Arup UrbanLife

The smart solution for cities

Transforming power-hungry urban areas into low-carbon smart cities via the creative use of technologies

ARUP

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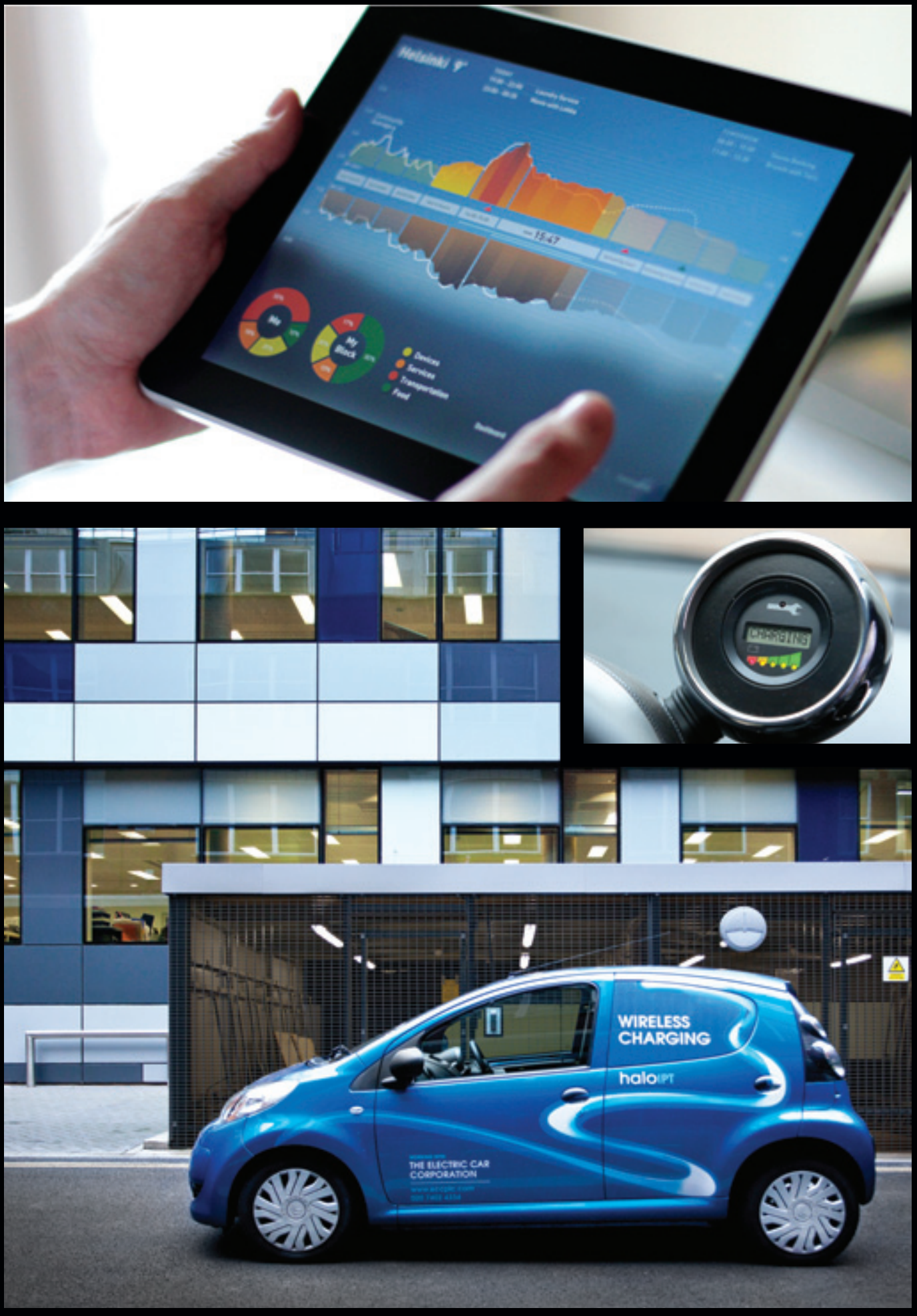
The challenges of climate change, population growth, demographic change, urbanisation and resource depletion mean that the world's great cities need to adapt to survive and thrive in the twenty first century. For leaders of growing cities, reducing emissions while increasing living standards and economic success represents an enormous challenge. Information and communications technologies, however, can help transform energy-hungry urban centres into low-carbon 'smart cities' of the future. Arup specialists' recommendations and case studies demonstrate a 'smart city' approach to urban development.

An iPhone application uses augmented reality to indicate the distance to the nearest rail and metro stops (one of the Smart City examples presented by Arup to the C40 and City of Melbourne workshop on Smart Cities).



Top An example of how information about home energy consumption can be delivered on mobile devices, allowing residents to make more informed decisions about their consumption patterns **Bottom** An electric vehicle powered by induction charging

50%
of the world's population lives in cities today

50bn
machine-to-machine interations by 2020

25%
Australian population use Facebook and is growing

2%
of global emissions produced by the ICT sector

1bn
transistors for every human being

30%
of London's carbon reduction is expected to be delivered by behaviour change

4bn
people have mobile phones today

US$78bn
economy annual loss due to traffic congestion

15%

reduction in emmisions via ICT is possible by 2020
(The Climate group)

Contents

Using ICT to deliver resource efficiency

Half of the world's population lives in cities, yet they are responsible for 75% of the world's carbon emissions. Both of these figures are increasing. City leaders across the world face the challenge of building new or adapting existing infrastructure, buildings and systems to meet the challenges of climate change, increased demand for resources, shifting demographics and increased pressure to reduce greenhouse gas emissions.

This report, the second in a series, presents a high level approach to the 'smart city' approach to urban management and offers practical case studies for mayors and city administrations to consider how smart cities can help deliver climate change adaptation and resource efficiency.

These recommendations were developed and refined at a C40 UrbanLife workshop held in Melbourne in 2010, which brought together Arup specialists and Melbourne city managers to recommend 'Smart City' strategies for reducing greenhouse gas emissions as part of a broader urban sustainability agenda for the C40 network of global cities.

Every city has its own context, and no single approach will transform each one into a 'smart city'. However, our recommendations form a starting point for considering an effective response by the political and private organisations that influence and operate the urban space.

Volker Buscher, Director,
Smart Cities

21st Century Smart Cities

Today's level of urbanisation is unprecedented and, according to the United Nations, the upward trend is set to continue. Cities are now the largest contributor to energy consumption, CO_2 emissions and climate change, and at the forefront of carbon reduction efforts. Greenhouse gas emission targets have been set, but reaching these targets will be a major challenge for expanding cities.

Urban sustainable development has emerged as a strategy and policy priority for city leaders. One way cities are responding is by building smart cities. A smart city is one that uses technology to transform its infrastructure and make better use of energy and resources. Information and communications technologies (ICT) can be deployed to create new, intelligent ways of making our urban centres more resource efficient and reduce their carbon footprint.

Information has a strategic role to play in reducing the carbon footprint of cities. Amalgamating information on city systems means it can be deployed, real-time, to city leaders, allowing them to make decisions about the most effective use of city resources swiftly – and, ultimately, feed those decisions back to the components of the city: transport providers, energy companies, building owners. Also – and this is often overlooked – information can be provided to the city's end users, and through awareness the behaviour change necessary to achieve resource efficiency can be achieved.

ICT and the city administration

Today, many cities are using ICT to improve performance at a departmental level, by deploying mobility, utilities, community and government e-services. Others are pushing the smart city concept even further, actively taking steps to make the concept an integral part of their development strategy.

Leading cities are deploying readily-available and relatively low cost technologies – smartphones, broadband wireless internet, netbooks and tablets, consoles, sensor networks and smart meters – to improve sharing of data and information between government and citizens. Thanks to smart systems city managers and residents can know with much greater precision, and in real-time, how much energy and resources they are consuming. Having better access to that information will help them to save energy. By improving the city as a system, transformation is achieved.

Residents can send data to and receive data from the government. Handheld devices, machine-to-machine systems and interconnected devices will help facilitate these interactions. Built around informatics and instrumentation, new smart reporting systems will improve information transparency and, in turn, create better informed citizens and more efficient cities.

A city's operations and planning can be based on ongoing monitoring, insightful visualisations and constant feedback loops that create more efficient systems and better informed decision making for leaders and citizens. Cities are real-time systems, and the opportunity is now available to manage them in a real-time manner.

The impact of open information

Urban management systems are evolving to reflect these changes. To better deal with more open, widely available information, city administrators are shifting from single departmental solutions to approaches that can address city-wide issues that can enable them to better:

- Mitigate climate change risk
- Increase efficiency of resource use
- Enhance economic development and the creation of jobs
- Support communities and make cities a better place to live and work
- Run cities more efficiently

Improving efficiency

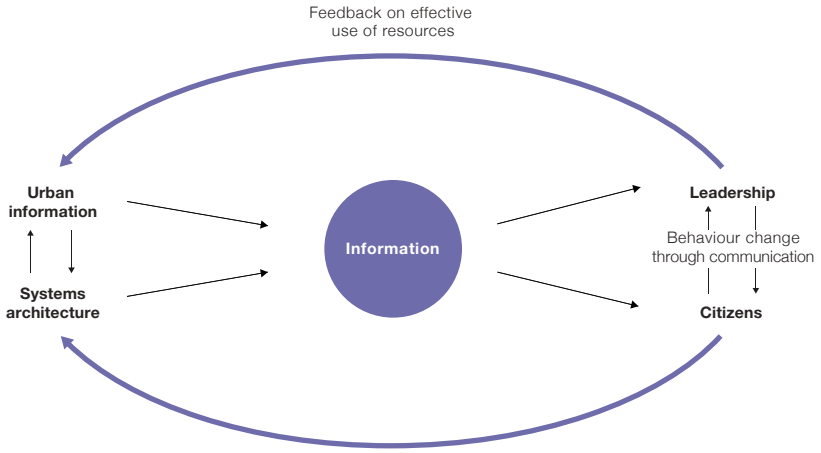
By harnessing a smart approach to administration, planning and partnering with technology companies, urban leaders have the opportunity to create economies of scale and scope for addressing challenges, to improve the efficiency by which they can deliver solutions across their cities, and create holistic, interconnected services built on civic needs and priorities.

Cities are getting smarter, as they turn to new technology-based strategies to overcome the challenges from rapid urbanisation. What makes a 'smart city' smart is the combined use of leadership, urban informatics and systems architecture — or smart systems — to enable residents to make better, more informed choices.

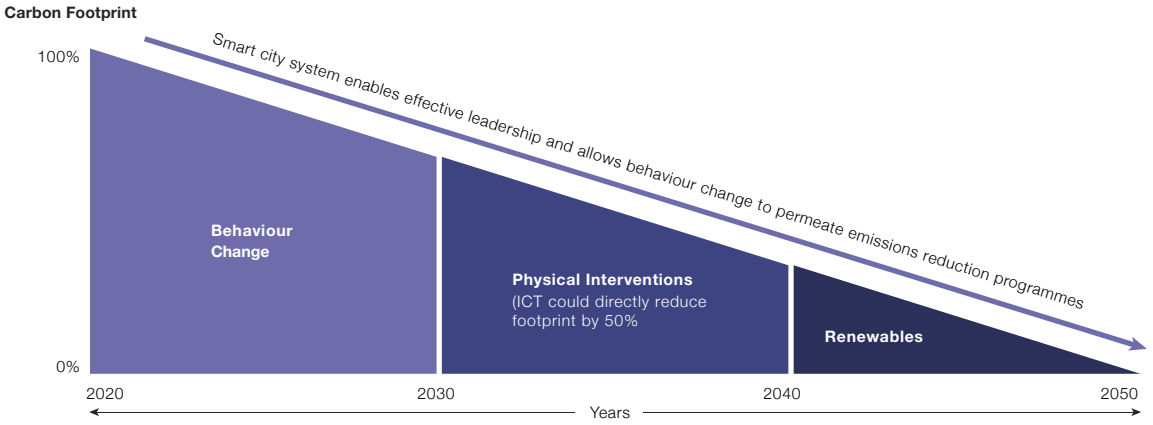
Smart cities will become part of the tool kit for urban leaders to create 21st century cities and regions better equipped to deal with climate change, population growth, demographic change and resource depletion, often in an environment of financial constraints.

The principle of a smart city

The smart city system



Behaviour change as a key element of emissions reduction



Smart city ways of thinking

Smart cities are not simply those that deploy ICT. They combine new technology with smart new ways of thinking about technologies' role in organisation, design and planning. Arup recommends that city leaders, as they plan smart city initiatives, envision ways that technology can create new urban user experiences; think about the smart city as a holistic system; and consider ways that new systems can result in positive behavioural change

New urban user experience
Recommendation

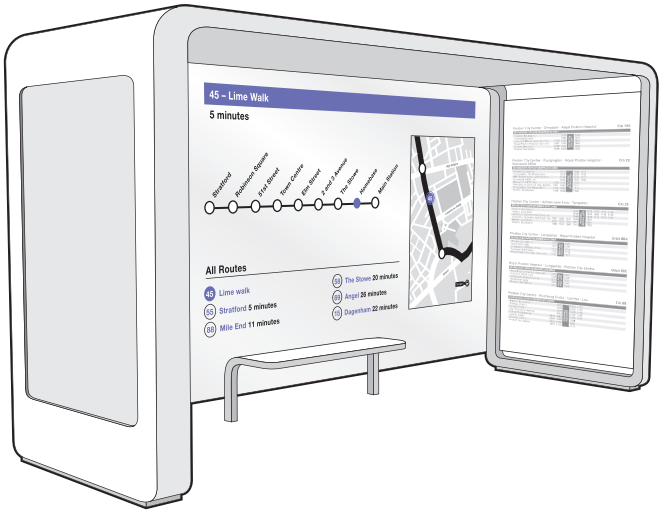
Think of the smart city as providing new experiences for its citizens. The smart city is to some extent already around us all the time. Today we use smart phones, the wireless Internet, net books and tablets, sensor networks, smart meters, and RFID tags. At the same time, we experience social media like Twitter and Facebook, ‘apps’ and Google maps. Indeed, many cities offer e-services to their citizens.

However, the smart city also describes a step-change in both intensity and extent of connection, in that almost all aspects of infrastructure – from transit networks to energy, waste and water; from housing to street trees – can wirelessly communicate information about their activities via sensors and networks. This concept is known as ‘the internet of things’, in which almost every device can produce and receive information about to some degree.

Smart urban infrastructure can keep track of city operations, predicting faults before they occur, while optimising delivery of resources or services to match demand. Sensors, located on existing infrastructure, can monitor water quality or air quality or mobile phone data, revealing patterns of movement and energy use in the city. The advantage for citizens is the sense that their city has a series of smart interfaces, enabling a richer, more efficient and more personalised experience. The advantage for cities is a more effective delivery of services, more efficient use of infrastructure and unprecedented strategic information on the use of the city and their services.

Information feedback loops connect these systems together, enabling the smart city system to be managed efficiently an allowing for behavioural changes required to make it happen. The strategic value derived from embedding data in such processes enables the system, and the city, to learn from its own activity, transforming almost all aspects of operation, from planning to delivery and beyond.

How the ‘internet of things’ can transform city systems



The possibility of the ‘internet of things’ is easily demonstrable on public transport. Tram-stops, bus-stops and train stations are ‘informationally-rich’ spaces. By offering real-time location-based information they will provide users with a better service, and provide city leadership with data on mobility patterns, occupancy rates and interaction. Users can make informed decisions about journeys, and the city can more effectively adapt the transport network to fit usage patterns.

Features a city might adopt are:

- Touch screen displays at stops to enable navigation through real-time displays of public transport
- Prominent signs to make important information legible from a distance
- Multi-lingual displays for tourists
- Free public wifi at all stops as well as onboard trams, trains and buses

Owner
Incheon Municipal Council

Location
Incheon, South Korea

Consultants
Gale International
Cisco
Kohn Pederson Fox
Arup

Completion date
Proposal phase

New Songdo City, Incheon
Case study

This new 'eco-city' constructed on marshland near Incheon, South Korea, is a private development by Gale International, supported by new 'hard infrastructure' provided by Incheon, and designed by Kohn Pedersen Fox and Arup, amongst others. However, the 'soft infrastructure' is arriving courtesy of Cisco which envisages a layer of urban services supporting residents and workers in the city, including direct access to healthcare, education, local municipal services, video conferencing, information and recreational facilities, amongst other everyday urban activities. These are delivered over high-speed networks and to multiple platforms in the home and office. With such developments, Cisco suggests embedding such an 'urban services layer' into the city can generate significant additional returns for developers, ranging from an extra US$3 per m^2 as 'standard', to US$8 per m^2 in an 'advanced' implementation, to US$13 per m^2 in a 'transformational' development, in which smart city services are integrated from the very beginning of the project.

US$13/$m^2$

Estimated additional return for developers using smart city services from inception

Top, Left and Right Visualisations of New Songdo City, a 1500-acre business district along Incheon waterfront. The aim is to create a wired (and wireless) hub for international firms operating in the yellow sea economic basin.

Smart behavioural change
Recommendation

Smart systems encourage changes in behaviours which prompt new choices and activities, creating a shift in the way we consume and share energy and, hence, contributing to the development of low carbon urban economies and societies.

Information enables better decisions

Building on the need to address emissions and the potential of a smart infrastructure for engagement and management, a core premise is that people make inefficient decisions as a result of poor information. With better information, behaviour change will follow, cutting emissions and increasing quality of life.

A city that learns

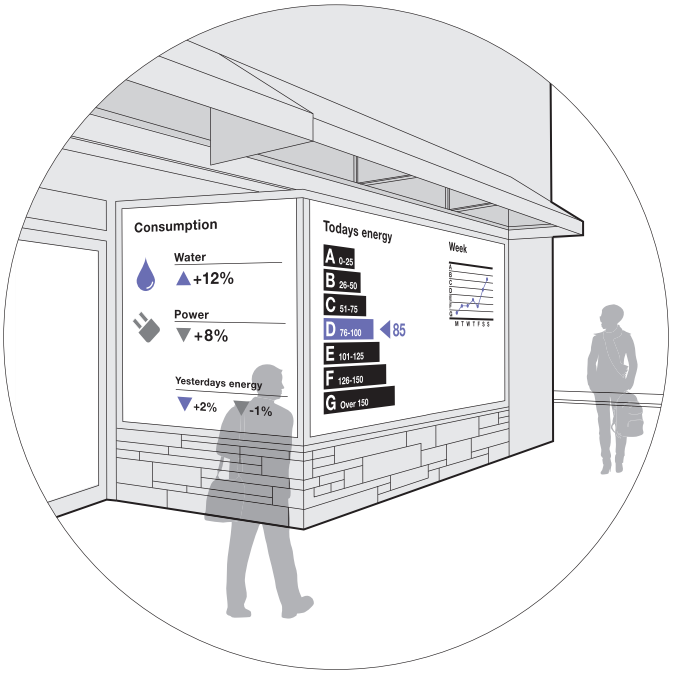
Imagine an interconnected urban system in which trees and green walls naturally cool streets and buildings; their green waste can be transformed into energy via anaerobic digestion or similar biological treatment; this energy can be used to power a fleet of street cleaning vehicles; the vehicles can make use of the recycled grey water from nearby apartments; the organic waste from the apartments can be used in greenhouses on the roof; and this can deliver food back to the apartments or the café at street level, and so on. Nutrient cycles are closed; water cycles are closed, while energy is transferred efficiently from one system to another.

Real-time information

A new generation of integrated hardware, software, and network technologies that provide systems with real-time information of the real world and advanced analytics to help people make more intelligent decisions about alternatives and actions that will improve how we use energy and resources.

While much attention is paid to technology, at the end of the day, smart cities are about giving people better information so that they can behave differently using energy and resources more efficiently.

Using smart metering to collate disseminate data



Civic smart metering is a city-wide service in which streets and blocks can broadcast their resource data – such as energy and water usage – to a service managed by the urban administration. The data is collated and verified, then distributed to public displays.

Displays are designed to deliver detailed information up-close whilst key information is viewable from a distance.

Making key data available in real-time enables civic pride in sustainability.

Owner
mySociety.org

Location
UK wide

Consultants
N/A

Fix my street, London, UK
Case studies

Fix my street

Launched in February 2007, FixMyStreet is a web service to help people report, view, or discuss local problems with their local council by simply locating them on a map. Built by MySociety, a not-for-profit company, in conjunction with The Young Foundation, FixMyStreet smartly routes reports of things that are broken or dumped, or need fixing, cleaning or clearing, direct to the relevant council in the UK. Similar systems include CitySourced in the USA, which uses an iPhone 'app' as the primary interface.

1,261
reports in the week of writing

3,444
fixes in the month of writing

A simple interface allows users to log and track local problems. A dashboard on the home page shows the outcome of the online community's actions.

Smart cities strategies

A smart city is one that uses technology to transform its basic infrastructure and optimise energy and resource usage. Arup specialists recommend a smart city development strategy that rests on three interlinked components: leadership, urban informatics, and systems architecture

IT Strategy
Recommendation

The primary layer of the smart city is the creation of an over-arching IT strategy. Arup sees this as the integration of procurement, design and operational models of ICT services and infrastructure through to the shape, profile and staffing of the city government itself.

Smart cities

Achieving the smart vision requires city administrations to adopt a top down, strategic approach where resources are aimed at most or all activities in the city that could benefit from smart systems.

Placing ICT at the heart of city administration and planning could result in a significant reduction in the cost of service delivery. A study by Capgemini on the benefits of adopting a more strategic approach to information management in UK local authorities, put the value at £18 billion per annum.

The changing role of IT in city administrations

Realising the smart city vision will entail repositioning Information and Communication Technologies as a strategic function. Most major cities have moved from ICT as a support function (stage 1), to offering online services to citizens (stage 2). The provision of real-time data allows the move to stage 3, where it is used to define projects, make decisions about outsourcing and procurement, operational frameworks and management, organisational structure and data policies.

Owner
Sitra

Location
Helsinki, Finland

Consultants
Experientia
Gallery Eco Capital
SRV
VVO

Completion date
2002

Low2No, Helsinki
Case study

This urban development project in Jätkäsaari, Helsinki, features a wide range of pervasive informatics strategies and services aimed at significant reduction in the carbon footprint of the community. With informatics strategy and services currently being developed by Arup and Experientia, these services will include in-street displays that report on personal and civic footprints in real-time, next-generation smart meter concepts for apartments and displays and services that highlight patterns of production—including urban agriculture and knowledge-based work—in order to reinforce innovation processes in the area.

The Low2No development is intended to become an exemplar in terms of carbon neutral urban development, including smart city solutions.

37%
reduction of personal carbon footprint compared to other areas of Helsinki

2021
year Low2No becomes carbon negative on a yearly basis

Top One of the screens on the Low2No Home Assistant, which gives residents information about their resource use. Low2No aims to reduce carbon footprints by 20% through influencing lifestyle choices. **Bottom** 'Carbon Neutral' Low2No will include in-street displays as detailed on p13

Urban informatics
Recommendation

The second layer of the smart city strategy is the development of informatics – which include web and mobile data services, urban scale displays and even installations within city architecture and infrastructure – that deliver important information to citizens and city managers.

Driving behaviour change

Examples might include feedback loops on energy consumption or environmental quality, or real-time transport information of visualisation of traffic flows. These can be engaging, design-led installations that work at a neighbourhood or civic level, as part of awareness change strategies, or functional web services that operate on mobile devices.

In Helsinki, Finland, GPS data from trams and buses is laid over Google Maps to show travelers where to locate their mode of transport. Provided with this kind of information, people feel they have more control of the transit network, and as a result, makes them more likely to use public transportation.

It is through informatics that activities that driving behaviour change can be affected and coordinated.

Using 'soft infrastructure' to transform a city

'Soft infrastructure', such as social networks, sensors and mobile devices, allow a relatively low cost, fast moving shift to the smart city whilst planning for a longer-term shift to hard infrastructure elements such as smart grids.

Owner
Barangaroo Delivery Authority

Location
Sydney, Australia

Consultants
Rogers Stirk Harbour + Partners
Bovis Lend Lease
Arup

Barangaroo, Sydney
Case study

The Barangaroo project in Sydney is a major urban development project on the harbour foreshore.

Arup, working with Rogers Stirk Harbour + Partners and Bovis Lend Lease, are developing an informatics strategy for the site which includes smart demand management techniques via engaging public interfaces onto the state-of-the-art sustainable infrastructure being developed for the project. The informatics services will address water use, energy use and other resource use. Yet the development will also benefit from a pervasive approach to ICT that enables smart workplaces, co-working spaces and across the public domain. Responsive public interfaces will display sustainable infrastructure patterns, real-time transit activity and community information, as well as enable a public art strategy.

> The vision for Barangaroo is for a place to inspire innovation for generations to come
>
> Barangaroo Development Authority

Displaying information in public spaces will enable residents and visitors to Barangaroo to make decisions on how they use water, energy and other resources.

Instrumenting resource systems
Recommendation

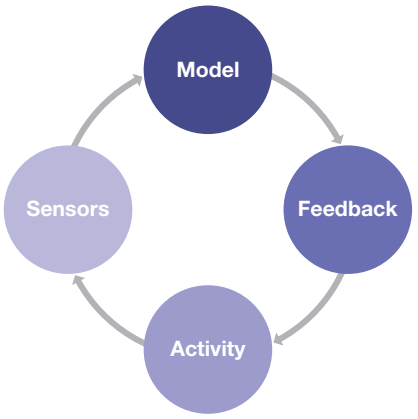
The smart city strategy's third layer, instrumenting resource systems, is the enabler of smart city systems. It entails the design of sensor instrument networks and associated technologies that report on the activity and performance of the infrastructure. Instrumentation and monitoring of a city's activities and operations means that the workings of operations are turned into data points and the system is made measurable.

Real-time reporting

Increasingly, reporting should be in real-time, as efficient operations require immediate feedback, and will be built upon a platform of software services and wireless networks distributed across the city's man-made and natural infrastructure.

Consider how instrumentation, combined with urban information architecture and informatics can modify home energy consumption. Sensors located in homes monitor energy use; these then send consumption data to the city's business intelligence centre where it is analysed and then quickly displayed to the user, who promptly turns off some of the lights at home. The interplay between the three strategic layers creates a feedback loop, producing information that helps people make better choices.

Feedback loops on urban activity



The impact of smart meters on home energy use is a simple example of an effective feedback loop. A meter monitors energy use on every day appliances. This is analysed and displayed to the user. In trials users have reduced energy use by up to 25% as a result of the information.

Owner
N/A

Location
Amsterdam and San Francisco

Partners
SF Department of Environment
City of Amsterdam
Amsterdam Smart City
Connected Urban Development
Cisco
Arup
CH2M Hill

Ecomap, Amsterdam
Case studies

Urbanecomap.org is an interactive web service that displays environmental footprints for Amsterdam and San Francisco (footprint comprises CO_2 emissions, waste and transportation activity, broken down by postal code). Created by Cisco and others, EcoMap attempts to raise awareness and build community activity around reduction of GHG emissions.

45.1%
Transportation as % of Amsterdam's emissions

78.1%
Transportation as % of San Francisco's emissions

Urban EcoMap is an interactive decision space that empowers individual citizens to make informed decisions about their daily lives, along with how to participate in the vitality of their communities. The site aims "to build awareness, fostering a sense of community, and provide actions for citizens to take to enable the reduction of greenhouse gas emissions in cities."

Arup has developed key concepts for thinking about smart cities and deploying strategies that make smart approach to urban development possible. These ideas relate to the combined use of information architecture, informatics and instrumentation to better connect people with information that they can use to make choices that reduce energy consumptions and reduce urban greenhouse gas emissions.

Smart approaches, founded on technical expertise, sustainable, integrated thinking and policy considerations, pave the way for urban decision makers to respond effectively to energy related issues that impact climate change. These approaches are designed to help cities build more efficient cities today, and reduce the adverse affects of climate change tomorrow.

Credits and further information

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Barangaroo
www.barangoo.com

The Climate Group, “Smart2020: Enabling the Low Carbon Economy in the Digital Age”, 2008.
www.theclimategroup.org

Fix my street
Fixmystreet.com

IBM, “How Smart is Your City?”, 2010.
www.ibm.com

Low2No
www.low2no.org

Real-Time Rome
http://senseable.mit.edu/realtimerome/

Urban EcoMap
http://urbanecomap.org

Capgemini
www.capgemini.com

New Songdo City
www.songdo.com

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