcast parameters that define an expected future price curve. The parameters would include repeating elements, encoding, for example, expected daily or weekly variations, so that, should reception be interrupted for any reason, the receivers would have a reasonable curve to fall back to.

The FlowCost Meter

The FlowCost meter captures the most recently broadcast price curve from an electricity retailer and derives from it the current price. The consumption in this 10 second (say) period is then multiplied by the price to calculate the cost of consumption, and it is this cost that is accumulated in the meter. The meter in effect does the billing calculations. For audit purposes, it may also accumulate the consumption. In this way, the approach does not require communications capability any greater than for reading current meters (although such communications remain helpful.)

Appliance Planning

The future price curve is also made available to smart appliances, which can then use it to plan consumption at minimum cost. The key decision for a consumer is the deadline to set the appliance or device, and the cost implications of their choice are visible when they do so. They will, in general, be able to choose between urgency or lower cost. but can also set policies about what to do about changes in the price curve.
When it comes to charging battery cars, the decision may be more complicated, depending upon the charge likely to be needed at the deadline. If price is particularly high, a driver

might be willing to make short journeys with less than a full charge, and postpone charging until the price is lower.

Some Sophistications

A flowcost meter may have further features to enhance competition and give a consumer greater choice: Multiple Broadcast Reception; and Fixed Price Contracts

Multiple Broadcast Reception

If a flowcost meter is in an area served by more than one electricity retailer, the FlowCost meter can receive broadcasts from each of them, and choose the cheapest for their expected pattern of consumption. So there would be a very real need for the electricity retailers to keep prices keen, although, no doubt, they would place a premium on a consumers account that has this flexibility.

Fixed Price Contracts

An electricity retailer needs the flexibility to change their price curve at any time, to reflect changing supply circumstances. However, this flexibility could be exploited for example by encouraging devices to postpone consumption, and then increasing the prices closer to common deadlines. However, an appliance and a flowcost meter could negotiate a fixed price for a particular consumption profile, and so hedge this risk. Undoubtedly, some premium would be chargeable for this.

Market Making

The profit opportunity for electricity retailers is significant. By trading in the wholesale market, and being able to influence the demand of their customers by price, they will have much greater flexibility in trading, as well as being able to offer their customers lower total costs. They will be able to match demand to variable generation, and so will be able to offer better prices to renewable or distributed generators (including, often, their own domestic customers).

This will need greater sophistication in their trading activities, and in understanding the demand elasticity that their changing price will encourage.

Of course, they will continue to maintain the account relationships with their customers, but much of the billing computation will be passed to their customers' meters. A rich new world of tariff opportunities opens up.

SETTLEMENT ISSUES

The vision of such active, market oriented participation by consumers and their appliances is an attractive one. The electricity supply industry can avoid the costs of reserve capacity that are used only rarely, relying instead on variation in demand to keep the overload more level, and more closely matched to renewable resources. Fuel based plant can be scheduled without the constraints imposed by keeping reserve available, so improving overall efficiency. Customers can benefit from the lower prices from improved markets.

Despite these attractions, there will be some residual uncertainties arising from the shared infrastructure. If the electricity flowing at any one time, it will not be possible to attribute it all with precision to the customers of each electricity retailer. Most of the time, this will be too small to be relevant, but, during times of volatile prices, the information from the meters might leave scope for settlement dispute between electricity retailers as to their liabilities.

We do have time for thorough debate on how best to address this, as early introduction of flowcost concepts metering will be into niche markets, with adventurous suppliers developing innovative products and negotiating arrangements with current settlement systems. It would be a shame if rigidity in the settlement schemes proves a barrier to this innovation.

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