Getting the green light:
Will smart technology clean up city environments?

THE ENVIRONMENTAL INDUSTRIES COMMISSION

Supported by: Bird & Bird Schneider Electric

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Forewords

The phrase ‘smart cities’ has become commonplace over the last year or two – from technology companies, politicians, policy makers and cities themselves. I’ve always been struck by how in all the video presentations and glossy brochures that predict what these future metropolises will be like, the sun always shines, the air is pure, the water is crystal clear and there is nothing resembling residual waste.

How we get from here to there is usually less clear. Through no lack of effort many of our cities are currently wrestling with poor air quality, low recycling rates, and high carbon emissions. Could smart technology help tackle some of these problems in new ways? EIC represents a wide range of businesses across the environmental technology and services sector. We put together a Task Force (ably chaired by Jason Brooks from WSP) which included companies with insights into different aspects of urban environmental issues and representatives from cities themselves (see Annex 3 for Task Force members’ organisations). We explored the ways in which smart technologies could help improve our understanding of environmental issues and how they create new types of policy intervention and opportunities for citizens to influence the cities they live in.

As you will see from the report, we did find real environmental potential in smart technologies, but we also found an immature market and a limited amount of hard evidence of real world impacts due the newness of much of the innovation in this area. We hope our report will stimulate discussion over how cities could exploit this potential in the future, and EIC will conduct further work in this area in 2015.

My thanks go to all members of our Task Force, to our sponsors Bird & Bird and Schneider Electric, and to Sam Ibbott at EIC who led the work.

Matthew Farrow
Executive Director
Environmental Industries Commission

The two central issues addressed in this report form part of a broader question on smart cities: what will unlock their potential? The report’s findings also reflect conclusions reached when considering the same issues in other contexts: unlocking the potential requires a multi-faceted approach. Law and policy needs to contain “sticks and carrots”; proscriptive when needed and enabling where appropriate. Smart cities solutions need to find the right balance between the “easy wins” to demonstrate proof of concept while implementing solutions that enable holistic approaches. Transactions need to be bankable while still finding ways to measure the value of social and environmental costs.

The EIC Task Force brought together thought leaders from a range of organisations who, in considering both the complexities of the underlying issues and the diversity of potential solutions, shared their knowledge and perspectives to set the central questions, analyse relevant data and identify themes and key conclusions.

One such conclusion is that a “smart city” is not always inextricably linked with an improved environment. This raises a number of questions, including when they should be so linked, and creates an opportunity for smart city stakeholders to develop approaches to increase the frequency of this link when deploying smart city solutions. These matters, along with others considered in this report, will be considered in the second phase of EIC’s work in this area.

Bird & Bird is delighted to support this initiative.

Michael Rudd
Partner
Bird & Bird LLP

1. Introduction

Fifty four per cent of the world's population live in urban areas, with this figure expected to grow to 66 per cent by 2050[1]. Within the European Union, the proportion is already estimated to be at 75 per cent[2]. As cities become dominant in our economies and societies, their environmental challenges come into sharp focus. We need to solve the environmental problems of cities if we are to have any hope of tackling our environmental problems as a whole.

At the same time there is great interest in the concept of 'smart cities' and the opportunities that exist around smart solutions that were not available to us in the past.

This report combines these two issues – the question of whether smart approaches can offer us new ways to tackle entrenched environmental challenges, and likewise whether a determination to tackle these challenges can stimulate new smart thinking.

Definitions:

There are many different definitions of a 'smart city'. In this report we consider smart city initiatives/applications as those which are based upon using the power of networked devices (both centrally controlled and citizen controlled) and analysis of 'big data' to improve the functioning and capability of cities. We acknowledge that there are wider innovations sometimes described as 'smart' but these go beyond the remit of this report.

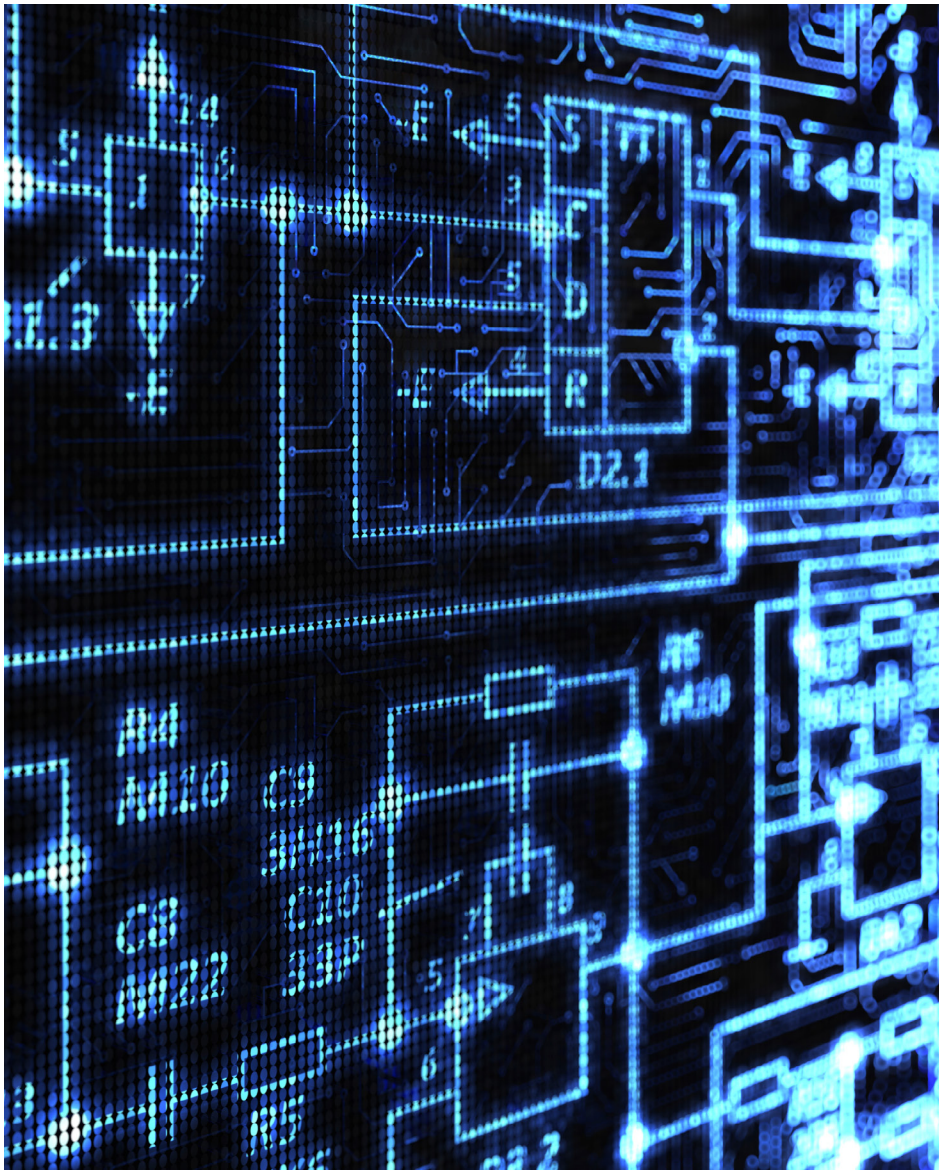
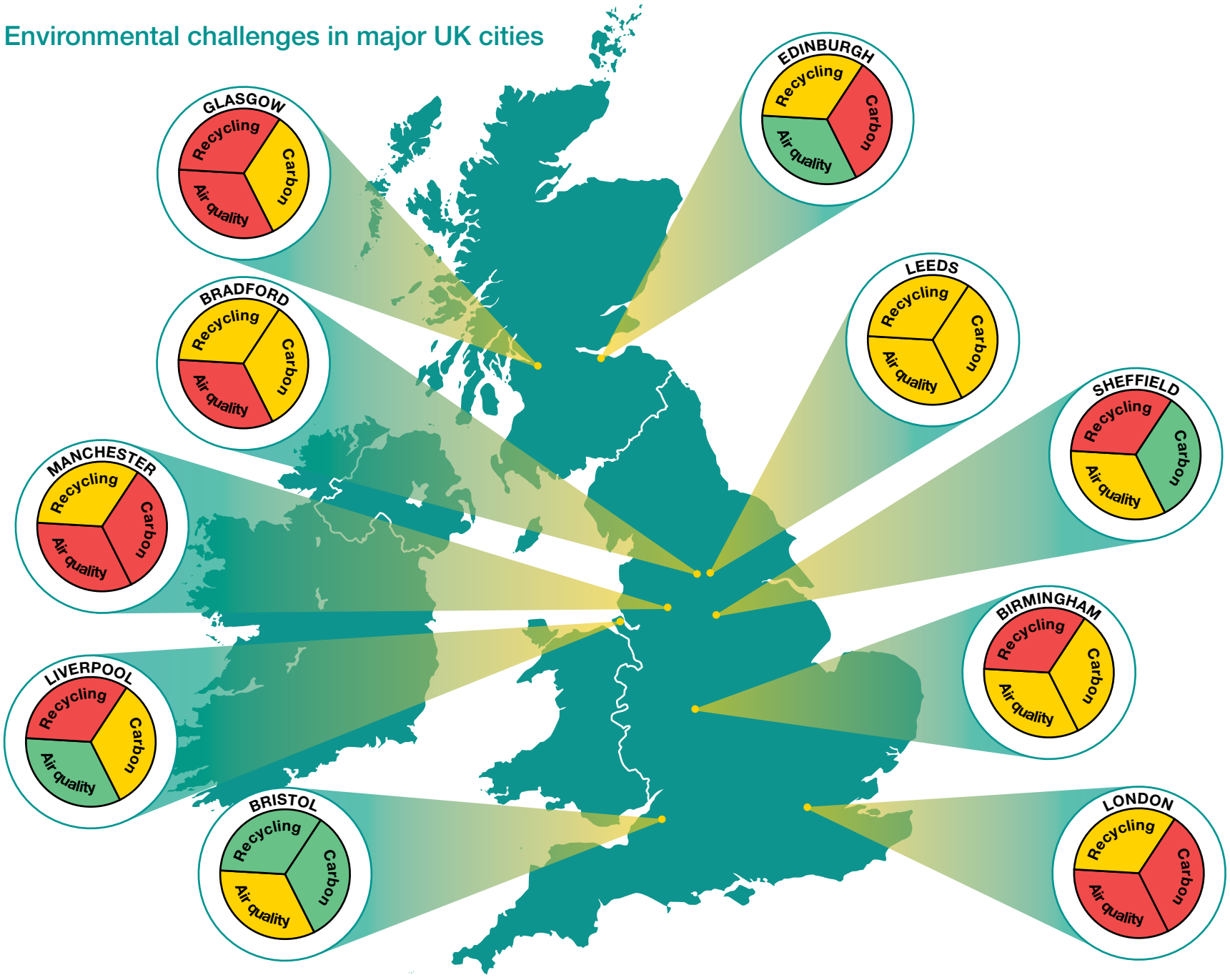


Exhibit 1: Environmental challenges in major UK cities



2. Our cities are struggling to meet entrenched environmental challenges

In the 19th and 20th centuries, British cities pioneered the use of progressive legislation to tackle environmental problems such as a lack of clean water and smogs. But while the environment of modern cities is vastly better than those of a century ago, in recent years UK cities, despite ongoing efforts, have made limited further progress. Exhibit 1 shows that most cities are some way off environmental targets and Exhibits 2 and 3 show examples of this lack of progress over the last decade.

Note to Exhibit 1:

Cities' environmental performance relative to statutory national/local targets is rated in three areas as follows:

- **Recycling:** (EU 2020 target for municipal recycling = 50%) Green: <10 percentage points below target; Amber: 11-20 points below; Red: >20 points below.
- **CO_2:** 74% national reduction in CO_2 required by 2050 from 2005 levels to meet Climate Change Act target, as per Committee on Climate Change. Green: 2005-12 reduction 15%+ (ie trend better than required for 2050;) Amber: 10-15% reduction; Red: <10% reduction.
- **Air quality:** Annual mean concentration of NO_2 – EU limit 40 ug/m3. Green: <30ug/m3; Amber: 30-40 ug/m3 Red: 40+.

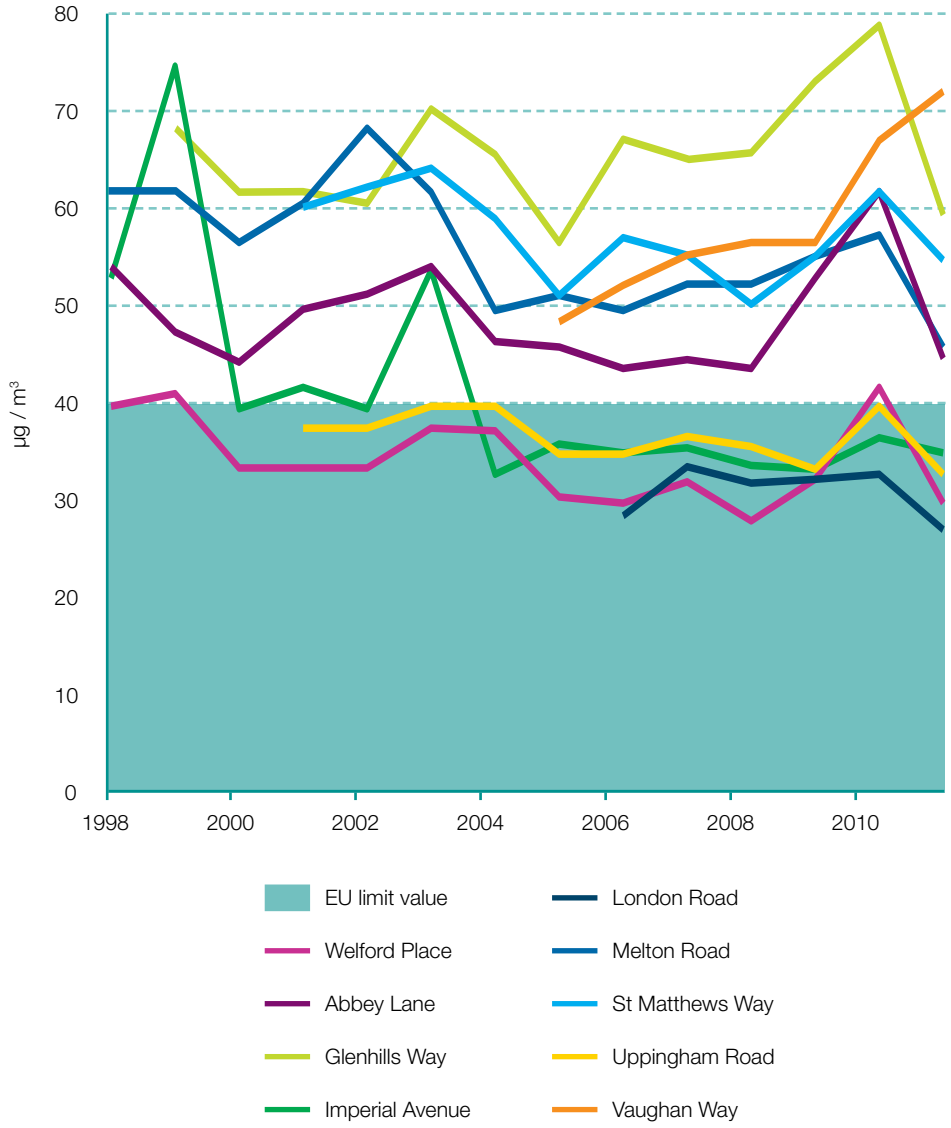
Ratings do not take account of demographic or economic changes or local factors and should be regarded as illustrative.

Sources: European Environment Agency; Centre for Cities; Defra

Exhibit 2: Limited reductions in CO_2 emissions in last 10 years (in kt CO_2)

Source: DECC

Exhibit 3: Mean annual NO_2 concentrations across Leicester



Source: Davis & Pollard, 2012

Urban water management is also a challenge

Average per capita daily water use in the UK is 150 litres[3]. Water consumption at this level risks water stress in some parts of the country and also raises carbon emissions through the energy use involved in pumping and treating water. The Government's target for England is to reduce consumption to 130 litres per person per day by 2030 (or possibly even 120 litres depending on new technological developments and innovation)[4]. This is consistent with Part G of the Building Regulations which requires new dwellings to use no more than 125 litres per person per day[5], and the (voluntary) Code for Sustainable Homes which runs on a sliding scale from 120 down to 80 litres per person per day[6].

Within this national context, cities face specific challenges. Urban population density means the risk of water stress is especially acute in some city regions. Mains water leakage can be harder to tackle when pipes are beneath congested city streets. And flood risk can be exacerbated by the volume of paved surfaces.

The institutional landscape can also complicate city water management. Water companies are private utilities whose geographical boundaries are usually much wider than individual cities. This can limit the amount of city-specific data on issues like water leakage, and also means that responsibility for acting on water issues may not be within the cities' direct remit. This report contains various examples of smart water initiatives which can help enable water utilities and city managers work together to improve water management.

Cities are constrained in their efforts to meet environmental challenges by a range of factors

It is important to recognise that the limited progress made is not through want of effort by cities. In practice, they face a series of constraints.

Some of these constraints are a consequence of the broader economic and political context. City leaders are focused on economic challenges (apart from London major UK cities have been unusual in failing to outperform the national economy in recent years[7]), and institutional structures also play a part.

Institutional challenges faced by cities

The Centre for Cities think tank argues in its 'Manifesto for a More Prosperous Urban Britain'[8] that UK cities face:

- 'not simply a lack of money – although many require significant investment – but also the lack of control over how the money that is spent in their area';
- a 'lack of any long-term certainty over the levels of funding from central government'; and
- 'an overly complicated system of local government, where city governments do not reflect the local economy, and where key powers and responsibilities are shared across different levels and by different institutions, often varying from city to city.'

Centre for Cities add that 'recent policies (eg City Deals, Growth Deals, Local Enterprise Partnerships, combined authorities) have taken small steps towards change but have struggled to alter the centralised nature of government'.

As well as these broad constraints, the specific environmental issues faced by cities are complex and intractable, as highlighted in various reports by the European Environment Agency and others[9,10, 11, 12].

For example, despite the gradual take up of hybrids and fully electric vehicles the increasing number of diesel vehicles in particular (and diesel engines on non-road mobile machinery on construction sites) in urban areas has led to high levels of NO_2 and particulate emissions – with a major impact on **air quality**.

Similarly, population growth and urbanisation has led to an increased demand for **energy**, with cities consuming between 60 and 80 per cent of energy worldwide[13] – much of which is wasted through a legacy building stock which is energy inefficient, and the poor use of energy even within more modern buildings. Combined, this contributes to an increase in a city's **carbon emissions**.

Although cities have increased **recycling rates** over the last decade, improvement has levelled off and almost all UK cities consistently recycle less than non-urban areas. A more transient urban population can make communicating local recycling policy harder, and the greater housing density limits domestic storage space for recyclables.

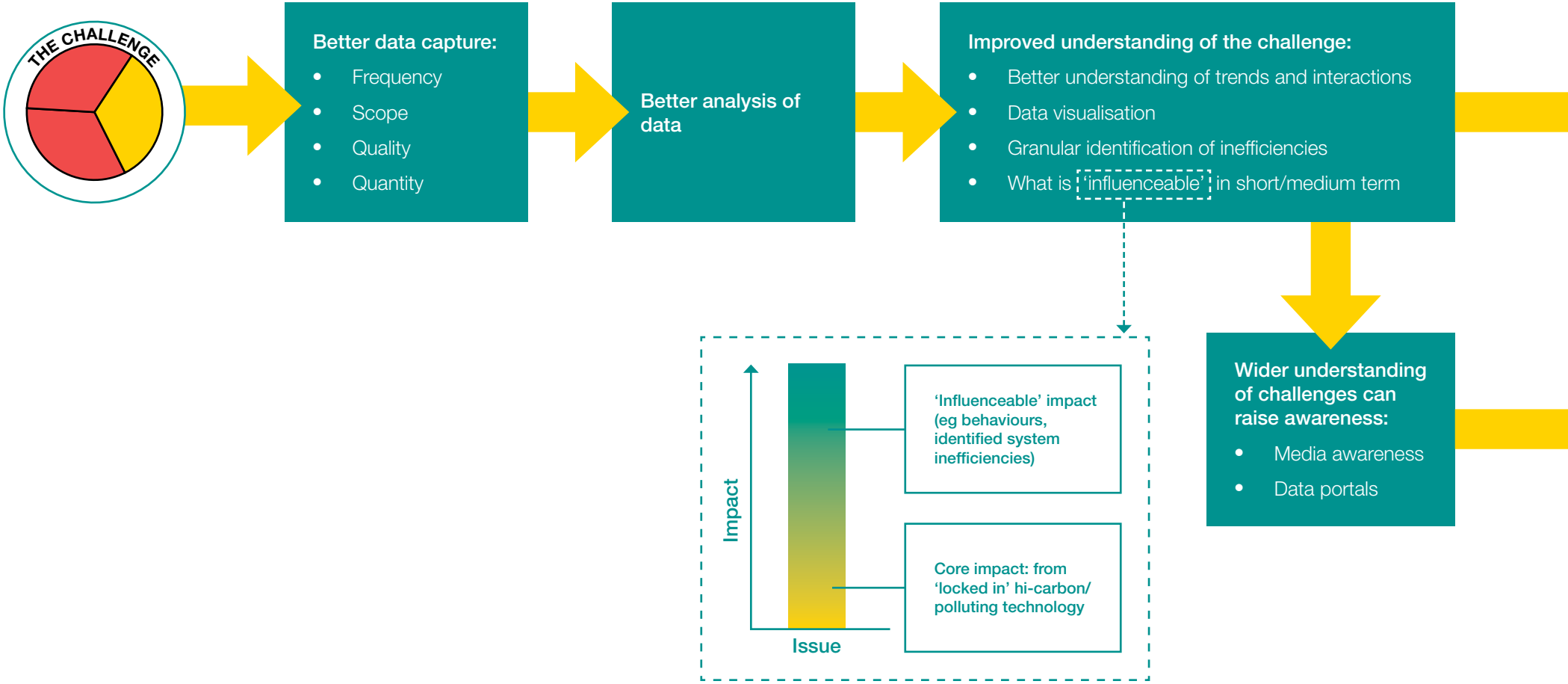
On **water**, an aging infrastructure and difficulty in access for pipe repair/ replacement in densely built areas leads to ongoing water leakage issues and contributes to water stress. UK national leakage levels worsened in the period to 2005 before falling back to 2001 levels. Water companies currently forecast only marginal further leakage reductions[14].

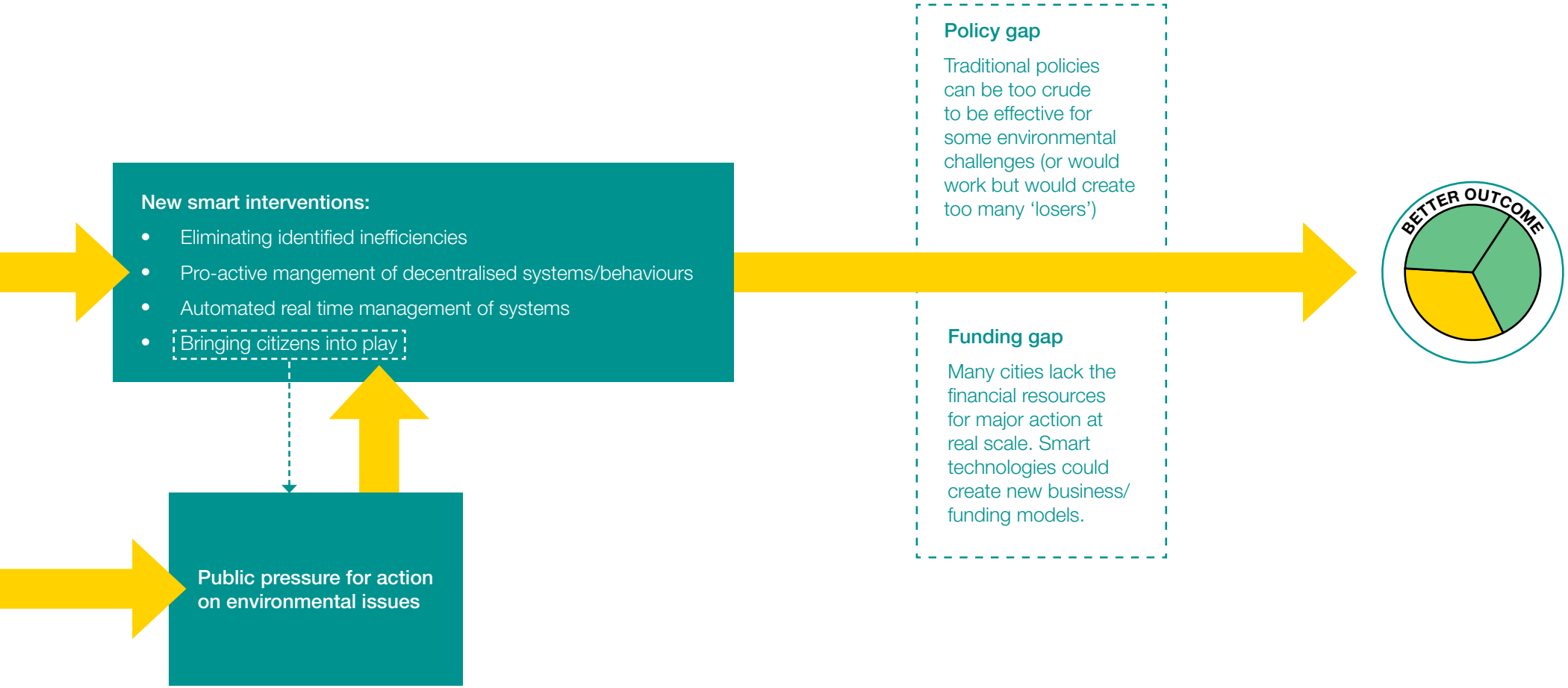
Finally, urbanisation has had an affect on our **local environmental quality**, and our sense of contentment with the places we live. While Keep Britain Tidy's Local Environmental Quality Survey of England 2013/14 found 89% of monitored sites rated as 'acceptable' or above for litter, respondents also noted that fast food and non-alcoholic drinks litter are increasing[15].

Despite these constraints, UK city leaders know that a clean, low pollution environment is a key part of making our cities attractive places to live, work and invest. Indeed, the Keep Britain Tidy survey argues that "if an area is neglected and badly maintained, crime and anti-social behaviour will increase, and vice versa. Safe communities require high quality environmental management."

The question is, will smart technology offer new ways to meet these challenges?

Exhibit 4: The smart environmental opportunity




New smart interventions:
• Eliminating identified inefficiencies
• Pro-active mangement of decentralised systems/behaviours
• Automated real time management of systems
• Bringing citizens into play
Public pressure for action on environmental issues
Policy gap
Traditional policies can be too crude to be effective for some environmental challenges (or would work but would create too many 'losers')
Funding gap
Many cities lack the financial resources for major action at real scale. Smart technologies could create new business/ funding models.
BETTER OUTCOME

3. Smart approaches can transform environmental data capture and analysis

As we have shown, urban environmental problems are often complex, with many factors interacting over time. Smart technologies and systems offer new ways to generate 'big data' which can be analysed to help policy makers understand problems and devise more targeted and sophisticated methods of dealing with them.

The main smart technologies used to capture data are **remote sensors** which electronically send data back to central databases (these sensors can be static or mobile, and can be linked to citizens' smart devices) and so called **'smart meters'** which record and transmit usage data from utility connections.

Examples of this include:

- **Milton Keynes 'internet of things'**[16]**:** Milton Keynes is deploying 1,000 sensors to create a 'big data' infrastructure. The intention is to create a state-of-the-art 'MK Data Hub' which will support the acquisition and management of vast amounts of data relevant to city systems. This will include data about energy and water consumption, transport data, data acquired through satellite technology, social and economic datasets, and crowd-sourced data from social media or specialised apps. By building on the capability provided by the MK Data Hub, the project hopes to drive innovation in the areas of transport, energy and water management.
- **Hong Kong air quality monitoring**[17]**:** In Hong Kong, a study was carried out whereby sensors were attached to the wrists and belts of researchers, along with a GPS system and camera to track spatial information. Researchers then travelled along standard commuting routes gathering data on carbon monoxide, nitrogen dioxide, temperature, heat, humidity, and PM10. This information is then displayed on a dashboard in the hope that by "making it public, citizens can take action – politically, or with their feet, on their daily commutes."
- **Sensors on public transport vehicles in Belgrade**[18]**:** Public authorities attached sensors to public transportation vehicles to monitor a set of environmental parameters over larger areas. These sensors were also able to provide further information to the end user such as the location of buses and arrival times at bus stops. Analysis of the stored data allows for better traffic calculation and prediction. A related database and 'offline analyzer' has also been created to make use of the collated data, though this is still in the experimentation phase.
- **Air quality smartphone app**[19]**:** The AirProbe[20] has provided more than 28m air pollution readings from hundreds of volunteers across Europe. It is combined with a small sensor box to allow individuals to monitor air quality readings and pollutants - such as ozone, NO2 and black carbon - and send the readings back to a central server.
- **IBM/AECOM 'Smart Water Management System'**[21]**:** The system aggregates data from disparate sources, providing comprehensive, real time, and system-wide views to better identify water leakage and create a platform for identifying trends.
- **Keep Britain Tidy smartphone app**[22]**:** The app enables citizens and waste management companies to report environmental crime such as flytipping and litter to local authorities in real time, and for authorities to inform the user of progress made in tackling the problem in response. The app sends reports directly to the correct local authority, making it quick and simple to use. Reports can include information on location, photos of the problem, and categorisation.
- **The Mayor of London's Water Strategy**[23]**:** recognises the potential of smart water meters to monitor water consumption and help detect leaks. The strategy points out that a 'sizeable proportion' of water is lost through leaks in the supply pipes which link individual buildings to the mains. Households are responsible for leaks in these supply pipes, but the low level of metering in London means that most Londoners are unaware of the problem. Although water meters inside the home are valuable for customers to monitor their water use, internal meters fail to pick up leaks outside the property. A suggested solution is to have boundary meters installed with smart technology to relay information to a display inside the home.

- **Thames Water 'Leakfrog'[24]:** Thames Water is installing boundary meters with its 'LeakFrog' technology, which is fitted to a customer's water meter overnight and shows the longest period of time taken for one litre of water to pass through a household's water meter. The shorter the time the bigger the leak. Between 2008 and 2012, 70,000 properties had LeakFrogs fitted and 2,100 properties were found to have large enough leaks to warrant pipe repair or replacement – saving over 10m litres of fresh drinking water a day.

- **Aggregating smart meter data to create energy usage benchmarks:** As explored in the EIC-Acclaro Advisory report on smart metering [see box], the rollout of smart meters provides an opportunity for the benchmarking of energy use across the non-domestic sector. By working in conjunction with Government, a taxonomy of properties can be created through anonymised aggregated energy-use data and the provision of secondary level data (ie building context). By enabling industry benchmarking, accurately informed by smart meter data, it can help to better identify energy efficiency opportunities and wasted energy.

Smart meters and behaviour change

In June 2014, EIC, in conjunction with carbon management consultancy Acclaro Advisory, published an industry-led report – 'Working Smarter: realising the potential of smart meters in business'[25] – which investigated the use of smart (energy) meter data as a driver for positive behaviour change in the non-domestic sector. The report found that whilst smart meters have an important role to play in providing more accurate energy use data and easier communication between supplier and customer, they had a minimal impact in themselves on the amount of energy a consumer would use.

To derive energy efficiency benefits and sustained behaviour change in a building's occupants requires the organisation to take a secondary step once the data had been collated. This principle is extended across a range of smart monitoring technologies and environmental sectors. A finer granularity of data helps better understand and predict environmental challenges – but further action is required once this data has been collated, irrespective of whether that action is automated or human controlled.

Data in itself does not automatically aid understanding, but a combination of modern data processing and smart technologies such as data visualisation software (including real time dashboards) can both help policy makers understand complex trends and interactions, and also help city managers and citizens understand real time activity. According to the Future Cities Catapult, for example, 'good data visualisation can enable... planners to see how air pollution, flooding and open space is relevant to different land uses across the city'.

Examples of this include:

- **Ambiental flood risk modelling[26]:** UK firm Ambiental uses smart data to more accurately undertake flood modelling and flood risk consultancy, helping government bodies and commercial companies to improve their flood planning and decision making. This analysis and modelling enables the customer to respond with greater flexibility and agility.

- **Greater London Authority's (GLA) 'London Dashboard':** The GLA has created a city-level, publicly-accessible dashboard for use by citizens and app developers (see overleaf for further details).

For environmental challenges this can help in two specific ways:

- Granular identification of instances of inefficient use of polluting resources.

- Better understanding of what elements of the environmental problem are core (ie caused by embedded high carbon/polluting technology which cannot be replaced in the short term) and what elements are influenceable through better real time management or behaviour change.

4. Better data can raise awareness

Publishing and making available hitherto hidden or uncollected data on environmental issues can raise awareness, and if newly configured or created data reveals the severity of environmental problems it can stimulate citizen concern and political will to address issues:

- **Air pollution forecast apps:** The advent of BBC daily air pollution forecasts which can be received via traditional news channels or by apps has played a part in the increasing awareness of air quality problems.
- **The GLA's 'London Dashboard'[27]:** is part of the London Datastore initiative[28]. The Datastore "has been created by the GLA as an innovation towards freeing London's data. We want citizens to be able to access the data that the GLA and other public sector organisations hold, and to use that data however they see fit – free of charge." The Dashboard has a section dedicated to environmental data which covers: household waste generated; household recycling rates; cost of waste management methods; carbon dioxide emissions (by sector); average nitrogen dioxide levels; average PM2.5 levels; and reservoir levels. The Dashboard includes an easy to understand 'surface' page with high-level graphs and information, with click throughs to more detailed information and the raw data. However, availability of data alone does not guarantee interest – the dashboard's environment page only received 55 page views in July 2014.
- **Manchester City Council[29]:** is in the process of creating an open data framework. The current environmental content of the framework includes data on waste management, contaminated land and environmental permits within the city.

5. Smart technologies create new policy tools

Improved analysis and raised awareness alone will not improve urban environments, but smart technology can also create new ways to take action in reducing pollution and cleaning up our cities. The table below shows how the examples we have looked at in this report can make a difference.

Exhibit 5: Application of smart technologies against environmental challenges

Challenge	Types of action			
	Cut out inefficiency	**Enable citizen impact**	**Proactive real time management**	**Automated real time management**
CO_2		Smart meters	ADR	Automated Demand Response Intelligent street lighting
Air quality	Backhauling apps	Air quality apps	Smart parking HGV route management	Taxi geo-fencing
Waste management	Smart bins	Recycling info apps		
Water	Water leakage dection			
Local Env Quality		KBT app		

Reducing structural inefficiencies in the use of physical resources and polluting activity

Much of the day to day activity in a city – driving vehicles around urban areas, pumping water, heating and lighting buildings – creates carbon emissions or air pollution. Where smart systems can identify when such activity is unnecessary, they provide the means for significant reduction in environmental damage.

For example:

- **UK company Arqiva:** is currently carrying out a smart water metering, leak detection focussed, trial with Thames Water for around 1,600 homes across two District Metered Areas (DMAs) in the Reading area[30]. Although it is too early to provide conclusive data on the effectiveness, indications show that it is helping to identify leaks through the provision of timely data on water consumption.
- **FREVUE London demonstrator project[31]:** This demonstrator project, managed by the Cross River Partnership, aims to show how electric freight vehicles can be deployed for 'last mile' deliveries in urban areas, in part using ICT to minimise the number of vehicle movements.

Bringing citizens 'into play'

We have seen in the previous sections how sensors linked to personal smart devices can help data capture on environmental issues, and how the greater understanding of environmental problems from smart data can increase public interest in such issues. But smart systems, technologies and apps can also bring citizens 'into play' in other ways.

First, they can enable policy makers to incorporate citizens' collective preferences as identified from social media data:

- **Geotaggers' World Atlas**[32]**:** The Atlas maps the specific locations where photos have been uploaded to social media sites and could be used to identify views citizens want to see protected.

Second, they can enable citizens to directly influence city policy choices:

- **Spacehive**[33]**:** uses crowd sourcing and community engagement to identify, prioritise and deliver investments in urban public spaces.

Third, they can help citizens protect themselves from short term environmental impacts, such as smart systems that send automatic texts to asthma sufferers warning them when air pollution is high, or flood warning apps.

Fourth, they can encourage citizens to be more proactive in managing their own impact by enabling them to directly monitor their consumption via smart meters and compare this consumption with norms, or by using recycling apps to ensure they recycle correctly.

Proactive real time management of city activity to reduce environmental impacts

Smart technologies can also be used to manage activity within a city in real time. This management may be undertaken expressly to reduce environmental problems (eg air pollution hotspots), or for another purpose (eg reducing energy costs) where there is an environmental benefit as a consequence.

Examples of this include:

- **Utrecht air pollution management:** The city of Utrecht, with funding from the EU, investigated the development of a smart route guidance system for road freight traffic to improve air quality within the city[34]. The measure focused on defining a method to guide freight traffic, in real time, along routes that are less congested based on air quality measurement.

  From September 2010 to April 2011 an investigation into the technical feasibility of 'clean route planning' for freight transport took place. The study showed that rerouting freight traffic in real time according to local air quality index contributes to a reduction in concentrated traffic pollution at the city level.

  Route navigation software was designed to calculate the most appropriate itinerary for a specific freight vehicle in real time, with an algorithm developed to reduce the emissions from freight transport, avoid road congestion, and decrease fuel consumption.

  As the measure was focussed on the research and development of prototype activities, the tests were evaluated on the process and future potential rather than the direct outcome. The approach is considered by the project administrators to be replicable in other cities. The study found that it is challenging to design a navigation tool for real time freight traffic control, but proved the potential for further development both of the process and a supporting app.

- **Smart parking:** Smart parking requires the rollout of ultra low power sensors that provide the real time status of every parking space – this information can be accessed through apps by drivers. The ParkRight app, developed by Parkopedia for the City of Westminster, provides real time parking space occupancy data[35] – monitoring over 41,000 on and off-street parking spaces. Likewise in Milton Keynes parking space sensors are being installed to investigate the potential for smart parking[36]. Smart city technology company Ethos Smart[37] argue that such technology could save up to 15% of city centre private car emissions by reducing wasted mileage spent looking for parking spaces.

- **Backhauling:** Backhauling is the process of transporting goods by truck from point A to point B, then ensuring the truck is refilled (for example with waste packaging) when returning from point B to point A given that it is a journey the truck is likely to be making anyway. The Department for Transport estimate that 25% of road transport operations make the return journey with an empty truck or lorry[38]. Informed by a smart app, there is the ability to better identify and match up empty trucks making a return journey with waste products that require transportation.

- **Milton Keynes smart bins[39]:** Milton Keynes is trialling 'smart bins' where sensors detect when public bins need emptying and send electronic messages to the waste collection authority to enable refuse collection vehicles to avoid needless journeys.

Automated real time management of city activity to reduce environmental impacts

- **Street Lighting:** Many local authorities have introduced energy efficient street lights, but the concept can be taken further. In Glasgow an Intelligent Street Lighting demonstrator initiative replaced 72,000 old fashioned street lamps with energy efficient LEDs, and sensors which brighten and dim in response to local activity – reducing energy consumption by up to 60%[40].

- **Hybrid powered vehicles automatically switching to electric propulsion[41]:** The Greater London Authority is looking at the future feasibility of requiring taxis operating in central London to be fitted with hybrid technology which can be automatically switched to electric propulsion through either sensors or external signals which are triggered when the vehicle enters a high pollution area – a process known as geo-fencing.

- **Smart grids/Automated Demand Response:** Commercial and industrial buildings are able to reduce electricity demand by turning off or down electrical plant such as lighting, air conditioning systems, pumps, fans and motors for short lengths of time without negatively affecting the building's performance or comfort conditions. Utilising the internet, an Automated Demand Response (ADR) server accepts Demand Response (DR) load reduction event information from DR programme operators such as National Grid at times when there is stress on the electricity grid. These signals are identified by an ADR Gateway device located on each building participating in the ADR programme. The Gateway will see this signal as an event and will trigger an appropriate, automated load reduction action based on the set of rules defined for the event and pre-approved by the building owner. At least 10% of the peak electricity demand in UK buildings can be moved or reduced by making temporary adjustments to the building's electrical load. In Element Energy's report on the potential of demand response in the UK's non-domestic buildings in 2012, they estimated that the load flexibility during peak hour, winter week day, ranged from between 2.4-4.4 GW.

  ADR is currently being rolled out in a large-scale test across Bracknell in Berkshire (which is deemed a 'typical British urban area') as part of Scottish & Southern Energy's 'Thames Valley Vision' and in collaboration with Honeywell, GE, the University of Reading, the local council and others. The intention is to install ADR across a range of 30 buildings by June 2015 – including commercial, public, retail, educational, healthcare, and leisure facilities. Within the buildings connected to date, over 150 'load shed events' have been conducted, without one being noticed by the occupants. It is hoped that ADR will replace the need to otherwise build a larger substation at a cost of £30m.

Innovative smart interventions like those explained above have the potential to over come the **policy gap** (ie when the complex, 'living' nature of city systems and social patterns is a challenge for traditional policy approaches, which can either be too imprecise to be effective, or are effective but at the cost of creating large numbers of 'losers' which can erode political support for action. An example would be air quality, where banning all diesel vehicles from urban areas would transform air quality for the better, but, rightly or wrongly politicians see this as not politically feasible) and the **funding gap**, where many cities lack the financial resources for major initiatives which are not either required for immediate legal compliance or directly related to economic regeneration.

6. Despite potential, smart initiatives have had limited impact on the environment

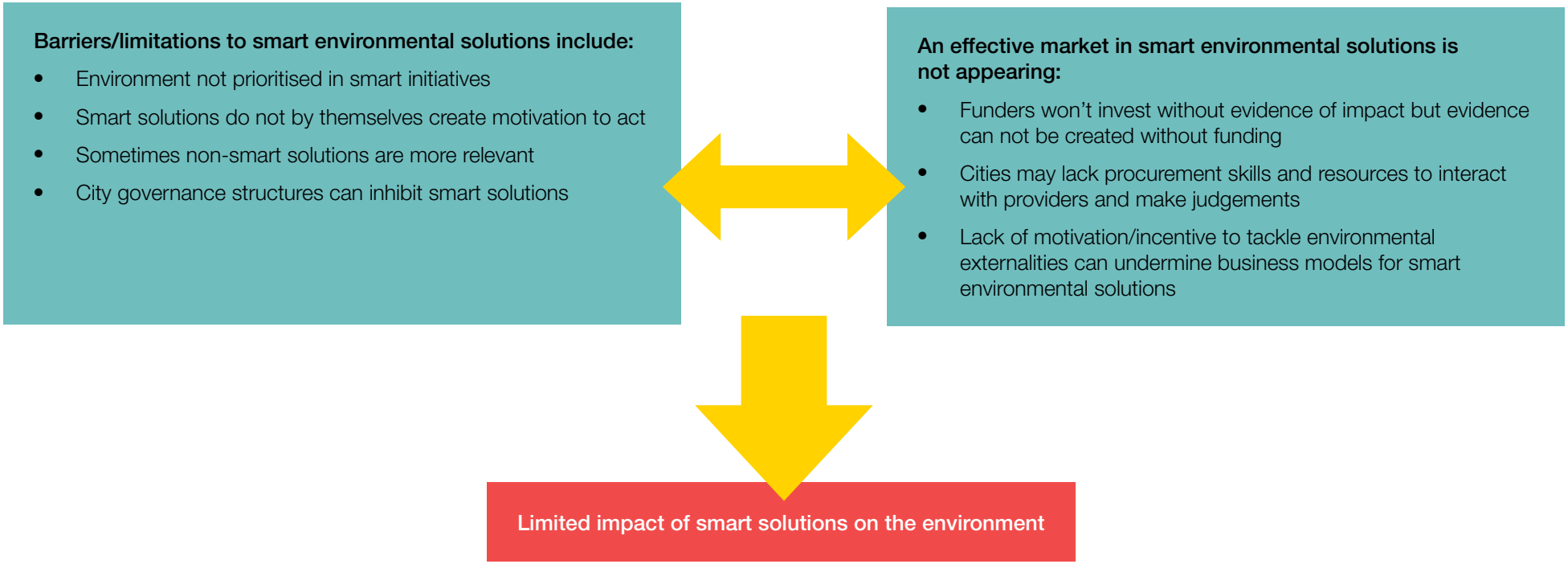
Despite the range of ways smart can help the environment and the innovative examples we have found, there is little widespread evidence yet of smart initiatives making a significant impact on environmental problems, and certainly no sign of a smart 'silver bullet' for environmental problems.

However, there are a number of smart initiative examples which would appear to be replicable across cities and claim to be able to reduce pollution/polluting activity by 10-20% (eg Amsterdam smart water meters – 15% reduction in water consumption[43]; Bristol smart grid pilot – 20% reduction in peak time energy use in pilot areas[44]; smart parking – eliminate 15% of city centre private vehicle emissions due to drivers unable to find parking[45]).

If modern cities were able to develop and implement smart best practice across the environmental areas of most concern to them, we could see in time some significant improvement in urban environments.

Clearly, this is a new field, and it may be that with time smart environmental solutions will become standard practice. But our research has also uncovered a series of barriers in the way of adoption and reasons why an effective market in smart environmental technology appears some way off.

Exhibit 6: Barriers to smart environmental technology development and market formation



Barriers to the development of an effective market in smart environmental technologies

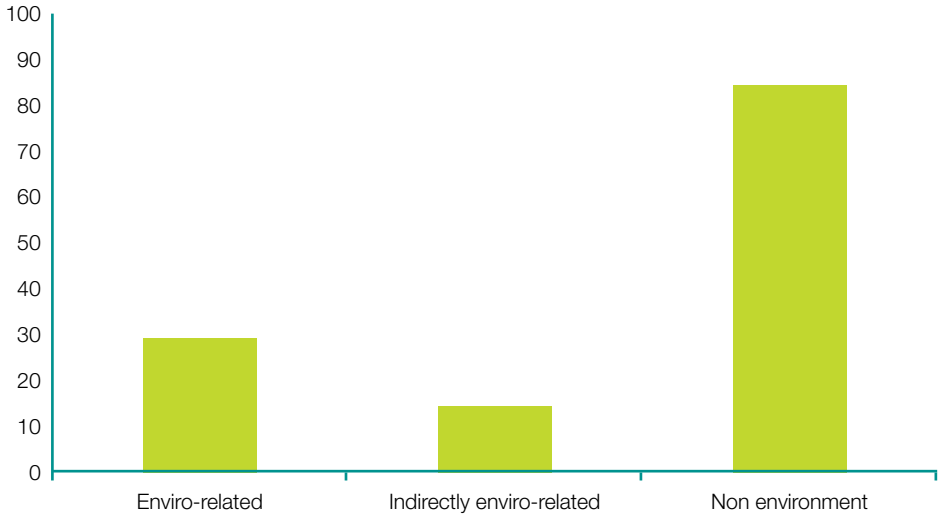
Constrained demand from cities for smart initiatives due to budget cuts and a focus on delivering statutory services

Local authorities will continue to face funding cuts, with a focus on delivering statutory requirements and a degree of difficulty to do much beyond this.

Lack of prioritisation of the environment in smart initiatives

Environmental issues may not be prioritised as cities develop smart initiatives. Exhibit 7 breaks down smart city initiatives by environmental relevance – cases where smart technology has been used specifically to tackle an environmental issue are the exception not the rule.

Exhibit 7: Smart city case studies by envionmental relevance



Note: case studies from following reports analysed: Future Cities Catapult, 'Future Cities: UK Capabilities for Urban Innovation'; Department for Business, Innovation and Skills, 'Global Innovators: International case studies on smart cities'; Arup, 'The Smart Solutions for Cities'; Centre for Cities, 'Smart Cities'; Birmingham City Council, 'Smart Action Plan'; New London Architecture, 'Smarter London'

Limitations of smart technology

Purely smart solutions are often not the most effective way to tackle deep-seated environmental problems. Sometimes traditional solutions are more effective, or a blend of traditionally engineered solutions with some smart elements is needed – getting this balance right can be difficult. [see box overleaf]

Lack of incentive to act undermines business models

Smart initiatives provide new ways to tackle environmental challenges, but they do not in themselves create a political or financial incentive to do so. This in turn can make it difficult to create business models and raises questions about who has a moral, legal or regulatory obligation to pay for the solution. For example, water leakage has traditionally been seen almost exclusively in economic terms, with the economic level of leakage taking account of the cost of water to determine the point at which the marginal cost of additional leakage management activity to save a further unit equals the cost avoided by not producing the unit. OFWAT, the industry reglator, argues that "companies have traditionally made this evaluation based on their internal costs" but add, encouragingly, that this may be starting to change "…recently the analysis has been extended to include externalities – social and environmental costs and benefits."[46]

Another example would be the Utrecht case study on page 16 where the city government hoped the feasibility study into re-routing freight traffic in real time would lead to 3rd party app developers coming forward, but without a clear business model this did not happen.

Likewise, the Centre for Cities has pointed out that business models for rolling out smart technologies are still underdeveloped, meaning they can be perceived to be a higher risk investment for cash-strapped councils[47].

Lack of evidence of impact of smart environmental initiatives

Even where there is financial or legal incentive to solve an environmental problem, smart environmental technologies can suffer from a 'chicken and egg' situation. There isn't always enough robust evidence or large-scale case studies to inform or justify major investment in smart solutions by cities, but this lack of investment is often the reason these case studies do not exist. In other cases, such as the Utrecht example, a feasibility study with valuable information was not followed up or disseminated in any co-ordinated way despite the potential shown.

Institutional barriers may inhibit potential benefits of integrating smart initiatives across city functions

The implementation of smart solutions, particularly integrated, cross-cutting smart solutions, can require a complex network of players within the decision-making chain – it is not simply a case of matching a seller with a buyer. Yet as the Centre for Cities has pointed out[48]:

- Cities find it difficult to work across departments and boundaries. Many of the smart cities initiatives include integrating different policies and information systems (such as linking cycling with carbon reduction). At present, budgets and strategies are seldom coordinated across departments and data is rarely shared. For example, the funding of roads, rail and sustainable transport is done separately.
- Cities have limited influence over some basic services such as gas, electricity and water, and services such as buses have been privatised. With so many divergent stakeholders it can be difficult to implement city-wide strategies.
- To try to overcome some of these problems the BSI has created a Smart Cities Framework (PAS 181:2014).[49] This establishes a good practice framework for city leaders to develop, agree and deliver smart city strategies. The smart city framework distils current good practices into a set of consistent and repeatable patterns that city leaders can use to help develop and deliver their own smart city strategies. [See annex 2 for further information].
- Although not specific to a city's environmental challenges, concerns have been raised about people's willingness to freely give up data and related issues around data protection. This report acknowledges the problem, but solutions to it go beyond its remit and requires the involvement of a far wider group of stakeholders.

Is smart always the right answer?

This report has identified many ways in which smart can help tackle environmental problems. But smart initiatives may not be effective at cutting out pollution at source. For example, in the case of air quality and diesel vehicles (buses, trucks, lorries) engine retrofits are required for older models. Smart examples such as clean route planning for freight transport explored elsewhere in this report can help avoid the concentration of air pollution in city hotspots, but only spreads the pollutants more thinly over a wider area without eliminating them.

Sometimes hard engineering solutions are required to manage physical flows. For example, Sustainable Drainage Systems (SuDS) have an important role to play in the management and redistribution of excessive surface water in urban areas. Likewise in buildings, building fabric and the level of insulation – cavity walls, lofts, double glazing – can have a huge impact on a building's energy efficiency levels.

Further, the safe, efficient movement of people and non-polluting transportation (such as bicycles) in ever-more dense inner city spaces is reliant on appropriate road and physical infrastructure design.

Its also interesting that the Veolia/LSE Imagine 2050 project[50] looking at future solutions to city environmental problems emphasises the role of nanotechnology and micro scale plant based effluent cleaning in homes more than city-wide 'smart ICT systems'.

Nonetheless, even when more traditional engineering solutions are the fore, blending them with smart elements can pay dividends. For example, the Bishan Mo Kio Park in Singapore was heavily relandscaped to turn a concrete storm channel into a natural river feature with impoved storm water carrying capacity[51]. However this landscaped approach has been augmented by smart sensors which provide advance warning of high water volumes in the river and so enable safe public use of the park.

7. Conclusions

- The smart city concept itself is relatively new, and the environmental aspect of smart city thinking even more so. This means that there is a lack of definitive evidence that smart technologies and applications have a major role in improving environmental outcomes in cities. However, there are encouraging signs that smart has a role to play, and given the urgent need for cities to make real progress in tackling environmental challenges the encouragement of smart environmental solutions should continue.
- At the same time it is important not to 'oversell' the impact of smart technology itself. In many cases the most effective approaches will be the blending of smart elements with more traditional engineering solutions.
- The immaturity of the market for smart technologies – especially those aimed at meeting an environmental challenge – and the number of applications still in the research and development stages, means that hard evidence of real world impacts is limited and dissipated. There needs to be more effort put into creating a central case study depository to enable a better understanding of where knowledge and tested best practice can be deployed elsewhere, and the better dissemination of hard evidence on what works and what doesn't.
- The smart city market will develop better and costs come down if there is a greater standardisation of approach to initiatives such as data portals. The BSI Smart Cities Framework could have a role here in encouraging the spread of good practice.
- While the aim is to develop city-wide approaches, this can be technically and commercially challenging in the short term. Often there will be value in piloting smart environmental solutions at sub-city scale where there is a desire to act matched with an appropriate governance or institutional framework. An example might be a university campus, or an area of a city with a small number of major landlords/developers who could be encouraged to sign up to common implementation of a smart initiative.

8. Next steps

The aim of this report has been to connect two debates – the traditional one about how cities can tackle seemingly intractable environmental problems and a new one about the potential of smart future cities – and to shed new light on both. The complex nature of the issues, and the proliferation of marketing material compared to hard evidence of environmental achievement in real word situations has meant that this has not been a straightforward project and is far from the last word on the topic. We hope that this report will stimulate a discussion around our conclusions, and about how all stakeholders can encourage the development of a viable market in smart green solutions that will enable cities worldwide to tackle entrenched environmental challenges. In 2015 EIC will develop its work in this field, both through events and further research that explore the themes we have set out.

Annex 1: Data centre energy use

Through an exponential growth in smart technologies there is the risk that some of their environmental benefits will be undermined through a growth in the off-site data centres – the 'engine rooms' which power much of these advancements, but which can be huge energy users and emissions emitters in themselves if not managed properly. Data centres currently use approximately 3% of Britain's total grid power[52], and they are expected to run 24 hours a day, 365 days a year without interruption.

In recognition of this issue, the European Commission's Institute for Energy and Transport has established a Code of Conduct for Data Centre Energy Efficiency. The Code has been created "in response to increasing energy consumption in data centres and the need to reduce the related environmental, economic and energy supply impacts." It focusses on two main areas: 1) IT load – relating to the energy consumption of the IT equipment within the data centre, and 2) Facilities load – relating to the mechanical and electricity systems that support the IT electrical load.

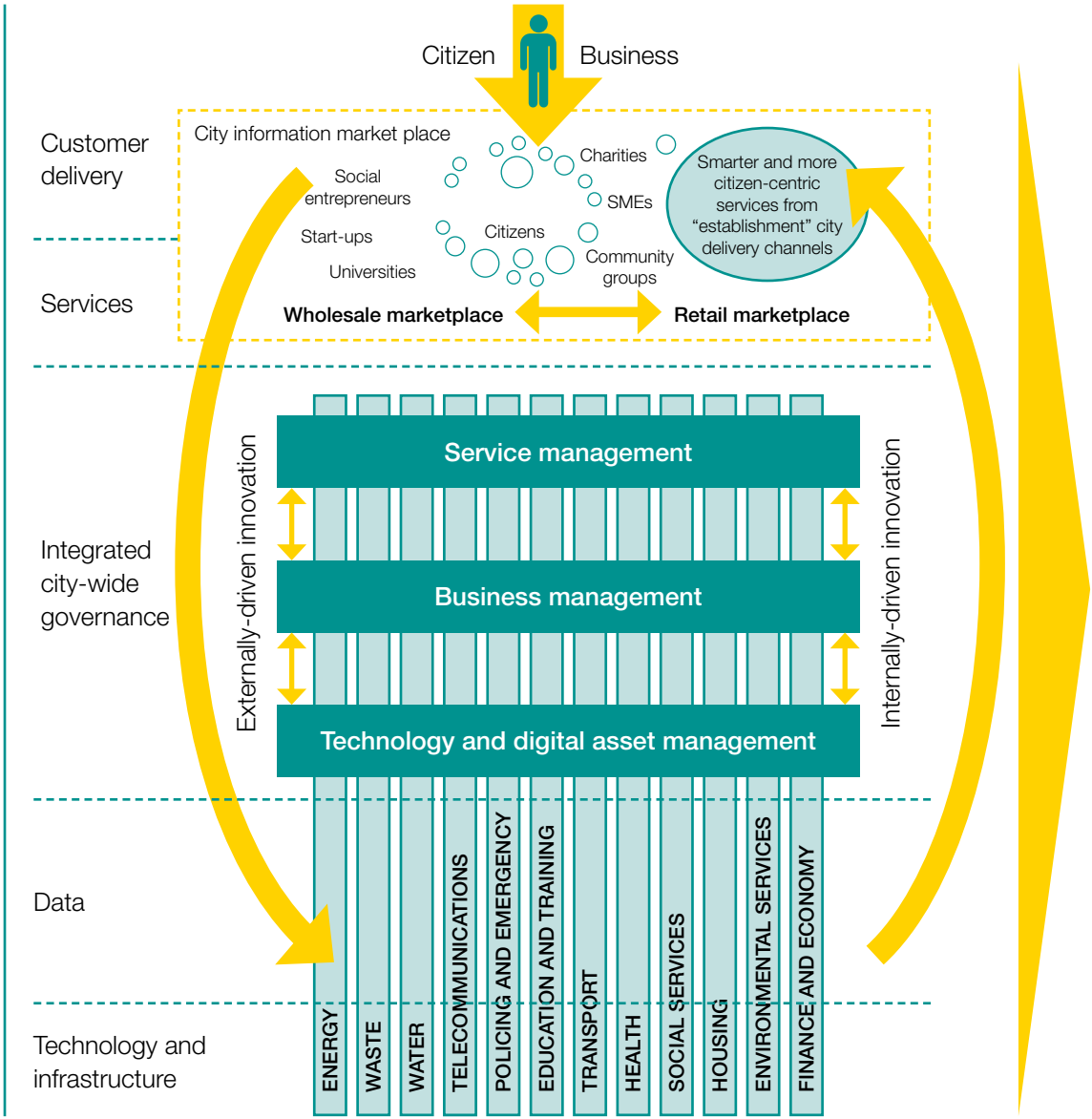
The data centre industry trade body, the Data Centre Alliance (DCA), acknowledges in its mission statement that "the data centre is considered a significant user of energy and a large contributor to climate change. At the same time, the data centre is also a key enabler of many green initiatives. Data centres are the very backbone of our IT systems but present a unique set of challenges with regard to energy use which is often misunderstood. Many good guidelines and codes have been initiated already that are recognised and supported by the DCA, but to maximise these successfully, coordinated strategies are needed to gain the maximum exploitation and adoption."

A recent report by the Natural Resources Defense Council (NRDC)[53] and Anthesis argues that while the largest data centres run by the likes of Google and Facebook are relatively energy efficient, the mid sized ones, potentially the ones powering smart city technology, are often very inefficient. NRDC proposes:

- a standard metric that would show average server CPU utilization. This would be a "simple, affordable, and adequate way of gauging data center efficiency that could be used immediately to drive greater IT energy savings in data centers;"
- incentives for data center operators to be efficient — and for customers to use efficient data centers: "Multi-tenant data center stakeholders should develop a "green lease" contract template to make it easier for all customers to establish contracts that incentivize rather than stand in the way of energy savings;" and
- more public disclosure of data center energy and carbon performance going forward.

Annex 2: BSI Smart Cities Framework: new integrated operating model

Traditionally, city level budget-setting, accountability, decision-making and service delivery have been embedded within unconnected vertical silos and delivery chains – silos which are built around functions, not user need. The BSI argues that smart cities need to develop new operating models that drive innovation and collaboration across these vertical silos. The individual citizen or business has had to engage separately with each silo, requiring them to make connections for themselves rather than receiving a seamless and connected service that meets their needs; something which is compounded by data and information which has typically been locked within these silos, limiting both the potential for collaboration and innovation across the city, and the ability to drive city-wide change at speed. The diagram [right] summarises the change to this traditional way of operating which smart cities (and the BSI framework) are seeking to implement.



Impact:

- City data unlocked from individual silos
- Logical separation of data, service and customer delivery layers
- Externally-driven innovation:
  - Enablement of new marketplace for city information and services
  - Citizens, SMEs and social entrepreneurs enabled to co-create public services and create new value with city data
- Internally-driven innovation:
  - Improved and integrated service delivery
  - Resource optimization
- Ability to drive city-wide change at speed

Annex 3: Members of EIC Smart Cities Task Force

Acclaro Advisory

Acclaro Advisory is a specialist consultancy providing organisations with a range of carbon management and sustainable business solutions. We work with multinational corporations, governments and NGOs. Based upon our established track record of delivering projects, we have an unrivalled understanding of both the emerging policy trends and the technical experience to enable clients to implement practical and measurable solutions. We provided a report on smart meters and have developed tools to capture and utilise energy data at a building scale and connect to a wider footprint. www.acclaro-advisory.com

Aecom/URS

With nearly 100,000 employees — including architects, engineers, designers, planners, scientists and management and construction services professionals — serving clients in more than 150 countries around the world following the acquisition of URS in October 2014, AECOM is a premier, fully integrated infrastructure and support services firm.

AECOM is ranked as the no. 1 engineering design firm by revenue in Engineering News-Record magazine's annual industry rankings. The company is a leader in all of the key markets that it serves, including transportation, facilities, environmental, energy, oil and gas, water, high-rise buildings and government. AECOM provides a blend of global reach, local knowledge, innovation and technical excellence in delivering solutions that create, enhance and sustain the world's built, natural and social environments. A Fortune 500 company, AECOM companies, including URS, had revenue of $19.2 billion during the 12 months ended June 30, 2014. More information on AECOM and its services can be found at www.aecom.com

BEAMA

BEAMA is the trade association for the UK electroctechnical industry, representing over 200 companies in the power, electrical and building services sectors. Our members, who range from multinationals to SMEs, manufacture the wide range of equipment required for end-to end electrical systems, and therefore will play a key role in the evolution of smart cities and associated technologies and services. www.beama.org.uk

Bird & Bird

Bird & Bird LLP is an international law firm, with a rare and invaluable grasp of strategic commercial issues. We combine exceptional legal expertise with deep industry knowledge and refreshingly creative thinking, to help clients achieve their commercial goals. Working at the intersection of business, regulation and technology, we continue to take a leading role in raising awareness of the challenges and opportunities to design and deliver smart cities, both in our chosen sectors (IT, communications, energy and healthcare), where we see great strides being made, and a diverse range of technological and process innovation on which we advise.
www.twobirds.com/en/sectors/energy-and-utilities/smart-cities

Cross-River Partnership

Cross River Partnership (CRP) is a public-private partnership that has been delivering regeneration projects in London since 1994. Comprising central London local authorities, Business Improvement Districts and other organisations, CRP's focus is on achieving environmental and economic enhancement and keeping London an attractive place to live, work and visit.
www.crossriverpartnership.org

Honeywell

Honeywell is a Fortune 100 diversified technology and manufacturing leader, serving customers worldwide with aerospace products and services; control technologies for buildings, homes and industry; turbochargers; and performance materials. With 131,000 employees in 68 countries around the world, Honeywell's turnover in 2013 was $31 Billion. **www.honeywell.com**

Keep Britain Tidy

We are an independent charity, which fights for people's right to live and work in places of which they can be proud. A single truth underpins our success – caring for the environment is the first step to a better society. 60 years ago, we started with litter. Today we do much more. We work at the heart of business, government and the community to help people understand that what's good for the environment is also good for us. **www.keepbritaintidy.org**

Landmark Information Group

Landmark Information Group identifies and translates environmental and property risk into facts, insight and opportunity. With data, technology and our team of experts are at the heart of what we do, we deliver intelligence and solutions to enable you to make informed decisions. **www.landmark.co.uk**

Manchester City Council **www.manchester.gov.uk**

Schneider Electric

As a global specialist in energy management with operations in more than 100 countries, Schneider Electric offers integrated solutions across multiple market segments, including leadership positions in energy and infrastructure, industrial processes, building automation and data centres/networks, as well as a broad presence in residential applications.

Focused on making energy safe, reliable, efficient, productive and green, the company's 150,000 plus employees achieved sales of 24 billion euros in 2013, through an active commitment to help individuals and organisations make the most of their energy. **www.schneider-electric.com/**

Temple Group

Temple Group is one of the UK's leading environmental and planning consultants, helping to deliver some of the UK's largest and most challenging programmes and projects from inception through to completion and operation. Temple provides a comprehensive and genuinely bespoke service to its clients, providing access to acknowledged experts in the UK and with successful international track record in the most cost-efficient ways. **www.templegroup.co.uk**

Veolia

The UK's leading environmental solutions provider, Veolia, has developed a new strategy as a manufacturer of green products and green energy that has placed it at the forefront of the circular economy. The company provides integrated water, waste and energy services for municipal, commercial and industrial customers and its innovative 'Imagine 2050' report with the LSE demonstrated its commitment to smart cities of the future. See **www.veolia.co.uk**

WSP/Parsons Brinckerhoff

WSP and Parsons Brinckerhoff have combined and are now one of the world's leading engineering professional services consulting firms. We bring together our 31,500 staff, based in more than 500 offices, across 39 countries to provide engineering and multidisciplinary services in a vast array of industry sectors, with a focus on technical excellence and client service. Our breadth of expertise puts us in a unique position to understand the challenges faced by today's cities, allowing us to deliver solutions that help them become more resilient, more adaptable and more sustainable in the future.
www.wspgroup.com www.pbworld.com

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Endnotes

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