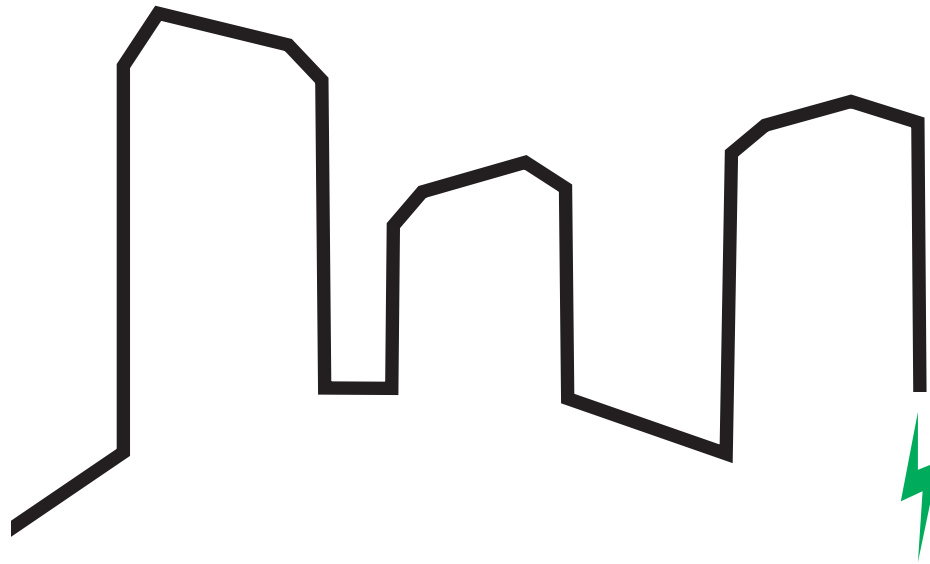




BRISTOL

SMART ENERGY CITY COLLABORATION

Towards a Smart Energy City:
mapping a path for Bristol

Reflections from 2015, the first year of the
Bristol Smart Energy City Collaboration



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Proviso | This publication contains the insights and conclusions which the Centre for Sustainable Energy (CSE) has drawn from the Bristol Smart Energy City Collaboration process to date. While the Collaboration members have had opportunities to review and discuss elements of this output, the contents of this report remain the responsibility of CSE and should not be seen as representing the views of any of the other organisations involved.

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1. What is the Bristol Smart Energy City Collaboration?

The Bristol Smart Energy City Collaboration is an initiative led by the Centre for Sustainable Energy (CSE). It forms part of the charity's contribution to Bristol 2015 European Green Capital. We have brought together a cross-disciplinary core group of ten expert organisations as Collaborators from the public, private, voluntary and academic sectors.

We share the goal of developing our collective understanding and mapping out the steps which need to be taken over the next few years to establish the conditions and capabilities for Bristol to realise an aspiration, shared by many cities, to become a genuinely Smart Energy City.

The core collaborators – who helped to shape and contribute to the work programme – were: Bristol City Council (both the Energy and City Futures teams); Arup; Demand Logic; DNV-GL; Knowle West Media Centre; KPMG; Secure Group; University of Bristol (Computer Science and Estates departments); Western Power Distribution.

The Collaboration also engaged more widely through a series of three workshops in September and October 2015 attended by relevant experts from more than 50 different organisations from across the country. Experts involved included: DECC; Energy UK; Smart Energy GB; Citizens Advice; BEAMA; Association of Decentralised Energy; Green Alliance; Sustainability First; Energy For London; Gemserve; Bristol Energy Co-op; Triodos Renewables; Universities of Bath, Bristol, Cardiff, Exeter, Lancaster, London (UCL), Nottingham, and Southampton; Wales and West Utilities; plus many others from commercial and voluntary sectors.



2. Bristol and its energy use

Bristol’s population (by the City Council administrative boundary) is 442,500 people. They make up 193,000 households, more than half of which live in pre-1945 homes, with 13.2% officially suffering fuel poverty (based on the new ‘Low Income High Costs’ definition of fuel poverty now used for England). The urban area that most people think of as ‘Bristol’ adds another 190,000 people.

In 2013 Bristol spent £210 million on electricity (£) and £120 million on gas (£)



Electricity

Bristol uses 1,862 GWh of electricity, 38% of it in the domestic sector).

There are 195,000 domestic electricity meters in the city (9% or 17,550 of them Economy 7), and 17,000 non-domestic meters.

The average domestic user (not Economy 7) consumes 3,450 kWh per year, compared to 65,500 kWh per year for the average non-domestic user.

Bristol has two grid supply points, five 132kV substations, 24 33kV substations and 1,858 11kV substations.

Peak demand in summer: c. 199 MW

Peak demand in winter: c. 310 MW



As of mid 2015, there was 89 MW of renewable electricity generation connected in the Greater Bristol area, 60% of which is wind or solar. 15MW of this is domestic scale solar PV, spread across 4,500 homes.

Gas

Bristol uses 2,738 GWh of gas (63% of it in the domestic sector).

There are 170,000 domestic gas meters in the city, and 2,000 non-domestic gas meters.

The average domestic user consumes 11,900 kWh of gas per year, and the average non-domestic user 374,000 kWh per year.

Based on 2011 Census data and other sources, Bristol's population breaks down as follows in terms of vulnerabilities which may be relevant to smart energy:

1. 16.7% of Bristolians have a long term illness or disability
2. 22% of the Bristol population is not 'white-British' and 16% are from BME groups. The main foreign languages spoken are Polish and Somali. For those for whom English is their second language, only 1.5% are not proficient in English. 180 different countries of birth are represented in Bristol's population, and 91 languages are spoken
3. 24% of residents are private housing tenants; 20% are social housing tenants.
4. 21% of the housing infrastructure is flats (both purpose build blocks and divided larger houses), 12% shared housing, and 60% terraces or semi-detached homes. Many of the terraced properties are solid wall. The high proportion of flats and shared housing might present a smart metering challenge.
5. 36% (a high percentage) of working age people are aged 20-39, including students, who are likely to be amenable to smart technologies. They are also more likely to be private tenants.
6. 13% of Bristolians are aged 65 or over, with high concentrations in certain areas. 20% of the population are under 16, and this proportion is projected to increase into the 2030's.

Where do Bristolians live?

 Private rental
  Social housing
  Owner-occupier



How old are we?

 Under 16
  17-64
  65 and over



3. The Aspiration and the Collaboration's approach

The Bristol Smart Energy City aspiration

By the early 2020s, having taken an integrated approach to smart meter roll-out and city-wide energy data capture and analytics, Bristol will have a public-interest organisation orchestrating smart use, smart distribution and smart supply of heat and power across the city.

Through a Bristol-wide Smart Energy City Collaboration, the city will have developed the capabilities and systems to access, manage and interpret local energy supply and demand data, enabling co-ordinated city and neighbourhood-scale interventions to:

- balance heat and power demand and supply across the city in real time
- curb energy waste and reduce peak demand
- enhance the financial value of heat and power generated in the city, particularly from variable sources like wind, solar and tidal
- reduce network losses and manage system constraints
- provide commercial leverage in the energy market to capture for the city, its businesses and households, the economic benefits of an optimised local energy system.

The challenge of realisation and the Collaboration's approach

This Smart Energy City aspiration is both attractive and relatively easy to describe. It fits squarely with Bristol City Council's strategic ambitions for the city and it chimes with the smart energy aspirations of many cities around the world.

But it barely hints at the complexities and challenges involved in its realisation. And it ignores the significant gulf between what will be required in 5 years' time and current practice in this field, which tends to focus on relatively small-scale technical trials.

Realising this aspiration requires: a detailed understanding of the complex web of technical, commercial, regulatory and social aspects involved; a clear sense of the skills, capabilities and facilities required across the city; a plan for how these might be viably established and how they might best be orchestrated; and a recognition of the counterfactual – how 'smart energy' is likely to develop in the UK in the absence of intentional and purposeful local initiative from cities like Bristol – and what may therefore need to be done to carve out space for meaningful city-scale approaches to thrive.

The Collaboration therefore established a programme of work to take place in the second half of 2015. Our aim was to start developing our collective understanding and to map out the steps which need to be taken over the next 5 years to both (a) establish the conditions and capabilities in Bristol to realise this aspiration and (b) identify and address barriers which may stand in its way. Our goal was to produce a dynamic road map revealing the steps from today's practice to Bristol as a Smart Energy City.

Instead of treating smart energy as principally a technical matter, we have focused on developing in depth understanding of the full range of factors which will influence success (or failure). These include the obvious: understanding the technical features of a city-scale smart energy system and getting our heads round the eye-watering amounts of data. But it also includes what will be involved in negotiating a route through market rules and regulatory issues which have been designed to date without city-scale initiative in mind. And it features the social and cultural influences which bear heavily on what can be achieved.

The Collaboration's approach has been inquisitive and open to uncertainty, accepting the complexities involved and the dynamic nature of these technical, regulatory, commercial and social-cultural dimensions. It assumes the need for a collaborative, flexible approach that can assimilate change and respond to emerging opportunities.

Rather than seek out 'answers', our principal goal has been to establish an understanding of the challenges involved and a workable approach to addressing them over time.

That said, there were four key questions which we set out to answer by December 2015:

1. Can 'Bristol' (or any city of its size in the UK) work as a viable organising scale for the management and application of smart energy data, and if so, on what basis?
2. What institutional and governance arrangements need to be in place to sustain progress for Bristol while enabling a flexible response to changing circumstances?
3. What are the key steps to take next in Bristol to enhance our collective capabilities and enable further progress towards our aspiration?
4. How can the lessons of the Collaboration be applied more widely?

This report shares our answers... so far (early December 2015).

Alongside understanding the nature and scale of the challenges involved, we have been keen to explore the temporal dimension of addressing these challenges. The 'when' as well as the 'what' and 'how' of the shift from the limits of current practice to the realisation of the city's longer term smart energy aspirations.

This is not just about the dynamic nature of the field and how it may change over time (resulting perhaps in a need for different solutions to those currently envisaged). It is also about how an approach can be developed which reflects an understanding of the many steps needed to achieve that shift – and the likely sequence in which they will need to be taken.

Quite specifically, what are the next steps needed which prepare us for taking the steps after next? We're thinking about the need for steps forward across technical, regulatory, commercial, and social-cultural dimensions. And steps needed to engage with and potentially challenge the policy-making and rules-setting processes which will have a significant influence on how easy or difficult it is to establish city-scale smart energy initiatives.

For example, what should we be doing in 2016 to enhance technical insight and capability, develop commercial understanding, promote suitable rules and regulations, start to build the necessary public and business buy-in? How can these steps help us collectively become better prepared, more able, and more engaged to move us – Bristol – further along a path towards becoming a smart energy city?

4. Framing the conditions for a Smart Energy City

We have endeavoured to walk right around the issues inherent in the concept of a smart energy city, exploring its different dimensions:

Technical (energy) – including: power, heat and gas flows in the city (incl. local supply and use information and future projections); distribution network system and operational issues; demand side opportunities (energy saving and peak shifting), from building retrofit to automated demand side response; energy storage.

Technical (IT) – including: IT, data handling, storage and analytics requirements; data comms and flows; SMETS and smart meter functionality; demand response automation opportunities; associated ‘internet of things’ and smart energy data app developments etc.

Commercial – including: value flows within energy system and within smart meter roll-out; access to national system balancing services and other trading mechanisms for recovering value; potential business models for city-wide approach; investment requirements and potential sources; energy supplier interest in supporting Bristol co-ordinated smart meter roll-out; relevant active innovation initiatives.

Regulatory/policy – including: government-mandated smart meter roll-out plans (incl. data access and/or protection issues, public engagement plans and support for vulnerable households); licensing and regulations for different activities within energy system (distribution, supply, meter operation, access to the Data Communication Company (DCC) etc); planning regulations and opportunities in new development for mandated ‘smartness’.

Social/cultural – including: public perceptions and issues (incl. data protection); individual and community engagement and behaviour change opportunities; support needs of vulnerable households and approaches to local provision; communication and dissemination routes.

The Bristol Smart Energy City Wiki (see page 47) includes detailed and referenced exploration of each of these dimensions, undertaken principally by the CSE team seeking to capture what is currently ‘known’ (and what isn’t known), current trends and future expectations.

We have found it useful to consider these dimensions as providing a framework which establishes an interconnected set of conditions which need to be met, more or less simultaneously and at a city scale, for the smart energy city aspiration to be realised. Put simply:

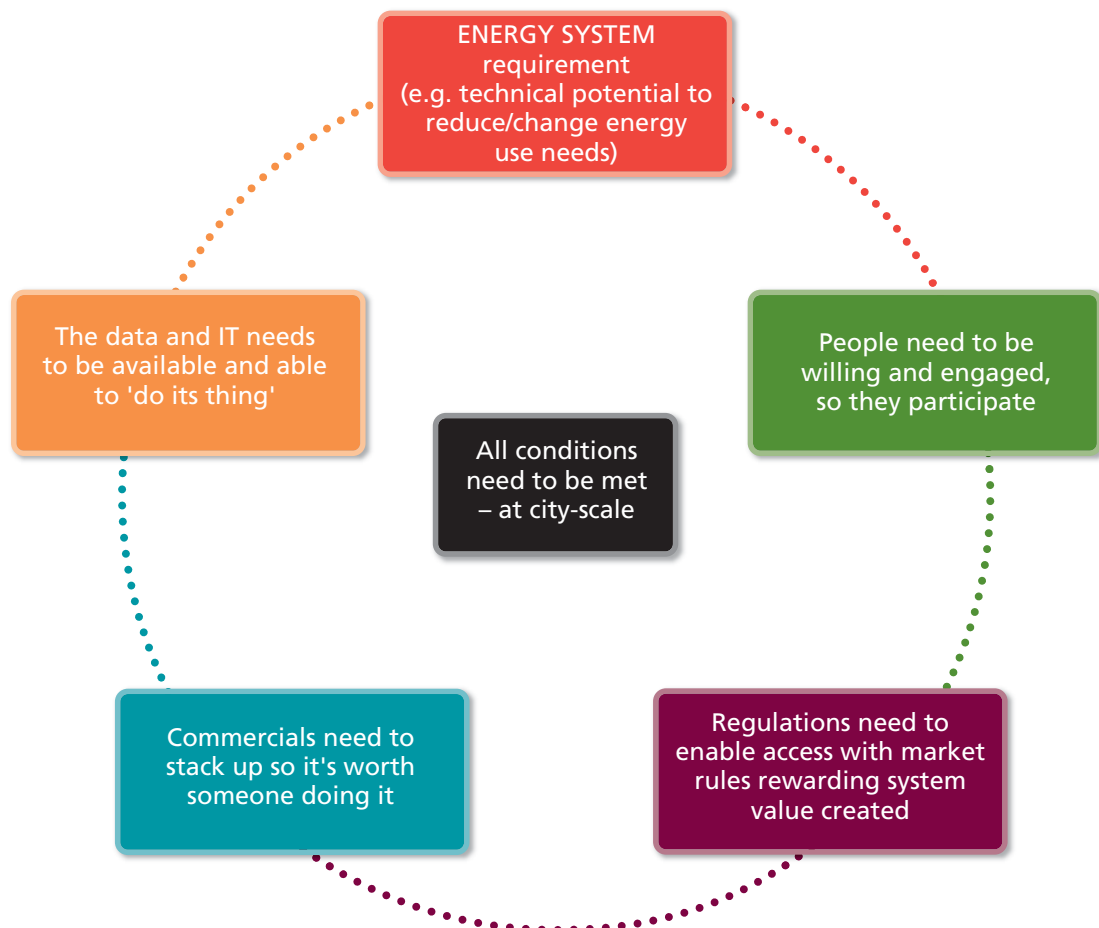
- The commercials need to work at a city-scale (without making heroic assumptions about local participation rates). This means that a viable business plan can be built on the back of delivering smart energy data-enabled solutions across a city, supporting the infrastructure and institutional capacity to underpin city-scale initiative.
- The city needs to have – or be able to hire or access – the capabilities and capacity to capture, manage, analyse and utilise smart energy data – and be able to organise and commit those capabilities and capacity to a city-focused smart energy initiative (as opposed to some other purpose).

¹ We should also note that whoever is currently earning that value (or whoever will lose out when a ‘Bristol’ does instead) will more than likely seek to protect their incumbent position against disruption from city-scale activity.

- Any energy system value created through smart energy interventions (such as reduced system balancing costs, avoided peak demand, reduced energy consumption etc) needs to be both (a) recoverable from the system's markets by those who create the value and (b) at least as easy and/or cheap and/or effective to create and capture on a concentrated basis in a specific city or locality as in a less concentrated way anywhere in Great Britain.¹
- Market rules and regulations and associated policies need to be set so that they enable city-scale smart energy initiatives to compete on equal terms with initiatives with less location- or scale-specific qualities (i.e. without the need for costly workarounds).
- There needs to be something about organising smart energy activities at city scale (or below) – such as stronger engagement, greater take-up, higher impact – which gives a city-scale approach an edge over national or corporate initiatives which are less location sensitive (but which are nevertheless likely to be active and available to people and organisations in the city).

We have captured this interconnected set of conditions in the simple diagram below. The outer ring of conditions are those required for the realisation of smart energy outcomes generally (rather than locally). Put simply: red = Energy; orange = IT/data; teal = Commercial; purple = Regulatory; green = Social/cultural.

By using 'the city' – i.e. a specific and bounded geographical unit – as our organising principle and scale, we introduce additional conditionality for each condition which may, or may not, make meeting them yet more difficult (an issue we explore in Section 7). This multi-dimensional framework can then be applied in relation to exploring more specific smart energy opportunities, assessing the extent to which each condition is currently met – and if not, why not and what might need to change to make it more likely to be met in future.



5. Exploring Smart Energy City Opportunities

To create some boundaries and focus for our exploration of these dimensions, the Collaboration chose to identify some specific opportunities associated with the smart energy city concept. We settled on five:

1. Curbing energy waste and peak demand (which embeds a related challenge to use smart energy data to help manage network constraints).
2. Enhancing the value of renewable electricity generated in or near the city (which links to a related challenge of improving local system balancing or 'power matching' within the city).
3. Using smart energy data and associated interventions to tackle cold homes/fuel poverty and the associated health and social challenges.
4. Capturing the economic benefits of a smarter energy city for the city (i.e. its people and businesses) (incl. business/employment development, smart energy data/services 'cluster' etc).
5. Developing a 'fine-grain' understanding of the energy system to enhance planning and operational capabilities at city level.

These remain quite broad with some overlap. But they are outcomes we agreed we want a smart energy city to deliver. And they explore sufficiently different aspects to ensure that we would cover a lot of ground as we developed our understanding of the issues and the steps that need to be taken.

Our work in 2015 has concentrated on the first three of these opportunities.² These were the subjects of the three expert workshops convened by CSE for the Collaboration in September and October.

In the next three sections, we have outlined our analysis of these three opportunities. These sections are developed from papers written as stimulus for the expert workshops. We have retained some of the repetition of material between the sections (so that the sections can stand alone). At the same time we also recognise that much of the detail explored for the first opportunity (curbing energy waste and peak demand) is also relevant to the other two.

The road maps emerging from this analysis and the expert workshops are shared in Section 6.

² We hope to develop our thinking further on Opportunities 4 and 5 in the next phase of the Collaboration. Opportunity 4, capturing the economic benefit for the city, almost certainly requires some or all of the first 3 opportunities to be realised in order to create some benefit to capture. For example, it is unlikely that a 'cluster' could develop in Bristol without some specific initiatives in the city to deliver smart energy outcomes, even if those were only the stepping stones for smart energy enterprises to grow by selling beyond Bristol. Nevertheless, realising this opportunity will require, in itself, some specific activities and a systematic approach towards nurturing relevant capability and enterprise in the city.

Curbing energy waste and peak demand

The opportunity: Using smart energy data to enable and stimulate people and organisations across a city to reduce demand and/or shift or cut peak demand

The potential for reduced electricity and gas demand in Bristol's buildings is significant – from building fabric and heating and ventilation control improvements, to more efficient lighting, appliances and energy using equipment.

Similarly, the potential to reduce peak electricity demand by shifting demand to other times of day or cutting usage at peak times is significant, with a potential reduction estimated at up to 30% of existing winter peak demand.

The question the Collaboration has addressed is not the scale of this potential but how the emerging availability and potential application of smart data at both individual consumer and city scale could more readily enable its realisation. And particularly what other conditions need to be in place such that this can happen and how these can develop.

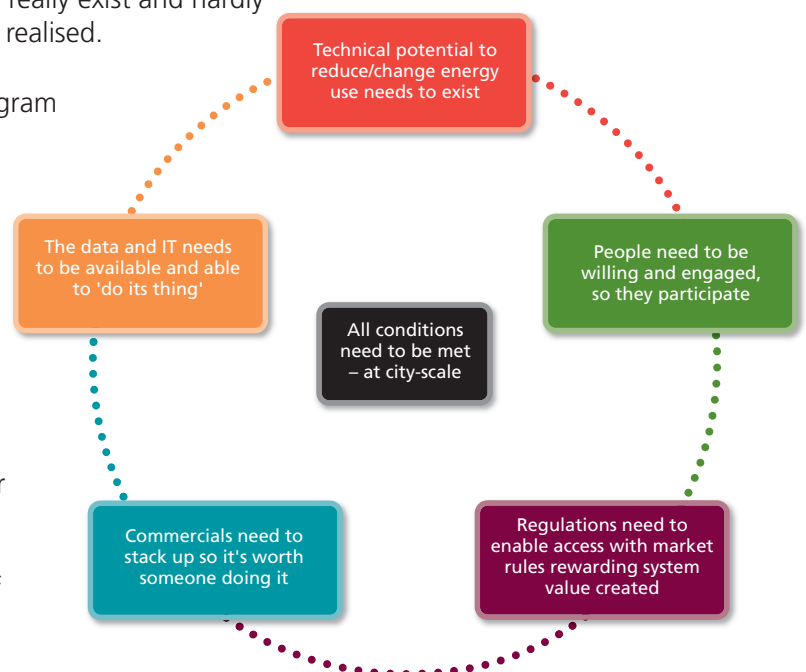
In the context of the framework for success outlined above, for this opportunity the conditions become:

- Whatever the potential, nothing can happen if the commercial arrangements don't stack up enough to fund interventions to secure change. Unless there is sufficient financial value in stimulating households and building occupiers to reduce consumption and change their energy use patterns, it is unlikely such activity will emerge in the market as organised services. The commercials need to be right.
- And the commercials being right will depend, at least in part, on how the market and trading rules are set and whether they enable anyone orchestrating demand reduction or peak shifting to capture a decent share of the value it creates for the energy system (e.g. by providing balancing services, reducing investment in new generating capacity, avoiding network reinforcement etc).
- But unless the public and building owners and occupiers can be engaged constructively with their smart energy data – and with offers of assistance to use it well or with interventions to put it into action – the market won't really exist and hardly any of the technical potential will be realised.

For this opportunity, the framework diagram therefore looks like this (right):

Our perspective is that only the 'technical potential' condition (the box in red above) is currently met. Some are a long way from being met and require change at national level (e.g. to market rules) which may or may not be forthcoming.

The Collaboration's task was to consider the status of these conditions and what we need to do now and over the next few years to make it more likely each of them will shift in the right direction.



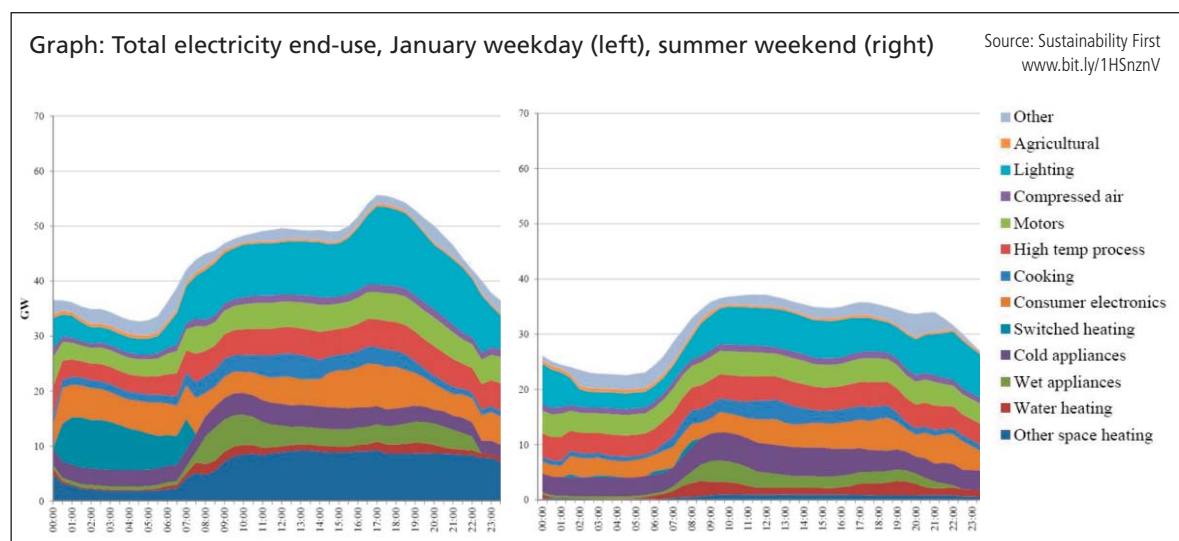
• Technical – energy

As mentioned above, there is considerable unrealised potential for energy saving and peak demand reduction across the city (though nothing particularly special about the potential in Bristol). That potential is being realised, but only slowly (electricity and gas demand are both reducing year on year – in line with national trends); technical innovations may be currently expanding the potential faster than it is being realised.

Bristol's building-related energy saving opportunities (from improved insulation etc) are relatively well-understood though there is limited information about opportunities in commercial buildings in the city. There has also been extensive work to understand district heating/CHP opportunities in the city.

With increasing levels of intermittent generation (like wind and solar) in the electricity system (at both distribution and transmission levels), the challenge of balancing supply and demand on the system is becoming greater. To date, the use of demand side response for balancing has been limited to large industrial customers, contracted directly with National Grid as the System Operator. There are increasing challenges to the distribution system, particularly from the volumes of solar PV connected. This requires DNOs like Western Power Distribution to take a more active role in network management than has historically been the case. However, at present these are not network challenges being experienced in Bristol so the near term prospects for such developments in Bristol are slim.

Planned closure of large power stations across the country is leading nationally to a tighter capacity margin (the excess of generating capacity over likely winter peak demand). However, this is being framed in terms of a need for new power stations (i.e. a supply shortage requiring a 'capacity market' to support new capacity) rather than in terms of the opportunity to curb demand and reduce winter peaks (i.e. a demand excess). Those winter peaks, which are extremely expensive to meet, are largely driven by the domestic sector, with lighting, cooking and space heating contributing significantly, synchronised by socially common patterns of work.



• Technical – IT and data

Most commercial buildings in the city already have half-hourly meters and reasonably sophisticated building energy management systems, but we anticipate that few will be using these to good effect to improve management of energy in the building (using, for example, services such as those provided by Bristol Smart Energy City Collaborator Demand Logic (www.demandlogic.co.uk)). This means there already exists a huge untapped potential for better use of energy data in

commercial and public buildings across the city to identify energy saving opportunities through improved system control, better fault detection and effective utilisation analytics.

Until the roll-out of domestic smart meters gets fully underway in 2016, the penetration of smart meters in households will continue to be extremely limited. This in turn limits the potential to undertake anything more than experimental interventions with small groups of individual households. It is likely to be 2-3 years before the proportion of households with smart meters reaches levels which enable more generalised approaches to succeed (though see 'Regulations' below on potential constraints).

At present, the expectation is that a Consumer Access Device (CAD) will be the main mechanism through which domestic smart meter data analytical and management services will be offered, with the potential to link to other sensors, appliances and controls in the home to provide energy management services (such as switching non-essential appliances off when the meter 'knows' that system prices are high or balancing services are needed).

There is extensive work being done in data analytics to improve the potential of smart meter data to provide fine grain information about household energy use patterns (for example, by revealing appliance specific characteristics), which could in turn be used to provide tailored energy management services to households.

Experimental work is being done in Bristol (the SPHERE project (www.irc-sphere.ac.uk/about)) to test how data from energy and a wide range of in-home environment and health related sensors can be used to improve household wellbeing and guide health and social care interventions. Other 'internet of things' experiments with an energy data component are also underway in the city.

Smarter heating controls for the domestic sector can potentially already deliver additional controllability, either directly by the householder or via a third party interpretation and management service. These do not need smart meter data to be effective.

There is currently no facility at city-level to capture, collate or analyse smart energy data from across the city or an agreed approach on how (or whether) it might be developed. However, there is already commitment and activity in Bristol to create a 'data commons' and the Bristol is Open initiative (www.bristolisopen.com) by Bristol City Council and the University of Bristol, potentially provides a framework for solving this data handling challenge. That said, there are and will be some significant challenges in securing access to this data, in terms of both obtaining the owners' permission and overcoming technical challenges of access, transfer and analysis.

• Commercial

The commercial aspects of using smart energy to reduce demand and/or shift or cut peak demand needs to be considered from two perspectives: the end consumer (who can directly benefit financially from reduced fuel bills by taking up existing cost-effective demand reduction actions) and the energy system (where demand reduction and peak shifting can change the cost structure, potentially reducing overall system costs through, for example, reducing generating and/or network capacity need or enabling lower cost system balancing).

From the end consumer perspective, the financial (or 'commercial') value for individual households and businesses of reducing their energy demand can already be significant – simply because of the fuel bill savings which can result from even quite modest investments in demand reduction. It will continue, in a smarter energy world, to make sense for households and businesses to make investments to reduce their demand and reap decent returns from the resulting lower energy costs. Better energy data may help them identify both the opportunities for action and monitor the resulting savings, increasing confidence in taking such actions.

However, it's widely acknowledged that households and businesses are currently generally reluctant (a) to make such rewarding investments themselves (for reasons which have been well-documented – and probably some which haven't) and/or (b) pay a third party to make the investments on their behalf by, for example, sharing the savings with the third party (as in an energy service contract).

As a result, it currently proves difficult to fund services on a commercial basis which are designed to stimulate and support people to shift their current behaviour patterns and building management approaches and take up such opportunities. Households and businesses seem unwilling to reward a third party for helping them to do this.

It is possible that the increased availability of finer grain data about energy use provided by smart meters will change this, not least by potentially enabling the development of more easily monitored savings underpinning more robust and trustworthy energy service contract offers. That said, this approach has been available for many years in the commercial sector where half-hourly metering is common and yet remains limited in reach.

The challenge in this sphere for a smart energy city approach is how to establish a clear commercial basis for playing a role in stimulating and orchestrating such activities by households and businesses across the city. Is there a market for this role? Can new business models emerge alongside the imminent proliferation of energy data and big data analytics which can make it a more attractive prospect to end consumers?

From an energy system perspective, there is often value (in the form of lower system costs) created when a household or business reduces demand or shifts or cuts their peak demand, particularly for the electricity system. Such action can reduce the need for additional generating capacity, reduce the need for local network reinforcement, and alter the financial metrics of balancing supply and demand.

National markets are being established by the system operator, National Grid, for 'capacity' and 'balancing services' though these are not obviously being designed with demand side approaches in mind. Moreover, it is currently difficult to see how the rules and structures being put in place would enable an operation effectively aggregating demand reduction and/or peak shifting activities across a city to recover from these markets the value created by its actions. Making the most of smart energy data – and enabling a city-scale operation to capture the financial value of it



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doing so – is likely to require some significant changes in the way these markets operate so that new business models can emerge and flourish.

The advent of half-hourly smart metered data for households creates opportunities for time-of-use (ToU) tariffs. When combined with in-house appliance controls which shift or curb demand to avoid high-cost times, these could improve energy management for both individual consumer and whole system benefits. ToU tariffs could be either static (better reflecting the system costs of typical peaks and thus stimulate reductions or shifts) or dynamic (to use prices to stimulate increased real-time system responsiveness to, for example, intermittent generation).

These developments may well create commercial opportunities to sell services to households and businesses which enable them to optimise their energy use and ToU tariff combination. Some such services are already emerging in the non-domestic market, in particular to reduce the risk associated with demand-related network and transmission charges.

However, for the domestic sector, until the electricity market is using actual half-hourly smart energy data (rather than just two demand profiles: standard and Economy 7) to settle domestic consumer usage, the introduction of ToU tariffs will be compromised. That's because, without half-hourly settlement) it will continue to be that case – as now – that any system value delivered by reducing or shifting peaks will not be able to be allocated to those consumers whose actions have created it. While this shift in settlement rules is on the cards, the timing of it means there is likely to be a hiatus between the installation of domestic smart meters and the opportunities for ToU tariffs to play a meaningful role in sending system-cost relevant price signals to consumers and enabling responsive consumers to be rewarded.

A central question that will drive the commercial viability of stimulating and aggregating demand reduction and/or demand response is what the system value will be of shifting demand 'on demand'. This is likely to be driven by the nature and scale of the balancing challenges on the system, which in turn will be largely driven by the proportion of generating capacity from intermittent sources like wind and solar. If this is large, the value of shifting demand will be significant and commercially viable markets will emerge (provided the increase in value can be anticipated sufficiently in advance with reasonable confidence). However, this value will also be shaped by the extent to which the markets have been structured from the outset (i.e. from now on) to anticipate and bring forward this increasingly valuable future demand side opportunity (as opposed to stimulating investment in long-life 'back up' generating capacity).





ss Great Britain

In addition, there may be commercial interests (such as, for example, Google) who may be able to extract sufficient value from other services and uses of customer data that it will provide such energy demand aggregating services as an 'add on' rather than as a core commercial proposition. Such offers would significantly influence the market viability of a purer energy 'play' of the sort likely to fit with a city-scale approach.

Energy suppliers are legally responsible for installing domestic smart meters in their customers' homes. This effective monopoly creates difficulties for third parties seeking to engage with householders to offer smart-meter-related services. The lack of co-ordination between energy suppliers in delivering the roll-out on an area-by-area basis creates particular challenges for a third party seeking to work with householders and businesses in a specific area, such as a city. It is not yet clear whether concerted effort by a third party (such as a council or local agency) in a particular area could tempt or cajole energy suppliers to roll-out installations simultaneously. To do so would create the potential to engage with consumers directly about the city's smart energy intentions and secure their interest and buy-in (including access to their data). Because of the lack of an area-based roll-out strategy, it is also not clear how such effort would be funded, even if it has the potential to reduce – for all suppliers – the local costs of roll-out by enhancing public confidence and 'first time' installation acceptance rates locally.

• Rules, regulations and policies

The roll-out of domestic smart meters is smothered in regulations, technical specifications and codes of practice. These, combined with the monopoly which energy suppliers have in the roll-out of smart meters (see above), are already limiting the potential for area-based roll-out and create a significant challenge to any enterprise seeking to organise co-ordinated capture and use of data and associated interventions across a city.

Regulatory regimes governing gas and particularly electricity transmission and distribution have tended to see only a limited role for smart energy data over the next five years. This is likely to constrain the development of new approaches to more active system operation at distribution network level which could have stimulated demand reduction initiatives. That said, there is support for innovation which may be sufficient to enable DNOs to develop new practices which can find value in a city-scale approach to stimulating demand reduction and peak shifting.

However, as noted above, Bristol's currently unproblematic network (particularly when compared with areas of the network further South West experiencing unprecedented and unanticipated solar PV installations) means that WPD's approach (and to some extent Ofgem's) to the regulated innovation funding is to focus on innovative approaches to solving its current network challenges rather than experimenting with new capabilities to apply in what are currently stable situations. Ofgem has recently been exploring what it calls 'non-traditional business models'. It is possible that this strand of work develops into opportunities to create 'spaces to experiment' where, under strict conditions, specific regulatory requirements are relaxed or changed to enable other approaches to be tested in 'real world' settings.

There are currently signs that DECC is interested in introducing a new obligation on energy suppliers to require them to reduce average demand from their domestic customer base, year on year. While this approach is still in development, its introduction would potentially stimulate far greater interest from energy suppliers in ensuring their customers are engaged with their smart meters and associated interventions such as ToU tariffs.

The governance of many of the rules – or codes – determining market behaviours and setting technical standards has been criticised (by, for example, the Competition and Markets Authority) for being too controlled by incumbent companies and being slow to respond to opportunities to improve system performance in the interests of current and future consumers (or the public

interest more widely). Unless addressed, this factor may inhibit developments in market rules which enable the opportunities represented by the growth in smart energy data to be realised. It will also favour incumbent utility-scale business models over more innovative city-scale ones, which encounter significant and costly barriers to market entry.

- **Social/cultural factors**

In considering how changes might occur in the way energy is supplied and used in the UK, social and cultural factors are often largely ignored in policy making and programme design which tend to be dominated by either technology-oriented thinking or econometric analysis. This may go some way to explaining why change in response to policy implementation has generally proved more difficult than commentators and policy-makers have typically anticipated.

Where social and cultural factors are considered, they are typically captured in rather simplistic behaviour modification theories or 'market barriers' (such as the 'tenant/landlord' one) which ignore the full range of technical, economic, social and cultural factors which shape how we use energy.

As Professor Elizabeth Shove has said: *"If we are to understand how people engage with energy systems, it is not the meter that needs to get smarter, but our understanding of what energy is for and how it is used."*

In relation to 'smart energy', public awareness appears to be low – and, it seems, largely disinterested. When asked, the public is broadly supportive of smart meters, with particular interest in how it will help them control their energy bills. A minority worry about data privacy and have little faith in suppliers using data to help their customers.

Public understanding of energy systems and the impact of their energy using actions and patterns of behaviour is weak. The supply-side dominated public discourse (of 'supply gaps' rather than 'demand excesses') detaches people from how the timing and scale of their energy use influences the supply system. However, when explored, researchers find a reasonable understanding of the need for energy system change together with an expectation of being involved and contributing (usually in unspecified ways) to such change in terms of how they use energy at home and work.

Expectations of future 'smartness' in our energy use must therefore be calibrated by a more sophisticated understanding of the socio-cultural factors shaping householder and business engagement with their energy use and any smarter services designed and offered to change it.

For example, while power system engineers can conceive of a 'smart energy' world in which the management of many domestic appliances is automated to serve system needs, there is more work to do to explore how households can come to be enticed by the 'opportunity' to let their dishwasher be switched remotely to run at 2 o'clock in the morning instead of 7 o'clock in the evening and what level of control or over-ride they would wish to retain.

In commercial buildings, owners and tenants tend to exhibit little interest in improving their energy management, even though the frequently unused data being collected by existing building energy management systems has significant potential to reveal extremely cost-effective opportunities for system optimisation requiring little by way of upfront investment. Investigating these opportunities and making decisions about taking action to realise them often slips unnoticed between premises management (for whom energy may be only a small component of their workload) and finance teams who pay the energy bills without question.

Enhancing the value of local renewable energy generation

The opportunity: Enhancing the value of local renewable energy generation by improving local balancing of supply and demand and finding more direct local supply opportunities

Smart energy data creates the potential to reboot the relationship at a local level between decentralised energy generation, particularly renewables like solar and wind, and local energy demand from households, businesses and other organisations.

New business models seeking to enable more explicit supply relationships between locally generated power and local homes and businesses are emerging. This is partly in response to the growth in community ownership of renewable energy projects and people wanting to buy 'their own power' and partly in response to businesses and organisations trying to find ways to reduce energy costs by buying 'on site' or very local sources of supply. These business models currently face some significant regulatory obstacles.

At the same time, the rapid growth of intermittent renewable energy generation connected to the local distribution network is increasing the challenges of managing the local network. This points to value in more local approaches to balancing supply and demand, potentially by combining locally orchestrated demand-side response (shifting energy use in time) with local energy storage (theoretically available from hot water and storage heaters to electric vehicles and large-scale batteries).

As of mid-2015, there is 89 MW of renewable electricity generation connected in the Greater Bristol area, 60% of which is wind or solar. 15MW of this is domestic scale solar PV, spread across 4,500 homes.

On the basis of national estimates, it is possible that up to 30% of Bristol's electricity demand could be responsively brought forward or delayed in time to match renewable energy output, though this partly depends on the time of year, week and day when the shift is needed and public or business willingness to shift it. This was explored in the previous section on 'Curbing energy waste and peak demand'.

The question which the Collaboration has addressed is how this complex web of different interests, patterns of generation and consumer demand, and emerging energy system management requirements could be organised at city-scale in the interests of local generators, distributors and consumers.

As an example of a possible approach to capture the opportunity, DNV-GL's concept of a Power Matching City builds out of experimental work at neighbourhood level in Groningen in the Netherlands and a data and virtual power trading platform developed for the purpose. More details (including a video and brochure) are available here (www.bit.ly/1NQHJAW).³

In the context of the framework of different conditions for success outlined above, for this opportunity the conditions become:

- Whatever the potential, nothing can happen if the commercial arrangements don't stack up enough to fund interventions to secure change. Unless there is sufficient financial value in

³ DNV-GL is exploring the feasibility of this approach for Bristol alongside their involvement in the Collaboration, as part of their contribution as a sponsor of Bristol 2015 European Green Capital.

organising local balancing and stimulating and aggregating appropriate demand-side responses, it is unlikely such activity will emerge in the market as organised services. The commercials need to be right.

- And the commercials being right will depend, at least in part, on how the market and trading rules and retail market licence conditions are set and whether they enable this sort of approach and enable the energy system cost savings it creates to be captured by the local services responsible for creating them (e.g. by providing balancing services, reducing investment in new generating capacity, limiting costs associated with network and transmission system use etc).
- But, unless the public and building owners and occupiers can be engaged constructively with offers of data-driven assistance to shift demand to match local generation intermittency and new types of electricity supply relationships, the market won't really exist and the technical potential will not be realised.

Our perspective is that we don't think any of these conditions are currently met. Some conditions are a long way from being met and may require change at national level (e.g. to market rules and supply licenses) which may or may not be forthcoming. More specifically:

The **technical potential** might well exist but it is not understood at the fine grain required on the demand side to know how much demand can flex in time, how various forms of storage could help, or whether there would be value in aggregating demand across different types of consumer with different usage patterns (for example a group of households, some different types of businesses, a university and a hospital). Output data for the supply side is potentially available from local generators (subject to their permission) at fine grain to understand typical patterns of output and the variability over time and typical weather patterns. But we are not aware that this work has been done for Bristol (though we are aware of examples in other European countries).

Some **people and businesses** and other organisations may be interested in 'buying locally' but haven't begun to think through the implications of what is involved in trying to match their demand far more carefully to local supply dependent on the wind or sun. And there are significant challenges inherent in engaging households and businesses in the demand side response services needed for local system balancing, likely typically to be tied in to Time of Use (ToU) tariffs to reflect real time local or national system costs.

For example, while power system engineers can conceive of a 'smart energy' world in which the management of many domestic appliances is automated to serve system needs (either locally or nationally), there is more work to do to explore how households can come to be enticed by the 'opportunity' to let their dishwasher be switched remotely to run at 2 o'clock in the morning.

That said, there may be some larger commercial or public sector organisations with high energy use, particularly some of those active in Bristol Green Capital Partnership, who would be willing to explore how their energy demands could be aggregated and analysed alongside local generation data for opportunities to orchestrate their demand more actively and thus contribute to system balancing.

The **regulatory frameworks and market rules** currently make it difficult to establish the sorts of direct supply relationship assumed to be at the heart of local balancing (though Ofgem has been exploring how it should react, if at all, to such non-traditional business models). And regulatory frameworks structuring outputs and incentives for district network operators may currently compromise either their commercial willingness and/or their ability to participate meaningfully in local system balancing initiatives on anything but an experimental basis as part of an innovation programme.

Establishing a **commercially viable basis** for such local activity is perhaps the most challenging. Aside from whether the emerging national balancing and capacity markets will be accessible to local city-scale initiatives, much will depend on what the system value will be of shifting demand 'on demand'. This is a central question that will drive the commercial viability of stimulating and aggregating demand reduction and/or demand response at any scale. The challenges of stimulating and aggregating demand response across customers of different energy suppliers may also prove costly to overcome.

The commercial viability of such activity is likely to be driven by the nature and scale of the balancing challenges on the system, which in turn will be largely driven by the proportion of generating capacity from intermittent sources like wind and solar. If this is large, the value of shifting demand will be significant and commercial viable markets will emerge (provided the increase in value can be anticipated sufficiently in advance with reasonable confidence). However, this value will also be shaped by the extent to which the markets have been structured from the outset (i.e. from now on) to anticipate and bring forward this increasingly valuable future demand side opportunity (as opposed to stimulating investment in long-life 'back up' generating capacity). It is not entirely clear (to us at least) what is the additional value (if any) of balancing demand and supply *locally* on top of the value it creates across the electricity system as a whole.

With all these challenges come the challenge of capturing **local energy data** from generators and consumers at sufficient resolution in real time to enable effective and timely interventions to be triggered to secure demand response. While this is undoubtedly feasible with the co-operation of generators and consumers, the necessary institutional and operational infrastructure does not yet exist.

DNV-GL's Power Matching City concept (www.bit.ly/1NQHJAW) acknowledges these many challenges – particularly the energy, data and commercial ones – and provides a city-wide approach which may help to address them.



Construction of wind turbine at Avonmouth

Smarter ways to tackle fuel poverty and associated vulnerabilities

The opportunity: Using smart energy data and related interventions to tackle cold homes/fuel poverty and the associated health and social challenges

This opportunity incorporates two different aspects of a smart energy city which are of interest to us:

- How can smart energy data combine with other sensors and data flows to improve services and enable new and useful interventions to meet household needs and reduce vulnerability?
- How can we ensure the opportunities and associated benefits unleashed by the imminent availability of smart energy data reach vulnerable and disadvantaged households as well as a receptive tech-savvy minority?

Some of the questions this raised for the Collaboration included: what should we be doing in 2016 to enhance engagement (both now and in the future) with smart energy technologies amongst more vulnerable households? Can we use smart energy data to help to create smart services that social landlords and health and social care providers can use to support their tenants/patients/clients? Are special precautions needed for such services to protect the dignity and privacy of vulnerable households?

Smart energy data creates the potential to develop new ways to assist households struggling to keep warm and facing vulnerabilities caused or exacerbated by living in a cold home. The roll-out of domestic smart meters over the next five years establishes an opportunity for this potential to be realised.

This assistance can be relatively direct: for example, Smart Prepayment Meters (PPMs) expand energy cost management options for households (compared with existing PPMs) and smart meters create opportunities for greater visibility of energy use and integration with appliance and heating controls, enabling better energy management in the home. Smart heat meters linked to smarter heating controls (such as those just installed by Bristol City Council for its 3,000 tenants on district heating schemes – see www.bit.ly/1NBhVqw) provide similar opportunities for more affordable warmth and lower energy demand.



Experience from the still limited early stage roll-out of smart PPMs suggests that they are popular with consumers. However, there is a need to explore in more detail how this popularity – and the development of new associated services – splits between younger, tech-savvy renters keen on ‘Pay As You Go’ options for energy (as with other services they buy) and the more traditional (and vulnerable) PPM households where heat rationing and self-disconnection are known patterns of behaviour with existing PPM technologies.

Integrating smart energy data with other sensors and data flows (such as internal temperatures, humidity, personal health information, movement sensors etc) opens up potential for provision of more services. Such data integration can provide information which triggers either the householder or a monitoring service (such as from a social care provider) to intervene to safeguard against risks such as excess cold or condensation, or to detect falls or other emergencies in the home.

There is currently extensive experimental trialling of these sorts of initiatives, though each trial remains relatively small scale. At this stage, the trials tend to focus more on testing the efficacy of the sensing technologies and the data integration and analytical techniques, than on exploring the value to the householder or health or care provider of that data becoming available and triggering appropriate interventions. That said, these trials are typically driven by an interest in the potential of such an ‘internet of things’ approach to provide benefits to the more vulnerable in society.

As they develop, such experiments will need to demonstrate services which can scale up and which are valued by the householder or the service provider (and preferably both). The latter will principally be interested in improved patient/client wellbeing by using the monitoring and interventions to reduce exposure to manageable risks (such as a cold home). Given current pressures on public expenditure, the new services will also need to demonstrate that they reduce costs overall through better patient management (such as reduced hospital admissions or emergency home visits).

The question we sought to address in the Collaboration is how this complex web of technical challenges, customer/patient/client needs, market developments and funding/commercial requirements can be understood and addressed across a city. This includes the question of whether there is particular value in organising at city-scale to address these issues. Put simply:

- Whatever the potential, nothing will happen if the commercial and/or funding arrangements don’t stack up enough to fund developments and interventions to secure change. Unless there is sufficient financial value in organising new smart-energy-data-enabled services for vulnerable households or providing specific support for them during the roll-out of smart meters, they will not emerge. Such value might come from: (a) payments or subscriptions from service users; (b) energy system benefits (such as reduced customer management and/or smart meter installation costs), or; (c) service providers commissioning services in the expectation they will reduce the overall cost of providing health or social care.
- And the commercials being right will depend, at least in part, on how the rules and regulations are set, for example, how they protect and support vulnerable consumers in relation to smart meters, how they manage the future smart PPM market and how they enable data integration between different disciplines (such as energy, housing and health).
- Policies associated with the development and regulation of data-driven social and health care services will also have a significant influence on the nature and scale of the opportunities relating to integrating smart energy data into such services.
- But, unless vulnerable households and those who provide services to them can be engaged constructively with affordable offers of data-driven assistance, the market won’t really exist for these sorts of services.



For this opportunity, the conditions for success framework diagram looks like this (above).

Our perspective is that only the 'realisable potential' condition (the box in red above) is currently met. Other conditions are a long way off (which is partly why the technical potential is not being realised) and may require change at national level. More specifically:

- **Technical – energy**

In relation to the **realisable potential to tackle cold homes** Bristol's housing-related energy saving opportunities (from improved insulation etc) are relatively well-understood, as is the distribution of fuel poor households across the city. There are particular technical and cost-related challenges associated with improving older solid-walled properties, in which most of Bristol's fuel poor live. There are also significant obstacles to improving thermally inefficient housing in the private rented sector (where tenants are far more likely to be fuel poor than in socially rented or owner-occupied homes).

There is also considerable unrealised potential for peak electricity demand reduction across the city (although there is nothing particularly special about the potential in Bristol). Some of this potential will exist within fuel poor and vulnerable households, though there is only limited understanding of the half-hourly energy demand profiles of such households and the extent to which some contribute disproportionately to peak demand (or even the extent to which 'fuel poor' households have similar enough demand profiles for this to be a useful categorisation in tackling peak demand).

Beyond improving the energy performance of the building fabric, there is extensive evidence that helping households navigate the energy market better and use their heating controls and appliances more smartly can reduce energy demand and cut the costs of keeping warm.

- **Technical – IT and data**

In relation to the IT and data, there is an imminent explosion in data from in-home and personal devices (monitoring a vast array of conditions, such as temperature and humidity, the activity of people in the home or whether the taps have been left on). This creates huge potential for the development of services which link data with interventions to support (or automatically deliver) better outcomes, or to safeguard against identified risk.

However, at present there are considerable constraints (beyond data access and privacy concerns). This is because smart energy data availability is dependent on the roll-out of smart meters and, particularly in relation to our concern here, on the roll-out of smart meters to vulnerable households at risk of being unable to keep warm.

Some energy suppliers appear reticent to install smart meters before the Data Communication Company arrangements and the technical specification (SMETS 2) are finalised; this may mean slow progress when the full smart meter roll-out starts in 2016. In addition, there are technical challenges, yet to be overcome, in installing smart meters in blocks of flats. This creates a particular challenge for Bristol where a fifth of its homes are flats (though many are sub-divided houses which may prove less technically problematic).

At present, Consumer Access Devices (CADs) will be the main mechanism through which domestic smart meter data analytical and management services will be offered, with the potential to link to other sensors, appliances and controls in the home to provide energy management services (such as switching non-essential appliances off when the meter 'knows' that system prices are high).

There is extensive work being done in data analytics to improve the potential of energy and other data (temperature, humidity, light, CO₂ levels) to provide fine grain information about household energy use patterns (for example, by revealing appliance specific characteristics), which can be used to provide tailored energy advice and energy management services to households.

Experimental work is being done in Bristol (the SPHERE project (www.irc-sphere.ac.uk/about)) to test how data from energy and a wide range of in-home environment and health related sensors can be used to improve household wellbeing and guide health and social care interventions. Other 'Internet of Things' experiments with an energy data component are also underway in the city.

Smarter heating controls can potentially already deliver additional controllability, either directly by the householder or via a third party interpretation and management service. These do not need smart meter data to be effective, though projects like SHIMMER (www.bit.ly/1OdJwu9) demonstrate how much more can be achieved if they are involved. SHIMMER combined smart energy data, solar PV, personalised energy advice, tariff checks, and budgeting in social housing and found that significant financial savings can be made by fuel poor households.

There is currently no facility at city-level to capture, collate, analyse and use smart energy data from across the city or an agreed approach on how (or whether) it might be developed and integrated with other data flows. However, there is already commitment and activity in Bristol to create a 'data commons' and the Bristol is Open (www.bit.ly/1xd3Tjq) initiative between Bristol City Council and the University of Bristol potentially provides a framework for solving this data handling challenge. That said, there are and will be some significant challenges in securing access to this data, in terms of both obtaining the owners' permission and overcoming technical challenges of access, transfer and analysis.

- **Social/cultural factors**

The influence of social and cultural factors is often overlooked in policy-making, which tends to be dominated by either technology-oriented thinking or econometric analysis. Consideration of social and cultural factors also tends to be rather simplistic, ignoring the full range of factors (technical, economic, social, cultural) which shape how we use energy. This may go some way to explaining why change in response to policy implementation has generally proved more difficult than policy-makers have anticipated.

"If we are to understand how people engage with energy systems, it is not the meter that needs to get smarter, but our understanding of what energy is for and how it is used"

Professor Elizabeth Shove

In relation to 'smart energy,' public awareness appears to be low. Once prepayment meter users (those who arguably could most benefit from smart meters) find out about them they are interested and understand the benefits they could derive from a smart meter. Smart prepay or 'pay as you go' offers significant benefits to people with disabilities and those on Priority Services Registers in terms of flexible top ups, accurate bills and feedback on energy usage via the smart meter in home display.

Smart meters are being marketed as 'be in control of your energy use' and can potentially be instrumental in increasing energy know-how and improving fuel budgeting. Smart meter in home displays have the potential to counter the current lack of public understanding of energy systems and the impact of their energy using actions and patterns of behaviour. The 3E project in Bristol (www.kwmc.org.uk/projects/3ehouses) with council tenants highlighted the positive impacts that accessing energy data can have, and that benefits can be maximised with ongoing community engagement.

For future 'smartness' in our energy use, more work must be done to understand the socio-cultural factors shaping householder engagement with their energy use and any smarter services designed and offered to change it. For those with limited ability or intention to make energy efficiency changes to their homes (tenants may move frequently or be restricted in the improvements they can make by disinterested landlords) what assurances or interventions are required so that 'smart' doesn't become just for the well off? How can the benefits of domestic appliance automation or Time of Use tariffs be communicated, encouraged and actualised (when appropriate) with those facing fuel poverty?

Smart Energy GB has the remit for communicating the benefits of smart metering to the general public and businesses. It has identified particular needs for a range of vulnerable groups (www.bit.ly/1m6Sldi) and is actively developing programmes to provide support which meets these needs, much of which will be delivered (and hopefully shaped) by local partners. Research has shown (Count Us In, 2015) that some people think that smart meters will automatically reduce their energy use, and that they don't need to change their habits to save energy. There is clearly a need for ongoing communication with householders to reduce energy demand, optimise energy management and tackle fuel poverty.

It is important that the development of smart services is sensitive to people's concerns about their personal autonomy and privacy, particularly for vulnerable households who may feel unable to advocate on their own behalf. The opportunities to use in-home data (including smart energy data) to support and guide vulnerable households, often via remote intervention, needs to be actively considered in the light of such concerns. This video (www.superflux.in/work/uninvited-guests) illustrates in a humorous way both how a well-intentioned smart intervention may backfire and become slightly sinister; it's a scenario that will need effort to avoid.



Luke Andrew Scowen | reproduced under creative commons | www.flickr.com/photos/lukeas09

- **Rules, regulations and policies**

The regulatory frameworks and market rules (the purple box above) for the roll-out of domestic smart meters are complex. The monopoly the energy suppliers have in the roll-out seems to be limiting the potential for an area-based approach which could build momentum geographically and with cultural communities, and provide area-based employment. This is important given behavioural insights evidence that having the right ‘messenger’ (person and language used/spoken) and social norms are key influences on people adopting new technologies or practices. Smart Energy GB is hoping to over-ride this limitation by developing local partnerships with a particular focus on support for more vulnerable households. However, the energy supplier monopoly also presents a huge challenge to any enterprise seeking to co-ordinate, capture and use smart energy data and associated interventions across a city.

Energy regulator Ofgem has established incentives for distribution network operators like Western Power Distribution (WPD) to take more action to deliver support and advice to households with energy-related vulnerabilities in their areas, including those on their Priority Service Registers. Bristol’s DNO, WPD, has been developing innovative new approaches to this, though as of yet there are no plans to integrate smart energy data to enhance safeguarding and improve targeting.

The governance of many of the rules – or codes – determining market behaviours and setting technical standards with the gas and electricity systems has been criticised (by, for example, the Competition and Markets Authority) for being too controlled by incumbent companies and being slow to respond to opportunities to improve system performance in the interests of current and future consumers, or the public interest more widely. Unless addressed, this factor may inhibit developments in market rules which enable the opportunities represented by the growth in smart energy data to be realised. It will also favour incumbent utility-scale business models over more innovative city-scale ones, which encounter significant and costly barriers to market entry.

There are currently signs that DECC is interested in introducing a new obligation on energy suppliers to require them to reduce average demand from their domestic customer base, year on year. While this approach is still in development, its introduction would potentially stimulate far greater interest from energy suppliers in ensuring their customers are engaged with their smart meters and associated interventions such as Time of Use tariffs. Simultaneously, DECC is planning to introduce a Fuel Poverty Obligation on energy suppliers (to replace the current 'ECO' arrangements) which is likely to ensure that a range of offers of free or heavily subsidised energy efficiency and heating improvements are available to fuel poor households.

• Commercial

The commercial factors need to be considered from the perspective of the end consumer, the energy suppliers and any service providers impacted by the cost of cold homes – health and social care services, and social and private landlords.

The end consumer can benefit financially from reduced fuel bills by taking up existing cost-effective demand reduction actions. However, for fuel poor and other vulnerable households, their low income will often make the necessary investment unaffordable. Those living in private rented accommodation face the problem that their private landlords are typically unwilling to invest in improvements (such as improved insulation) which they believe benefits only their tenants. The availability of smart energy data is unlikely to change this situation, though it may make it more feasible for third parties to develop viable energy services approaches based on better data monitoring to prove savings.

Registered social landlords (RSLs) such as housing associations have upgraded the energy performance of their housing stocks significantly over the past 15 years. They will often recognise the financial value to themselves as landlords of having tenants who can afford to keep their home warm because the homes are energy efficient. Some RSLs will also fund energy saving advice and interventions directly with tenants because it makes financial sense to invest in such services because they reduce the tenants' energy costs, cut the risk of fuel debt (which often spills over into rent arrears) and improves tenant wellbeing.

Beyond the energy sector, the increasing costs of providing health and social care to an ageing population should create interest amongst providers in using in-house and personal monitoring data to reduce risks (or excess cold, falls, etc) and potentially avoid high cost interventions such as hospital admissions. The well-evidenced role of cold homes in exacerbating many health conditions (e.g. the NICE guidance on tackling the health impacts of cold homes, published in March 2015 (www.nice.org.uk/guidance/ng6)) should lead to greater interest amongst health and social care providers in becoming involved in integrated solutions to target at-risk households with appropriate support and interventions.

Smart energy data could significantly enhance such services (and remote monitoring and response services like Bristol's Telecare), though the evidence that data-driven interventions will improve care cost-effectively currently remains very limited. This is mainly because most experimental trials are at the stage of testing and perfecting the monitoring, capture and analysis of data from multiple sensors rather than exploring the impact over time on client/patient health and/or health or social care costs.

6. The road maps: from 2016 to Bristol Smart Energy City

The analysis outlined here of the current status of these conditions for each of the three Smart Energy City opportunities was the backdrop to the Collaboration's expert workshops in September and October 2015.

The workshops considered in particular the steps which need to be taken in Bristol over the next few years to establish the conditions and capabilities required for Bristol to realise these opportunities. The output is a set of road maps, one for each opportunity, attempting to show the steps from action now towards future initiatives leading to Bristol Smart Energy City. These were then reviewed and refined by the Collaboration in November.

In keeping with the approach of the Collaboration, we have considered steps which relate to each of the dimensions we have explored – from seeking to stimulate greater public understanding and engagement with peak demand (through, for example, public art) to developing a specification for the data capture and analytics requirements for a Smart Energy City.

Our principal focus has been on what needs to happen next (i.e. 2016) in order to a) make the steps after that more feasible; b) develop understanding; and c) improve capacity in the city to create and take advantage of future opportunities and to react smartly to changes in policy or markets or public sentiment.

We have rather crudely divided the steps – or activities – into 'Doing', 'Preparing' and 'Exploring' and shown a timeline from 2016 to 2020 in an attempt to show how they relate to each other.

Doing: activities which can be done now with more or less immediate impact. For 2016, these are mainly designed to change – hopefully for the better – the context in which future work takes place.

Preparing: steps which need taking now so that Bristol is ready to participate more fully in smart energy activities in a year to two years' time. In 2016, these mainly feature work to design, and enlist participation in, more significant near-future pilot or city-scale activity

Exploring: initiatives to take now to improve prospects for future activity, such as engaging with national policy-makers and regulators about Bristol's plans or efforts to build consensus amongst key organisations in the city around the purpose of the Smart Energy City, creating the potential to establish clearer governance arrangements in a few years' time.

Spotting similarities between the road maps

We are aware that some actions or 'steps' appear on more than one of the road maps. This reflects the level of overlap between the opportunities (particularly the first and second) and how actions can serve more than one purpose.

Defining overall priorities

In reviewing and refining these road maps in November, the Collaboration identified the ten priority next steps to take in 2016. These are described in [Section 8 below](#).

The five conditions

-  ENERGY SYSTEM requirement (e.g. Technical potential to reduce energy use exists)
-  People need to be willing and engaged, so they participate
-  Regulations need to enable access with market rules rewarding system value created
-  Commercials need to stack up so it's worth someone doing it
-  The data and IT needs to be available and able to 'do its thing'



Road map 1: Using smart energy data to curb energy waste and peak demand

	2016
DOING Things to do now for impact now	Secure mass take up of Demand Logic style diagnostic services to enhance energy data analytics in commercial and public buildings Commission public art to reveal city's daily demand peaks LED lighting swap initiative (reducing demand and peak in domestic sector) Trials of approaches to engaging households with energy advice during and after smart meter installation Establish portal within Bristol data commons initiative for people to share and visualise their energy data
PREPARING Things to do now to prepare for action and impact in 1–2 years	Engage with suppliers and Smart Energy GB on what would constitute an irresistible offer from Bristol to justify 'all in one year' smart meter rollout Enlist larger local loads (e.g. universities, hospitals etc) to create group sharing data and exploring opportunities for aggregated demand response Engage with National Grid on how city-scale demand response can feature in their planning Develop community-scale household demand reduction trial Put funding bid together for local experiments and market innovation Spec out framework for data capture and analysis for city-scale initiative, including consent and access requirements Understand market readiness/penetration of different technology and services plan integration with Smart Energy City initiatives and explore with developers and suppliers their interest in Bristol as pilot city-scale initiative
EXPLORING Creating conditions which make impact possible in future	Engage with Ofgem and DECC on market rules and governance and opportunity to carve out 'space to experiment' for Bristol Articulate a clear purpose for Bristol Smart Energy City Consider how to embed Smart Energy City aspirations into new build in Bristol Knowledge tracking and R&D opportunities – both with academics and market innovators

Background against which events on this timeline are taking place

DCC goes live and domestic smart meter mass roll-out starts

ToU tariff trials

CADs widely available

Smart Energy GB engages with local partners

New Supplier Obligations in place

The five conditions



2018

- Test commercial and public users demand response aggregation potential across city

- Peak alert apps to encourage load shedding (linked to 'use now' app function to make most of local renewable generation – in Roadmap 2)

- Deliver Bristol smart meter roll-out support service, co-ordinated with all suppliers and with data capture and engagement driver

- Smart-enabled household demand response – trial aggregation on small scale

- Tests of domestic DSR automation & ToU tariffs

- Actively promote take-up of key smart energy technologies within the city, tying technology suppliers and service providers into Smart Energy City plans

2020

Bristol Smart Energy City up and running

- Establish governance and commercial model for Bristol Smart Energy City

- Map out compliance requirements

- Commercial viability modelling for 2020 operation

- Local policies to require smart enabled technology in new build

'Next day'
supplier
switching
goes live

Energy Settlement
to half-hourly

Plans for RIIO-ED2
emerging

Rollout complete





Road map 2: Enhancing the value of local renewable generation

	2016
DOING Things to do now for impact now	Commission public art to reveal city's renewable energy production and real time electricity demand Large scale trial of storage linked to local renewable generators Establish portal within Bristol data commons initiative for households and businesses and local generators to share and visualise their energy data
PREPARING Things to do now to prepare for action and impact in 1–2 years	Enlist larger local loads and local renewable generators (eg City Council, Triodos Renewables, Ecotricity etc) to create group sharing data and exploring opportunities for aggregated demand response and local system balancing Prepare for pilot of Power Matching City (or equivalent approach) Engage with National Grid on how city-scale system balancing can feature in their planning Put funding bid together for local experiments and market innovation Spec out framework for data capture and analysis for city-scale initiative, including consent and access requirements Explore new distribution charging methodology which reflects local supply initiatives which reduce system use (learning from WPD project SYNC)
EXPLORING Creating conditions which make impact possible in future	Engage with Ofgem and DECC on market rules and governance and opportunity to carve out 'space to experiment' for Bristol Review Power Purchase Agreement and financing terms with local renewable generators to understand potential for changing future supply arrangements Articulate a clear purpose for Bristol Smart Energy City Knowledge tracking (e.g. learning from Low Carbon Network Fund projects) and R&D opportunities – both with academics and market innovators.

Background against which events on this timeline are taking place

DCC goes live and domestic smart meter mass roll-out starts

ToU tariff trials

CADs widely available

Smart Energy GB engages with local partners

New Supplier Obligations in place

The five conditions

■ Energy
 ■ Social/cultural
 ■ Regulatory/policy
 ■ Commercial
 ■ IT/data

2018

- ■ ■ Peak alert apps to encourage load shedding and 'use now' alerts to improve matching of demand with local generation output

- ■ ■ ■ ■ Pilot Power Matching City (or equivalent approach)

- ■ ■ ■ Tests of commercial sector and domestic DSR automation & ToU tariffs to reflect local generation availability

- ■ ■ Trial new distribution charging methodology to reflect better the distance between generator and supply customer

- ■ ■ ■ ■ Local smart electricity system design blueprint, incl. generation, demand management, storage options

2020

Bristol Smart Energy City up and running

- ■ ■ ■ ■ Establish governance and a commercial model for Bristol Smart Energy City

- Map out compliance requirements

- Commercial viability modelling for 2020 operation

'Next day' supplier switching goes live

Energy Settlement to half-hourly

Plans for RIIO-ED2 emerging

Rollout complete





Road map 3: Smarter ways to tackle fuel poverty and associated vulnerabilities

	2016
DOING Things to do now for impact now	Pilot different approaches to local vulnerable customer support programme for smart meter rollout Data sharing and mapping of Priority Service Register customers (WPD, WWU and willing suppliers) Trial Smart PPM post-installation support for vulnerable homes Trial data communication solutions for smart meters in flats (as national exemplar) CSE and Knowle West Media Centre to integrate efforts on smart energy and 'Internet of Things' opportunities for vulnerable households
PREPARING Things to do now to prepare for action and impact in 1–2 years	Map out Bristol-wide service to engage/support vulnerable households for smart meter rollout, engaging Energy UK and Smart Energy GB to test for integration with national planning Explore with WPD and WWU smart data opportunities for vulnerable customer support Undertake local trials of 'thermal safeguarding' for households vulnerable to under-heating Engage with health service over cold home thermal safeguarding trials Test data visualisation approaches with different types of vulnerable household Analyse vulnerable customer segmentation and improve demand profile understanding to assess potential for demand response and aggregation Explore opportunities to link vulnerable household support services with City Council Telecare and other care support and monitoring services Identify and/or design CAD applications which suit vulnerable households
EXPLORING Creating conditions which make impact possible in future	Build consensus over Smart Energy City serving public interest and inclusivity Ensure city strategy specifically includes smart energy as part of goal to achieve 'digital inclusion'

Background against which events on this timeline are taking place

DCC goes live and domestic smart meter mass roll-out starts

ToU tariff trials

CADs widely available

Smart Energy GB engages with local partners

New Supplier Obligations in place

The five conditions



2018

2020

- Embed lessons from trials in full roll-out of service across city
- Trial smart data enabled vulnerable customer support with WPD/WWU
- Cold home thermal safeguarding trials with health service
- Assess quality and value of range of different CAD applications for vulnerable households
- Establish long-term funding and/or commercial case for smart energy services for energy vulnerable people
- Ensure Bristol Smart Energy City governance reflects need for inclusivity and shared benefits

Bristol Smart Energy City up and running

- Establish governance and a commercial model for Bristol Smart Energy City
- Map out compliance requirements
- Commercial viability modelling for 2020 operation

'Next day' supplier switching goes live

Energy Settlement to half-hourly

Plans for RIIO-ED2 emerging

Rollout complete



7. Does a 'Smart Energy City' make sense?

The challenges of a city as the organising principle

The notion of a 'Smart City' is now well established in public discourse. Many cities have embraced it as an aspiration and global consultancy and technology firms routinely promote their services under a 'Smart City' banner. However, its meaning is fluid in terms of what gets to be 'smart' within a city, how 'smart' it becomes, and whose interests the smartness serves.

'Smart Energy' is a similarly widely promoted and espoused concept, particularly as real-time, fine-grain energy data becomes more ubiquitous. And it has a similarly fluid meaning, especially when embedded within the notion of a Smart City, and thus bounded geographically.

One of the central questions which the Bristol Smart Energy City Collaboration set out to explore was whether the notion of a 'Smart Energy City' is actually meaningful and useful. Our exploration of this question has focused less on the potential for energy-related 'smartness'; many prospective examples of smart ways to use energy data can be catalogued.

We have focused instead on whether Bristol (or any city within the GB energy system) works as a viable organising scale for the management and application of smart energy data.⁴

This section outlines briefly our conclusions so far. They can be encapsulated in the phrase 'it depends'. However, the nature of the identified dependencies and the challenges created by the current market trajectory combine to ensure that the realisation of a Bristol Smart Energy City will require considerable effort locally, and significant change nationally, if it is to meet our aspiration.

Our overall conclusion is that a meaningful Bristol Smart Energy City will probably only be realised if, over the next two or three years, co-ordinated, integrated, and ambitious initiatives in the city can demonstrate enough benefit and gain (relative to mainstream approaches) to disrupt and shift that current incumbent-dominated market trajectory.

If that happens, and is combined with active engagement with the regulatory and policy-making process, the market rules and regulations are likely to change to start to enable, rather than obstruct, the city-scale approach.

In line with the approach taken in the Collaboration to all of the issues we have explored, we have considered this question from a number of different perspectives: commercial; energy system; regulatory/policy; IT/data; social/cultural. This section is particularly focused on what is known about the extent to which the conditions can be – or are likely to be – met at city-scale (the central black box of our framework of conditions for success reproduced in Section 4).

⁴ Our conception of a Smart Energy City is thus qualitatively different from just using the city as a lens through which a variety of national and corporate smart energy initiatives are observed playing out in a given geography, with or without local involvement above and beyond the directly engaged consumers. It is also distinct from what a municipally owned energy company (such as Bristol Energy) might develop in terms of its own smart approaches with its own customers. In our conception of a Smart Energy City there is orchestrated engagement with national initiatives and purposeful organisation of smart energy activity at and below city-scale for the benefit of the city and its people and businesses (see the Bristol Smart Energy City Aspiration (see Section 3).

Put simply (and to repeat part of Section 4), in the context of examining the validity of the city-scale as a meaningful organising principle in relation to smart energy:

- The commercials need to work at a city-scale (without making heroic assumptions about local participation rates). This means that a viable business plan can be built on the back of delivering smart energy data-enabled solutions across a city, supporting the infrastructure and institutional capacity to underpin city-scale initiative.
- The city needs to have – or be able to hire or access – the capabilities and capacity to capture, manage, analyse and utilise smart energy data – and be able to organise and commit those capabilities and capacity to a city-focused smart energy initiative (as opposed to some other purpose).
- Any energy system value created through smart energy interventions (such as reduced system balancing costs, avoided peak demand, reduced energy consumption etc) needs to be both (a) recoverable from the system's markets by those who create the value and (b) at least as easy and/or cheap and/or effective to create and capture on a concentrated basis in a specific city or locality as in a less concentrated way anywhere in Great Britain.⁵
- Market rules and regulations and associated policies need to be set so that they enable city-scale smart energy initiatives to compete on equal terms with initiatives with less location- or scale-specific qualities (i.e. without the need for costly workarounds).
- There needs to be something about organising smart energy activities at city scale (or below) – such as stronger engagement, greater take-up, higher impact – which gives a city-scale approach edge over national or corporate initiatives which are less location sensitive (but which are nevertheless likely to be active and available to people and organisations in the city).

In addition, it would help if there were specific energy system challenges which benefited from – or were more easily solved – through concentrated city- or sub-city-scale action.

Drawing on our consideration of the smart energy opportunities and through the expert workshops, we have come to the following conclusions (so far). We have organised them into three categories: those aspects where city-scale looks potentially strong as an organising principle; those where city-scale looks weak but where Bristol may be to provide an answer (through purposeful local action or because of the specific characteristics of its population and/or the local 'ecology' of public, private, voluntary sector and academic organisations in the city region), and; those where city-scale looks weak.

Where city-scale looks potentially strong

a. The shift to more active electricity distribution network management favours local action

More active management of the electricity distribution network will be required over coming years to enable increased penetration of intermittent energy sources (such as wind and solar). In addition, the advent of smart meters creates an opportunity to encourage and reward reductions in peak power demand and improved local matching of supply and demand, both of which have both local and national system benefits.

These shifts will tend to favour local action because network challenges are usually local in nature. While this may need action at scales smaller than a city (since network challenges are often in a

⁵ We should also note that whoever is currently earning that value (or whoever will lose out when a 'Bristol' does instead) will more than likely seek to protect their incumbent position against disruption from city-scale activity.

smaller geography), the development will tend to encourage distribution network operators (DNOs) to develop capabilities and put in place commercial arrangements which support local action to reduce and/or shift demand and to balance local demand better with local intermittent supply.

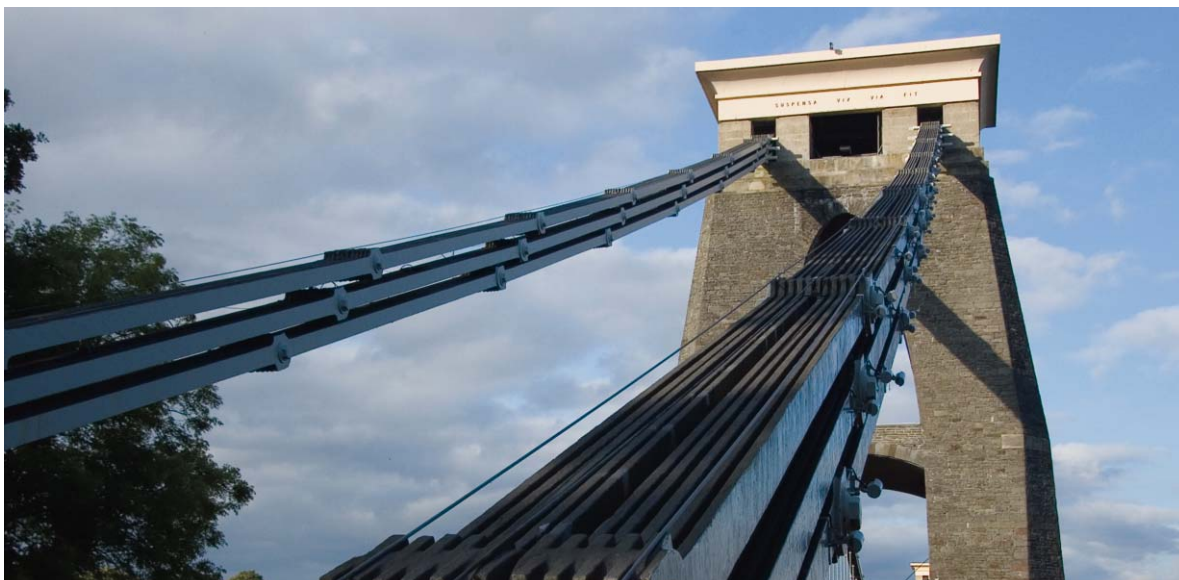
However, it should be noted that Bristol's electricity distribution network is relatively strong and, compared with other parts of Western Power Distribution's network, currently has few operational issues in terms of need for active management and demand response to cope with significant intermittent generation. On the basis of current network innovation funding rules, this will tend to limit the potential for DNO or Ofgem-sanctioned resources for specific active management experiments and/or pilots in Bristol (unless the rules are changed).

b. A sense of shared place and purpose can potentially support more rapid changes in social norms and common behaviours – so why not for smart energy?

The widespread adoption of smart energy applications will require a significant shift in behaviours and beliefs across the population of both citizens and businesses, starting with a willingness to accept and engage with smart energy data and associated services. In addition, optimising smart energy outcomes may require a focus more on collective benefit (or avoided cost) than individual consumer or company gain, a significant cultural shift in itself.

We believe that a city-scale approach can offer genuine added value in this sphere of shifting social and cultural practices in homes, businesses and other organisations. A concerted and concentrated city-scale action built around a strong sense of common city-oriented purpose has the potential to create this shift more effectively than generalised national or specific individual consumer or company engagement approaches. Such concentrated effort is likely to enable more interest, better understanding and thus greater take-up, reorienting social norms in an area ('what people do round here') more quickly than more diffused approaches. Given this, concentrated action may also have lower costs per engaged person or company. It can therefore reduce the costs of securing behaviour change and technology adoption.

This may not currently be fully understood amongst those tasked with enabling aspects of smart energy such as, for example, the smart meter rollout (i.e. energy suppliers and Smart Energy GB). Nevertheless, there is likely to be political and market interest in testing more local approaches. The challenge will be to ensure that these are not simply tokenistic local channels for national or corporate 'smart' initiatives, but ones where a genuine city-oriented and city-influenced approach and benefit is to the fore.



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c. Using smart approaches to tackle fuel poverty and associated vulnerabilities

Identifying and supporting households struggling to keep adequately warm in winter is a largely local challenge since interventions often need to be direct and in person. There are many opportunities offered by smart energy data and other smart technologies to improve this support and add in services such as thermal safeguarding which could produce health and wellbeing benefits and associated cost savings to local services. While such services are likely to emerge from national providers, it is at local level that the follow-up interventions will need to be available and delivered. It is also at a local level that any health service or social care cost savings would accrue and therefore where the potential exists for smart service funding arrangements to be negotiated.

d. Local heat and cooling, energy storage, and electric vehicles

Developing the smarter, lower carbon heat and cooling solutions required for the UK to meet its carbon targets points towards localised collective solutions, such as district heating and cogeneration. Whether the fuel for the heat/cooling source is gas, biomass or geothermal, or electricity for large-scale air, water or ground-source heat pumps, the scale of application is local (not least because heat cannot be viably transferred over large distances).

Even where the approach to decarbonisation of heat is at individual building scale, the power network implications of large scale rollout of heat pumps require local solutions linked to local demands and heating application characteristics. Indeed, given the potential role of electricity in future heat supply for either individual buildings or districts, the future interactions between local heat demand and supply and the local power network emerge as a potentially critical focus for the use of local smart energy data (i.e. real time and fine grain supply and demand data).

It is difficult to see how such developments could take place without strong city- or sub-city level initiative to identify and 'curate' local opportunities to manage and apply the data to optimise local power and heat systems.

A similar conclusion can be drawn in relation to the development and application of energy storage, a potentially vital technology in enhancing the system (and thereby commercial) value of intermittent and mainly decentralised renewable sources like wind and solar.

Any significant growth in the use of electric vehicles (EVs) in the city will place significant demands on the local distribution network (10 fast-charge points in Asda's Bedminster car park could require a new substation) but would also open up prospects for innovative services which take advantage of the EV batteries mobile energy storage to help smooth demand and supply over time.

Where city-scale looks weak (but Bristol may be able to provide an answer)

e. Smart meter roll-out co-ordination to enable data access: can Bristol do something so attractive that suppliers can't resist the locally needed collaboration?

A key requirement of a meaningful smart energy city is access to smart energy data from organisations, businesses and households across the city. The domestic smart meter installation has been identified as a prime moment to secure the required consumer consent to access their smart energy data. Achieving this across the city would require a co-ordinated approach to smart meter roll-out and the co-operation of the energy suppliers mandated to get the meters installed nationally over the next 4 years. But Bristol will need to organise itself to achieve this because suppliers have shown little or no appetite for area-based co-ordination of installations.

We believe there is a possibility that suppliers could be convinced to co-ordinate their smart meter rollout in a given area at a given period of time (e.g. Bristol in 2017). To do so would require a

really well organised, efficient local support service which managed to reduce household installation refusal rates, provide the required support for vulnerable households, and improve (and reduce the costs of) liaison with gas and power distribution networks for any remedial works needed. It would also need suppliers and national engagement initiatives (such as Smart Energy GB) to step back to enable the local approach to come to the fore, while still providing any funding they would have spent trying to achieve the same outcomes.

Bristol potentially has the interest and the organisations to put together such a service. However, establishing the necessary commitments to, and an effective governance structure for, such a service will be challenging, as will securing development and delivery funding. Is this a question of 'build it and they will come'?

f. Smart energy technology adoption rates: are there enough early adopters in a city?

Where smart energy applications require the adoption of new devices or services (such as smarter heating controls, more demand responsive technologies etc), the typical technology adoption curve (www.smartideastore.com/technology-adoption-curve) would suggest that the initial market of 'innovators' and 'early adopters' is relatively small. It may therefore be too dispersed at these early stages to have sufficient representation in a particular city to benefit from concentrated activity.

This dispersion will tend to favour a market-wide national or global corporate approach. While this will likely lead to the increasing penetration of some smart energy technologies, the associated installations and services are unlikely to be linked up with local initiatives with an eye to serving local collective and well as individual consumer interests. Given that some system-level smart energy benefits can only be achieved at certain levels of technology penetration, this could prevent any concentrated city-scale smart energy initiatives from getting ahead of the curve and enabling more to happen sooner in a given place as a result.

That said, Bristol's (recent) tradition of leadership in testing out smart technologies and its high proportion of well-educated, sustainability-minded citizens and businesses (such as the membership of Bristol Green Capital Partnership (www.bristolgreencapital.org)) may mean that it is one of only a few places where the concentration is sufficient for early city-scale activity to be both feasible in practice and meaningful in scale – to get ahead of the curve.

g. The need for local capacity to capture, manage, analyse and utilise smart energy data

An effective city-scale approach to smart energy will require city-level capacity to capture, manage, analyse and utilise smart energy data. This is challenging, given there are no significant policy or energy market developments which enable or support the emergence of such an approach – and several which stand in its way. However, as with other aspects of developing a smart energy city, there is potential for this to change, particularly if there are working examples of how it can be done and the potential benefits it can offer.

There is work to do to establish a clear locus for action and governance structure for this in Bristol and a mechanism for securing consent to capture data (see also point e above and point j below). However, there is already commitment and activity in Bristol to create a 'data commons' and the Bristol is Open collaboration between Bristol City Council and the University of Bristol provides a potential framework for solving this data handling challenge.

h. Smart energy applications on the demand side are not yet available as services to buy (as opposed to technology to buy and install) so the playing field with energy supply is not level

Many smart energy applications require technology to be bought and installed. Or, put another way, the demand side of the energy system infrastructure needs investment to made more efficient and



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more controllable and responsive. But for this to work as an attractive market proposition to consumers, this upgrade needs to be financed in a way which makes it at least equivalent, from a consumer's perspective, to the way they currently purchase supply, one unit of output at a time.

On the supply side for gas and electricity there are mature capital markets that provide finance. In simple terms, these turn future cashflows from customers buying output one unit of gas or electricity at a time into capital to finance the energy supply infrastructure. This means the consumer doesn't face the upfront capital cost of, for example, building a power station or drilling a gas well, but instead pays for this as a component of the unit cost each time they make a purchase of electricity or gas.

This does not typically happen on the demand side, where the end consumer is typically expected to provide the upfront capital cost of the required upgrade. To address this, capital markets need to find effective business models to finance technology-based smart energy services so that the services can appear to the end consumer as 'pay as you go' – buyable 'one unit at a time' in the same way electricity and gas can be. Until this happens, consumers are faced with high one-off costs for demand side improvements and the challenge of financing them themselves from anticipated future savings. This is a major brake on the growth of smarter energy applications, though the advent of more accurate and real-time, remotely readable energy consumption data may underpin more robust contractual mechanisms for the investor to recover (or share) the financial value of energy savings achieved.

While it is unlikely that city-scale activity can have any significant influence on this key development in the emergence of smart energy, there is interest in Bristol in how to raise capital locally (e.g. a Bristol Green Bond) to solve precisely these sorts of sustainability challenges.

Where city-scale looks particularly weak

i. Energy market rules and governance favour incumbents and are slow to change

The rules structuring the energy market, smart meter roll-out and data access, and the regulatory controls on distribution companies have been established in ways which generally suit the current dominant models of energy supply and energy system development and management. The governance structures for these rules is such that change is slow and processes are dominated by

incumbent businesses. The Competition and Markets Authority has recently drawn the conclusion that this is not in the interests of energy consumers. It is also clearly not in the interests of innovative (in the context of the GB energy system) models of energy system governance such as might emerge from a city-scale smart energy city initiative as envisaged here.

In part to address these obstacles to the sorts of innovation potentially unleashed by the growth in smart energy data and applications, the energy regulator Ofgem is exploring what it has called 'Non Traditional Business Models' (NTBMs). These include various approaches to more local supply opportunities and different commercial configurations of generation-distribution-supply at local level. However, Ofgem has yet to turn its attention to the changes required in existing market rules and governance arrangements to create the space in it which these NTBMs could emerge and thrive.

This means that, for the next few years at least, city-scale activity is likely to have to work against the grain of market rules and regulations. It also means that changing those rules to better suit city-scale activity is likely to require sustained engagement with regulators and policy-makers. Some short-to-medium term relief may be possible if regulators were prepared to negotiate a 'space to experiment' where key regulatory constraints are relaxed to enable innovative local smart energy initiatives.

j. Where's the locus for action? City administrative boundaries vs energy system infrastructure 'boundaries' and municipal ambitions in licensed energy supply

As with some other UK cities, the administrative area of Bristol City Council does not overlap particularly coherently with what 'city-scale' determined by energy system considerations (such as distribution network configuration) would probably look like. We have not, within this initiative, yet been able to determine the latter, though it's probably fair to say that it would include the additional 190,000 people and many large businesses and organisations which are located in the Bristol urban area but not within the City Council administrative boundary.

However, this points to a wider challenge of where the locus for action sits for a 'smart energy city' and the various initiatives it encompasses. Who leads? Who has to be involved to legitimise a city-scale approach? What does the governance structure look like?

While it seems clear that Bristol City Council (and potentially neighbouring local authorities) are key partners in any 'smart energy city' programme for Bristol, it is less obvious exactly what the Council's role should be. This is particularly the case given that Bristol City Council has recently set up a wholly-owned licensed energy supplier (Bristol Energy) which is (as at December 2015) just in the process of market entry. Irrespective of the potential merits and benefits of this approach, the direct commercial interest in the energy market which it creates carries the risk of compromising the Council's ability to play what may have been an obvious role in a Smart Energy City: honest broker.

This potential conflict of interest is not insurmountable but does suggest a cross-sector partnership approach to developing city-scale approaches that is not initially led by the City Council. It may also be appropriate for this to sit closer to the Council's 'data commons' and open and programmable city aspirations than to what have become more commercial energy interests.

For the next year or so it may be enough for a set of different smart energy initiatives to be loosely co-ordinated across the city in a 'learning and changing through doing' phase. This could happen through a continuation of something akin to the Bristol Smart Energy City Collaboration. Such an approach would enable a clearer picture of the functions required within a Smart Energy City and how they might best be sited and undertaken in the interests of the people and businesses of Bristol (loosely defined to date as 'the public interest'). However, the questions outlined above will need to be resolved in time (two years?) to ensure the timely emergence of a coherent entity capable of realising the potential of Bristol Smart Energy City.

8. The first next steps for 2016 and how to take them

The Bristol Smart Energy City Collaboration met in mid November 2015 to review the road maps emerging from the expert workshops and the wider issues which had been identified in the process to date. Our purpose was to identify the priority next steps which need to be taken in 2016 in Bristol to progress towards realising the Smart Energy City aspiration. These are outlined below.

The first ten next steps for 2016

1. **Enhance smart energy data analytics in Bristol's commercial and public buildings** by promoting Demand Logic style analytics and heating and cooling system optimisation based on existing (but typically much underutilised) building energy management system data. The Bristol Green Capital Partnership and its Go Green programme could provide a rich source of recruits.

Purpose: To increase the quality of energy management and reduce energy demand in larger buildings in the city using currently available data, while building a network that could provide basis for aggregated demand response services in future.

2. **Commission public art to reveal peak electricity demand** and intermittency of local generation and undertake associated public engagement programme. A local landmark such as St Michael's hospital chimney, Brandon Hill tower, the Wills Building or Clifton Suspension Bridge could be illuminated in different colours, depending on real-time local system status.

Purpose: To stimulate public conversations about peak demand and opportunities to change supply and use of power locally, with the aim of creating a more fertile culture for subsequent efforts to reduce and/or shift peaks and balance local supply and engage people in smart energy services.

3. **Design and develop local domestic smart meter roll-out support service**, having tested with energy suppliers and Smart Energy GB what they would need to see in such a service to (a) commit jointly to an 'all in one year' local roll-out (e.g. in 2017) and (b) step back to enable the local approach to come to the fore while still providing any funding they would have spent trying to achieve the same outcomes.

Purpose: To establish a consistent approach to engaging and supporting local people during the smart meter roll-out so as to maximise buy-in longer term to city-scale approach to data-sharing, effective use of smart energy data to stimulate demand reduction, and demand response aggregation.

4. **Pilot a local vulnerable household smart meter support programme**, building on existing services for energy vulnerable households and testing a range of interventions for different types of vulnerable households, working closely with Western Power Distribution and Wales and West Utilities Priority Service Register teams.

Purpose: To develop better understanding of the needs of different sorts of vulnerable household during and after smart meter installation and how these may best be met locally.

5. **Undertake local trials of 'thermal safeguarding'** for households vulnerable to under-heating their home, building on existing and recent 'Internet of Things' projects by the Centre

for Sustainable Energy and Knowle West Media Centre. This should involve engagement with vulnerable households, energy advice specialists, and health and social care practitioners, and test data analytics, user interface designs, and how best to respond to achieve safeguarding in practice.

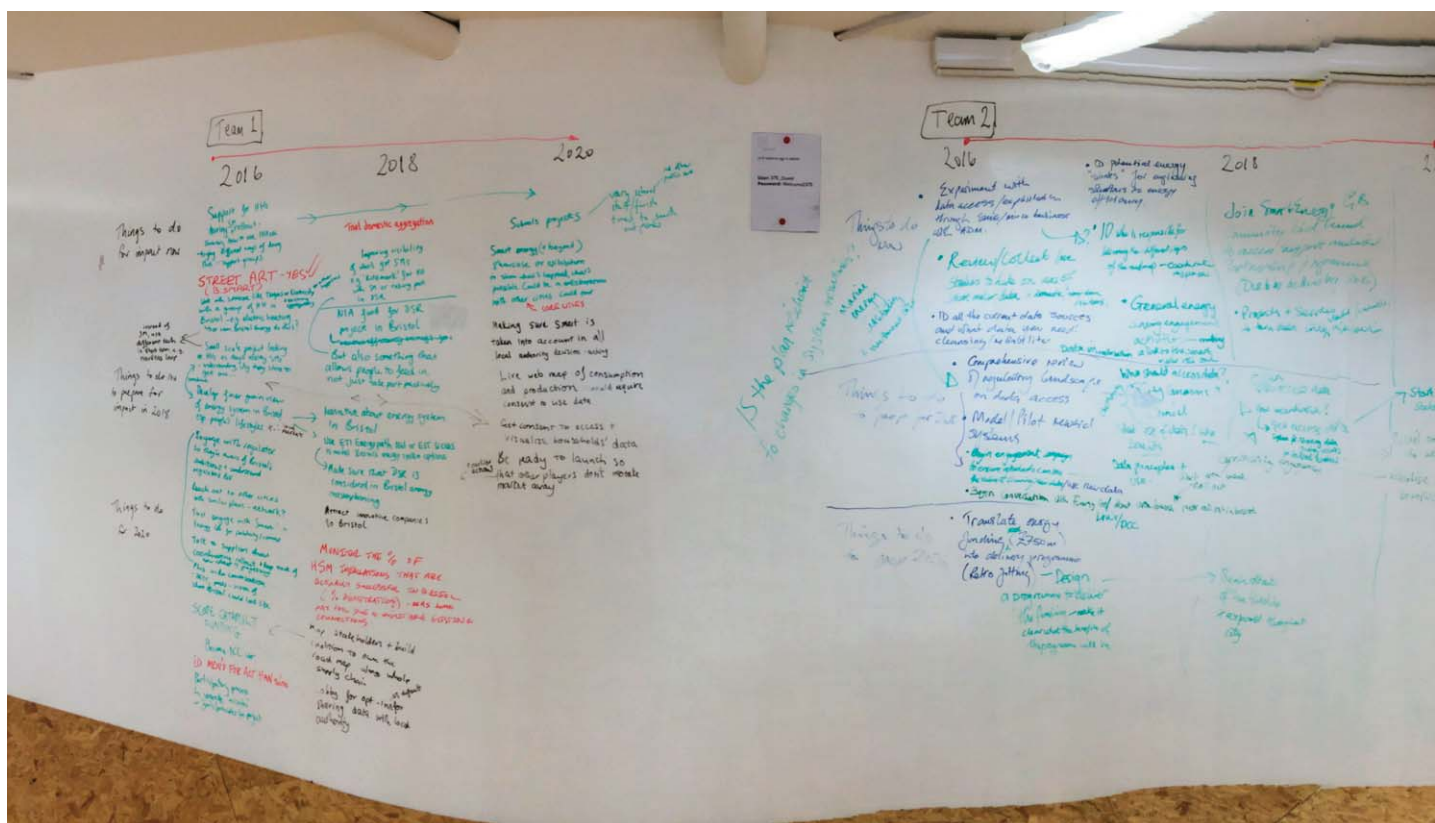
Purpose: To develop more knowledge of energy use and lifestyle patterns of different types of vulnerable household and explore the potential value (e.g. avoided harm and reduced demand on services) of integrated data analytics to trigger effective responses to reduce the risk of harm from under-heated home.

6. **Explore public and business sector interests** in participating in local balancing and/or demand response initiatives to improve understanding of how services would need to be structured and the sorts of rewards that would need to be involved for success. This could also include enlisting organisations to provide their half-hourly energy data to enable initial analysis of how different organisations' energy use profiles combine and their potential for demand reduction and response.

Purpose: To improve understanding of the opportunities and potential commercial basis for local system balancing and demand response aggregation, and to build interest in the potential for a locally focussed approach.

7. **Put together pilot of 'Power Matching City'– or similar** – enlisting local loads and local generators to capture data, optimise balancing and test virtual trading platform to realise and distribute system value created. (NB: a pilot like this is included in the work programme of the new EU-funded REPLICATE being led by Bristol City Council and due to commence in 2016).

Purpose: To learn about the challenges of data access, capture, management and analytics from multiple sites and users and test the practical and regulatory challenges for local system balancing in UK.



8. **Engage with Ofgem and DECC** to explain the constraints on city-scale initiative created by current market rules and regulatory frameworks and the limited options for change given governance arrangements and to make the case for change and/or relaxation of rules to test potentially beneficial approaches.

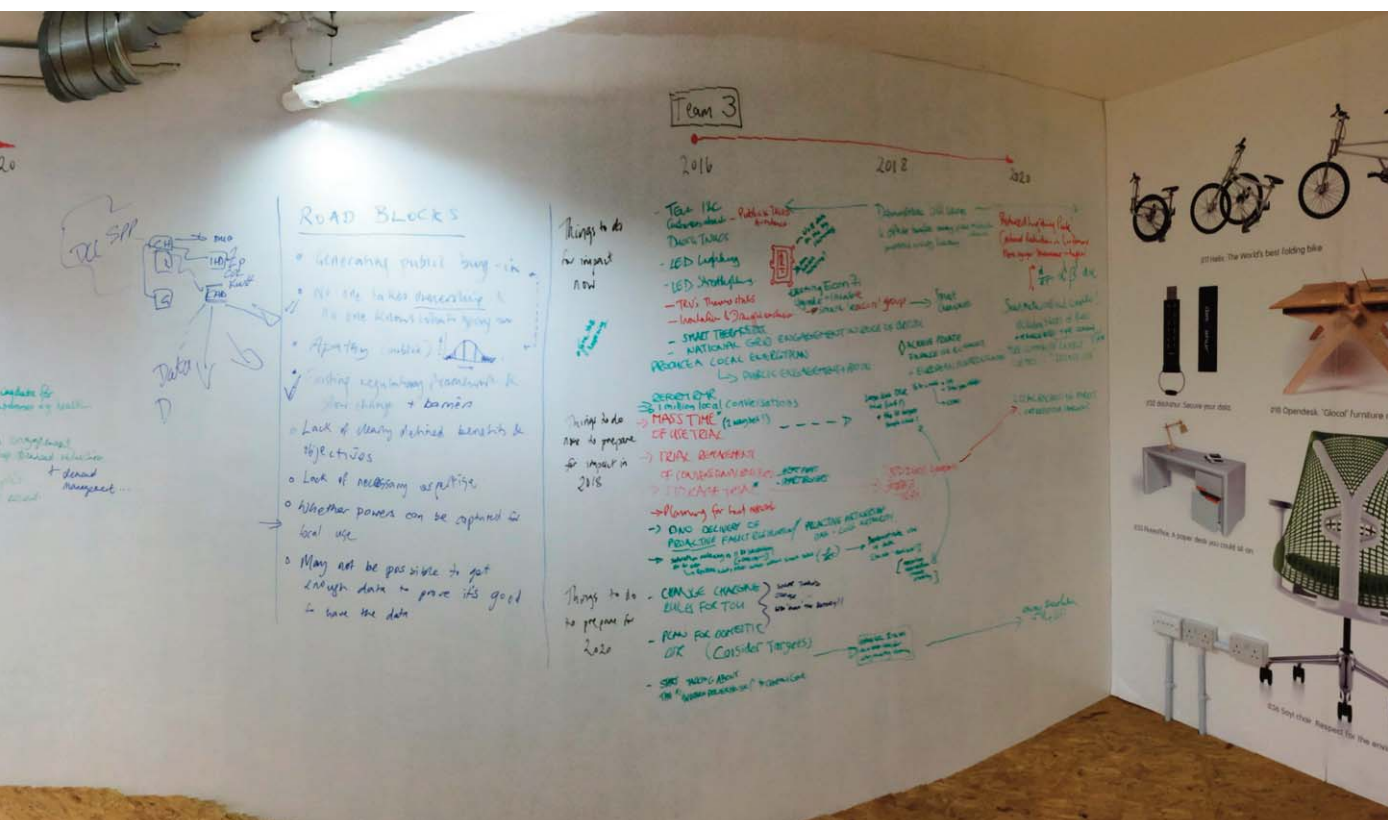
Purpose: To seek to carve out a 'space to experiment' to demonstrate the potential value of re-orientating rules and regulations to enable and encourage city-scale approaches (e.g. trial of a distribution charging methodology which reflects reduced system cost of locally supplied power).

9. **Build local consensus on purpose of Bristol Smart Energy City** as an inclusive endeavour serving the public interest to meet sustainable energy goals. The Collaboration has in 2015 started a conversation about these issues and found some broad consensus amongst its relatively small group of participants. The engagement and discussion now needs to broaden.

Purpose: To (hopefully) create the foundations of shared understanding of what Bristol Smart Energy City could be, establishing support from key organisations for strong, locally-driven initiatives which (a) ensure smart energy services develop in the city for the public interest and (b) shape how the city collectively responds to opportunities emerging from national and global corporate initiatives.

10. **Develop the specification for the data capture and analytics** which would underpin a city-scale approach. This would identify both the nature of data and the analysis needed for different city-scale smart energy applications and their current or anticipated availability. It would also address the complexities of securing consent for data access and the challenges of data security and associated compliance requirements.

Purpose: To prepare the ground for consideration of the practical and commercial case for developing a city-scale approach to smart energy data capture and analytics.



Taking the next steps

At this stage 'Bristol' need not mean any particular entity or group of entities in the city which needs to be taking the steps. Our view is that, at these still early stages, it is less relevant who takes these steps in Bristol than that they are actually taken, provided:

- a. The intent of organisations to take the steps are shared with other interested parties around the city
- b. Activities, findings and learning are shared on an open and timely basis between interested parties
- c. All initiatives share a spirit of collaboration and have an eye to the wider public interest.

As a cross-sectoral partnership, the Bristol Smart Energy City Collaboration has the potential to provide a non-aligned 'honest broker' role and a co-ordination and challenge function to smart energy initiatives in the city. It can also create a space in which people can come together to identify gaps, resolve issues, share learning and develop new initiatives together.

The Collaboration's inquisitive style and public interest focus can help to ensure that the combination of smart energy initiatives which emerge in the city over the next two years from various sources has a shared purpose and builds a momentum that can subsequently underpin a more coherent and formally structured delivery model capable of realising the Bristol Smart Energy City aspiration.

Sustaining the Collaboration will require some commitment of time from members and funding to maintained the momentum developed in 2015. Its focus will shift from specifying and undertaking the initial programme of exploratory work to enabling and encouraging collaboration between emerging smart energy initiatives across the city. We believe there is a strong case for putting together a consortium proposal for innovation and/or economic development funding to support some of the local trials and preparatory initiatives described here, building a local smart energy city cluster.



For more background information and some references:

The Bristol Smart Energy City Collaboration wiki

As part of the Bristol Smart Energy City Collaboration, we have developed a 'wiki' where we have been collating background information, references and analysis about different aspects of smart energy – energy, data, commercial, regulatory and social/cultural – and sharing our thinking across the team. This publication is based broadly on the information and references collated on the wiki, together with our reflections on Collaboration discussions and workshops.

The wiki is a work in progress so we know it's still pretty rough with proofing errors, gaps awaiting input etc. But it does usefully bring together a lot of existing information about smart energy developments which we have pulled together as part of our background research. We hope it will be of interest and value to others.

https://bristol-smart-energy.cse.org.uk/wiki/Main_Page

The wiki is open access but, if you want to contribute or edit content, you will need to register with CSE via the wiki website to create an account.

Banksy Versus Bristol Museum Summer Show, Bristol 2009



