

# Future Cities Dialogue

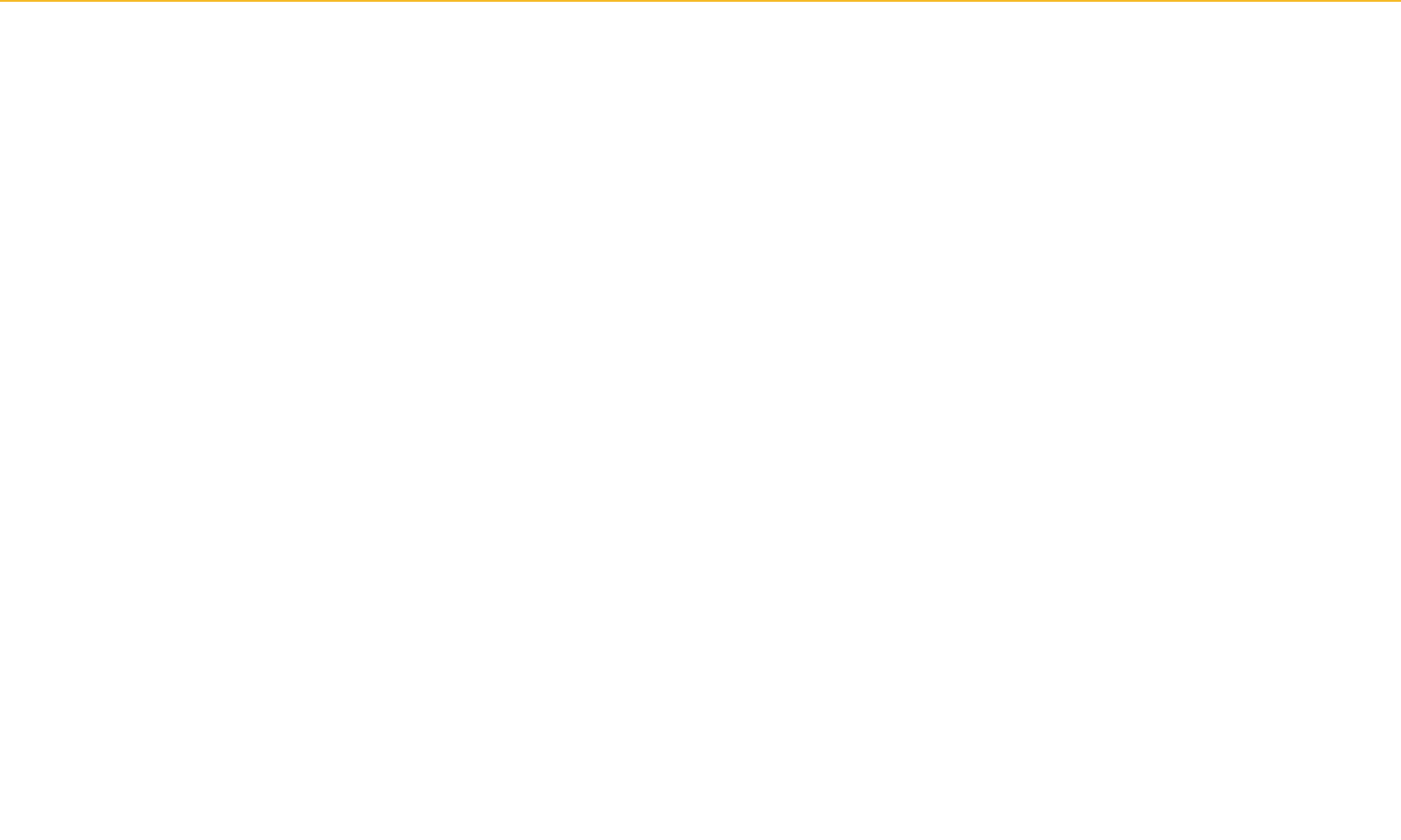
A project investigating urban  
system integration in the UK



Ipsos MORI

Innovate UK





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system integration in the UK

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REPORT



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# Foreword

by Dr James Taplin, Innovate UK

The concentration of people and their resources means that cities are the engines of economic growth around the world. The cities that do best are those that look after their citizens most successfully. By improving the operation of cities, we improve the quality of life of the citizens, which improves the success of cities, and therefore improves the economy.

Innovate UK works with people, companies and partner organisations to find and drive the science and technology innovations that will grow the UK economy. To do that effectively, we need to understand where the world is going – particularly how urban areas are likely to change – and what people want from their cities. The market for city operations is peoples' needs, so knowing what the future holds and what citizens want allows us to support the initiatives that will flourish by best meeting the market needs sustainably into the future.

This project gives us both of those things – coherent visions of what integrated urban systems, that improve the operations of our cities, could look like in the future and direct citizen insights into alternative futures and technologies. We know that cities can't meet the challenges they face without integrating their urban systems better and, for the first time, this work shows us what that could look like in practice at a city-scale. It is groundbreaking in its focus, in the use of the public to develop the visions, and in shaping Innovate UK's understanding of people-led system needs.

In addition to the future visions, the project also gives us eight clear principles for successful system integration – principles that we should follow when supporting new business solutions. Many of these principles may not be surprising, but having them validated by clear public opinion gives us a much stronger rationale for action and strategic direction for our support. They tell us that we should foster integrated urban solutions that are resilient and evolutionary, tech-enabled but not tech-centred, well-governed, sustainable, human-centred, globally-linked, value-networked, and transparent.

This summary report presents the conclusions of the project, but is not the end of the work. Quite the opposite – we will use the intelligence it provides to shape our onward activities, and we encourage others to use the wealth of trends, scenario and citizen insight materials to explore their own future changes and opportunities. We encourage stakeholders to use the work to understand their role in creating successful, sustainable and resilient urban areas, and to work with us to realise them together.

# Introduction



Cities thrive by meeting the needs of their citizens. Throughout history, those that have done this best have been the most important, and those that have done it longest have been the most powerful. People's basic needs haven't changed much throughout that time – they still want shelter, and food, and security, and entertainment, and the ability to grow as individuals – but what has changed is how they expect those needs to be met. The most successful and resilient cities are those that have been able to adapt to the changing world around them.

In 2008, for the first time, we became an urban rather than rural species – more of us lived in cities than lived in the country – and over the next few decades this trend is set to increase. By 2040, more than 70% of us will be living in urban areas globally.<sup>1</sup> This change, and the associated global population, after growth, brings constraints as well as opportunities. Cities are increasingly important as engines of economic growth, but also of climate change impacts too. Global shortages of the resources we currently rely on to meet our needs make it impossible to pursue a 'business as usual' approach. Societal changes in age, family groups, migration and so on put new demands on city infrastructure and services. So how our cities need to change to thrive in the future is a major concern for leaders around the world, and a huge innovation opportunity for business.

Cities have to do more with less. This means they can no longer just look to do things better, they have to do better things. A critical way to do this is to integrate city systems so that they reinforce rather than antagonise one another. A simple example is health – obesity and respiratory conditions from poor air quality are huge challenges facing the UK and elsewhere. Building urban transport systems such that they encourage more exercise and remove polluting vehicles from urban areas would help solve both of these complaints, but all urban transport planning in the past has been designed solely to meet the needs of the transport system – how to get people and goods from a to b. Taking a systemic approach to city planning allows the whole to be seen together, and to create infrastructure systems that work synergistically.

In our highly networked world, it is a simple and intuitive idea. But integrating infrastructure systems is fraught with legacy challenges – the legacy of the way urban systems have been built, and the legacy of citizen expectations about how they should be used. Because this is such an important market opportunity for those who create the solutions, one of Innovate UK's four thematic programmes is focused on the challenge of Infrastructure

<sup>1</sup> <http://www.unicef.org/sowc2012/urbanmap/#>

Systems – understanding how to optimise and integrate infrastructure in cities such that it is more efficient and resilient.

This piece of work supports that in a number of ways. Firstly it looks at the variety of initiatives that are being developed in isolation and applied to city challenges to understand the impacts of their convergence. It helps us understand which approaches are mutually incompatible, and by extrapolating to 2040 we have an idea of the kinds of futures that citizens can expect. For the first time, this work shows what city-level system integration could look like as a whole picture, rather than as a series of disjointed snapshots. Having these visions is crucial to galvanising practical action and planning an effective strategy. With them we can help stakeholders across the economy understand the role that each of us needs to play to build successful and sustainable integrated systems, but without them we have nothing to aim at or measure progress against.

Most importantly, we have also consulted directly with the public on how they feel about these different scenarios and solutions, and their likes and dislikes have shaped the process and the results. Cities are nothing without their citizens, and citizen-centric solutions are at the heart of our strategy for Infrastructure Systems. This is not whimsy but solid commercial sense: innovation that doesn't tackle real problems in a way that works for cities and their populations simply won't find a market. Our work accelerates innovation from the collaboration between integrated city solutions and citizen needs that deliver societal, environmental and economic benefits. This project is therefore essential in helping us understand what these citizen concerns and needs really are. We will continue to support business-led projects that explore these.

Hundreds of people have been involved in this project, both expert and citizen, and their knowledge and insights have allowed us to create three coherent and plausible visions of how we could be living in 2040, and the sorts of businesses and technologies that we'll be using. As with all futures, these are not predictions, but rather snapshots created to illustrate the range of likely futures that we will face. Reality will likely lie somewhere between them, and will be a blend of each of them in different places and times. There are similarities between the three visions that give a strong steer as to the sorts of solutions that will do well no matter what, and differences that show some of the options we will have in meeting people's needs. Since we want to build a sustainable and resilient future in which our cities are thriving thanks to the solutions provided by strong and successful UK businesses, what is most useful to Innovate UK are the principles for successful system integration that have been demonstrated by this project. We may not know for sure what the future will be, but by using these principles to guide our strategy and support we can ensure that the world we help build will be fit for purpose in 2040.



# Scenarios for urban systems integration

The future is likely to be dramatically different from today, in ways that we cannot predict. However, we can explore possible pathways using futures tools, such as scenarios and visions. ‘Futures’ is structured thinking about the future to improve decisions made today. It helps identify risks and opportunities, inform strategy development, and stimulate innovation. Scenarios, in particular, are useful to:

- build capacity for long-term and systemic thinking
- catalyse insights about uncertainty, change, and interconnectedness
- give a mandate, motivation, and confidence to change current practices
- create a safe space for dialogue among people in multidisciplinary roles, and an opportunity for stakeholder engagement
- generate a longer-term and more sustainable strategy, and new and disruptive product and service innovations
- challenge existing norms, prioritise issues, and support programme design

To explore some of the possibilities for what urban systems integration could look like in UK cities, we have created three scenarios. The scenarios are experiments in evidence-based imagination – explorations of alternative possible futures, rooted in rigorous research and testing. They were developed using a combination of primary and secondary qualitative research, as well as consultation with over two hundred stakeholders across the UK and beyond. These stakeholders included futurists and thought leaders, specialist experts on topics ranging from water to energy and food, as well as a representative group of citizens in York, Glasgow and London. More information about the project methodology can be found on the project website.

The initial research generated key ‘meta’ drivers of change and trends influencing urban development, globally and in the UK; as well as the ‘meso’ and ‘micro’ level trends influencing the development of six key urban systems: food, energy, water, waste, transport and health (all of these trend cards are available on the project website).

We used the drivers and trends in a series of workshops with experts in the six systems to identify possible future pathways for each of the systems. These pathways were then tested in public dialogues, allowing us to understand the preferences of UK citizens around future solutions in their cities. Using the system outcomes in combination with the insights generated through the dialogues, we created draft scenarios looking at possible future

integrated cities, and then tested and finalised these via another round of citizen dialogues and an expert workshop composed of Innovate UK staff and external specialists in the six systems.

These scenarios are not predictions. Rather, they depict imaginary but plausible alternative futures in order to stimulate more creative and systemic thinking today. They also provide a means to model the viability of specific integration opportunities in the context of the complex uncertainties facing urban centres in the future. In this project, we used the scenarios to identify opportunities for Innovate UK to support integrated urban solutions through competitions and other interventions (a full explanation of the scenarios is available on the project website). This resulted in a map of specific integration opportunities across the six systems, and a set of design principles for system integration – all of which are summarised in this report. We hope that the scenarios and related tools will open up a space for new ways of thinking about how to create inclusive and resilient solutions in UK cities.

We've made all the resources developed as part of the Future Cities Dialogues freely available online so anyone can use them.

- Research file: factors shaping the future of urban energy, water, waste, health, food and transport systems
- Research file: future technologies that might have an impact in our future cities
- Research file: macro factors shaping the future of UK cities
- Research file: how urban systems work today (energy, water, waste, health, food and transport)
- Full detailed scenarios
- Scenario posters for use in workshops
- Methodology

More information can be found at <http://www.forumforthefuture.org/project/future-cities-dialogue/overview>





### SUMMARY

This is a world where devolution has really taken off and been a success. The UK has moved to a more federal model in which large cities are politically and culturally powerful. These cities have restructured their financing and closely integrated systems at the city and regional level – such as health, transport, water and waste.

There is a strongly utilitarian ethic that aims to provide high quality, extremely efficient mass solutions. Health and social care are a national obsession; policy in all areas – transport, energy, food – is structured around improving public health and lowering carbon emissions.

Ubiquitous technology saturates urban environments and is taken completely for granted, giving a real-time detailed picture of the city and allowing for complex coordination of services. Data-sharing is widely accepted as a necessity for high-quality services; Big data and behavioural 'nudging' are liberally deployed to solve complex urban challenges and maximise public health and wellbeing.





#### A DAY IN LIFE

"I live in Harchester in a Victorian terrace. The houses are really warm since they put the insulation in – we barely put the heating on last winter. The street hardly has any cars in it, cars are so expensive to run now and public transport is so good. Only the automatic delivery trucks use our road now, although you hardly ever see them, they seem to do stuff in the middle of the night. Makes it handy for breakfast though, all the food for the day waiting for you when you wake up. And you get just the right amount for the recipes you ordered, all pre-chopped, so cooking takes no time at all."

"Kids play in the street quite a lot – their trackers don't let them spend too much time in front of screens or in VR – and if they run around enough they earn little treats, which seems fair enough."

"There's still a corner shop on our street, but no chippie. His license got revoked, they said there were too many takeaways in the area. Now it's a 24 hour walk-in neighbourhood health service which is quite handy actually – if your tracker flags up anything or you have a cut that needs stitching – anything like that – you can pop in and see the nurse, and chat to the remote doctor if you need to. There is also an actual real physical doctor but I've never seen them, they're only for the serious stuff."

"The corner shop nearly closed down too at one point, they said he had too much unhealthy stuff – chocs and alcohol and that. Now he mainly does healthy snacks, which is ok up to a point but it means you have to practically plan an expedition just to get a bar of chocolate or a bottle of vodka. It's half an hour on the bus just to get somewhere with a decent selection, but I suppose it has meant that I've cut back a bit."

"A lot of people on our street cycle, quite a few have got those electric assist bikes. When its summer there are bikes everywhere! And the park around the corner gets really popular. It used be a carpark but they converted it 5 years ago. It's a nice local space, all the neighbours use it too, sometimes we have a spur of the moment barbeque there if it's a sunny weekend."

"They say that the city is really complex now but it doesn't feel like that to me. Everything just seems to work, and I'm glad that I don't have to think about it."

#### FURTHER RESOURCES

If you want to know more about how this world operates, the systems that people use, the way those systems have been integrated, and the products and services that people are using please see the detailed scenario report at: <http://www.forumforthefuture.org/project/future-cities-dialogue/overview>.





### SUMMARY

This is a high-tech, highly integrated world. The internet of things is everywhere, and virtual reality is commonplace and widely used for work and leisure. People wear devices that gather data about their health, eating habits, and leisure, and then sell this information to private companies or exchange it for services.

There are high levels of automation and correspondingly high rates of unemployment and inequality; a large section of society survives on a small basic income topped up by sporadic work in the virtual economy.

Cities are private sector led and 'pay to play' – there is huge choice in terms of products and services on offer, all with the aim of selling as much as possible. Public services are minimal, and even areas like health and education are dominated by the private sector.



### A DAY IN LIFE

"If you look down the street in my neighbourhood, you won't see many cars. Parked cars used to line the streets, but hardly any cars are parked anymore, driverless taxis move people around. Because of these, traffic accidents have gone down immensely and children can freely play in the street. That is, the few children who still like playing outside. With the great developments in virtual reality, many kids prefer to play with each other in the virtual world and it makes sense, because many of them go to school there too."

"Drones flit back and forth in the sky carrying deliveries of food and medicine to people. These drones also communicate with the power grid so that if a street light goes out, for example, they can replace it. Most people get their food delivered because it's so inexpensive and easy. In fact, the convenience store on the corner also serves as a food distribution centre and ships meals out to people in the neighbourhood. They fill prescriptions from online doctors too."

"Solar panels dot the roofs of the houses, they're so cheap that nearly everyone has them. The smart grid for energy and the water system makes sure that the system isn't overloaded and keeps track of who is using what. We have to pay for what we use, but that seems only fair."

“Recycling trucks come on Tuesdays. Rubbish trucks only come once a month, mostly because there is very little that isn’t recycled. Companies are responsible for disposal of items that cannot be recycled so most things are built to stay out of the rubbish bin.”

“There is a small park on the corner of our street owned by UniGadget. It is really pretty and well maintained, and it doesn’t take you long to block out the UniGadget advertising billboards. Lately, some older unemployed people have taken to hanging out in the park. There aren’t many other places they can go for free to socialise.”

“Some people are worried about the changes that have taken place – they say that people are unemployed, disconnected from each other, and the world is too competitive. But I like the convenience of living in the city and the constant new services and experiences to choose from. Things are supposed to be competitive and connected here – it is what makes city life exciting.”

#### FURTHER RESOURCES

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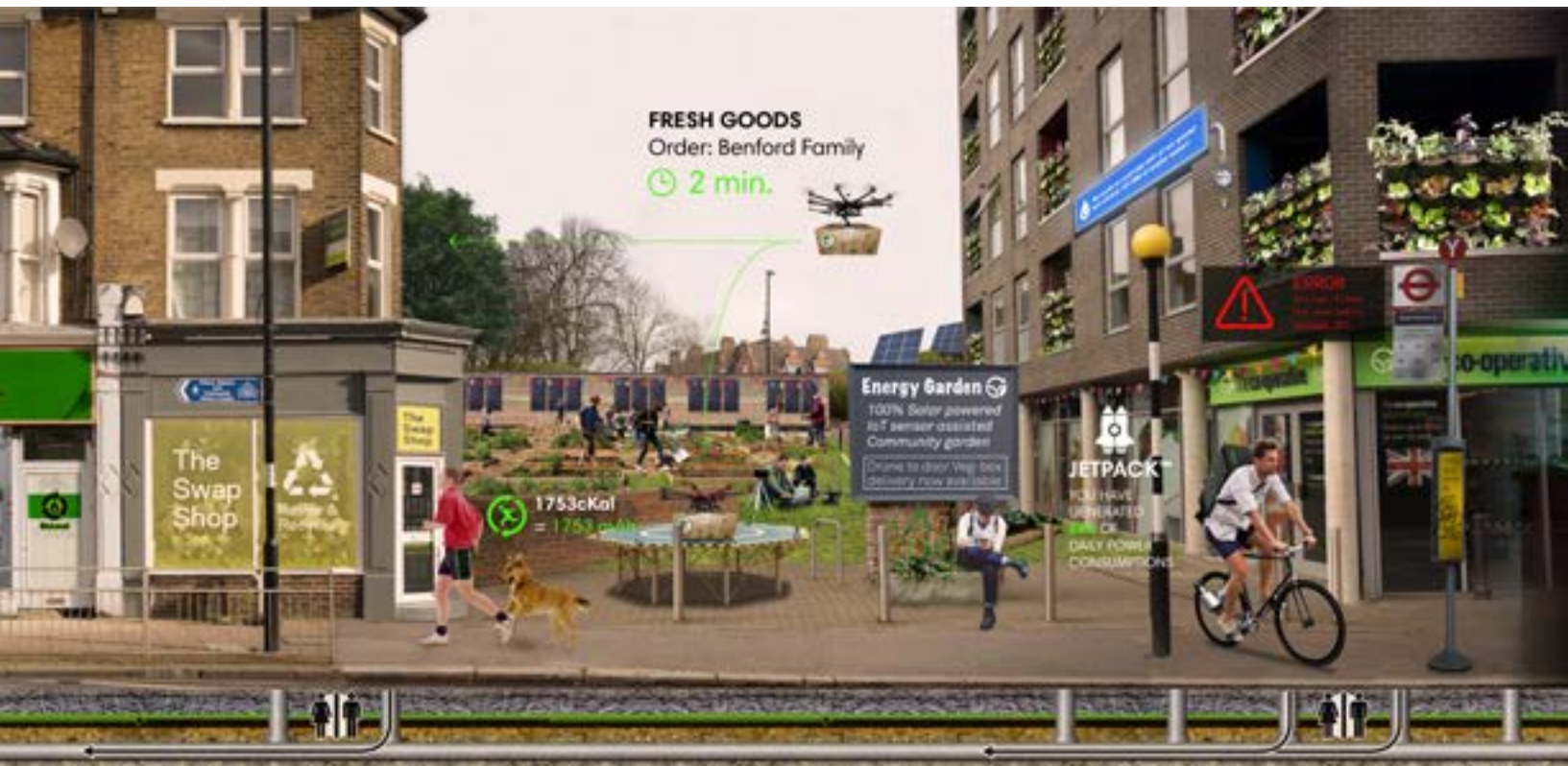
#### SUMMARY

Despite a low-growth global economy and continual low public spending, many UK communities have found a way to flourish through a focus on self-governance and the philosophy of living better with fewer, more durable goods. Life is facilitated by technology but very much grounded in physical spaces; people value the ability to connect with each other in person without technology at the centre.

UK cities are dense and centred around small, self-contained communities. Urban services are integrated on a small-scale and by repurposing existing infrastructure. They are often locally-run, and include everything from health to energy to food supply. Innovation is citizen-led and enabled by distributed manufacturing technologies and digital platforms.

There is an egalitarian ethos, but inequalities remain and are particularly prominent between different communities – some are wealthy and resilient, and others lack access to resources and struggle with economic and climate shocks.





#### A DAY IN LIFE

"The gurgling sound I hear as I'm walking down the street is the pipes carrying waste water from the neighbourhoods' toilets into our local AD plant. Along with the food waste from our community bins, it is helping generate the entire neighbourhood's gas supply."

"I swing by the local energy garden on my way to the bus stop. I have a little veg patch there, and I spend a bit of time checking the wireless sensors and harvest some carrots and cabbage. It's quite a basketful, so I programme the local farm drone to deliver some back to my house for dinner, and head to the local Swap Stand with the rest, to see what's on offer to trade that morning. But before I leave, I make sure to log my gardening activity on my wearable so that it sends the info to my healthcare provider – I get a discount on services in exchange for time spent doing physical exercise."

"After that I head to our local community innovation hub, where I've rented a maker space. I'm meeting up with my team to design and create a portable battery pack which can be connected to any energy generating object – whether that's a bike, a scooter, or your legs! We've been jointly funded by the local health and energy co-ops to do this."

#### FURTHER RESOURCES

If you want to know more about how this world operates, the systems that people use, the way those systems have been integrated, and the products and services that people are using please see the detailed scenario report at: <http://www.forumforthefuture.org/project/future-cities-dialogue/overview>.

# Design principles for systems integration

The speed of urbanisation globally means that, between now and the end of the century, we will need to design and build as many urban solutions as we've done in all of human history. This is an opportunity to create cities which are more integrated and deliver better outcomes for citizens and for the environment.

In the words of Fritjof Capra, the systems theory expert, "the material world, ultimately, is a network of inseparable patterns of relationships". In practical terms, urban systems integration is the conscious attempt to meet multiple goals with a single, unified solution, in an effort to enable better, more sustainable, more efficient lifestyles.

When people talk about systems integration, the examples that come to mind most often are those of 'smart' city solutions – like automated traffic management systems and smart payment cards. In some ways, this is because there currently aren't many up-and-running examples of more complex, more nuanced system integration projects. One interesting new example of this more systemic approach is Southern Staffordshire Community Energy.<sup>2</sup> This energy co-op will install solar panels on hospital roofs, saving the NHS money on energy bills, cutting carbon, and generating money for a community fund to address local fuel poverty. Frequent hospital visits from over-65s with cold-related and respiratory diseases will trigger a referral by the doctors to the fuel poverty charity Beat the Cold, who will visit people's homes to see how they can be improved. The NHS saves time, space and money, Beat the Cold address the root causes of illness linked to fuel poverty, older patients get a more comfortable life, and anyone who invests in the SSCE share offer gets a return on their money.

Highlighting examples like this can help people understand what urban systems integration can look like in practice. This is critical because an integrated systems approach requires a fundamentally different way of working. For systems integration to be successful, many different stakeholder audiences and beneficiaries need to understand why system integration is valuable and how it can be done well – and, for this, simple, clearly communicated concepts are key. Below, we have articulated the design principles for effective urban systems integration that have emerged as the key themes in this project. We have also included in this section some of the integration concepts developed at our final workshop in response to the scenarios, to illustrate current thinking about what future integrated solutions might look like in UK cities.

<sup>2</sup> <https://www.ethex.org.uk/SSCE>

### INTEGRATED URBAN SOLUTIONS SHOULD BE:

#### 1. Resilient and evolutionary

Systems need to be designed and integrated in a way which leaves them open to evolution and adaptation in the face of change. And because systems are interrelated and non-linear, integration must allow for changes to be made to parts of the system without failure of the whole. A cautionary example is what happened during the Paris floods in 2016: an underwater sensor blocked by a piece of rubbish led Parisian authorities to underestimate the rising waters of the Seine for hours.<sup>3</sup> What that points to is that we should not over-optimize systems integration for efficiency because that can reduce their resilience. What we need is some redundancy or fault tolerance so that integrated systems are not overly vulnerable to one component failing, and can self-stabilise.

We should also not look for generic solutions to apply over all urban areas. As in ecological systems, resilience comes from diversity. Creating an ecosystem of opportunities and system integration solutions allows urban areas to adapt as circumstances change. Each solution can rise, and fall, and fail, and evolve in different places and at different times according to the needs of citizens and their cities.

Dynamic integration should also be able to map first and second order impacts as part of the design process. Being able to ask “what if” questions can help conjure up and prepare for different scenarios. For instance, we wouldn’t want to create a mobility system which improves traffic flow, but increases obesity and air pollution as a result of more people driving cars, leading to negative knock-on effects in the healthcare systems and the local climate. On the other end of the spectrum, we do want integration solutions with cascading positive consequences. For example, the introduction of the landfill tax in the UK drove huge amounts of innovation across a number of different areas of the economy, including an upsurge of interest in recycling, remanufacturing, energy from waste, anaerobic digestion, and improvement in treatment of special wastes. It also released capacity for funding by increasing gate prices of disposing waste to landfill.

<sup>3</sup> <http://www.msn.com/en-ca?refurl=%2fen-ca%2fweather%2ftopstories%2fparis-flood-estimates-off-due-to-blocked-sensor-evacuations-possible%2far-BBtPEIUP>





At a workshop in late 2016, we used the scenarios with a group of expert stakeholders to see how they could prompt innovation to successfully meet the needs of these future worlds. It was a rapid creative exercise to generate broad ideas rather than detailed business models, and we have illustrated three of the workshop concepts to help bring future integrated system solutions to life. The concepts are a taste of the sort of products and services we might need to support system integration in the cities of the future.

#### INTER-CITY RESOURCE TRADING

In a devolved future in which cities or regions manage their own systems, different cities will be rich in different resources which they can trade with other cities for the resources that they are lacking. Wetter city regions may be net-exporters of water to drier regions, and those with an abundance of renewable energy generation potential can trade their surplus with cities and regions that don't have sufficient resources to meet their citizen needs. Those without physical resources to trade may instead trade skills – in financial, or telehealth services for instance. And regions with less to give may instead offer to receive unwanted materials – such as waste reprocessing services.

Trading these physical and intellectual goods will be handled by a central system (top illustration) that tracks the value of the different offerings and manages the trading links between cities – ensuring transparency and fairness in their dealings. An important additional part of this service is the flexible and modular infrastructure (bottom illustration) that can be used to transport physical resources, like water and power, between trading cities, and can be reconfigured and moved when those trades have been completed.

## 2. Tech-enabled, but not tech-centered

Very often, when people talk about the integration of different systems, they talk about 'smart' attributes and integration via digital technology. Many cities are turning to technology companies to integrate new, 'smart' technologies into urban systems, from traffic control to flood management. Undoubtedly, strong digital infrastructure is critical to systems integration. Urban systems will become better integrated through digital intelligence – both in terms of their functionality and in how they relate to other systems. We know that digital technology is a powerful enabler of system change by enhancing information flows and enabling greater stakeholder collaboration. Take the electricity grid as an example here: where we get energy from, how we recapture energy generated by other systems, managing peak loads, energy storage, electric vehicles and lithium-ion batteries, all of these things will join up more intelligently via digital solutions to help us calibrate demand and supply.



### MINING THE ELECTROMAGNETIC SPECTRUM

The electromagnetic (EM) spectrum is already crowded with the volume of communications that it has to handle. In all three of our scenarios, the flows of data and communications between people, and things, look set to increase substantially. For our urban systems to operate efficiently, understanding how to optimise the system as a whole across all parts, rather than simply optimising one system, will likely require simultaneous, constant and rapid communications between billions of devices.

To handle these flows, additional parts of the EM spectrum will need to be mined and brought into use, and dynamic demand management will control the nodes of devices and users across the EM bandwidth to optimise their communications needs. Most of this will be handled automatically, but some nodes may choose to use different parts of the spectrum depending on signal congestion, or environmental factors affecting communication quality.



However, as ours and others' research has shown, digital infrastructure is not necessarily the most important precondition for good integration, or the most challenging element of creating integrated solutions, nor is it free of risks. Apart from the obvious challenges, such as cyber vulnerability, technology-centered solutions might not always be appropriate. If your biggest economic drag as a city is the diet of the local people, for example, then a 'techno fix' is unlikely to be most helpful. There is also the risk that whenever a city builds a technologically-centred integration solution and outsources the running of that solution to a tech company, it is deskilling people. As many citizens indicated during our dialogue series, technological solutions should be calibrated in such a way to encourage social interaction and build skills.

### 3. Well-governed

It is the shape and quality of governance systems that is a key determinant of the success of system integration, as well as the general 'look and feel' of that integration. For instance, more centralised, top-down forms of governance will result in completely different types of integration solutions than distributed, localised governance.

Governance can also come from different places. Right now people assume (and express a preference) that government should safeguard and underpin basic urban services, but that is possibly because we currently don't have very many alternative models, although this is changing. There are plenty of instances where – in the absence of effective public or private sector service provision – citizens and communities have taken matters into their own hands to deliver the innovation needed in their daily urban life. For example, when Australia abolished its Climate Commission, thousands of Australians chipped into Australia's biggest crowd-funding campaign, and created a new, independent Climate Council. In the US, the Detroit Blight Removal Task Force aims to remove 'blighted' residential structures in the city using an environmentally-conscious approach, improve safety in the city, and create economic opportunities. As more differentiated forms of governance begin to emerge, the possibilities for different models of systems integration will grow as well.

### 4. Sustainable

If the purpose of system integration is to enable better lives, then it should actively enable sustainability. Sustainability is a quality of the whole larger system, not of just one part. Therefore, we cannot have a sustainable waste system within an unsustainable broader urban network. Any urban systems integration solution must enhance our social and political foundations, and do so within environmental limits. Examples of this type of integration include things like recycling nutrients from waste waters (e.g. phosphorus) in order to use in food/farming systems, or using urban growing systems to improve physical and mental health outcomes for communities.

In many ways, the sustainability of our urban solutions is essential to the question of the long-term viability of our cities in the face of threats like climate change. Unless we act

quickly, we could be looking at a dystopian scenario of an average temperature rise of well over 2 degrees by the end of this century. Existing infrastructure for services like energy, sewage and transport can't cope in this context. It is a foregone conclusion that many cities will need to find a way to deal with regular flooding and huge storm surges.

Integrated solutions should also actively enable urban natural capital. This is an often forgotten but essential element of the fabric of a city. The competitiveness of a city is inextricably linked to its 'liveability', of which things like green spaces and clean air are key features. It is well known that proximity to green spaces in cities increases property values, and is a factor in attracting workers and businesses to locate in one area over another. Maintaining the connection between urban environments and nature was also a strong preference expressed during the project's public dialogues. For example, people had a strong dislike for any kind of automated, 'lab-grown' food system, even if that system was highly efficient on all fronts, because they felt that the process of growing, cooking and eating whole foods has many societal benefits.

As citizen engagement has made clear, people in UK cities are looking for urban solutions which will help build social fabric. Many spoke of the need to continue facilitating local culture, heritage and creativity. In some cases, this was the response to perceived alienation which could result from focusing too much on technological solutions and efficiency. People expressed a clear desire for technologies which encouraged social engagement rather than creating alienating environments where people spend more and more time sitting in front of screens alone, even if that meant more efficient access to services such as online grocery shopping. There was also a sense that new integrated infrastructure projects should blend well into the existing fabric of the city and preserve rich heritage rather than, say, drive more traffic into historic city centres or create commercial developments which only cater to a small minority of the wealthy.

## 5. Human centered

Integrating systems means integrating people. In the process of doing so, therefore, we have to consider people's attitudes, aspirations and behaviours. Will behaviour change be necessary in order to make the system integration successful?

In order to create integrated systems in cities we need to envision them, and this is a profoundly participatory task. That vision should be widely distributed and owned. This is the case for governance, but also for planning. A well-integrated set of systems needs to use whole system policy planning – meaning that urban planners talk to transport planners, who talk to public health officials, and so on – in designing the solution. For example, a solution which looks only at concentrating health expertise and not accessibility to health services or broader community needs, might result in large hospitals being built outside of city centres – a solution which creates traffic congestion, exacerbates air pollution, and is not very accessible for people living in core urban areas.

Moreover, ensuring that systems integration draws on local innovation networks means that the beneficiaries of the integration have a strong stake in how that integration is designed and run. Fureai Kippu, for example, is a time banking solution in Japan, an innovative model of volunteering in which particular skills, services and time can be exchanged as credits. Users can exchange aspects of care not covered by the Japanese national healthcare system, such as food preparation, bathing, shopping and reading. Drawing on this type of citizen-led innovation can be an extremely powerful way to deliver integrated urban solutions. This system has helped enable many older people to remain in their homes, significantly reducing time spent in retirement homes and hospitals and improving mental health and quality of life. In many ways, the biggest barrier of cities in implementing integrated solutions is not technology or money, but the capability of people living in those cities to think about and act on that integration. Technology companies can give you products, but they cannot give you a vision. Integrating urban systems in the face of global issues, such as population growth and climate change, is a challenge which requires skilling up people to ask the right questions and stimulating participation.

At a more basic level, there is also a need to provide a more comprehensible picture of what urban systems are about and how they run. Some systems are visible to people in their daily lives, and therefore easier to understand. The healthcare system is one such example. However, other systems are much more abstract and difficult to understand, such as energy or water. People want to know that they can switch on the lights or turn on the tap without any trouble, but the workings of the systems that provide these services are invisible and therefore hard to grasp. It is no wonder then, as one of our interviewees put it, that “the average person spends six minutes thinking about their energy bill per year”. However, it is really important that people get a better understanding of how systems run, because this will allow them to engage with these systems better. It will also mean that integration of systems will be more comprehensible, and potentially also that citizens might be more engaged in the design and operation of integrated solutions.

## 6. Globally linked

Many of the urban issues we face today – from overcrowding to traffic congestion to pressures on healthcare systems – are issues endemic to many cities around the world. So, although the solutions we craft to tackle these will undoubtedly be adapted to local circumstances in order to be effective, there is much we can learn from the practice of other cities. An expert from one of the urban innovation agencies we interviewed was struck by how many “cities I’ve spoken to are worried about the lights going out”.

This is why global urban networks like C40 and EMBARQ are so useful – they help distil urban planning and delivery lessons, and translate them to other contexts. And here is where one of the biggest benefits of digital technology can be powerfully leveraged: it not only connects hard infrastructure but also helps create communities of interest around the world.



### LIVING GREEN INFRASTRUCTURE FOR BUILDINGS

By no means all of the integrated system solutions we need are hi-tech or digital. Green infrastructure incorporates living plants and micro-communities into the fabric of a building – as cladding, green roofs, and essential parts of the indoor and outdoor living spaces. In all of our scenarios, we see green infrastructure being used to improve the quality of life of citizens, and to help manage city systems better. It has a role in managing multiple system goals – such as rainwater collection and sustainable urban drainage, shielding for buildings, insulation to reduce energy needs, cooling the urban heat island effect, natural resilience to climate change impacts, enhancing mental wellbeing, and playing a part in urban food production.

Living green infrastructure can help buildings and communities take more control of their own resource needs, and collectively manage their resource consumption – selling surplus services on to other buildings and communities.

This is particularly useful in the context where cities are increasingly gaining more political power and control over how they run, and becoming truly global in terms of value flows, whether that's people or capital or know how.

#### 7. Value networked

The challenge with integrated solutions is that their value might be less straightforward to articulate. Integrated solutions must be done in such a way that they are financially sustainable and deliver value for money, and yet their core value might not be about delivering financial returns. With integrated solutions, such as green roofs and rooftop gardens for example, both tangible and intangible value will accrue to a large number of beneficiaries, which makes that value harder to articulate. But this is critical because it is a precondition to getting many of the necessary stakeholders on board to support, design and deliver the integrated solution.

To go back to the example of green roofs, they can deliver improved air quality, a boost in urban food supply, physical and mental health benefits, biodiversity and wildlife enhancement, a reduced albedo effect, lower energy use in buildings (because of less need for heating and cooling), and reduced storm-water runoff. However, getting investment and buy-in for a city-wide green roofs scheme may be challenging because they will not necessarily deliver a straightforward financial return to a bounded network of beneficiaries. Instead, the 'green light' requires a mapping exercise to identify the key areas of value which will be delivered, and the beneficiaries. And then a 'value network' should be formed to design and deliver the integrated solution on that basis. In this case, one can imagine a green roofs scheme could include a partnership between commercial real estate developers, energy companies, environmental agencies, healthcare organisations and food suppliers, amongst others.

#### 8. Transparent

There are privacy and security concerns around the use of 'smart' technologies to integrate and deliver urban services. The amount of sensors in our world is already huge, whether people are aware of it or not is another question (and potential challenge), as is our ability to make something meaningful of all that data being collected.

Research suggests that people are willing to give up a degree of their privacy in exchange for a useful service. For instance, people share personal data on a dating site in hopes of finding a good match, or location data on a smart phone in order to get to where they need to go. Where things go wrong is where people feel they haven't consented to the use of their data for something. Feedback from our citizen dialogues consistently showed that people were not comfortable with any system outcome where their data was collected and used without their consent, 'owned' by others, and where they had no ability to 'turn off' the data-harvesting technology. Transparency in systems integration is therefore key, as is respect for privacy.



The question of data ownership also has other interesting dimensions and challenges. For instance, open sharing of data is sometimes precisely what's necessary (and often missing) in order to understand what the nature of key urban challenges is, and how to craft an effective solution. Take energy security in cities, for example. A city's starting problem might be that it does not know the energy consumption patterns of its citizens, because that data might belong to network operators, or building managers. This makes it difficult to understand what your main energy challenge is and to act on it.



# Mapping integration opportunities



At the workshops which generated future pathways for the six systems (food, energy, water, waste, transport and health), we asked the system experts to map specific opportunities for how each of the systems could integrate with the other five. For example, at the food system workshop, we asked the stakeholders to generate ideas for how the food system could best integrate with energy, health and so on.

After a series of six workshops, this yielded a composite map of specific integration opportunities, showing where two or more systems could be integrated more effectively in urban areas, and how.

This map is by no means comprehensive, but it does provide a quick glance at where the experts think the opportunities for integration lie, and where there are particular 'hot spots' of opportunity (e.g. both the food and the waste workshop stakeholder saw lots of opportunity to integrate these two systems better) versus where further research might be needed to better understand integration potential (e.g. waste and health generated fewer integration ideas than some of the other system combinations). We offer this map as a starting point for thinking about specific integrated solutions to pursue, for cities, public sector bodies, businesses and other organisations working in this space.

	WASTE	WATER
WASTE		
WATER	<ul style="list-style-type: none"> <li>× Use parks as urban drainage system</li> <li>× Capture methane from waste water to reduce emissions</li> </ul>	
ENERGY	<ul style="list-style-type: none"> <li>× Convert sewage into energy</li> </ul>	<ul style="list-style-type: none"> <li>× Mini hydro</li> <li>× Water heat storage</li> <li>× Solar water pumps</li> <li>× Water harvesting to decrease energy use for water companies</li> </ul>
FOOD	<ul style="list-style-type: none"> <li>× Anaerobic digestion of waste for gas supply, with the residue used as compost for urban farms</li> <li>× Use waste taxes to subsidise urban food growing</li> </ul>	<ul style="list-style-type: none"> <li>× Use grey water for urban farming</li> <li>× Use water to deliver nutrients to households</li> <li>× Use urban farming to mitigate flood risk</li> <li>× Circular urban farming systems using aquaponics and hydroponics</li> </ul>
HEALTH	<ul style="list-style-type: none"> <li>× Mine food waste to understand public health profile better and provide targeted health advice</li> <li>× Use microbes from waste to improve health</li> </ul>	<ul style="list-style-type: none"> <li>× Access to water</li> <li>× Nutrient or mineral 'enhanced' urban water systems</li> <li>× Blue/green spaces for health benefit</li> <li>× SUDs as parks</li> </ul>
TRANSPORT	<ul style="list-style-type: none"> <li>× Convert sewage into fuel (e.g. biogas)</li> </ul>	<ul style="list-style-type: none"> <li>× Car parks as water retention basins</li> <li>× Permeable surfaces for flood water management</li> </ul>

ENERGY	FOOD	HEALTH	TRANSPORT	Intelligent cross-system logistics e.g. passenger transport also carries food, waste, healthcare supplies, and energy.
<ul style="list-style-type: none"> <li>× Develop local protein supplies that are circular urban food solutions: e.g. micropigs, rabbits and other animals which are fed on food waste, are high-quality protein sources, and whose waste can be used for energy.</li> </ul>				
	<ul style="list-style-type: none"> <li>× Food waste and sewage co-processing</li> <li>× Extract nutrients and flavourings from waste and waste water</li> </ul>		<ul style="list-style-type: none"> <li>× Food waste and sewage co-processing</li> </ul>	
<ul style="list-style-type: none"> <li>× Convert food waste into energy</li> </ul>				
<ul style="list-style-type: none"> <li>× Energy harvesting through physical activity – in gyms, on kinetic road surfaces – which is also linked to improved health via the use of personal health trackers</li> <li>× Use energy efficiency measures as a way to create healthier home environments</li> <li>× Real-time home energy consumption can flag health issues</li> </ul>	<ul style="list-style-type: none"> <li>× Smart phones that track personal nutrition and health profiles, flag concerns to healthcare system, and offer tailored nutritional advice</li> <li>× Growing urban food to improve physical and mental health</li> <li>× Food delivery systems linked to household health profiles</li> </ul>			
<ul style="list-style-type: none"> <li>× Use EVs for energy distribution and demand management</li> <li>× Use energy generating surfaces in transport corridors</li> <li>× Use transport land for solar generation</li> </ul>	<ul style="list-style-type: none"> <li>× Grow food in transport corridors</li> <li>× Urban food growing to decrease transport of food into cities</li> </ul>	<ul style="list-style-type: none"> <li>× Decreasing high-carbon transport modalities to cut air pollution and increase exercise levels (more walking and cycling), leading to improved health outcomes</li> </ul>		

# Conclusion

Developing future scenarios is as much about the process as the end-point. This report summarises the outputs of the work but can't convey the impact it has had already in shaping strategy, building collaborative networks, educating, and changing opinions. It is designed as a high-level overview and we encourage you to use the many additional resources that have been generated throughout the work to run your own futures exercises and understand your own challenges and opportunities.

Urban areas can use the scenarios as stimulus for the types of futures that they want to build for their citizens. Businesses can use them to develop products and services that will meet citizen needs, no matter what the specifics of the future may be. Operators in individual systems can look at the types of system futures they may be facing, innovate accordingly, and develop integration opportunities with other system operators that improve the resilience of all. Technology developers can better understand the public response to their solutions, and tailor them appropriately to reach a willing and receptive market. Policy makers can use the materials to understand where their interventions will be necessary to create the conditions that will deliver successful solutions. And citizens can use the trends, system choices, and scenarios to better understand their options, and to have the information they need to build their futures as they want them to be.

So we see this work as the start of a collaboration across the economy – one where we have a shared vision of where we want to get to, know the conditions we need to meet to achieve it, and can each play our part in delivering better cities of the future.

We would like to thank all those who contributed to the project.

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