Smart Metering

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The Fiendishly Complicated United Kingdom Enduring Deployment of smart meters hit a problem earlier this year when the Government introduced a twelve month delay. You might have expected the Government would have put some real effort into reviewing what had gone wrong. If they had, rather than accepting bland platitudes, it would have become clear that the program was out of control. Under the surface, too many cooks had ratcheted up the technical complexity to the point where it is no longer fit for purpose. As a result, it's lining up to be the next major Government IT disaster. However, no-one seems to want to point out that the Smart Metering Emperor is stark naked.

This report looks at what has gone wrong, turning a British lead into something that will deliver nothing except even higher energy bills for consumers.

Nick Hunn
WiFore Consulting

nick@wifore.com
+44 7768 890 148

Smart Metering is FCUKED

Executive Summary

Having delayed the Fiendishly Complicated United Kingdom Enduring Deployment[1] of Smart Meters earlier this year because of technical delays, you might expect that the British Government would have spent some time reviewing the technology they had mandated. If they had done so, it would have become clear that the program was out of control. Under the surface, too many cooks have ratcheted up the technical complexity to the point where it is no longer fit for purpose. However, it appears that no-one wants to point out that the Smart Metering Emperor is stark naked. That's largely because those overseeing the programme don't have the depth of technical knowledge to understand the implications of what is going on.

As always with big Government driven IT programs, whilst there's money to be made by the metering industry and consultants, momentum rules. It seems perfectly justifiable to carry on and saddle consumers with a £12 billion white elephant which will further inflate domestic energy bills. As a result of this lack of due diligence, smart metering is firmly on course to be the next big UK Government IT disaster.

It's not that there's a fundamental problem with smart metering, but there are massive mistakes in the way that the UK has decided to do it. When the programme started, it was seen as world-leading. It should have set a global standard for smart metering, giving UK plc a commanding lead in exporting expertise to the rest of the world and creating long term employment opportunities. Instead it has resulted in an out-dated, over-complicated system which will be incompatible with any other solution in the world, cost more than any other, fail to deliver the promised customer benefits, add risk to our energy security, threaten jobs, further alienate customers and make the UK energy industry a laughing stock.

If we look at the issues, the GB smart metering program appears to have a unique capacity not just to duplicate major errors from previous Government disasters, but to combine many of them into one overarching Government- destroying fiasco.

There is a parallel with other UK Government led IT disasters, where a focus on the overall benefit obscured the failures of the underlying technology strategy. The NHS spine is a good example. Nobody denies the benefit it could have delivered had it worked. Smart Metering appears to be a close cousin, where there is a major disconnect between the strategy and the implementation. As with the NHS Spine, those at the top failed to comprehend that the underlying technical detail was out of control. In both cases, the specifications lost sight of the benefits and users of the system. Government departments, working way beyond the limit of their technical knowledge allowed vendors to introduce arbitrary new features.

The same pattern is apparent with smart metering. Unsupervised specification creep allowed has allowed utilities and vendors to play a game of technical one-upmanship reminiscent of schoolboys competing to see how high they can pee up a wall. In a further twist, nobody appears to be asserting long term ownership and control of the GB metering

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[1] It is technically the GB deployment, as it doesn't cover Northern Ireland. That in itself is a strange decision, as it leaves Northern Ireland as a no-man's land between the GB mainland standard and the incompatible IP based approach of Southern Ireland. FCUKED seemed a particularly appropriate acronym for the GB deployment.

specification, allowing it even more scope for constant change, largely defeating its purpose of defining an interoperable standard.

As with the NHS, many within the industry are only paying lip service to the programme. Most utilities don't want smart metering. In fact they seem to have used the wrong dictionary. It is difficult to find anything smart about the UK deployment, until you realise that the utilities use smart in the sense of "it hurts". They consider they have a perfectly adequate business model which has no need for new technology. In many Government meetings, their reluctant support seems to be a veneer for the hope that it will all end in disaster, letting them go back to the world they know, of inflated bills and demands for money with menaces. That brings back another parallel with the medical profession's quiet but relentless opposition to the Summary Care Records scheme which eventually brought it to an ignominious end.

Even when smart meters are deployed, there is no evidence that any utility will use the resulting data to transform their business, rather than persecute the consumer. At a recent US conference a senior executive for a US utility which had deployed smart meters, stated that their main benefit was "to give them more evidence to blame the customer". That's a good description of the attitude displayed by our utilities.

The other challenge is the eternal one of calculating the financial benefit. Whilst everyone expects Government projects to overrun and under-deliver, smart metering takes this to a level which makes the HS/2 assessments look like models of financial prudence. Successive analyses have shown no net benefit, so DECC has made up illusory benefits in an attempt to justify the smart metering deployment. Each of these has needed more unproven technical complexity to be incorporated into the meters to deliver the benefits, making the overall cost uneconomic. So the cycle is repeated until a set of make-believe benefits can finally be submitted to gullible Ministers as firm returns for the programme. Alex Henney – an industry veteran who has charted deregulation and the rise and demise of competition within it, summed up the case as, "civil servants have cooked the numbers to come up with a net benefit" [1]. Many agree with him. Taken together it's repeating the classic failure cycle of a changing specification leading to conflict and more change, while driving costs out of control and causing deadlines to slip [2]. In 2012, a Cabinet Office review gave the project a red light and recommended it should be abandoned [3]. DECC drove through the light and carried on.

There is an obsession to make "smart" meters do things which are far better done over other channels, such as demand response and consumer engagement. But because the industry is so technically backward, it's picked an architecture that is several decades out of date and which cannot deliver the information in the way which customers want. Today consumers have smartphones. They want the same sort of smart experience from their utility. Instead they're going to get a retro '70's technology experience, whilst paying twenty-first century prices for it. It's a back to front world, where utilities are leading the Government down a path that it and consumers will regret.

It is becoming more urgent as consumers scream about the current cost of energy bills and trust in utilities is at an all-time low. The current plan will not deliver short term savings; instead it will see energy bills rise still higher. That's a toxic legacy for any Government. The party in power when the smart metering bubble bursts will probably find itself unelectable. There is still time to address this, but the current blinkered approach from all concerned is fast driving us past the point of no return.

The European Mandate

The reason we're where we are derives from a gung-ho interpretation of a European ruling by the previous Labour Government when Ed Milliband was Secretary of State for Energy and Climate Change. His over-reaction was supported by Chris Huhne when he took over as Lib-Dem Minister in the Coalition and was further endorsed without any real scrutiny by the Conservative Charles Hendry. Hence all three parties carry an equal responsibility for its sorry state. What is commonly called the "European 20-20-20 Agreement" [4] was a symbolic piece of marketing spin, where EU leaders got together to promote a snazzy slogan with the mission statement of generating 20% of our energy from renewable sources by 2020, simultaneously reducing Europe's CO_2 emissions by 20%.

The target is largely marketing hype, designed to allow European leaders to look smug whilst other countries continue massive expansion of coal fired power stations [5], making Europe's posturing effort insignificant. All it does for the European consumer is to make them bear the cost of renewable energy before it is mature, so that politicians can claim that they are helping to save the world. It is the factor behind the "green levies", which are hurting UK energy consumers by giving uneconomic subsidies to anyone who's prepared to stick their snout into the feed-in trough. In essence they're a costly sticking plaster to cover up successive political delays in making any decisions about a proper long-term energy strategy. How Ministers are going to convince consumers to pay an additional smart metering levy on top of this from 2015 is a mystery. Particularly as for most consumers this increase will appear on their bills long before meters appear on their walls.

Despite what is often claimed by our politicians, there is no firm mandate for smart metering within the 20-20-20 directive. The directive only encourages the introduction of smart metering "*where economically reasonable and cost effective*" [4]. Back in 2007, the consultancy Mott MacDonald performed an appraisal of the costs and benefits of Smart Metering in the UK for BERR [6] and concluded that it has a net present value of minus £4 billion. That inconvenient piece of data was ignored. Germany has just come to a similar conclusion about the costs and walked away from a smart meter deployment [7]. The degree of technical creep in the GB specification means that the cost of the metering equipment within each home has almost doubled from what was anticipated in the Mott MacDonald report, from around £75 to £143. This has added an extra £2 billion to the deployment cost, making it difficult to see how the current GB deployment can have any hope of being cost effective. Moreover, the complexity of the architecture and technology, accompanied by an untried specification, means that it is very difficult to claim that the planned deployment is "cost effective". It is high risk for the sake of high risk, with little attention to the benefits or an understanding of those risks. So it fails the EU Commission's criteria for smart metering deployments on both counts.

The Background to Smart Metering

The concept of smart metering is simple. It's been around for many years in the form of Automated Meter Reading (AMR), where a meter returns a reading of the energy used to your energy supplier every week or month. This can theoretically save a supplier money in three ways:

- Saving the cost of meter readers (although they still need to visit every few years for safety checks),
- Saving money from disputed, estimated bills, and
- Saving money by identifying and preventing energy theft.

If there were a stand-alone economic benefit for smart meters, utilities would have already deployed them. However, deployments have only happened where there are exceptionally high meter reading costs due to geography (Scandinavia), or massive levels of theft (Italy). Elsewhere smart metering has not been shown to be cost effective. It has only been deployed where Government or local regulators have allowed the cost of deploying and running a smart metering infrastructure to be passed on to the consumer, allowing utilities to install them for free.

In the US and Canada, utilities which have deployed smart meters have publicly stated that their only value has been in detecting illegal cannabis farms [8]; hardly a good reason to blow £11 billion on a national deployment. Surprisingly it's about the only benefit DECC have not factored in.

Because the sums don't add up, organisations like DECC have had to conjure up new, illusory savings. The effect of this is to increase the technical requirements on the meters, leading to a smart metering system that is vastly more complex than the already unaffordable AMR solutions.

Turning Accepted Learning on its Head

The basic principles behind smart metering have been tried and tested in other industry sectors using the well established machine-to-machine (M2M) model. You start with a simple measuring device or sensor (the meter) which periodically sends the data it has measured to the cloud or a central server, which then acts upon the data it has received. The key thing that every industry other than the energy sector has learnt is the benefit of the inherent asymmetry of this model. You make the measuring device simple, because it's cheap, reliable and is easy to make secure, and you put the complexity at the server. It's an approach which minimises the cost of the overall system, as you have lots of cheap meters and a few expensive servers.

To understand why the proposed British deployment has gone so wrong, you have to recognise that the utility sector is one of the most technically backward of any industry. It is an industry with practically no knowledge or expertise in wireless protocols, M2M architecture, big data, data security or data analytics – all key components of a viable smart metering system. Its internal IT systems are archaic, as are many of the staff running them. Faced with the perceived complexity of smart metering their reaction was to throw any M2M learning aside. Their priority was to avoid the hassle of installing up-to-date servers and applications – they just wanted a quiet life until retirement.

This reticence for change at the head end is made apparent in a response to the recent Government consultation on the latest version of the Smart Metering Equipment Technical Specification (SMETS2) [9]. In it, the industry reiterated its opposition to following the accepted M2M paradigm, stating that the "costs of back office data retrieval and processing were likely to be significant". The estimated costs ranged from around a million pounds to

close to a hundred million pounds. The spread of estimates is worrying by itself – it implies little knowledge of what they're trying to do. Against the overall smart meter deployment cost of £11 billion, these figures represent between 0.01% and just under 1% of the total cost. Both estimates are insignificant in the overall budget.

Despite the minimal cost of doing it correctly, the fear of updating its IT infrastructure led the industry to turn the M2M model on its head, insisting that any smart complexity required had to be built into every meter, allowing utilities to go on tending their simple, outdated mainframe servers. For them, complexity and cost elsewhere was fine – it was someone else's problem. The important thing was that nothing impinged on their IT systems.

Every other major industry made the move from analogue to digital operations years ago, embracing data and benefitting from the business transformation which comes with it. But our energy utilities turned their back on this approach, preferring to deploy an outdated system that increases the cost of consumer bills rather than facing the prospect of migrating to a 21st century IT system.

Compounding the Mistakes

This back-to-front approach of making meters complex and the servers simple laid the framework for technical architecture mistake to follow technical architecture mistake, building an ever larger and more unstable house on foundations of sand. This first error was rapidly compounded by a second fatal flaw, when DECC decided that meters should be rolled out by energy suppliers, rather than the Distribution Network Operators. It was a purely political decision, of the sort that consigns projects to the scrap heap. The only other country to have made this choice is New Zealand, which subsequently onserved that "costs were higher than budgeted and benefits much lower".

The flaw which results from this decision is rather subtle, but inserts its tentacles into every aspect of the smart metering architecture. When a customer switches supplier, which is something the Government actively encourages, their meter must continue to work with the new supplier's network. This means that all meters must be interoperable. That may sound easy, but it's not. To complicate matters, each energy supplier is allowed independently to purchase meters from any supplier who claims that their meter is interoperable.

To try to ensure the required level of interoperability, the Government did two things. It decided to develop its own technical specification to define how meters would work (of which we'll hear more later). It also created an entity called the Data Communications Company or DCC which is a central body that would take data from every meter and pass it to the relevant energy supplier. The wireless connections to each meter are provided separately by one of two consortia of Communications Service Providers who supply an interoperable communications hub fitted in every home. These hubs contain two wireless links – a long range one to the DCC and a short range one to the electricity and gas meters.

This is a level of complexity far in excess of any other country's smart meter roll-out. Everywhere else, meters either connect directly to the Distribution Network Operator or to a monopoly energy supplier. They do this by building a simple (and cheap) radio into each electricity meter. Here in Britain, DECC has specified the additional complexity of a

communications hub in every home to connect the meters. Note that meters is in the plural, as that's another important difference. The GB deployment is the first major programme to extend smart metering to gas as well as electricity. This introduces another unknown set of costs and benefits, as well as bringing in some serious technical constraints, most notably the absence of a power supply for a smart gas meter. It means any wireless technology in the gas meter must be capable of running off a battery for up to fifteen years. That's very difficult to achieve and has forced some very limiting technical choices onto the radio standards used across the whole deployment. The inclusion of a gas meter, which most other deployments have omitted, has effectively become the technology tail wagging the British smart metering dog.

As Mott MacDonald's report pointed out, this complex model of smart metering is not cost effective. To address this, DECC needed to find some way to turn the report's conclusions around and justify the business case. To do this they followed the suggestions of a report [10] by Faraqui of Brattle – another energy consultancy. In it, Faraqui confirmed the view of the Mott MacDonald report, estimating the EU-wide cost of smart metering at €51 billion, whilst the resulting benefits would only be between €26 billion and €41 billion. That left a gap of between €10 billion to €25 billion. In an attempt to fill this gap Faraqui proposed using smart meters to allow the introduction of dynamic tariffs. He argued that by charging more for electricity at times of peak demand, generation costs could be reduced, providing a new "virtual" benefit.

Faraqui's dynamic tariffs are what are more commonly known as Time of Use (ToU) tariffs, where the cost of a unit of energy used by a consumer varies at different points in the day. They're not new – the well established Economy 7 and Economy 10 are simple ToU tariffs, which provide cheap off-peak energy. Faraqui's innovation was to extend these price changes to hourly intervals throughout the day. Rather than using them to encourage the use of cheap off-peak energy, they'd be used to increase its cost at times of peak demand, setting prices at levels which could persuade consumers to change their energy use behaviour.

For the scheme to work, consumers would need to be able to see what was being charged at any particular time. As nobody believed that users would go and stare at their smart meters, DECC concluded that the GB deployment would need to supply an In Home Display for every home, which users could move around with them to see the meter's calculation of consumption and cost in real time. That decision added another £450 million to the cost of the deployment.

What is not generally appreciated is that the cost of energy which these IHDs provides is unlikely to be the same as the cost on the bill. That's because the billing servers within the utilities include lots more information in their calculations, such as built up credit, dual fuel savings and a range of other discounts. Hence displays come with a caveat that "the displayed cost is for indication purposes only". If an M2M model had been used, consumers would have access to the current cost from the servers, not an estimated one from the meter. Those arguing that smart metering is an end to estimated bills are only partly right – they're taking one step back by giving users estimated display values.

Once users knew they were being targeted with draconian rates at peak times, DECC assumed they would change behaviour and move their usage to cheaper periods in the day. Hence, DECC calculated a massive cost benefit to the programme by extrapolating this to savings in generation capacity as a result of consumers saving energy at peak times. (We'll

look at the validity of those assumptions in a minute.) Incidentally, although there is no evidence that electricity savings models can be replicated for gas, as central storage of gas makes gas ToU tariffs irrelevant, DECC added them into their benefits equation anyway. Utilities didn't object. With doorstep selling banned, they were anxious to find another way of manipulating their customers. For them, smart pricing was a very attractive endgame. Once again, their definition of smart would hurt.

DECC's third mistake was to forget the M2M model once more and decide that the information displayed on the IHD should come directly from the smart meter rather than from their servers. Having made that decision, it demands the use of a secure, wireless Home Area Network (HAN) which can connect displays to meters. So not only do meters need to be interoperable, but every model of meter needs to be able to talk to every model of IHD, which all need to be able to talk to every communications hub, which leads to thousands of combinations of devices, all of which will need testing. That's necessary if you want customers to switch supplier, as if any of these items is replaced or changed they still need to work perfectly together. That meant that DECC needed to find an interoperable wireless standard for this new HAN requirement.

The EU Directive [4] was clear that member states "shall ensure the interoperability of those metering systems… …and have regard to the use of appropriate standards". Earlier this year, the Council of European Regulators admitted that Europe still lacks a common standard for smart meters, as well as having a lack of interoperability [11]. This didn't stop DECC from selecting ZigBee, a wireless standard which had been built into many American smart meters. Unfortunately they only appear to have read the PR for ZigBee rather than testing the technology. For the UK it is far from "appropriate" and proving unfit for purpose.

ZigBee and the Smart Energy Profile

ZigBee is a wireless standard which has been around since 2003. Its key selling point is its mesh networking capability which has made it relatively expensive and complex. Where mesh technology comes into its own is in extending range, as messages can hop from one ZigBee node to another, covering a much larger area. However, to achieve that you need to install multiple devices within a space, each costing between £15 and £100 which increases cost and makes security more difficult to control.

Because of these practical considerations, ZigBee has struggled to find a market over the ten years of its existence. It has not been helped by the fact that Bluetooth and Wi-Fi have been accepted as the wireless standard within phones and laptops, leaving ZigBee chasing specialist niche markets. Whilst Bluetooth and Wi-Fi ship in the billions and hundreds of millions every year, funding massive development efforts, helping to make them more robust and driving cost down, ZigBee has largely been the plaything of academia. It is incompatible with any mobile phone, PC or laptop, nor is there any likelihood that it will ever be incorporated into any of them. This means that smartphones and tablets will never be able to talk directly to any ZigBee smart meter, which is a serious omission for a standard that is meant to be used to enhance consumer engagement.

ZigBee's break came when it persuaded a number of US utilities to adopt it for their smart metering roll-out, developing the Smart Energy Profile 1.0 (SEP 1.0). Ironically, despite ZigBee's differentiating feature of being a mesh, these meters generally didn't utilise it.

Instead they use ZigBee to support a direct link to an In Home Display or an HVAC controller for demand response.

It is worth pointing out that Bluetooth and Wi-Fi did not put much effort into winning this market. They viewed the global smart metering market, which constitutes around 75 million chips a year, as insignificant compared to their current markets, which total in excess of a billion chips per year. That is an important point to realise, especially when small local markets, such as Britain, decide to develop their own variant of smart metering specification. The volumes involved are so small compared to other wireless opportunities that most chip manufacturers will not be interested in supporting them. Many involved in managing smart metering programmes fail to realise that it is the chip companies who do most of the work in writing the wireless and SEP specifications, as well as implementing the smart metering and wireless protocols within their chips. Meter manufacturers and utilities do not have this expertise – they merely take and use what they are given.

The size of a market such as Britain is not that large – we are only putting meters into 30 million homes, spread over seven years. It costs each chip company around $10 million to develop a new chip and protocol stack. If the specification keeps changing, as it is in the GB case, these companies quickly find the market uneconomic and walk away. As they do, fewer competent people contribute to or review the specifications. They become progressively poorer quality standards, with an increased risk of security holes. More worryingly, the standard faces the prospect of early obsolescence, as chip vendors may decide the market is no longer of any commercial value. The last point is important. Meters traditionally have a life of 25 – 35 years. A ZigBee chip has a much shorter life. A chip and protocol stack bought today will not work with one bought four years ago. Neither of them will work with one bought four years before that. This discrepancy in product lifetimes seems to have been ignored. ZigBee standard obsolescence rates are currently considerably shorter than the duration of the GB deployment, let alone the working life of the meters. If we have to replace meters every five years because the technology becomes obsolete, it will add another £16 billion to domestic energy bills.

Although ZigBee chips have been incorporated into around 40 million meters, most have never been used to make a connection. The current estimate is that only around 50,000 meters actually use the ZigBee link and these are using the most basic features of the standard. Effectively, SEP 1.0 is still an untried standard and is already illustrating shortcomings that need to be addressed. It is generally acknowledged that the current frequency agility scheme, which protects it against interference from Wi-Fi does not work. There are open issues with Over the Air (OTA) upgrades, which will be needed for updating smart meters, and the current tunnelling protocol has shortcomings for end-to-end security, which the GB specification requires. None of these are unusual for a wireless standard at this stage of its development – it's only when large numbers of first generation products are deployed that these issues become apparent and get rectified. However, it indicates ZigBee's lack of maturity. These problems are fixable, but the process of fixing them and ensuring they are robust will take 3-4 years, once deployment starts in earnest. Today they're only just emerging and being discussed.

Those in charge of the programme seem to think that the GB version of the ZigBee SEP standard is complete. Sadly it is not. The SEP 1.0 version of the specification used elsewhere in the world exhibited problems and was followed by a version 1.1 to fix them. The UK Government and industry should have stopped at this point and worked to fix any remaining bugs. It did not. SEP 1.1 did not support some of the fancy new features that

DECC required to make its business case balance, so it was updated to SEP 1.1b and them to SEP 1.1.1. As the lack of ownership allowed participating companies to introduce specification creep, this was discarded to be replaced by an even more complex SEP 1.2. That version is still not complete and work is continuing on it. However, a recent security review decided to change the end-to-end security model, which means that even when complete, SEP 1.2 will not be usable. Instead the specification group needs a further revision – SEP 1.3, in order to meet the SMETS2 requirements. That specification is unlikely to be complete before the end of 2016.

Revisions of this level of complexity normally take 18-24 months, then need a few years of deployment to settle down, as each version inevitably introduces a few new bugs. This time frame is typical when there is a global effort to write the standard, followed by a global deployment providing sufficient scale to help identify issues. The GB team has gone down a route which is specific to the British deployment, so will fail to benefit from this process. It has meant that the specification has been rushed through and comparatively poorly tested or peer reviewed. Those working on the specification constantly complain about issues with interoperability of the features, including security and the all-important Over the Air upgrade mechanism. It is telling and worrying that test events at this stage are still described as Proof of Concept events.

During this process, energy suppliers have put off deploying smart meters, as they do not want them to become stranded assets. Unfortunately that means there has been no volume of devices supporting these interim versions, which in turn means there has been no chance to discover bugs within the field. Because of that, by the time that SEP 1.3 is completed and deployed, it will have three new generations of bugs built into it.

As the first few GB meters are installed, these new problems will inevitably surface. If we compare the evolution of other wireless standards, a realistic date for the GB specification to become mature, fixed and robust is around 2020. In other words, over £11 billion will have been spent before we discover whether the specification is fit for purpose. Other wireless standards cope with this process because they acknowledge that early adopters will replace products every few years. That generates the volume and experience to design the next generation, with the old products thrown away. Nobody expects meters to follow that route – they are expected to work on the day they're installed and keep on working for twenty years or more. That's equivalent to imagining that everyone would only ever buy one mobile phone. It's sobering to consider that a third of current UK meters were installed before the advent of the World Wide Web and around 5% before the first PC. No other wireless product has lasted a fraction of that time, even when the best engineering brains have been designing them. To expect that GB specific smart meters, largely designed by wireless novices, will buck that trend is pure fantasy.

Incidentally, ZigBee has been plagued with patent infringement issues. As a fairly recent radio specification, it has inadvertently used technology which is owned by a variety of other companies. The few companies which have deployed any quantity of ZigBee products have been taken to court for infringement – a fate likely to befall those supplying products using the GB specification. It's another additional cost that DECC has ignored.

Because those overseeing the programme are not au fait with technology and in many cases not even early technology adopters, they blissfully unaware of this cycle of maturity. People who never buy personal products until they are stable rarely experience the first decade of issues as wireless standards settle down. Since those in control and many managers in the

utility sector lack that experience, they have no idea of the level of immaturity of the products they are planning to roll out.

How we got here - Enter the Technology Muggers

DECC is not the only culprit in bringing the GB smart metering standards to the disastrous situation we have now reached. They were ably assisted by our utilities, meter manufacturers and chip companies – the latter desperate to find someone who would buy their ZigBee chips. It is instructive to go back and look at how, between then, they set the programme up to fail.

Back in 2008, Britain was looked on as a leader in the energy supply market. We were one of the first countries to deregulate, since when the six major suppliers engaged in aggressive strategies to use switching for customer acquisition. This culminated in a peak of almost 30% annual switching. It was a period of surprising arrogance for the UK energy companies. Many utilities around the world looked on admiringly, not least at how well our energy suppliers were managing to hoodwink the regulator and mis-sell to consumers.

With the announcement of the GB smart metering deployment, that admiration grew. The prospect of a system that would allow consumers to switch on an almost daily basis was and still remains unparalleled. The system also gave suppliers the ability to turn every meter into a pre-pay meter at no cost to themselves.

When deregulation was being put in place in UK in the early 1990s, despite prior assurances to the contrary, the number of customers moved to a pre-payment meter soared. Official numbers usually ignore self-disconnect, where users deliberately let the meter cut off as a way of budgeting. The Consumers Union calculated that if self-disconnects were included, disconnections with prepayment meters soared from 48,000 cases prior to deregulation in 1991 to 912,000 in 1998 [12]. Whatever the true figure, the industry secretly hoped that smart metering would allow them to perform the same trick again. It gave the prospect of a future where customers were either eternally in credit, or else automatically switched to a pay-as-you-go tariff. Either way, the energy supplier won. Customers could be milked using impenetrable ToU tariffs, pushing up bills under the guise of energy security. Utilities could blame the increases on the failure of successive Governments to come up with a credible energy generation strategy, hopefully deflecting criticism from themselves.

After years of largely academic debate about how to put all of this into practice, British Gas made a pre-emptive move in 2010 by pushing its own specification for smart meters [13]. This was prepared at the height of doorstep selling. It openly states that it's designed "to support future tariff development". Some of those behind these specifications have suggested that this was to allow personalised tariffs, with the aim of using them as an additional doorstep tool for even more efficient mis-selling.

This set the scene for the complexity we have now. Other utilities joined in, each adding their own ideas to the new specification, with little comprehension of the implications. That made them a sitting target for a range of technology companies, who saw the opportunity to mug them. It created an unholy alliance which lost all sight of the original reasons for deploying smart meters as utilities focused on promoting their lack of understanding, and technology providers took the opportunity to bend the specification to help sell what had

been commercially unsuccessful products. There is a basic rule that is drummed into protocol designers, which is that "perfection has been reached, not when there is nothing left to add, but when there is nothing left to take away" [14]. It is a good mantra to limit complexity. Never has that rule been so comprehensively ignored as it was by this disparate group.

But then the plan went wrong. With the end of doorstep selling, switching plummeted to less than 10%. Most remaining switching was supported by generous web discounts from the utilities to Internet switching companies as a method of customer acquisition. These are gradually being phased out, bringing switching into the low single percentage figures. A recent report from VaasaETT [15] suggests that this is a standard cycle for deregulated energy industries and that switching will now remain at this level or decline further regardless of Government exhortations to switch, largely because of a completely disenchanted set of customers.

With the appetite for switching gone, much of the system architecture constraints driving meter complexity disappeared. Yet no-one questioned the decisions already made. Ministers continued to cajole consumers to switch; the VaasaETT report concluded they wouldn't. Despite the changing marketplace, the programme continued with the DCC at its centre – an unwanted five billion pound gorilla wreaking havoc with the system's architecture.

As rising energy prices became a political hot potato, ministers started calling for simpler tariffs and for consumers to be automatically placed in the most cost-effective plan – both diametrically opposed to the direction DECC was still taking. That should have been a wake-up call to review what was being done, but the smart metering committees were going full pelt in the opposite direction. Meter complexity was being ratcheted up, with support for ridiculously complex tariffs [16], which would be beyond the comprehension of any consumer without a maths PhD. Not only were the committees and their taskmasters not reacting to the changing public and ministerial climate, they were about to add several new features to the specification which would highlight their technical incompetence and pile on further costs.

Exhibiting Technical Incompetence

Although the Government and most of the utilities thought they had chosen a robust, established standard, the truth was very different. Although most meter companies appear to be global, they generally consist of a ragbag of disparate, national companies that have been acquired, with limited consolidation. As meter requirements, even for dumb meters, differ in each country, they remain as largely independent companies, with varying degrees of shared technical knowledge.

Shortly after the British Gas specification was published, three of the UK meter vendors joined forces to form what was euphemistically named the Smart Specification Working Group or SSWG. Unlike any real standards group it was a closed shop, trying to extend the British Gas and ZigBee specifications, largely as a technical barrier to stop other companies competing for GB smart metering contracts. Their view of working with the ZigBee Alliance was to write the new version of the Smart Energy Profile in isolation and then attempt to integrate it into the ZigBee specification. It's an approach that has led to the UK

specification veering away from that being deployed anywhere else in the world, and has caused some degree of rancour from others in the ZigBee community, who see it as a bully's approach to the standardisation process. It is a closed process which effectively denies the true meaning of standard.

ZigBee operates at 2.4GHz – the same frequency as Bluetooth and Wi-Fi. It is a shared piece of spectrum, so any radio operating in it will suffer interference. As any Wi-Fi user knows, it's also a frequency that has limited range within a home. A series of trial runs by DECC suggested that these two effects would mean that their preferred choice of ZigBee would fail to connect an In Home Display to a meter which is sited externally or in a basement in around 7 million homes, with apartments and tower blocks being worst affected. To get around this, the programme, aided and abetted by the SSWG, decided to redesign the ZigBee standard to operate at the lower frequency of 868 MHz. This increases the range (that's just physics) and should result in coverage in all but around one million homes. The recent review of Smart Metering for the German Government highlights the same issue, concluding that they should avoid 2.4 GHz altogether, with a preference for 868 MHz or lower for all meters. It also recommends that this decision should be made before starting to write a technical specification. That point was made in the early smart metering consultations in the UK in 2008, but was ignored.

Looking back through history, developing a new radio standard, at a different frequency, to a level where it is robust, takes around 5 – 7 years and costs between $10 million and $50 million. Chip companies and SSWG members persuaded DECC they could do it in six months for peanuts. That was in the middle of 2011. The group has still not progressed past evaluating different options for the radio which means that there is no realistic hope that an 868 MHz solution will be ready much before 2018.

A radio operating at 2.4GHz cannot talk to one running at 868 MHz, so this immediately gives an interoperability problem. Anything deployed before 2018 will operate at 2.4 GHz, so when 868 MHz radios are ready, any further deployments will need communications hubs which incorporates both radios, increasing the cost still further. The same will be true of future replacement meters and IHDs.

The concern about range also fed into the design of the communications hub. A hub needs to be within range of the electricity meter, as it draws its power from it. That was a requirement to ensure that customers didn't unplug it. Over time, the decision was made to design the communications hub to plug directly into the meter – what is called an "intimate hub". This isn't unlike the meters which were made for the US market, where the long range and ZigBee radio were an integral part of the meter. For the GB specification it was decided that although they connected together to form one piece, the comms hub would still use the ZigBee radio link to communicate between the hub and the meter, over a distance of a few centimetres.

Any radio engineer would run screaming if they heard this proposed. One of the first rules of radio is to ensure that two radio transmitters are never placed too close together. If they are, the strength of transmission from each can overpower the receiver in the other, causing it to lose its sensitivity. It's a phenomenon known as front end overload. It's the same effect as when you stand in front of a loud speaker in a club and try to hold a conversation. Unfortunately neither DECC nor the meter manufacturers appear to employ any competent radio engineers. This decision will result in poor performance and early failures, increasing

the need for replacement equipment, service visits and increasing the operational cost. Again, it's a cost that DECC has not counted.

A further indication of the lack of understanding of digital systems came with the introduction of a local randomisation offset capability for auxiliary load control switches in electricity meters. These are used to supply power to devices such as storage or water heaters. Put simply, this offset capability adds a random delay to the time where a night storage heater turns on to ensure that the whole country's heaters don't turn on at the same time, as that would overload the network. Any digital designer with M2M experience would take the approach that an intelligent head end should set this offset individually within each meter, allowing the use of central intelligence to optimise switching times in each local circuit to balance demand. Instead, the industry, led by one of our larger utilities, insisted on replicating the autonomous, random analogue timer that currently runs independently in every meter [9]. They had no concept of the basic principles of remote device management. It is a blindingly clear indication that those writing these specifications are still stuck in an earlier, primitive age and are unqualified for their role in contributing to these specifications.

Security

Cybersecurity in the grid is a hot issue. Smart Meters pose a number of new security problems. The most basic of these is privacy. If someone can access usage data from a meter, they can use it to determine information about the homeowner, including whether they are in the house. More sophisticated analysis can also reveal what appliances they are using. In terms of personal risk it's not a major issue, but it needs to be addressed. The German analysis is very strong on the concept of privacy by design – making it a core of any technical specification. Although the same view was put forward in the early days of framing the GB specification, in practice this approach was quickly abandoned with privacy very much tacked on at the end.

A second concern is how to prevent people from hacking into the meter and changing the readings that are sent back to the utility. That may be from users trying to falsify their usage to reduce bills, or hackers disrupting the system by injecting false information. Again, both need security to be considered as part of the overall model. The simpler that is, and the lower the complexity on the meter, the safer the system is likely to be.

The real risk comes when every meter is capable of disconnecting the user. Simply reading meters generates privacy and billing issues, but the damage is likely to be restricted to a number of individuals. When you allow remote disconnections, the risk moves to another dimension. The paper "Who controls the off switch" [17] highlights the risk of a hacker or disgruntled employee turning off a large number of meters. That sudden change would cause immense damage to the grid and components within it, as well as removing power from millions of users. The resultant cost would be immense. As the paper explains, "this is the cyber equivalent of a nuclear strike; when electricity stops, then pretty much everything else does too."

To prevent this happening, overall security of the system is imperative. That requires an architecture which is designed to be secure from the start. Despite the initial sentiment, the GB specification has had its security assembled at the end of the process like a collection of

Lego bricks. There are many levels of attack, gaining access at the head end to turn off millions of meters, changing tariffs so that prepayment meters run out of credit, changing security credentials to stop meters reporting back, forcing gas meters to perform multiple calculations to drain their batteries, and many more a bright engineer could imagine. It's not clear that the security put in place will be effective against external attack – once again it has been cobbled together at the end. There is no indication that a far larger deficiency has even been acknowledged – the quality of firmware engineering within the industry.

What lets hackers into a device is poor firmware – mistakes or holes that occur because the software was not written to high standards. If you look at the location of UK meter suppliers, most are sited in rural areas. That's because their core skills are metal bashing – many started off their business making or repairing agricultural equipment. They are not experts in wireless and security. In almost all instances they are relying on contractors or overseas developers to write their protocol stacks and much of the firmware being written is best described as hobbyist. There is such a dearth of qualified engineers prepared to work for the salaries these companies offer that a rogue programmer could easily find employment and then proceed to incorporate Trojan code into the meters. This could cause millions of meters to disconnect simultaneously at some point in the future, causing untold damage to the grid. Other industries such as automotive, medical and aerospace understand these issues and have formal development procedures to ensure critical code is safe. That experience and oversight is missing in the metering suppliers. They're coding on the fly, desperate to ship products that are orders of magnitude more complex than they expected when they first stepped onto the smart metering treadmill. Despite the £12 billion cost to the public and the much greater potential costs if meters are compromised, they're doing the most critical parts of smart metering on the cheap, with all of the dangers that brings to the UK economy.

Engaging Consumers

Because no-one in charge understood the technology, development continued unquestioned. The assumption was that the constantly increasing complexity was necessary and good, so effort was poured into further attempts to extract and justify more financial benefits from the hoped for consumer behavioural changes. When no more could be ascribed to energy efficiency, attention turned to demand response.

Taking energy efficiency first, it's instructive to understand the history of the gas or electricity meter. We have them in our homes because it's the only way that a utility can tell how much energy we've used. (Note the past tense of used.) It's a unique business model – everything else we use or buy is charged at the time of consumption, or shortly after. That means we inherently understand the cost of almost everything else, whether that be food from a supermarket, fuel for the car, holiday flights or cinema tickets. Where we don't have that immediate information, we can normally phone up or find out what the balance is, as with phone bills or our bank accounts. No other industry divorces us so comprehensively from an understanding of the cost of what we're doing.

In the UK, utilities take that a step further by averaging our payments over the course of a year to "insulate" us from bill shock in the winter months. That means we have even less of an idea of what our energy usage costs. Over the years, they've trained us, like Pavlov's dogs, to pay the bill without question when it drops through the letterbox. So effective is

that training that it's estimated that around 30% or customers on direct debit don't even read the bill.

With the UK utilities having effectively divorced us from any understanding of what our energy consumption means, it is difficult to try and get users to change behaviour. Smart meters provide the opportunity to bring us back into touch with our energy. That can happen in two ways – by taking regular readings, it is possible to provide users with a far more regular profile of their energy usage. That information can be used to determine whether they would benefit from grants or advice to make their home more efficient. It also lets them gauge their energy usage against others. Although a simple measure, it's important, because most people have no real idea of whether they are being energy efficient or not. In the real world, most energy efficiency knowledge is close to folklore, as has been proven by countless consumer surveys – people do not know which device uses the most energy, or which it is most cost-effective to replace.

It explains the persisting belief in In Home Displays. What the committees forgot is that any energy display in the home will only be effective if consumers accept it. They need to want to use it, so it needs to be compelling. The In Home Displays being proposed for the GB roll-out look like electronics test-bench instruments from a previous era. There's a historical reason for that. The first major UK deployment of energy displays was made under the CERT program, which predated widespread adoption of smartphones. The CERT displays were designed to be cheap, and that price point was used for the current specification. But they are a world away from the smartphones and tablets which users now expect to use as their source of information. In other words, the specification has built in a historical anachronism. In his Digital Sixth Sense keynote at Uplinq [18] this year, Qualcomm president Paul Jacob pointed out that in 2012 more than twice as many smartphones and tablets were sold compared to PCs. By 2017 it will be six times as many. Yet the UK is basing its home area networking on a product that was conceived before the iPhone, may not be fully deployed until after Apple is no longer a major player in consumer electronics, and which is not compatible with any phone or tablet in the world. They are so unengaging that the industry has invented the metric of "mean time to kitchen drawer" to measure how long they're used for. The general belief is that's around 10 days, and falling.

The message seems to be getting through in a few places. It's telling that the day-ahead pricing trial for 1,100 customers that EDF started in February 2013 has ended up sending alerts to the users' mobile phones as a more reliable way of alerting them than using their smart meters and In Home Displays [19]. In other words, the display is redundant. It is the first time the industry has shown any understanding of the fact that the current metering system might be out of date.

So does Consumer Engagement work?

There is no doubt that making consumers more aware of what uses energy, and how much of it, is a good thing. Multiple surveys show how little users understand about energy efficiency. Education and direct experience helps, but whether that translates to long term, sustainable changes in behaviour is more questionable. There have been many trials, but most use very few participants – frequently less than a hundred, and in many cases these are volunteers or employees of energy companies, who are unlikely to be representative.

The company with the most experience is OPower in the US, who have build a highly successful company on the simpler and much cheaper approach of providing targeted information with electricity bills. They've been doing this since 2008 and have results from 218 large scale deployments [20]. Their conclusion is that if these schemes were applied to the whole of the US, they have the potential to reduce domestic usage by 1.6%. That's a lot less than DECC is counting on in its projected savings.

The most interesting information in this report is where OPower predicts the potential savings from state to state. They're far from uniform, with several states only likely to achieve a fifth of these savings. Latest OFGEM research on the energy usage of different household suggests this may be case in the UK [21]. It breaks the UK down into twelve categories of energy users. Although they have yet to correlate these against the capacity to save energy, it looks as if many groups will have difficulty in modifying behaviour. Taken together with the OPower findings in the US, it suggests that the DECC assumptions could easily be overstating the case by a factor of ten.

That's just the picture for electricity. Similar concerns arise when looking at gas consumption. British Gas, in their upbeat report on smart metering [22], calculate that 71% of the CO_2 savings for GB will come from gas savings. However, the European Environment Agency point out that gas consumption is determined principally by structural dwelling characteristics, and may not be responsive to behaviour change programmes [23]. If that is the case, another large chunk of the DECC savings disappears.

Britain is not the first to fudge the numbers to try and justify the cost. As far back as 2009, New Zealand's Electricity companies told the Minister that it was evident that estimated benefits were considerably lower than those in overseas studies and the costs much higher. It's a common observation – smart metering is always greener on the other side of the fence, because savings are a future illusion that can be conveniently massaged to balance the numbers. Reiterating Alex Henney, "civil servants have cooked the numbers".

If all else fails, there's Demand Response

The final refuge of the current smart metering bandwagon is demand response. This plays to energy security and the concern that at points of peak usage, Britain may not have enough generating capacity, resulting in blackouts. By using Time of Use pricing to apply financial pressure on consumers to make them change their usage patterns, it should be possible to decrease the peak demand. The accountants at DECC can then allocate savings that result from the need to build fewer power stations, as well as throwing in savings for industry not having to stop work.

There is no doubt that demand response is useful in some countries. The southern US states are a prime example. In Dallas, domestic energy usage in the afternoon jumps from 8.5 GW on a cool March day (64°F) to 35.5 GW on a baking August day (109°F), solely because of air conditioning. Norwegian homes have similar winter spikes as most of them use electricity for heating. But these scenarios don't reflect the UK. We have one of the most temperate climates in the world, thanks to the Gulf Stream. But that doesn't stop those looking for benefits applying results from other extreme climates to the UK.

Even in the US there are questions about how effective consumer demand response is? A recent SmartGridNews [24] report pointed out that the savings from a Pepco initiative, which recruited 150,000 customers, partly by door to door sign-ups only saved 200MW of peak demand. That's the same as you'd get from installing advanced automation in fewer than 100 industrial companies.

In the UK, demand response is largely untried. Like consumer feedback, it has advantages, but with a public which no longer trusts utilities, it is difficult to see how it can be accomplished unless there is a massive issue with supply, resulting in widespread blackouts. According to OFGEM, the risk of that happening is around 2015/16 [25], way before smart metering is deployed in enough volume to help. So demand response has no valid part in savings resulting from smart metering.

Where's the Big Data?

Data should be transformational, but if it is to be so, you need lots of it. Every other industry is looking at big data and analytics to see how it can change their industry and their individual competitiveness. The UK is a leader in much of this analytics work across almost every business sector.

There's just one sector which is doing its best to deny data. Utilities have constantly pushed back on the amount of data collected to the point that the only business change we're likely to see is the loss of meter readers. Smart metering is the only chance they will get to change this – it's a once in a generation opportunity, but it's being thrown away. Instead the design of the DCC and the awarding of the CSP contracts are concentrating on seeing how little data can be collected.

There are privacy issues with collecting large amounts of energy data, but the system should be designed to allow it. Currently there is barely enough to verify that smart metering is working correctly. If the Government really wants the UK to take the lead it should be pushing for a big data capability. Instead it seems intent on squandering the opportunity.

Conclusion

At the start of the year, referring to the smart metering programme, the minister – Charles Hendry said that the Government had been "too hands-off" in the past, which is why the scheme was brought "in-house". He needs to realise that being hands-on is no help if those in-house are technically deaf, dumb and blind.

In the UK, the industry thought that it was using taxpayer's money to design meters that would open up export markets outside the UK. Instead it has added a level of complexity which means we've got meters that are too expensive for anyone else to consider, consigning the UK public to paying through the nose for an exercise in specification creep. The end result will be meters so complex that they will probably never deliver the benefits they claim.

That need not be the case. This is not an attempt to discredit smart metering, but to step back from the current deployment plans before it is too late and review how best to achieve the benefits that smart metering offers. There is an irony that there are UK companies who are successfully deploying smart metering systems to India and South America at a fraction of the cost of the proposed UK deployment. These systems follow the M2M model of simplicity at the meter. They work and are probably more appropriate for what the UK needs, yet we continue to insist on a committee generated camel of such stupendous complexity it is unlikely that it will ever work. And will almost certainly never deliver value.

The best comparison I can think of for this is that of the fixed line telephony sector in the final years before digital mobile networks. In the 1980s, BT, GEC and Plessey invested heavily in building their new System X digital telephone exchange. They were convinced it would be an export success, selling to many countries around the world. As the development progressed, it suffered from similar specification creep. It was eventually shipped, but the list of overseas sales didn't get much further than Kenya, Gibraltar, Colombia, St Vincent's and the Falkland Islands. Most of the rest of the world looked at the complexity and moved to mobile networks. The same is happening in smart metering. Whilst we're building complexity onto what has been deployed in the US and Australia, the rest of the world has discovered there are more efficient ways to do it. The irony is that these simpler deployments in countries like Brazil and India employ technology from other UK companies. The difference is that they come from the telecoms and M2M sectors, not the smart metering industry.

We should not forget that there can be real advantages to be gained from smart meters. That's why many other countries are deploying them. Of these benefits, those advocated by DECC, utilities and consumer groups, such as accurate billing, are probably the least valuable. Over the years the UK utilities have done a remarkably good job of educating consumers to send in their meter readings, whether by phone, email or web. Consumer surveys show that inaccurate bills are no longer their primary concern. The real advantages in smart metering come from using the data it generates. That lets consumers understand how they use energy. Utilities can apply that to help them become more efficient energy users, along with gaining a better understanding about how the grid needs to evolve.

The real challenge facing our energy industry is distributed generation. It's a transformational issue that needs real-time data. If we don't use this smart metering deployment to support that need, we'll need to throw this generation of meters away and start a Smart Metering 2.0 programme around the time that the current deployment is due to be completed.

For multiple reasons, we've ended up with a system that is perhaps best described as being designed to be what the utilities would have wanted in the 1990s to help them mis-sell to the public. By allowing them to subvert smart metering, we are at immediate risk of throwing away the opportunity to provide what Britain needs to transform its energy supply business in the 21st century. Unless that's acknowledged and change brought in, GB consumers will end up paying £12 billion for yet another Government IT disaster.

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Nick Hunn

WiFore Consulting
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