

Making the smart grid work:
The future of smarter energy



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Energy in the UK is at a critical juncture.

A fundamental transformation must be completed to enable a **smarter energy future**, starting with the imminent **mass roll-out of smart meters** to every electricity and gas customer and progressing to the **establishment of a smart grid**, which will better balance and moderate the end-to-end energy system.



Part of a series of papers on IBM Smarter Energy

THREE CRITICAL ROLES FOR THE SMART GRID

The transition to a smart electricity grid in the UK represents a tremendous opportunity but also carries significant risks, which means concerted action by all stakeholders is vital. The “trilemma” – sustainability, affordability and security – must be addressed together in order to meet our energy needs in a way that safeguards national security and economic prosperity while meeting government commitments on climate change and greenhouse gas emissions. A smart grid facilitates tackling all three issues effectively and efficiently:

1. De-carbonising the energy supply. Within the next eight years, up to 30 per cent of the UK’s power supply is slated to come from renewables¹. A smart grid allows for a larger penetration of renewables into the grid by catering for the inherent variability of the majority of renewable generation. It has the capacity to improve system balancing by dynamically matching demand to supply, meaning there will be less call for fossil-fuel-based back-up to deal with periods of lower renewable generation and less need to expensively curtail renewable generation in times of excess. Improvements in the efficiency and management of the distribution network will reduce outages and decrease the need for network reinforcements.

Over time, consumers will adopt more energy efficient appliances as well as habits, encouraged by better information, new energy services, dynamic pricing and the judicious use of automation.

2. Reducing the cost of energy. A smart grid will help energy customers to interact with suppliers in new and better ways. It will encourage downward pressure on energy prices as demand is selectively reduced or shifted to times when supply is more readily and cost-effectively available. It is designed to reward customers for foregoing their consumption or shifting their energy usage to different times of the day. It enables individual customers to be both consumers and producers, and groups of customers to pool their volumes to become “virtual power stations”. The smart grid also encourages a more efficient use of assets and improved grid reliability, which will reduce the cost of producing and delivering energy, as well as the cost of renewing infrastructure.

3. Increasing the security of energy supply. A smart grid improves the security and safety of energy provision, reduces the vulnerability of the grid and is safer, for both maintenance crews and the public. In the future, variability and unpredictability of both supply and demand will lead to a higher risk of system imbalances and outages. For example, demand will be susceptible to charging patterns influenced by the increased

adoption of electric vehicles as well as peaks of usage caused by weather and entertainment events. Supply will depend on whether the sun is shining or the wind is blowing, as well as on the market and how much storage or generation capacity exists to be dispatched. International markets for gas and electricity and the national interconnectors that facilitate energy imports and exports can result in huge swings in price and availability. The smart grid balances the system in such a way as to maintain critical energy supply and protect the most vulnerable from the price consequences of shortage. The grid also provides security to counter the threat of terrorist attacks and the impact of natural disasters – so that the “lights stay on” and critical services are not interrupted.

MAKING A SUCCESS OF THE SMART METER PROGRAMME

The considerable investment required for the installation of smart meters across the UK – £12bn or more – adds to the pressure already being imposed on consumers by rising energy bills, without necessarily producing immediately visible benefits. Furthermore, many are expressing doubts about the planned roll-out, creating an imperative that demonstrative benefits are realised².

Retailers, meanwhile, are being held to a government mandate that affords little time to trial the deployment of smart meters³. It puts the onus on leaders in the energy sector to make absolutely the right decisions in the next two years if the key technical and budgetary risks are to be negotiated successfully.

Delays to the programme will put its success in peril, not least because they may contribute to a loss in consumer confidence. Consumer unrest or even rebellion may be provoked by excessive or anomalous energy bills, as has been the case elsewhere in the world⁴. Consumers rightly have privacy concerns about who can access information regarding their personal energy use. They worry about security and their own vulnerability to malicious actions. Consumer groups are concerned that individuals who pre-pay for energy and who are in economically vulnerable households will be unduly penalised by paying for smart meters without seeing any benefits.

The distribution network operators (DNOs) have some additional time to prepare for the development of smart grid capability, although they must ensure that smart meter deployment paves the way for future smart grid applications – which may be difficult in a programme driven by suppliers and concerned with preventing capital costs rising and timescales slipping.

In the interim they need to make the most of the positive opportunities presented by the £500m Low Carbon Networks Fund (LCNF) – the world’s biggest electricity network innovation incentive. Such an exceptional opportunity demands that the very best and most experienced systems thinkers are

53m
smart meters
are due to be installed
across the UK in the
next decade.



deployed to take full advantage. But, once again, the cost of this innovation falls on the energy customer, so the imperative is to ensure that large and real benefits flow to the energy end users and do so sooner rather than later.

Over the next decade game-changing technological innovations will emerge, conferring significant advantages on those who seize the opportunity. The smart grid revolution will be led by those companies that fully embrace R&D, but only if they are able to retain the confidence and support of their customers as well as the regulators.

DOES THE SMART GRID STACK UP?

In the stampede to adopt smart grids, not everyone is a convert, and to overcome these fears and objections requires all stakeholders to be actively engaged and the positive benefits to them clearly demonstrated.

Margaret Hodge MP, chair of the Committee of Public Accounts, believes that a £11.7bn programme to install 53 million smart meters in the UK by 2019 as part of the broader journey towards a smart grid must necessarily be “subject to significant uncertainty”¹⁵. She also cautions that “consumers will benefit only if they understand the opportunity to reduce their energy bills and change their behaviour... Otherwise, the only people who will benefit are the energy suppliers.”

Moreover, Hodge notes that there is currently no transparent mechanism to ensure that savings made by energy suppliers are passed on to consumers. She observes: “The track record of energy companies to date does not inspire

FIVE STEPS to building a better smart grid in the UK

- **Emphasise the benefits – be sure to get to the good stuff quickly.**
- **Engage and enthuse the end energy customer with education and information.**
- **Provide a financial incentive for greater customer participation and automated tools to help customers take control of their energy usage.**
- **Design smart grids as extensible end-to-end systems, looking at three equally important and connected flows: energy, information and money.**
- **Design the DCC – and with it, the specification of smart meters and their roll-out – to be smart grid ready.**

“Our approach has shown that **smart grids can be achieved incrementally**, by building upon common platforms and capabilities – one innovation drives more innovation”

Adrian Clark, manager, intelligent networks, Energy Australia.

A WORD IN THE REGULATOR'S EAR Future-proofing the DCC

The UK smart meter deployment will involve the creation of a data communications company (DCC) – a small, regulated, central body that will handle data and communications services between smart meters and authorised smart meter data users. It will be responsible for the procurement and management of all smart metering data and communications services.

The DCC will be pivotal to the success of the smart grid. It must deliver an efficient, resilient and flexible service, and it must be designed with the bandwidth and latency headroom to provide capability beyond smart metering.

The DCC will need the space to evolve and add functionality over time. It should be constructed with an inherent extensible capacity and functionality. This acknowledges that data flows may need to increase from daily to on-demand or to real-time. In any event, the commercial construct must be designed to accommodate the future smart grid ecosystem, even given any technology and economic constraints that may limit its initial feasibility and realisation.

What is absolutely certain is that the industry cannot – and should not – plan for parallel infrastructures for smart metering and the smart grid, nor should it allow for the possibility that smart grid requirements will force major changes to the DCC to be implemented midway through its first contract of operation. We simply cannot afford to do this, either in financial terms or from the perspective of energy customers. And, crucially, we cannot afford to restrict growth for UK plc.

confidence that this will happen.” She then urges: “The department should clearly set out what energy suppliers’ responsibilities will be for engaging with consumers to deliver the benefits of smart meters; and how they will be held accountable to both the department and consumers.”⁶

Without the right level of engagement, the deployment of smart meters – an essential ingredient for a successful smart grid – can run into turbulent

opposition, as was the case for Pacific Gas & Electric (PG&E), a utility company based in northern California.

Even as PG&E was installing about six million smart meters out of the 9.7 million it planned to put in, a groundswell of opposition grew up to protest against the “forced” installation. Some felt so strongly that, in one incident, a roadblock intended to prevent the meters being delivered led to the arrest of 30 people⁷. Protests centred on fears about inaccurate bills and energy bill price spikes; concerns over the security of personal data; and worries about health impacts.

Ultimately, the California Public Utilities Commission (PUC) compromised and created an opt-out proposal that was voted in by state regulators in February 2012. Customers wanting to avoid a smart meter in their home can now pay a fee to cover the costs of reinstalling analogue meters and a monthly charge to cover manual meter readings⁸. California PUC commissioner Alan Simon is reported as saying that over 145,000 PG&E customers are expected to take advantage of the opt-out⁹.

Nor are PG&E customers alone. In 2011, the Maine PUC passed a landmark decision allowing 612,000 Central Main Power customers to opt out of its smart meters, also for a fee¹⁰. Opt-out proposals are also on the table at San Diego Gas & Electric, Southern California Edison and NV Energy in Nevada.

The fact that smart grids enable two-way information flows and empower operators to control the use of energy create some concerns over their security for many consumers. Ross Anderson, a professor in security engineering at the University of Cambridge Computer Laboratory has warned that smart metering introduces a “strategic vulnerability” that hackers could exploit to remotely switch off elements of the gas or electricity supply grid¹¹. Software errors introduced during an update also pose a risk.

Meanwhile, security researchers at IOActive have highlighted flaws in poor authentication, lack of encryption and inadequate authorisation in smart meter roll-outs during research that looked at installations in the US and Europe¹².

Despite these issues, a deployment when handled properly can generate positive results for all concerned. For example, the deployment of 825,000 smart meters by Portland General Electric (PGE) of Portland, Oregon, (not to be confused by the similarly named utility PG&E cited above) in December 2010 was a success, following a long-term, slow and deliberate policy of customer consultation, engagement and education. PGE was responsive to consumer concerns in the process and respectful of customer demands throughout. The process has resulted in far higher levels of customer satisfaction, with only two people opting out.

The path to consumer adoption of smart meters and, by extension, a smart grid, will not necessarily be a smooth one. But, as the PGE example



2019

The deadline for installation of smart meters across the UK.

demonstrates, there are ways in which the roll-out of such programmes can work to the benefit of all.

TAKING HOLD OF THE OPPORTUNITIES

For retailers, active and engaging communications campaigns will be essential to bringing consumers along on the journey. After all, consumers hold the key to realising the benefits of smart meters. Without their acceptance of, and engagement with, smart meters, the benefits simply won't accrue.

Consumers need to be given information clearly and often if it is going to increase their awareness of their own energy use and influence their behaviour. Consumers also require incentives to drive changes in demand behaviour – for example, significant pricing differentials between peak and off-peak consumption. Trials to date suggest that even when peak pricing is double that of off-peak, it is insufficient to drive behavioural change. Consumer attention also wanes quite quickly, so automation and regular price signals are needed to sustain the beneficial behavioural changes.

There is a paradox that must be overcome. On the one hand, studies and trials suggest that visibility, involvement and exposure to significant price volatility are keys to success. Customers need information, control and a financial incentive to change their behaviour in a significant and sustainable way. On the other hand, customers do not want their every waking hour to be spent monitoring their energy usage; nor are they all able or willing to engage with complex choices and tariffs. There is no doubt that automation is key – which depends on the smart grid behind the meters – but it cannot come at the expense of customers assuming that “everything is being taken care of” by their supplier.

Additionally, given how much influence consumers have on the success or failure of smart grid deployments, retailers need to move towards a renegotiation of the customer offering, along the lines of the

changes that telecommunications companies have made successfully.

This might mean shifting from the traditional model of charging by period to something oriented more towards transactional billing. One could imagine different tariffs and demand-response schemes for different categories of device and usage, with core services such as heat and light dealt with in one way but optional use such as washing machines or TVs handled in another.

NEGOTIATING THE LANDSCAPE

In order to demonstrate the real potential of the smart grid, DNOs and their collaborators should use the LCNF trials to explore where the current system lacks the capacity to deal with future volumes. There is widespread concern that there will not be enough capacity to cope with increased flows and the changing dynamics of a new energy network – one that includes variable supply, increased distributed production and the spiky demands of electric vehicles – while at the same time having sufficient excess to provide the necessary resilience and security.

The LCNF trials provide DNOs and their partners with a chance to test a wide variety of assumptions and to investigate the ways to manage flows intelligently within the current asset base capacity. This constitutes a huge opportunity to understand how to save on asset upgrades in future. Through active involvement and leadership in the trials, the proactive DNOs and their partners will build the skills and capabilities to navigate the transformational journey over the coming years.

There is a danger that a preoccupation with smart meters and connection to the network of new power generation will prove detrimental to the UK smart grid in the long term. It is vital that DNOs focus attention on what

“Securing our energy future requires a diverse, balanced strategy to meet the energy needs of a growing population, (applying) transformational technologies such as the smart grid”

Bill Johnson, chairman, Progress Energy.

MAKING SMART GRIDS A REALITY

The government cannot fully control the uptake of renewables, the adoption of electronic vehicles or the extent of micro-generation that takes place. However, in respect of the smart grid, the regulator must recognise that it is crucial that the benefits are passed on to consumers as quickly as possible. The government can influence this in a couple of specific ways.

First it needs to give retailers an incentive to accelerate the mechanisms that stimulate demand-side management. Consumers are being asked to create new habits and will need every encouragement to do so.

Second, the regulator must give DNOs good reasons to accelerate the application of smart grid technologies and Suppliers incentives to create new business and service models that create value and benefits for customers. In this way benefits can be realised sooner, which will help create a virtuous circle of actions reinforced by results.

the end-to-end UK smart grid architecture will look like, how it will operate and the role played by different stakeholders in this operation. It is important that they help key stakeholders and participants in the energy ecosystem to explore a set of potential business models they could deploy in the future smart energy landscape.

A criticism of the LCNF projects to date is that they have been somewhat disconnected and have not slotted into an overarching strategy that sets out a coherent route map towards a wider smart grid, although admittedly this is partly by design. Likewise, most of the projects are – understandably, given the network-centricity of the programme – more focused on the business of moving energy along wires than they are on meeting evolving end-user needs in innovative and profitable ways. In this respect, we need the DNOs to be proactive, leading and facilitating the involvement of the other existing players in their energy ecosystem and encouraging the emergence of new intermediaries between energy users and energy providers. While regulatory leadership is clearly necessary, input from a broader range of constituencies can only enrich the regulator's understanding and help to refine its approach.

And what will be the characteristics of this evolving smart grid ecosystem? The changes in the flows of energy, with distributed and local generation, energy conversion, storage and demand-response-management all combine to create a very different system model.

The management of these flows by a smart energy system requires complex, timely and secure flows of information across the network to feed the analytics, optimisation and process orchestration that is the "smart" in "smart grid". What may be less immediately obvious is that the system must deal with new, more granular and more volatile financial flows.

Almost certainly, the price of energy will become more liquid – as it ranges from a weekly schedule to a spot price. A key implication is that many more transactions will need to be recorded and reconciled.

As has happened with the digitisation and opening up of other traditional industries, it is to be expected that new players will emerge, providing a variety of energy, energy-related and non-energy services enabled by the smart grid and smart meter information.

The future smart grid will be the informational and financial flows that will open up between regulated and free-market players. The regulator must design market reforms and incentives to allow business models and flows to emerge. Meanwhile, market participants will need to anticipate, explore and show the agility required to evolve.

PAY NOW, DON'T REGRET IT LATER

Before the RIIO regulatory framework submissions are due to go into effect in 2016, a massive opportunity exists to reduce network asset reinforcement using smarter IT. Network asset reinforcement is the traditional but costly response to an ageing or under-capacity infrastructure. However, that requirement can be reduced when IT infrastructure investments are made to make the network more intelligent and, therefore, more robust.

For example, IBM, along with major UK energy suppliers and DNOs, participated in a study that suggests an order of magnitude of savings by adopting a smart infrastructure for electric vehicle charging. Taking a "system of systems" approach produces a tenfold payback – where an investment of approximately £100m can mitigate the need for physical infrastructure expenditure well into the billions.

In another example, self-healing network technology was used to create an intelligent network by deploying an array of sensors installed at regular intervals. Should the network detect an outage, the smart technology instantaneously re-routes power to isolate the precise position of the outage and minimise the number of customers in the vicinity who will lose their supply.

This represented a considerably more favourable outcome than the wholesale shutdowns that are routine in non-smart networks. Moreover, the smart technology gives a maintenance crew an alert as to the precise location of the outage.

The intelligent network can ensure that maintenance regimes are more accurately targeted, and it can direct more evenly distributed and efficient utilisation of resources. The results of smart IT on the network are operational improvements and a significantly lower cost of physical re-enforcement.



That the UK does not suffer from cascade shutdowns in the way other countries do is a testament to the engineering strength – and built-in redundancy – of the transmission and distribution network we enjoy today. But as the demands on this feat of engineering escalate amid ever more severe cost constraints, and as ageing infrastructure needs to be replaced and extended, this important aspect of the smart grid will be ignored at our peril.

NEXT STEPS: THE BUSINESS TRANSFORMATION JOURNEY

We need DNOs to be custodians of a smart grid future, taking steps to ensure a more intelligent network with the capacity and flexibility required to underpin a smart energy future.

But the DNOs cannot be held responsible – or indeed take responsibility – alone. They are constrained by the current price control regulation, which hinders a longer-term future view and the creation of an end-to-end smart grid that extends beyond its regulated scope.

The regulator must create a market framework that allows DNOs to collaborate, be creative and implement the technology required in the future. The framework should encourage innovation by suppliers and service providers – both those currently operating and new players – more vigorously.

In this way, the DNOs can play a role in establishing a platform for change and collaboration, and the market can drive the types of innovation and customer benefit that have already been experienced in the digitisation of other industries.

It is too early to say whether the new RIIO regulatory framework and proposed energy market reforms will be enough to achieve this. At IBM we believe they are pointing in the right direction but may not be sufficient, given the scale of the challenge ahead.

IBM has participated in more than 60 smart grid projects worldwide, from innovative research projects to full-scale deployment and software solutions. Our experience tells us that highly significant roles will emerge for every stakeholder within the raft of changes engulfing the energy sector. The stakes for every participant will be high. As part of this process, DNOs will need to take decisive actions to realise the smart grid:

- Create a blueprint for the top-down architecture looking at flows from an energy and financial perspective.
- Identify the hot spots and key issues that will affect the network, exploring key drivers from a socio, geo and economic perspective.
- Design LNCF trials to address these issues, ensuring that the trials operate end-to-end.
- Rationalise data and build analytics capability.
- Execute trials to drive a transformative platform – ensuring that real and meaningful customer benefits arise from the trials and leaving a lasting legacy for the £500m investment.
- Plan to integrate the trial learning so that it becomes business as usual.
- Optimise operations through intelligent control centres.

At IBM we believe that the most proactive companies, regulated or otherwise, will establish themselves as key players in the new smart grid market ecosystem. And that early action will be a component of success. We believe that these companies will be the most influential in creating a more sustainable, affordable and secure energy supply. As such, they will play a critical role in determining much about the future prosperity of the UK.

“Distribution network operators will need to **take decisive** actions to realise the smart grid. These include executing trials to drive a transformative platform – ensuring that real and meaningful customer benefits arise and **leaving a lasting legacy for the £500m investment”**



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76 Upper Ground
South Bank
London
SE1 9PZ

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IBM contacts

IBM has created a smart grid maturity model that provides a clearly articulated journey for smart grid transformation. It establishes a common framework and language, and defines all the elements involved in a smart grid transformation. For more information on how IBM can help your organisation, please contact:

Jon Bentley

Leader, Smarter Energy,
IBM UK & Ireland
+44(0)117 929 5962
jon.z.bentley@uk.ibm.com

Laurence Carpanini

Director of Smart Metering
and Smart Grids, IBM UK
+44 (0)7710 397642
laurence.carpanini@uk.ibm.com

Steve Hornsby

Partner, Supply Chain,
Energy & Utilities, GBS,
IBM UK & Ireland
+44(0)7703 401541
steve.p.hornsby@uk.ibm.com

Taco de Vries

Smart Grids Specialist,
E&U Centre of Competence, IBM
+44(0)7824 302227
taco.de.vries@uk.ibm.com

Phil Westcott

Managing Consultant, GBS,
IBM UK & Ireland
+44(0)7767 484542
phil.westcott@uk.ibm.com

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