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The Smart City Market: Opportunities for the UK

OCTOBER 2013

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The Smart City Market

Opportunities for the UK

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Executive Summary

Cities have always been places of opportunity and even more so now. Recent estimates say that 80% of global GDP is generated in cities. People are attracted to cities to find jobs, friends, culture and enjoy the excitements of urban life. The current megatrends of rapid urbanisation, climate change and resource depletion need to be acknowledged and understood by cities. Cities are starting to address the challenges of this new urban context. The C40, a network of 58 of the world's megacities committed to addressing climate change, reports that its member cities have already taken 4,734 collective actions to address climate change and economic growth.

This underlines that cities are also the sites of tremendous innovation. Cities can be great proving grounds for technologies, providing opportunities for people to invent new things, and opportunities to test and sell them. Cities therefore present an opportunity for suppliers and consumers of smart technologies. Smart technologies could help address some of the challenges of urbanisation by helping to optimise resource consumption and improve services through better management of demand and supply. The scale of the possible savings is significant. A recent survey of water utilities found that utility companies could save between $7.1 billion and $12.5 billion each year by using smart water solutions.

Findings of the study

Our market assessment of smart solutions in five verticals: water, waste, energy, transport and assisted living showed the following common themes:

- The market potential for smart products themselves is large and these smart solutions provide a catalyst for further growth in traditional design and engineering services and new services. We estimate the global market for smart city solutions and the additional services required to deploy them to be $408 billion by 2020. Breaking this down by vertical, in transport for example, Pike Research estimates a global market for smart transport solutions based on digital infrastructure to be $4.5 billion by 2018. These solutions are enabling solutions for a wider market of $100 billion by 2018 which includes the physical and digital infrastructure for parking management and guidance, smart ticketing and traffic management. Also included in this $100 billion are the traditional and new services such as heavy engineering, road design and big data analytics which are required as a result of investment in digital smart transport solutions.

- Benefits of smart city solutions: Smart solutions across the verticals optimise resources through better information on where resources are being consumed. This information enables better monitoring and management on the part of the utility and also enables consumers to make more informed use of resources, and lower their consumption. This in turn reduces utility operating costs and extends the operating life of existing infrastructure. Smart technologies also provide opportunities for new services to citizens.

- There is still confusion in the market as to the distinction between Smart city solutions and Future city solutions. Future city solutions are innovative physical projects which are often but not exclusively associated with low

carbon economies. Smart city solutions apply digital technologies to address social, environmental and economic goals. Smart city solutions can combine physical and digital infrastructure or can be based on digital infrastructure alone. This confusion is a barrier to growth of this market as confused customers find it difficult to justify investment.

- Smart city solutions are disruptive technologies which require system wide deployment to yield the most benefits. Existing processes will need to change. Furthermore successful deployment will require collaboration between multiple actors in value chain. This could be a barrier in some verticals where there is little incentive for established players to change.

- Furthermore it is often difficult for innovative companies to deploy solutions in the UK due to a fragmented vision of how cities can take advantage of smart technologies and a reluctance to deploy untested but innovative products and services. UK SMEs have told us of having to go abroad to deploy pilot projects due to utility companies and local authorities not willing to trial their products and technology.

- The UK has particular strengths in design, research, finance, and engineering services which could account for up 25% of the total smart cities market.

Opportunities for UK business and UK cities

There is great potential for UK business in this growing market. Furthermore there are benefits to UK cities and citizens by deploying smart solutions. This in turn would improve the chances of UK companies by opening the market here and providing them with a platform to export their services. In the verticals, Government needs to take a lead in removing barriers to innovation and facilitating collaboration between multiple diverse actors. This has already begun to happen in the Assisted Living and Transport verticals, but more needs to be done.

There is also a need for cities and government to take a cross-sectoral approach. Cities and government have traditionally considered these resources by verticals: energy, water, waste, transport and health have been considered and managed separately. Our study takes the same approach since the deployment of smart solutions has happened largely within these vertical value chains, without much interaction between different verticals. However cities are starting to look at smart city solutions as part of a more integrated approach to information technology and data. Furthermore they are looking to smart solutions and open data to address wider economic and social challenges. This cross-sectoral approach leads to additional opportunities for cities and citizens, and should also yield additional opportunities for UK industry. The Future Cities Catapult and Demonstrator have succeeded in catalysing the UK market by drawing local authorities' attention to the potential to use technology to address city challenges, but barriers including funding and leadership still remain.

Recommendations for government and cities

We recommend that government considers the following areas:

- The five verticals studied in this report are fundamentally material to our society and economy, and government has an enabling role. Government

should collaborate with cities, business, and academia to help form a vision of how cities and the five verticals will benefit from smart city solutions. Relevant Departments and regulators in each of the five verticals should commit to this vision and a roadmap for deployment. This would give industry clarity on what is expected and help to address the current fragmentation of the market. The TSB's Future Cities Catapult will have a role in coordinating a common vision for the sector which could be a platform for growth.

- Cities need help to develop capability in leading and facilitating collaboration with industry, academia and citizens because deploying solutions requires collaboration between different actors in the value chain. There is a role for government and its agencies in convening multiple stakeholders.

- Large scale trials of whole systems should be implemented, with a focus on business models and deployment, rather than just technology.

- Cities and utilities need to find ways to make it easier to deploy innovative products and services. Cities should look for ways to attract capital and create organisational structures which have the authority and capacity to deliver innovative programmes.

Introduction

This report was commissioned by The Department of Business Innovation and Skills (BIS) and considers global market opportunities for UK industry in smart city technology across five urban market verticals: energy management, water management, transport management, waste management, and assisted living services. The study explores the market structure and size, the trends in the market, and global regional highlights. The UK's strengths, barriers, and opportunities are identified and the role of Government in strengthening UK capability in global markets is considered, taking into account the Governments previous and existing activity on these topics.

This report has been written in tandem with the "Global Market Smart Cities Study - Case Studies Report" which reports on the experiences and identifies lessons learnt from six leading cities around the world.

Methodology

This report is the result of primary and secondary research conducted by Arup. Experts from within Arup and from across industry, academia, and non-governmental public bodies, across all five verticals have provided input through interview, comment and correspondence. A full list referencing contributors is provided in Appendix A.

Estimating Market Size

The global market for smart city technology and associated products and services is difficult to define and harder to forecast, with research organisations using different forecasting approaches. Our research has shown that valuations of smart technology markets can vary significantly between sources. For example in transport, research organisation Markets and Markets predicts the smart transport market to reach $156.3 billion in 2020, whilst Pike Research predicts a mere $5.55 billion. Such differences in estimates arise from differences in the technologies assessed and the scope of economic activities included by the different organisations.

This study makes use of estimates that include the wider set of economic activities such as design and consultancy, where possible, as these are more relevant and appropriate for UK industry and the UK economy. Our approach in this report considers a variety of forecasts from different sources, all of which are referenced wherever used.

By considering a variety of forecasts we can arrive at a composite figure for the market in 2020. Estimates forecast the smart energy technologies market (including smart grid) reaching $220 billion worldwide by 2020[1], whilst other sources estimate smart transport to be $156 billion[2], and smart water to be $22

[1] Zpryme Research, *op. cit.*
[2] Markets and Markets Research, *op. cit.*

billion[3] globally by 2020. Additionally, Arup conservatively estimates both smart waste and assisted living technology markets to reach $5 billion[4] each globally. Collectively these figures aggregate to reach an estimated annual $408 billion worldwide by 2020.

The figures in the paragraph above represent an estimation of the total spend on smart technology in the utility sectors examined in the report. These values include the broader direct spend on services such as design, consultancy, engineering and installation, which the investment in smart technologies will bring. A breakdown of the direct spend is difficult to estimate accurately, especially for services like design and consultancy. Market research experts like Pike Research have noted innovation that follows the investment in smart ventures will open new possibilities and therefore a breakdown of the different market components in the different utilities is difficult to quantify accurately, although some market research experts have attempted to do.

Eric Woods, Research Director with Pike Research, noted 'The differences in valuations in the smart transportation market and other smart city markets reflect the difference in scope of the forecasts and also how they are related to the smart city concept. Three key distinctions can be made:

- The total spend on 'smart' transportation technologies and services
- The total spend on 'smart' transportation relevant to cities
- The market related specifically to smart city investments'

Pike Research has based their valuation of the smart transport market on the specific opportunity offered by the growth in smart cities (defined as the integration of technology into a strategic approach to sustainability, citizen well-being, and economic development). These include technologies which have been developed to provide integrated traffic monitoring and management services, improve congestion management, to control road user charging, enhance emergency response, provide real times public information systems and provide smart parking solution.

These questions aside, and taking the aggregate figure presented above of a $408 billion global market in 2020, if UK industry were to aim to take a 10% share of the market, perhaps mostly in the UK's traditional strengths of product design, and infrastructure design engineering, these activities would be worth an annual $40.8 billion to the UK economy.

[3] Frost and Sullivan Research, *op. cit.*
[4] Arup estimates based on interviews with industry experts

1 Smart Energy Management

Energy systems around the world are seeing increased demand as populations rise and energy consumption per head increases. Energy systems in developed economies are facing increasing maintenance and upgrade costs to keep up with demand and ageing infrastructure, whilst those in developing countries are racing to keep up with exploding energy demand. These factors drive the need to improve energy management to drive up energy efficiency and resilience.

Smart energy management technologies can help utilities and distributors to forecast and manage loads better, reduce the need for costly infrastructure expansion, and improve service quality and customer satisfaction. Meanwhile consumers benefit from service quality reliability improvements, new tariff options, the ability to reduce their energy bills. However, the full benefits to all parties will not accrue unless the whole energy system is made smart end-to-end.

The opportunity for UK business is large with global market estimates such as a forecasted $220 billion by 2020 for smart grid technology.[19] However, the technology alone cannot achieve this systemic change. Changes to the way the market operates are crucial and leadership here would give additional opportunity for UK business internationally. Transformational change to the current market paradigm in the UK is required to maximise the sectors growth and potential.

UK business has a responsibility to think big and move faster to drive this transformational change. Government has a role in convening the necessary collaboration between all aspects of the vertical market, whilst regulators must continue to work to enable change.

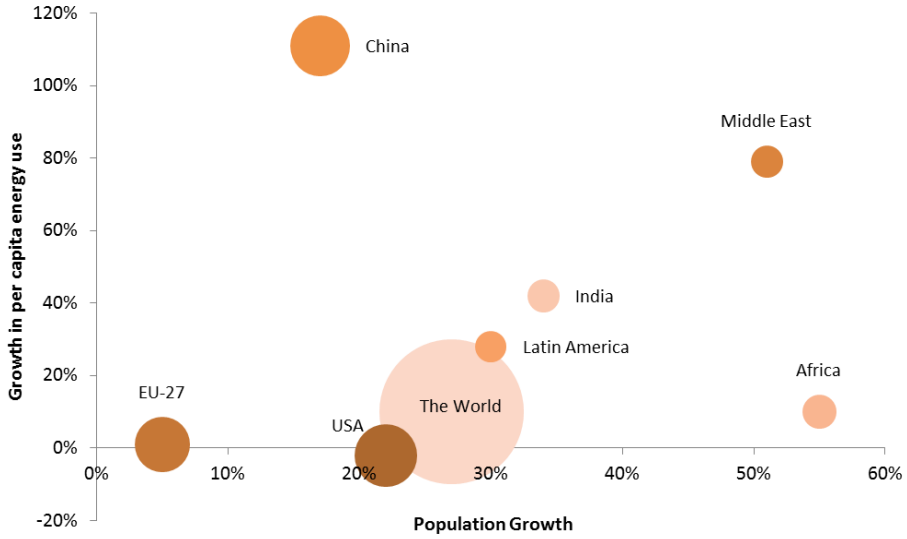
1.1 Introduction

Demand for energy is increasing around the world, spurred by economic and population growth, particularly in emerging economies. As their standard of living and GDP has grown, countries like China, the Middle East and India in particular have witnessed a massive growth in per capita energy use, although their energy use is still far below that of the US.

Smart energy management technology is defined here as technology that makes use of data or information to improve the management of energy. This is sometimes closely tied to, but is distinct from technology which generates renewable or sustainable energy.

For this report we focus only on smart energy management technologies in the urban context.

Figure 1.1: Growth in energy use and population (1990 to 2008) and relative total energy use (2008) Source: Arup analysis based on International Energy Agency data shows the growth in per capita energy use versus growth in population over an eighteen year period, as well as the total relative energy use across the globe.



Note: Bubbles depict total energy use within country or region. Energy use includes all fossil fuels, renewables and nuclear .

Figure 1.1: Growth in energy use and population (1990 to 2008) and relative total energy use (2008) Source: Arup analysis based on International Energy Agency data

This surge in energy use is expected to continue. The International Energy Agency estimates that global energy demand will increase by over one third up to 2035, driven by improvements in living standards in the developing world; and that the demand for electricity in emerging economies drives a 70% increase in global demand[5]. Massive investment has gone into the energy sector to try to ensure there is adequate capacity and reliability to meet this growth in demand.

In poorer regions, however, investment is targeted at providing stable access to electricity: an estimated 1.3 billion people still lack access to electricity.[6] Meanwhile across the world, steep increases in energy prices have made energy use a significant financial burden on households. In the UK alone, the number of households considered to be living in fuel poverty jumped from 2 million in 2004 to almost 5 million in 2010.[7]

Increasing energy efficiency, promoting energy conservation and improving how we manage energy is vital to addressing the challenges facing the energy sector. Investment in energy management can help countries to better adjust to fluctuations in demand, reduce the need for capacity expansion, and decrease greenhouse gas emissions, while providing valuable savings to customers. Smart energy management is central to this solution; it enables the benefits of energy efficiency and improved resource management to be fully realised and promotes the development of a flexible and resilient energy sector.

[5] International Energy Agency, World Energy Outlook 2012.
[6] Ibid.
[7] DECC: Annual report on Fuel Poverty statistics 2012

Energy Market Supply Chain

Energy markets (i.e. markets for electricity, gas, heat etc.) around the world vary significantly in their nature. Energy sector policy, regulation and governance are the key driver of market dynamics.

Figure 1.2 below shows a generic view of a typical energy supply chain (in yellow). In markets which have not been fully deregulated, utilities are public or private and tend to enjoy natural monopolies where they may be involved in both wholesale generation, retail distribution and in some cases, transmission. In the US for example, there are almost 3,400 electric utilities, of which about 350 are private; however, these private utilities are responsible for 80% of generation and 75% of retail sales. Other more competitive markets feature fewer utility companies, but the ownership of the supply chain is much more fragmented. The UK, for example, has one of the most "deregulated" energy markets in the world, with separate operators for transmission, distribution, supply, and retail. This variety in market topologies makes generalisation more difficult across geographies and this should be borne in mind when reading this chapter.

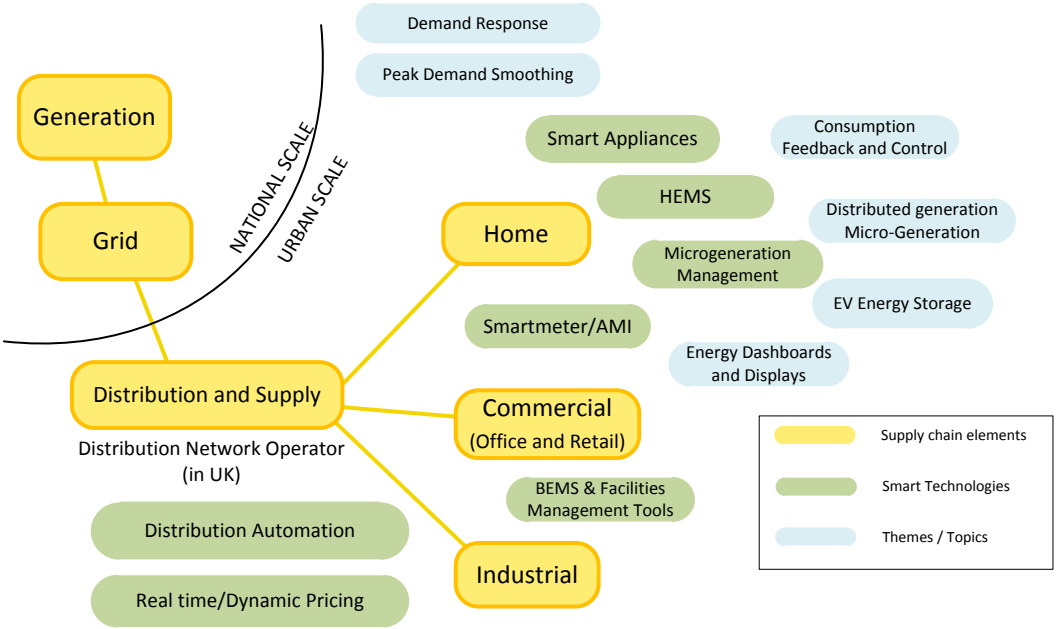


Figure 1.2: A generic energy market diagram, showing the elements of the supply chain (yellow) and the associated smart technologies (green). Wider smart energy management concepts are shown in blue. Source: Arup Analysis

In this chapter we consider the market for smart energy management technology products and services. We consider the management of three forms of energy: electricity, heating, and cooling in the urban context.

The following sub-sectors are considered and are shown in green on the diagram in Figure 1.2 above:

- Home Energy Management Systems (HEMS)
- Smart Appliances

- Smart metering and Advanced Metering Infrastructure (AMI)
- Building Energy Management Systems (BEMS)
- Smart grid technology at distribution scale (including Distribution Automation (DA) and Distribution Management Systems (DMS))
- Real-time / Dynamic pricing infrastructure
- Microgeneration management

The intended benefits of smart energy management

There are strong benefits for introducing integrated energy management systems – from smart grids to smart meters to Home Energy Management systems (HEMs) and smart appliances.

These include the following:

- Transmission and distribution networks benefit by being able to improve load management and forecasting, incorporate energy storage, and by having easy access to data to analyse, monitor and manage power quality, reliability, losses and outages.
- Retail utilities benefit through efficiency gains in meter reading, reduction in billing errors, reduction in service calls, theft detection and ability to provide improved customer service.
- Customers benefit through more accurate and timely billing, new tariff options, improved outage restoration and ability to understand and manage energy use.

It is estimated that European households could save 10% of their consumption, i.e. around €60 per year on average through smart meters[8]. Shaspa, a European SME, estimates that 170 billion kWh globally per year are wasted by consumers due to a lack of power usage information[9].

The US Government estimates the cost to modernise the electricity grid is about $165 billion, but the benefits far exceed this amount, by a factor of at least four[10]. A more recent study by EPRI estimates the costs to realise a US Smart Grid at about $400 billion, but the benefits exceed this by an even larger factor of 4.5 [11].

Improving energy management in commercial buildings, including investment in more advanced control systems and recommissioning buildings to ensure they are

[8] Next steps for smart grids: Europe's future electricity system will save money and energy, European Commission press summary, 12 April 2011
[9] Shaspa interview March 2013
[10] Modern Grid Benefits, US National Energy Technology Laboratory, August 2007
[11] Estimating the Costs and Benefits of the Smart Grid, Electric Power Research Institute, 2011

functioning properly has strong return on investment, about 40% for new buildings and 90% for older buildings, according to Pike Research[12].

However, it should be noted the full benefits may only accrue if fully integrated systems are developed. By way of example, the full benefits of home energy management (HEMS) tools become available to consumers once homes are provided with real-time pricing information - HEMS tools will then be able to make intelligent automated decisions on the cheapest moment to switch on energy hungry devices in the home. With HEMS installed in homes, distribution network operators (DNOs) will be able to take full advantage of distribution automation (DA) – distribution networks could then respond to real-time changes in domestic demand caused by the automated decision-making provided by HEMS. In summary, real-time pricing allows HEMS to vary demand intelligently (benefiting consumers), whilst distribution automation allows network operators to respond to this varying demand (benefiting operators). Take away one of these technologies and the full benefits are no longer obtainable.

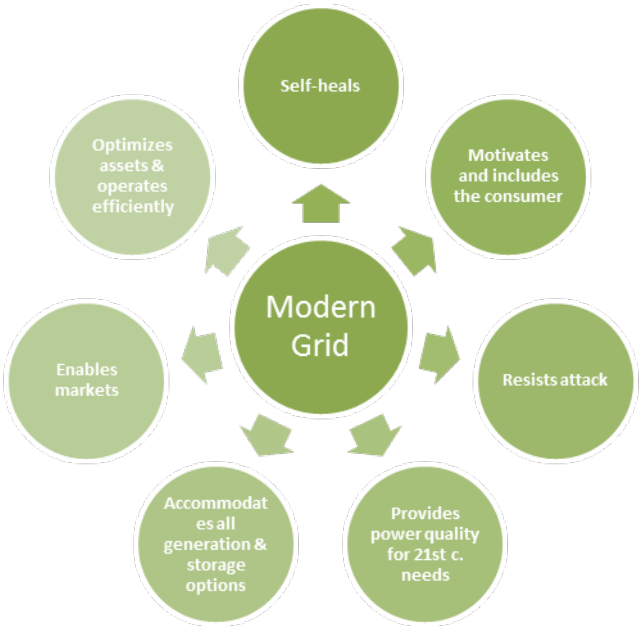


Figure 1.3: Seven principal characteristics of a Modern Grid[13]

1.2 Drivers

The market for smart energy management products and services is primarily motivated by the desire for efficiency, driven by economic and environmental factors. A Frost and Sullivan study[14] reports European utilities are driven most by the demand for energy efficiency in the immediate term through to 2020, whilst the need to improve ageing infrastructure comes to the fore in 6-10 years, from 2014 to 2020. The rising cost of energy, rising maintenance costs for ageing infrastructure, the looming capital cost to replace end-of-life infrastructure,

[12] http://www.navigantresearch.com/newsroom/commercial-building-retro-commissioning-revenue-could-surpass-1-8-billion-in-the-united-states-by-2014
[13] "A Systems View of the Modern Grid", US National Energy Technology Laboratory, 2007
[14] Utility Strategies for Smart Grids in Europe, Frost and Sullivan, March 2012

increasing global populations and the continued rise in consumption per head, all contribute to the need to increase efficiency in the way energy is generated, distributed and consumed.

The principle drivers are:

- Aging infrastructure
- Energy efficiency
- Growth in renewable energy
- Need to increase resilience

Ageing infrastructure

High income countries around the world are facing a major challenge with respect to the age and condition of their energy infrastructure. Power transmission assets are outdated, not fit for purpose and at the end of their useful life, which is threatening the stability and reliability of the grid. In the US for example, former Energy Secretary Bill Richardson once declared that America was "a superpower with a third-world grid"[15], while in the UK, a former Secretary for the Department for Energy and Climate Change (DECC), has said the energy infrastructure in the UK "was in such poor state that it would cost scores of billions of pounds to overhaul"[16]. This need to address ageing infrastructure is both a driver and opportunity for improved energy management.

Increasing energy efficiency

Industrialised countries around the world have been investing heavily in energy efficiency. Within the EU, a target has been set of 20% reduction in energy demand by 2020. In the US, there has been strong push to promote energy efficiency and expand decoupling in the energy sector (a policy which provides stable revenue to utilities regardless of sales volume and encourages them to deliver energy efficiency savings). Energy efficiency received a major boost in the US via the 2009 American Recovery and Reinvestment Act, which directed over $12 billion to energy efficiency initiatives.

National and city Governments in Europe, North America and East Asia are pushing the energy efficiency agenda by:

- Enshrining energy performance standards in building codes
- Establishing agreements, emissions trading schemes, incentives and penalties for the most energy intensive industries
- Mandating that utilities deliver energy efficiency savings
- Creating large scale public and domestic sector retrofit and energy efficiency programmes

[15] http://articles.latimes.com/2003/aug/15/opinion/ed-power15
[16] www.guardian.co.uk/environment/2011/jul/12/chris-huhne-energy-market-invest

- Establishing innovative funding mechanisms to encourage investment, such as the Green Deal in the UK

- Encouraging roll out of smart meters to build awareness of energy use

The push for energy efficiency has been driven by three key factors:

Carbon reduction

Energy efficiency is seen as one of the most cost-effective ways to reduce carbon emissions.

Rising, volatile energy prices

Massive increases in energy prices, and the volatility of these prices, pose a significant risk that needs to be managed or mitigated by users. In the UK for example, the fuel price index for gas and electricity far exceeds the general retail price index, as shown in Figure 1.4.

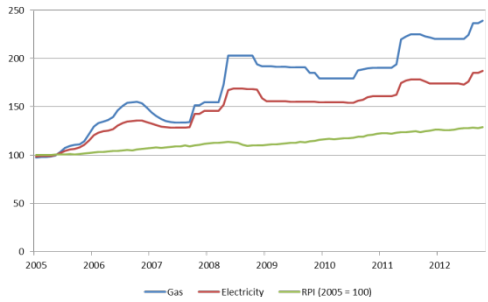


Figure 1.4: UK Fuel Price Index

Fuel poverty

The concept of fuel poverty is one that has gained much momentum due in large part to rising fuel prices. In the UK, a household is considered to be in fuel poverty if it "spends more than 10% of its income on fuel to maintain a satisfactory heating regime"[17]. Fuel poverty has ramifications that are far beyond utility bill levels - cold homes have a negative impact on respiratory problems, minor illnesses, and children's educational attainment, and are linked to higher levels of excess winter deaths. It is estimated there are 5 million homes in fuel poverty in the UK. When comparing performance across countries, studies have shown that fuel poverty is driven more by poor energy performance of homes rather than high fuel prices[18].

Growth in renewable energy:

Renewable energy sources such as wind and solar produce intermittent supply which threaten the stability and reliability of electricity networks. Grids are designed around conventional energy generation technologies, and will need to adapt using smart technology to support the continued growth and integration of renewable energy in the future.

Increasing resilience

There is a need for increased resilience of our energy system in the wake of increased environmental (extreme weather) and socioeconomic (shifting economic contexts) uncertainty globally. Cities and utilities are driving the development of more resilient energy systems by diversifying and decentralising their energy

[17] https://www.gov.uk/government/organisations/department-of-energy-climate-change/series/fuel-poverty-statistics

[18] The Cold Man of Europe, Energy Bill Revolution and the Association for the Conservation of Energy, March 2013.

systems, encouraging greater energy conservation and using smart grid technology to redirect supply during outages.

1.3 Value Chain

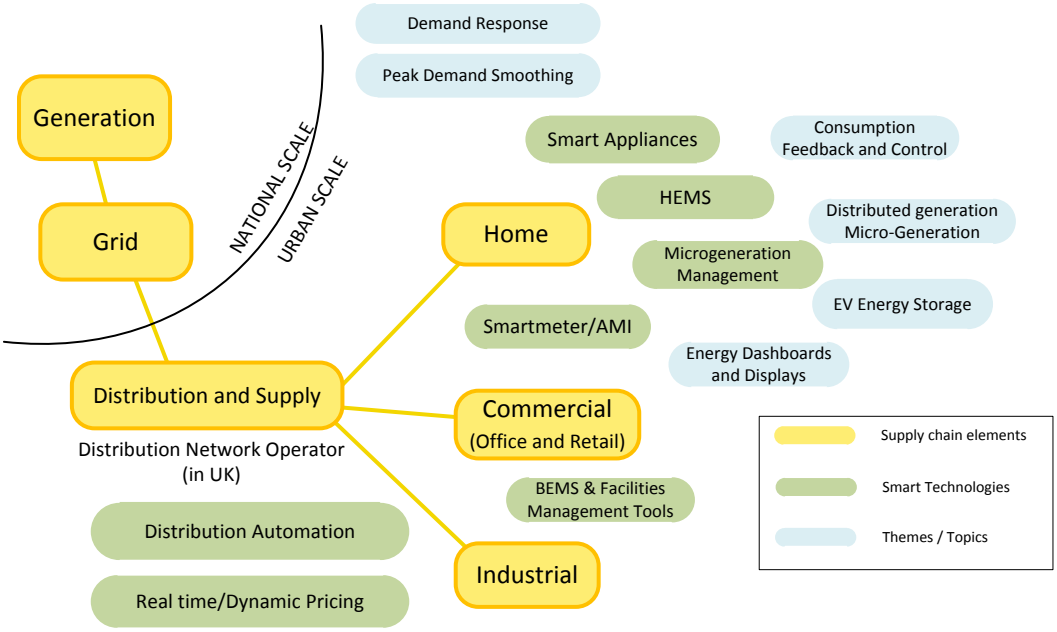


Figure 1.5: A generic energy market diagram, showing the elements of the supply chain (yellow) and the associated smart technologies (green). Wider smart energy management concepts are shown in blue. Source: Arup Analysis

The structure of energy markets (electricity and gas) varies internationally. Some countries have nationwide monopolies that operate along the whole vertical (from generation through to retail), whilst other countries have very stratified vertical markets with private companies operating in each stage of the market. Yet other countries have a wide array of small regional monopolies that generate, distribute and sell all the electricity within a specific geographic area. In some countries it is typical for cities to own their own energy monopoly, though this is not the most common arrangement. The diagram in Figure 1.5 shows the generic elements of an electricity supply chain which is common to most countries.

This report focuses mostly on the urban scale as shown in Figure 1.5, ignoring the transmission grid and generation, to focus on the distribution, supply, and consumption in the home, commercial and industrial sectors. This report also concentrates on the smart energy management technologies shown in green in the diagram as these are the most relevant elements to the city context:

- Real time / dynamic pricing infrastructure
- Distribution automation (DA) / Distribution Management Systems (DMS)
- Building Energy Management Systems (BEMS) and Facilities Management (FM) tools
- Smart metering and Advanced Metering Infrastructure (AMI)
- Microgeneration management

- Home Energy Management Systems (HEMS)
- Smart Appliances

Uniquely, appliances are not conventionally viewed as part of the energy vertical, but smart appliances are shown here because of their interaction with demand response, HEMS and real time pricing.

Figure 1.6 shows some of the key industry members in the field and their roles. Note that many large multinationals operate in different areas of the vertical market, as may be expected, whilst most SMEs appear in the new areas of the market such as demand side management and home energy management.

Many of the new market sub-sectors created by smart technology require the convergence of multiple industry members from different backgrounds, sometimes from previously unrelated sectors. An example is illustrated in Figure 1.6, with telecommunications companies joining in the AMI sub-sector with meter manufacturers and IT companies.

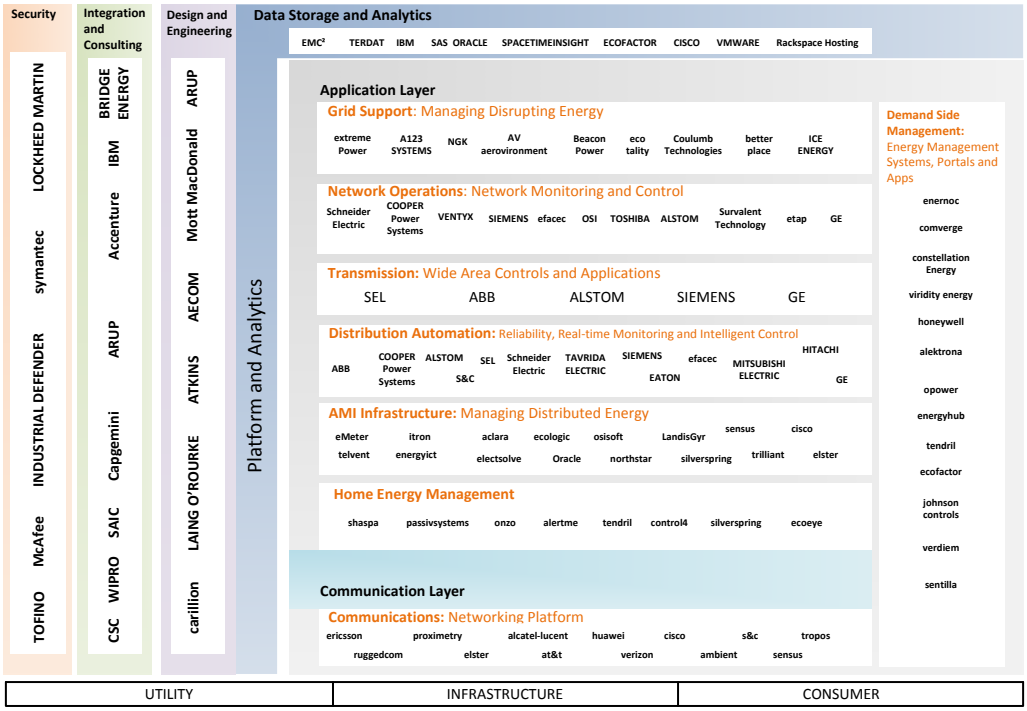


Figure 1.6: Map of smart energy management industry players. Source: Arup, GTM Research

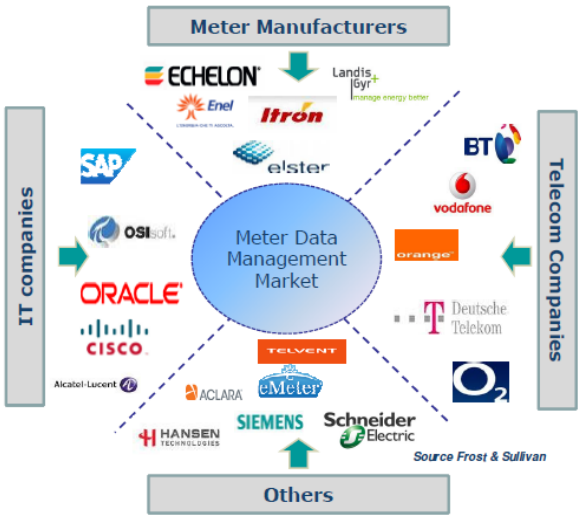


Figure 1.7: An example of the convergence of different sectors around smart energy management technologies. Source: Smart Energy Focus: AMI, Frost & Sullivan

1.4 Market size

Our research has shown that valuations for the smart energy management market vary significantly depending on scope and definition i.e. which sectors and technologies are accounted for. As described in the previous section, the smart energy management market includes a wide range of technologies, products, and services, and definitions of the market can vary widely in interpretation. Different research experts such as Pike Research, Markets and Markets and industry bodies such as Zpryme have published differing valuations for the sector. Additionally, the market is moving rapidly and the technology developing continuously. As such market estimates and forecasts from different sources are not directly comparable and can vary significantly. It was not possible to find consistent valuations broken down across all technology categories or regional subsectors; however, the selected market estimates discussed below do help inform a picture of the market.

An estimated global market size of $220 billion is forecast by 2020[19] for smart grid technology globally, whilst $500 billion will be spent globally on smart grid initiatives by 2030[20]. This valuation includes an estimation of the smart technologies which will be used, the amount spent on innovation, on design consultancy and engineering, on infrastructure development and installation, on ICT, software and analytics and on automation and control. The report describes Europe and North America as the “first mover markets”.

This $500 billion valuation also considers ancillary industries and services, which will be directly influenced by the investment in smart grid solutions. These services include traditional grid at the national (transmission) scale as well as at the urban (distribution) scale, smart meters, demand response and home energy management. Also included is integration of new smart technologies into legacy

[19] Global Smart Grid Technology Forecast (2012-2020), December 2012, Zpryme Research
[20] The Networked Grid 150, Report and Rankings 2013, GTM Research

systems, development and deployment of business and data analytics which will interpret live data and better manage energy within cities.

The BRIC countries are expected to offer strong growth opportunities, as exemplified by research from Zpryme estimating India's smart grid market to grow from low levels in recent years and reach $1.9 billion by 2015. China is expected to grow to $15 billion by 2016, despite home energy management not achieving significant penetration in China's domestic market[21]. In contrast, the Japanese home energy management market alone is expected to reach $2.3 billion by 2016.

The home energy management (HEMS) market worldwide is expected to reach $85 billion by 2015[22].

Looking more specifically at smart energy management products, the global opportunity is conservatively estimated to have been $2.1 billion in 2012, and is expected to grow by 12% annually to over $5 billion in 2020. A study by Pike Research suggests the strongest growth regions will be Europe and Latin America with annual growth of 21% predicted. By 2020 the two largest regional markets will be Europe and Asia Pacific. China will be the single largest market for smart metering. The table below shows a regional breakdown. The authors, Pike Research, do not include services such as design, consultancy, installation, or maintenance in their estimates and so these figures cover a narrower slice of the wider opportunity for UK business in the smart energy management field.

Energy	2012 (million)	2015 (million)	2020 (million)	CAGR (2012-2020)
North America	844	816	1,206	5 %
Europe	394	1,415	1,795	21 %
Asia Pacific	720	1,130	1,638	11 %
Latin America	60	130	280	21 %
Middle East & Asia	94	133	209	10 %
Total	$ 2,113	$ 3,623	$ 5,127	12 %

Table 1.1: Smart energy management market estimates. Source: Pike Research Q1 2013

The valuation by Pike Research considers the investment likely to be made in smart energy related to innovation and technologies by cities adopting a 'smart city' strategy. This valuation can be described as the 'seed' money required to release the much wider potential of smart energy solutions. These include the opportunities which the development and deployment of smart technologies could bring and the additional services and infrastructure required as a result of their deployment.

Eric Woods, Research Director with Pike Research, noted 'The broader opportunities in Smart Cities could be 10 to 20 times greater than those noted (in Smart Cities by Pike Research, 2013)' and 'innovation after investing in smart

[21] Smart Grid Market Assessment, GTM Research
[22] Home Energy Management Systems Products Market, November 2011, SBI Energy

ventures will open new possibilities'. Eric Woods also noted that 'The other aspect of smart city investment to consider is that it is a catalyst for new opportunities around technologies and services'' and that 'these broader opportunities would include economic benefits of investment in smart [energy] in terms of the development of new businesses and services and the impact on local economic performance'.

1.5 Market and Technology Trends

The smart energy management market is developing rapidly across all technology sub-sectors (shown in Figure 1.5). This section explores the market trends for smart energy management technologies, in the context of global patterns and regional variations.

Smart Distribution Networks / Distribution Management Systems

In a global survey of utility executives by PennEnergy almost a third of respondents reported already having deployed advanced distribution management systems (DMS) in their network, with a further 40% expecting to do so within the next two years[23]. This trend is strongest in the USA – the sample of utilities surveyed was relatively US heavy and this is also reflected in the strength of the US in DMS rollouts (see Section 1.6).

Smart metering/AMI

Electricity meters have evolved significantly since they were first introduced as a means of automating meter reading and improving billing accuracy. Today's most advanced smart meters can provide real time energy use data, power outage detection, dynamic pricing, switching between suppliers, and a Home Area Network interface.

Europe has led the way on AMI with a more extensive deployment than other markets[24]. Europe expects to deploy 212 million smart meters between 2011 and 2020[25]. European innovation in this sector is seen primarily as a result of EU Smart Grid policy directives around energy efficiency, consumption based billing, interoperability, standards, and climate goals.

Several companies including Itron, Landis + Gyr, Elster, GE, Trilliant, Sensus and SilverSpring Networks have capitalised on EU compliance to offer AMI systems with a focus on open platform protocols and interoperability.

Europe's progress on AMI has until now mostly focused around the smart meter. As the smart meter rollout continues and the need to process real-time information grows the next area of focus, meter data management should be poised for growth.

[23] State of the Smart Grid 2013 Survey (infographic), PennEnergy Research, June 2012
[24] Frost & Sullivan, GTM Research
[25] Smart Meters in Europe, Pike Research, Q3 2012

Smart appliances

Growth in the overall domestic appliance market presents continued opportunity for smart appliances. Sales of smart appliances are project to exceed 24 million units by 2017[26]. However, smart appliance manufacturers have yet to successfully capitalise on this apparent opportunity so far. In survey after survey[27], consumers have shown no willingness to buy smart appliance outside their 10-year average replacement cycle, unless they are available at the right price and deliver tangible energy savings.

Currently though, most manufacturers are marketing the non-energy features of their smart appliances such as grocery tools. These non-energy features have not yet gained traction with consumers. Consumers do not currently view smart appliances as energy and cost saving[23].

Moreover, economies of scale, better technical integration, and the emergence of dynamic pricing are critical elements to realizing the potential of the smart appliance market.

Microgeneration management

The market for microgeneration management technology is closely tied to the market for microgeneration. The UK's microgeneration stock is predicted to grow to between 1 and 4 million units by 2020[28]. The UK Government published its action plan for microgeneration in June 2011[29].

BEMs

Industrial energy management systems are relatively well established and are already tuned into real-time pricing schemes and demand response in geographies where utilities provide this information. BEMs are similarly well established in the commercial sector, but the technology is in the midst of rapid innovation, as new ways of analysing, accessing and managing energy performance have evolved. However, demand response has not yet been widely adopted in offices and retail spaces due to the impact on occupant comfort and productivity.

The necessary adaptation of existing buildings is perceived as too costly and complex for landlords or developers to consider. Questions also exist around how energy management technologies fit with future workplace design and ways of working, though they are expected to be mutually beneficial.

Other emerging trends

Cloud services: A trend that has already taken hold in other sectors, uptake of cloud-based services amongst utilities is increasing from an almost standing start a few years ago. Cloud-based technology services are enablers for delivery of innovative services to both ends of the supply chain from utilities to consumers;

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[26] Smart Appliances, ABI Research, Q1 2012
[27] Smart Appliances, Pike Research, Q3 2012
[28] The Growth Potential for Microgeneration in GB, Element Energy
[29] Microgeneration Strategy, DECC, June 2011

Opower and Tendril's cloud-based services are two such examples. The market for cloud technology in energy management is forecast to reach $4 billion by 2020.[30]

Energy as a service (an embryonic trend): A newly developing market concept, energy-as-a-service is an innovative business model for energy utilities. This shifts energy companies from being energy providers – delivering energy to their clients – to becoming 'energy service providers'. Such energy service providers would deliver packaged energy-efficient solutions to clients. For example consumers might have heating and cooling services provided by the 'utility company' rather than the consumer owning their own boiler and air-conditioner equipment as is currently the norm. The provider might also provide and maintain the smart appliances in the home. The consumer no longer pays for electricity or gas, but pays for the services of heating, cooling, use of a washing machine, fridge etc.

The concept could be one route to deliver much of the innovation presented by smart energy proponents. A fundamental building-block is the availability of actuarial data (i.e. reliable energy consumption profiles for different consumer types). Actuarial data could unlock the financial services required to enable energy-as-a-service to domestic and commercial consumers, by allowing energy service providers correctly price their services to consumers based on accurate models and predictions of consumer energy usage. This has already happened to some extent in the industrial consumer sector (c.f. aggregator service companies, also known as NOCs). The Investor Confidence Project (ICP) is a widely supported international industry body, based in New York State. ICP is devising standardised processes and documentation to increase investor confidence and encouraging finance deal flow[31].

Vehicle to Grid Technologies: As smart grids are rolled out and electric vehicles (EVs) gain uptake in the market, there is the potential to enable electric vehicles to charge during periods of low demand and to be used as distributed electricity storage devices. EVs could be used to feed electricity back to the system during periods of peak demand, enabling more efficient load management.

1.6 Regional Highlights

According to Innovation Observatory's report "Smart Grid Technology Investment: Forecasts for 2012-2030", the countries making the largest investment in smart grid infrastructure up to 2030 are (in order): China, USA, India, Japan, Russia, Germany, France, UK, Spain and Turkey. Further information about some of these key markets is provided below.

Europe: A Smart Grids Task Force has been set up by the European Commission to provide policy and regulatory directions for the deployment of Smart Grids, focusing on issues such as standardisation, consumer data privacy and security. The Grid4EU initiative brings together a consortium of six European energy distributors to test the potential of smart grids in areas such as renewable energy integration, electric vehicle development, grid automation, energy storage, energy efficiency and load reduction. Under EU legislation, 80% of consumers will need

[30] Cloud Solutions for a Smarter Grid, Zpryme Research, February 2013
[31] ICP project website: http://www.eeperformance.org/project-allies.html

to have smart meters installed by 2020. Within Europe, Italy is the real leader - Enel SpA has deployed smart meters to more than 30 million customers. Home Energy Management slow to grow so far, but still promising. Smart Appliances slow to grow, but European manufacturers in the vanguard.

USA: The US Government has been developing standards and providing significant funding to support the development of smart grids. It has also set up a Smart Grid Task Force to ensure awareness, coordination, knowledge sharing and integration of the various smart grid activities of the federal Government.

Smart meters and AMI have been deployed to about 36 million customers. California leads the way on smart meters, demand reduction and smart grid trials. Progressive utilities such as Duke Energy, SCE, and PG&E, along with Government stimulus and incentive packages such as ARRA have given rise to optimisation of the hardware and software around distribution management. Homes in the US typically do not have time-programmable thermostats; the drive for smart energy management systems could help the US to leapfrog technology to use much more advanced, dynamic home energy management systems.

NOCs are well established in the commercial and industrial sectors and their use of demand response technology is growing.

India: India is ranked as the third largest market for smart grids; it is expected to install 130 million smart meters by 2021[32]. Its motives for smart grid developments are focused largely on meeting and managing future demand, which is expected to quadruple by 2030, as well as reducing losses to the electricity network, estimated to be about 30%[33]. As a country which does not yet have full household electricity penetration, India is poised to leapfrog technology when it develops its smart energy networks. India is already facing severe challenges with its grid - in July 2012 it suffered the biggest blackout in history, which cut power to 700 million people in 28 states. The blackout has helped to galvanise support behind India's grid modernization programme. India has created a Smart Grid Task Force and a Forum which has brought together leading suppliers from around the world, such as GE, Siemens, and Schneider Electric. The Government is carrying out pilot smart grid programmes in 8 cities. Cities have set targets for smart meter installation, such as Bangalore which aims to have one million smart meters installed over the next year. With its myriad of utilities, India is not an easy market to penetrate; nonetheless, it is very open to attracting foreign partners. The state of Maharashtra, for example, has partnered with Siemens to install smart grid technologies.

Japan: Japan is moving rapidly following the shock to the energy market caused by the Fukushima disaster. The energy sector is now undertaking a massive transformation. Japan is moving away from nuclear power; all but two of the country's nuclear reactors are offline, and has set a target of 30% energy from renewables by 2030. Recognising the urgent need to deploy smart grid technology, Japan is seeking to build one of the world's most advanced next generation smart grids and has formed international partnership to speed the deployment of smart meters. The Japanese Government has been promoting smart city initiatives in four cities: Yokohama, Toyota City, Keihanna Science City and Kitakyushu. Each of these cities is piloting innovative energy management

[32] http://cmrindia.com/india-energy-vision-2015-the-future-lies-in-smart-grids
[33] http://articles.timesofindia.indiatimes.com/2012-08-01/india/32979728_1_power-sector-transmission-technical-loss

technology and experimenting with different technical solutions that can support sustainable lifestyles.

China: China is the world's largest market for smart grid investments. Faced with the need to provide energy to a growing population whose standard of living is rapidly increasing, and under strong pressure to reduce its carbon emissions, China is undertaking a massive programme to modernize its electricity network. The state grid corporation of China has developed a three phased plan through which it will invest about US$600 billion into its national transmission network, including $100 billion for smart grid technology. Funding is being used to develop technical standards, undertake pilots, develop smart grid management systems, and deploy smart meters and electric vehicle charging networks. China is seeking to leapfrog technology, and develop systems that will become the global standard. From a market entry point of view, China has a solid advantage, the state grid controls more than 80% of the country's electricity supply, however, the Chinese market has been viewed as being less open to foreign suppliers and more focused on encouraging home-grown innovation.

Brazil: Brazil has been leading on smart grid development in Latin America, but its commitment to smart grid development has weakened recently. Brazil has already developed its renewable energy sources, nearly 89% of Brazil's electricity came from renewable sources in 2011[34]. According to Smart Grid News, Brazil's interests in smart grid development are focused more on the challenge related to "lowered distribution tariffs, universalization, and improved power quality and loss reduction". The Government had previously set a target of 63 million smart meters by 2021, but in August 2012 this was struck down by the national electricity regulator due to high costs. Brazil now requires utility companies to provide smart meters to new buildings or to customers who request them. This has severely curtailed the smart energy market in Brazil, and was a severe blow to international suppliers which had already started to invest in the Brazilian market. Brazil is proceeding ahead with several smart city and smart grid pilot schemes, such as the (Smart City) Búzios project.

1.7 UK Strengths, Gaps, Opportunities and Barriers

In the context of the drivers, market trends, and the global market opportunity, this section explores the UK's strengths, the gaps in the supply chain, the opportunities for UK industry and the barriers to be faced.

Strengths:

The energy industry as a whole is a well-developed part of the UK economy with a total direct contribution of £20.6 billion or 1.6% of GDP in 2011[35], and the UK's experts in the technology, consulting, engineering, legal and financial aspects of the energy industry are well-regarded globally. Indeed, UK power standards are roughly aligned with the EU market and with several major Commonwealth economies such as Singapore, Hong Kong, India and Pakistan. This makes entry into these markets easier for UK industry and expertise. This is particularly helpful for SMEs who would otherwise struggle with redesign costs to enter other markets with less similar regulatory regimes.

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[34] Brazilian Energy Research Company, National Energy Balance Report (BEN 2012)
[35] Powering the UK, Energy UK and Ernst & Young, 2011

Energy efficiency policies and programmes: The UK has very strong policies, programmes and incentives geared at energy efficiency in the built environment. It is carrying out a national roll out of smart meters and is promoting large scale energy efficiency retrofit through initiatives such as the Green Deal.

Finance sector: London's financial sector is now a world centre for banking, investment and venture capital. The industry will need to develop novel finance packages to fund the innovative business models that smart energy management will enable. The UK is already a key player in green finance, and is host to organisations such as the Green Investment Bank, the London Energy Efficiency Fund, the Climate Bonds Initiative, and Climate Change Capital.

World-leading skills: The UK also has internationally recognised expertise in skills that are necessary for innovation in the market; namely, product design, user interface design, and service design. These skills are particularly important for the consumer-facing retail aspect of the market e.g. HEMS in the domestic environment. Product design is a traditional strength for the UK[36] especially when tied to the UK's solid mechanical and electrical engineering expertise. The strengths of these product design and engineering skillsets in industry are backed by world-leading academic institutions such as Imperial College London, the Royal College of Art, and Central Saint Martins.

User interface design and service design are relatively new skillsets that the UK has helped pioneer and can be most often observed in the innovative output of East London's startup scene. These skillsets will be fundamental to the widespread adoption of smart energy management technology in the home and office environments where the usability and service design aspects of products available on the market today are not yet sufficiently refined.

UK SMEs: UK SMEs hold some dominance in the HEMS market, in global visibility at least. Many of them offer relatively innovative products and have developed delivery partnerships with large utilities in the UK and abroad.

Commercial Demand Response: The UK has an active market of demand response aggregators (e.g. EnerNOC UK, and new entrant KiWi), based on National Grid's STOR[37] programme. This gives the UK a good footing to build upon when developing more extensive demand response services in a smart grid. However this remains limited to relatively mid-to-large size commercial and industrial customers.

Finally, as the coordinator of a regulated marketplace, the UK energy market regulator Ofgem is in a strong position to override any market failures and drive innovation in the energy market.

Gaps in the UK supply chain:

UK hardware challenges: There are relatively few UK-centred companies with significant market positions in the sub-segments of smart meters, building energy management (BEMS), and smart appliances. Some international firms based in the UK have capabilities in these sub-segments.

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[36] The UK ranked fourth – International Design Scoreboard, 2009, IfM and Design Council
[37] STOR stands for Short Term Operating Reserve

Gaps in Data Management: currently cornered by multinational IT vendors and US-based SMEs. This may already present a barrier to new entrants. However, a survey of European energy utilities in March 2012 reveals that almost three quarters of respondents feel that their existing IT infrastructure is not suitable for smart grids and is a major challenge to integration[38].

Gimmicky Smart Appliances: Product manufacturers are not yet marketing smart appliances on their cost reduction or energy saving features. Instead they are still marketing features that some consumers see as unnecessary gimmicks. Surveys show consumers will not buy smart appliances until they see the potential energy and cost benefits[23]. The may also require publicity campaigns to increase public awareness.

Opportunities:

The UK has the opportunity to develop an international competitive advantage across many of the sub-sectors in a global smart grid market forecast to be worth $500 billion by 2030[20]. The section discusses some of the key opportunities for UK industry in the short to medium term.

Vibrant home energy management SMEs: The UK has a large number of active SMEs in the home energy management market. These SMEs show signs of strong innovation in comparison with international competition. They put the UK within reach of, if not already at, the forefront of the global HEMS market.

Strong national regulator: Ofgem is in a position to enable major market transformation to override any market failures. If Ofgem (or DECC) acts upon this opportunity, the UK could take the lead internationally, placing UK industry on an excellent footing to sell into other international markets.

End-to-end market leader: The UK could become the first market with an end-to-end smart electricity grid, from transmission to distribution automation, dynamic pricing, demand response, to home energy management, smart appliances, commercial building and industrial energy management. This could give UK industry an excellent skill and capability base, and a powerful platform for marketing these internationally.

Business model innovation – 'energy-as-a-service': As described in Section 1.5 – Market Trends, this embryonic but innovative concept has still to be fully defined and understood. Assuming the UK can realise its strengths as already outlined, and forge pioneering cross-industry collaborations, this would be an ideal opportunity for the UK to leapfrog to the very front internationally. The US industry has begun to explore the concept of 'energy-as-a-service' through cross industry bodies[31].

[38] Utility Strategies for Smart Grids in Europe, Frost & Sullivan, March 2012

Barriers and Challenges:

No incentive for demand management: Distribution Network Operators (DNOs) typically do not see value of demand reduction since the distribution network is not typically the pinch point. More importantly, DNOs are currently not incentivised to promote demand response and other smart energy technologies that may reduce energy consumption. The DNO is rewarded for transporting more electricity, not less. In general internationally, energy utilities are rewarded for selling more electricity, not less. Indeed, utilities responding to a recent survey expressed fear over loss of profits due to lower energy use[38].

Lack of real time or dynamic pricing: Unless they become popular with consumers for other usability features, smart appliances and home energy management products will not get off the ground without real-time pricing, which will require the wider set of smart energy technologies.

Domestic appliance oligopoly: The nature of the domestic appliance market makes it hard for SMEs to develop their own products and services or build retrofit products upon the established manufacturer's products without partnerships with manufacturers. Manufacturers are slow to move but alliances (e.g. Energy@Home) are beginning to show signs of movement.

Integration and standards for the Smart Grid: The EC's Joint Research Centre has identified the integration of different technologies as the key challenge in 2013. Progress is being made on this front but utilities will become more comfortable in making investments once integration and standards are well-established.

Lack of strong vision: Our conversations with suppliers and has revealed a perceived lack of the UK Government's commitment to vision. A clearly defined and articulated vision from Government is required to help industry invest confidently, and increase the availability of private funds for SMEs and pilot projects.

Regulatory constraints: General sentiment garnered during this study indicates a potentially widely held opinion that the UK's regulated market won't innovate as fast as other less regulated markets without strong directives from the regulator or Government. This is perhaps reflected in the fact that there are few UK-centred companies with significant market positions in many of the sub-sectors. New initiatives like Ofgem's RIIO [39] are a good start.

Concerns about safety and privacy: The roll out of smart meters has been met with much scepticism and concerns over privacy, safety and health. Consumer advocacy groups assert that smart meters emit harmful radiofrequency waves. Concerns over privacy, how energy use data is stored, accessed, maintained and used has sparked campaigns against the use of smart meters.

[39] RIIO stands for Revenue equals Incentives plus Innovation plus Outputs

1.8 What the UK Government is doing

Several Government bodies and public organisations have been active in the topic of smart energy management for some time. The industry has learnt much from pilot programmes, trials, and test environments, many of which have been delivered in partnership with DECC and Ofgem.

A number of new pilot programmes have been established recently or are commencing imminently and will add to the knowledge and understanding within UK industry, Government and the regulator. Crucially these pilots will go some way in to addressing some of the barriers outlined above, such as the lack of standards, concerns about safety, and demonstrate innovative partnerships between industry and Ofgem. A few are listed below:

- Low Carbon London – led by UK Power Networks
- New Thames Valley Vision – a Low Carbon Networks Fund project
- Orkney Active Network Management Scheme - Smart Grid Solutions and Scottish Hydro Electric Power Distribution
- Scottish Power Distribution
- National Grid Data Exchange
- Smart Systems and Heat Programme – Energy Technology Institute (ETI)

The UK Government, through BIS and the TSB has established the Future Cities programme and the Future Cities Catapult (due to open in July 2013). Whilst it is not the primary goal, smart energy management will be an integral part of the 'future city' outcomes these programmes will be delivering.

The Department for Energy and Climate Change (DECC), in tandem with Ofgem, are working to address some of the investment and regulatory barriers highlighted earlier.

- Smart Grid Forum – in partnership with industry and Ofgem, creating consensus on the future of the network
- Smart meter roll-out completed by 2019 – putting in place a key aspect of smart energy management
- International Smart Grid Action Network (ISGAN) – working with the EU, sharing information and learning, with €100m funding.
- Electricity Market Reforms (EMR) – legislation allowing reform of the electricity market. EMR contains relatively little on smart energy management other than demand response, but could create a good background for further reform.
- RIIO[39]taking effect 2015 – the new price control framework designed to better incentivise network operators to make the right investment choice for the future.

- Low Carbon Network Fund – £500m has been made available to support trials of new smart technologies and approaches. This will then be continued by the Innovation Stimulus under RIIO.

1.9 Recommendations

The study has shown that innovation in the UK energy market is happening in patches but the UK's position is waning as other countries move faster (such as the EU, Japan, China, USA). This view has been echoed by opinion garnered through interviews held during this study[40].

Seize the opportunity

The UK has the opportunity to develop a world-leading position by becoming the first end-to-end smart energy market, which no other country has yet achieved. Realising this opportunity will require ambitious disruptive transformation of the current market model. This change to a new market model would deal with current market failures such as non-incentivised distributors. Through close involvement in this transformative change, UK industry could gain global recognition as leading experts in the new energy market paradigm.

The UK has globally competitive strengths in the skills that are fundamental to the end-to-end smartening of the energy market (engineering, service design, and user interface design). It has expertise in financial, legal and actuarial products, as well as an influential regulator with the power to correct market failure. These competitive strengths give the UK the opportunity to become a world leader in energy-as-a-service provider.

Government Leadership

Delivering such transformative change along the whole market vertical will require a close collaborative partnership between the many actors in the full supply chain including the regulator Ofgem and policymakers in DECC. Industry and Ofgem already work together on specific programmes such as Low Carbon London and the New Thames Valley Vision[41]. However, such collaborations must become deeper and more ambitious, exploring the opportunities presented by an end-to-end smart market, and new 'energy-as-a-service' business models identifying, understanding, and quantifying the tangible and intangible benefits to consumers, producers, suppliers, and Government.

DECC can encourage this collaborative approach, but industry should have a role in leading it. Government, through DECC, will need to set the agenda by committing to a clear vision and articulating this widely, giving confidence to investors, producers, distributors and consumers.

[40] Interviews held during this study with industry actors (SMEs, multinationals, institutes, and regulators). Refer to Appendix A.
[41] More programmes are listed in the preceding section

UK business has a responsibility

UK industry should take the lead on developing and driving innovation through collaborative partnerships. For example, collaboration between SMEs and major utilities can deliver strong benefits to both parties, and speed up innovation in the marketplace. Industry should also take the lead in driving collaboration with Ofgem and DECC to help reform the market.

Industry bodies should widen their collaboration to include other sectors such as finance and investment to drive even more forward-thinking innovation, helping to quantify and crystallise new business models. Actuarial and investment houses should be encouraged to get involved in the reforms of the energy markets. Cross-industry collaborations (as exemplified by ICP in the US31) should be established to accelerate the pace of innovation.

Utilities are beginning to explore changes to the way they operate. The next step will be to adapt to changing market models and innovative business models. UK utilities should seize the opportunity to define new service propositions (‘energy-as-a-service’) and retake the lead internationally.

2 Smart Water Management

The demand for water and the cost of treating water are increasing, while a reducing supply of water means most cities are now facing huge challenges in managing and delivering safe supplies of water to those living and working in cities. The United Nations predicts that global water demand will rise by 40% between now and 2020 and that this will be 50% higher in developing countries. In the UK, utility companies are experiencing losses of up to 27% of treated water due the poor condition of the water network. Smart water management solutions are a means by which water companies use technology to optimise performance, minimise disruptions and conserve water.

There is growing demand for smart water management solutions from the public, who expect utility companies to use technology to deliver better and more cost efficient service. The global smart water market is expected to be worth over $22 billion by 2020. UK water companies and utility companies have the ability to deliver and succeed in this challenging and growing market if certain barriers can be addressed. The success of these solutions relies on collaboration between multiple different stakeholders to ensure that funding models, developing innovation, trialling of solutions and setting common strategic visions for smart water solutions in the UK are addressed to ensure that the full benefits of smart water can be shared by all stakeholders.

2.1 Introduction

Water is an invaluable and critical resource for a city and as such poses a number of significant challenges for cities across the globe. In cities where drought or low precipitation is common, water needs to be conserved and managed efficiently and sustainably. Some cities face the opposite problem: heavy rainfall which brings flooding that overwhelms city infrastructure, damage homes and spreads water-borne diseases. These impacts will continue to increase with climate change.

The challenges ahead for the water sector are considerable. Population growth, increasing energy costs, water scarcity, climate change, water quality and the design and management of water infrastructure are some of the complex issues which are changing the market. The drive to provide better services at an affordable cost is challenging. Water utilities and vested stakeholders will need to use technological innovation to bring about much needed improvement to the water sector. These challenges also provide opportunities to those countries and businesses that are ready to exploit them.

Globally, utility companies which apply smart water solutions could save between $7.1billion and $12.5 billion each year from using smart water solutions[42]. These potential savings could be achieved through the use of smarter leakage and pressure management techniques of water networks, interpreting data which enables strategic capital expenditure management, smarter water quality monitoring and smarter network operations and maintenance in the water cycle.

[42] Water 20/20 Bringing Smart Water Networks into Focus, SENSUS 2012

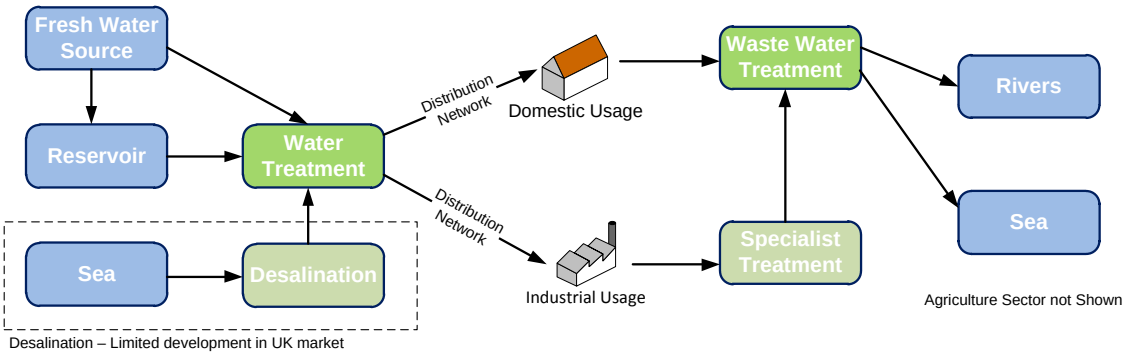

Figure 2.1: Water Value Chain Source: Arup

Figure 2.1 provides an overview of the water cycle from sourcing the water, to its treatment, its delivery to domestic and industrial users, to its final treatment before it is discharged back into the water course. (The agricultural sector is not shown).

Smart Water:

The context for 'smart water'- exists within the context of the water utilities market. The market potential for smart water solutions themselves is large but the application of these solutions provide a catalyst for further growth in traditional design and engineering services as well as new services. A smart water system is one in which technology manages the distribution and management of water resources, where advanced water treatment is present, where demand-side efficiency is enabled and where products improve water efficiency and food production.

There are a number of different views on what a smart water network is. Pike Research have based their valuation of the smart water market on the specific opportunity offered by the growth in smart cities (defined as the integration of technology into a strategic approach to sustainability, citizen well-being, and economic development), while Frost & Sullivan take a more holistic view of the sector and include the basic infrastructure (pipes/valves) and design services which will be required to be transform the network. Our definition of a smart water network is one which offers utilities an opportunity to improve both efficiency and customer service whilst reducing water scarcity. A smart water network is a fully integrated system where products and systems are integrated to enable water utilities and customers to:

- Remotely and continuously monitor and diagnose problems, to take pre-emptive measures to manage maintenance
- Use remote sensors to optimise performance
- Comply with waste water regulation and conserve water
- Reduce supply disruptions and improve customer service
- Manage water consumption more proactively and maintain price stability
- Provide users with intelligent information which enables them to make choices about their water usage.

The water utilities industry and smart water utilities industry comprises of numerous companies who provide a wide range of services and products for collection, treatment and monitoring of water and wastewater. These are provided and adapted for multiple purposes and end users. The water industry is highly fragmented and at utility services level, it is highly capital-intensive.

At present the water industry lacks an adequate holistic understanding of water supply, its use, and how it flows. A common theme across all of the water sector reform effort is a need for improved data collection and the transformation of that data to generate actionable information.

Agriculture has the largest share of the water market globally. In 2010, this was estimated to be 63.4% of the water industry's overall volume.

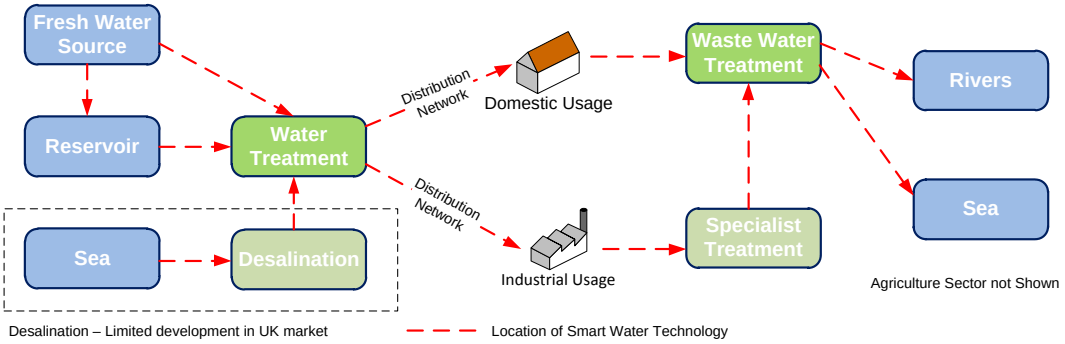

Figure 2.2: Opportunities for smart technologies in the water value chain Source: Arup

Figure 2.2 provides an overview of the water cycle where smart technology could be applied (primarily in the distribution systems) to enable a smart water network.

At present, a fully integrated smart water network does not exist in the UK or globally. The Cleantech Group i3 define 'Smart Water' as technologies that use water-related products and are integrated with IT solutions to enable automatic detection/analysis. i^2O, a water technology company based in Southampton, is selling an advanced pressure management solution which is recognised as the world's first. The system automatically optimises and remotely controlling water pressure in your network. Water utilities from Kuala Lumpur to London have used the pressure management solution from i^2O.

The OECD[43] note that innovative techniques and business models will be needed, to secure water-related services which will consume less water, reduce energy and capital requirements. The OECD state that the private sector will play an important role in this change and that public policies can go a long way to supporting the development and diffusion of innovation.

[43] Water Outlook to 2050: The OECD calls for early and strategic action. Dr. Xavier Leflaive, OECD Environment Directorate, Paris, 2012

Opportunities:

Due to the presently ineffective nature of water management systems worldwide, many experts believe that technology and smart water management are the only real way to enable the huge reductions to the present capital and operational running costs currently incurred by the utilities. The table below identifies areas where smart water management could reduce cost significantly.

Utility companies could save between $7.1billion and $12.5 billion each year from using smart water solutions[42]. These potential savings would come from changes in four key areas in the water sector.

Potential savings in the water sector	
Amount	**Water Sector**
$3,443m	Leakages and pressure management – reduction in leakage levels and exact detection of leaks, predictive modelling to estimate potential future leaks.
$4,348m	Strategic Capital Expenditure – improved dynamic assessment, maintenance, and replacement, planning and designing of network to optimise spending.
$431m	Water quality monitoring – automatic water sampling, testing and quality monitoring.
$1,557m	Network operations and Maintenance – Real time automated valve/pump shutoff to facilitate flow redirection and shutoffs; more efficient and effective workflow planning

Table 2.1: Global opportunities in the water sector Source: Water 20/20 Bringing Smart Water Networks into Focus, SENSUS, 2012

A leading international investment company, SAM, which focuses on sustainable investments, has identified four sectors of the water industry which show potential for growth[44]:

- **Distribution and management of water resources:** upgrading water mains and sewer infrastructure, developing systems for supplying freshwater and removing wastewater, companies who act as utilities or manage water resources
- **Advanced water treatment**: companies who treat and disinfect water or provide necessary control systems and analytical instruments
- **Demand-side efficiency**: products and services that boost the efficiency of water use in households or industry
- **Water and food**: products that improve water efficiency and reduce pollution in crop irrigation and food production

[44] SAM Study, Water: a market of the future 2010

2.2 Drivers

Global Drivers of Change

There are numerous drivers of change in the water sector. Each driver is influenced by geography, politics, history, climate and availability of funding. The motivation to improve this sector is being driven by a growing public awareness of a need to respect the environment and a desire to ensure that we can continue to supply water in an affordable and sustainable manner.

Access to clean water and sanitation: A major global priority, enshrined in the Millennium Development Goals, is to ensure that people living in developing and newly industrialised countries have access to clean drinking water and adequate sanitation. According to the UN, approximately 2.5 billion in developing countries still lack access to improved sanitation facilities and nearly 800 million people lack access to an improved source of drinking water. Massive investment by multilateral and bilateral institutions is being directed to improve this situation.

Poor condition of infrastructure: Utilities are facing a massive challenge with respect to ageing infrastructure. In the UK much of the water sector infrastructure that has been put into place over the last hundred or so years is in poor condition and due for replacement. Ageing infrastructure is more than a technical challenge; it is also a financial challenge. In 2001, the US based Water Infrastructure Network estimated that up to $1 trillion would be needed over a 20 year period to sustain the country's water and wastewater infrastructure[45].

In the UK, some utility companies are experiencing losses of up to 27% of treated water[46] due to the poor condition of the water networks. Water utilities globally lose an estimated $9.6 billion on leaked water annually. Of these losses: nearly $8 billion is attributed to wasted operational expenditures on water production. More than $1 billion spent on energy pumping are wasted. More than $600 million of chemical costs are spent on lost water. In addition to the $9.6 billion, approximately $2.5 billion is spent annually on leak detection efforts.

Yet due to the relatively low cost of water and significant cost to upgrade systems, most utilities are not incentivised to address this leakage issue. Under the latest performance regulations, half of the utilities companies operating in England and Wales will not be required to reduce their leakages rates before 2015, despite figures showing they have been losing more than 3.3 billion litres every day. While annual customer bills in the UK have risen at an average of £64 to £376 since 2001, Ofwat has reported that tougher action on leaks would mean even higher bills. Ofwat reported that 8 of 21 water companies had been set zero reduction of leaks targets to 2014/15.

Rising operating costs: A 2012 survey by Black & Veatch[47] found that the ageing water infrastructure network, managing capital costs, financing, increasing energy costs and expanding regulation ranked highest amongst the concerns of the water industry.

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45 Water Infrastructure Network, Clean & Safe Water for the 21st Century, A Renewed National Commitment to Water and Wastewater Infrastructure, April 2000.
46 www.bbc.co.uk/news/uk-17622837; how much does your water company leak?
47 2012 Strategic Directions in the U.S. Water Utility Industry: A Black & Veatch Report

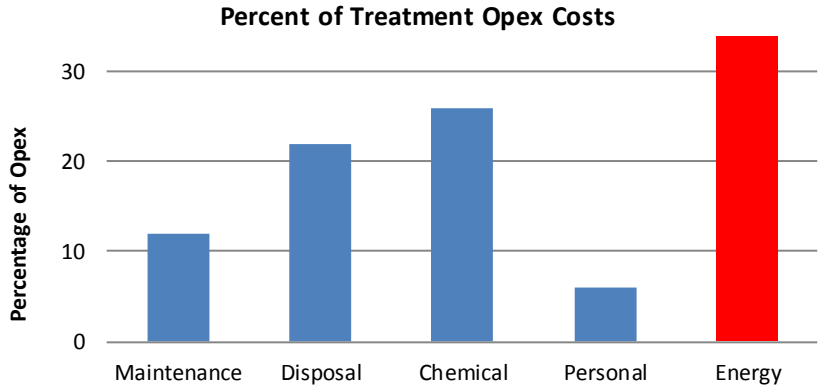

Table 2.2: Percent of Treatment Opex Cost Source: Dr. Mark Husmann, Pöyry Environment GmbH

Table 2.2 shows that the greatest cost for the treatment of water in Germany relates to energy requirements. Rising and volatile energy costs are key concerns for utility companies. According to the German Federal Environmental Agency, wastewater treatment facilities are the biggest single energy consumers of municipalities with a share of 20% of the total energy consumption.

Table 2.3, below, shows the energy costs in England and Wales as a share of operating costs have risen significantly over a six year period.

Energy as a cost factor in Water Treatment – England & Wales		
% of operating costs	**2003-04**	**2009-10**
Water & Sewerage	8%	13%
Sewerage	14%	24%
Sewage Treatment	27%	38%
Sludge Treatment	10%	6%

Table 2.3: Electricity as a cost factor in Water Treatment – England & Wales Source: Dr David Lloyd Owen

Drive for efficiency: Improving network efficiency, reducing energy costs have been identified by those operating in the water industry as their main goals.

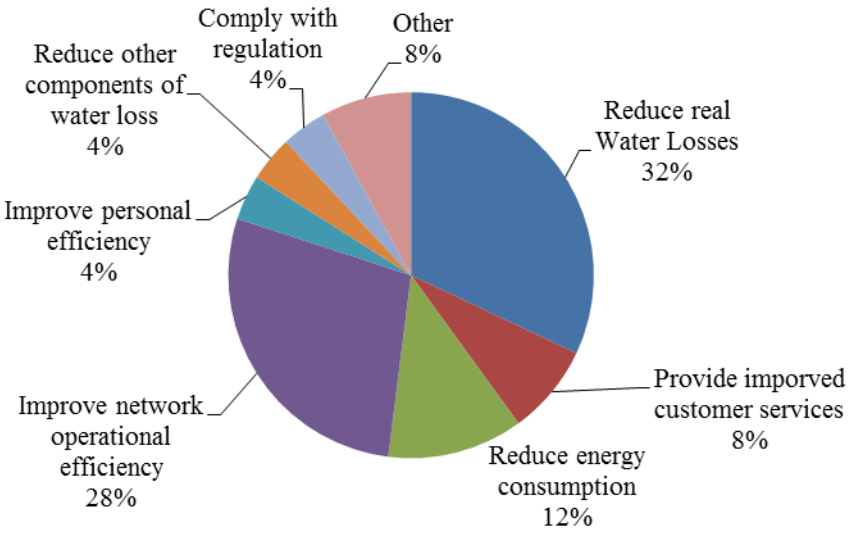

Figure 2.3: Key Goals In relation to Water Network Management Source: TaKaDu Ltd, 2012

Figure 2.3 shows survey results by TaKaDu where participants were asked, "In your role, what are the three key challenges related to water network management?" TaKaDu noted that almost half cited efficiency issues as the most significant one.

Increasing demand and dwindling supply: Demand for water is soaring, and not just to cater for the personal needs of individuals. In future, more water will be needed to produce food for the world's burgeoning population. The supply of freshwater is limited; however, its demand is growing rapidly. As water becomes scarcer, the cost of supplying water will increase. According to United Nations projections, global water demand will rise by 40% between now and 2020 and that this will be 50% higher in developing countries. As demand increases, utility companies will have to find more efficient methods of managing the water network and diversifying supply, such as through the provision of reclaimed water. In 2007, the UN identified the UK as a country which is vulnerable to water scarcity issues, particularly in the Southeast of England (see Figure 2.5).

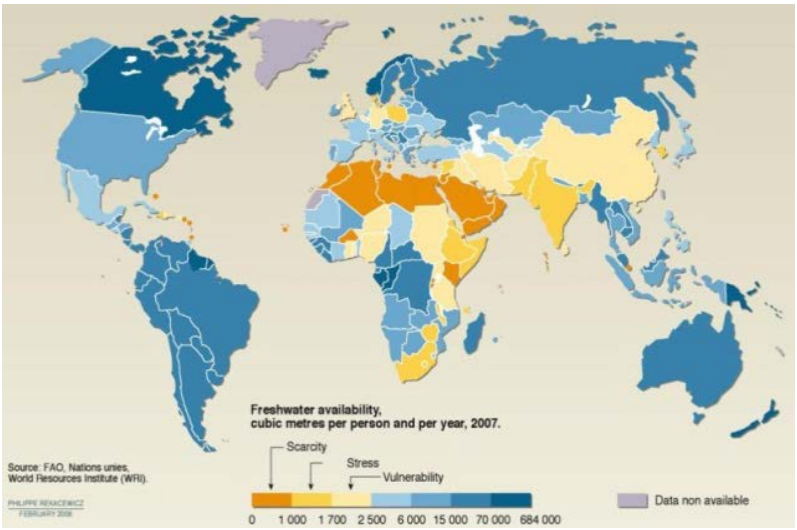

Figure 2.4: World Water Scarcity Source: Vital Water Graphics. UNEP

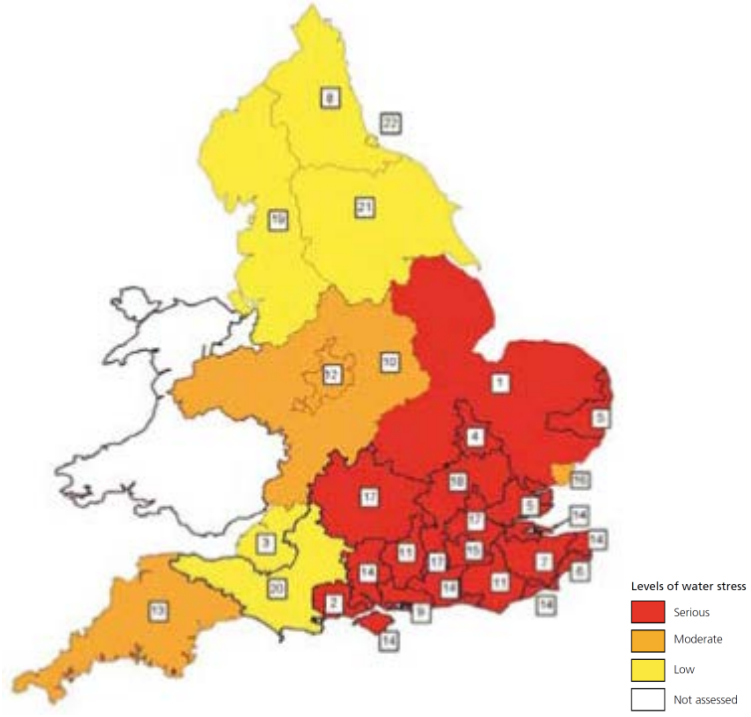

Figure 2.5: Water Stress in the UK - Source: Environment Agency, 2007

The State of Illinois is developing a $1bn Clean Water Initiative to be phased in over two years using State Revolving Funds and bond sales to upgrade its water infrastructure. It is estimated that the state of Illinois will spend $32bn over the next 20 years on their water network

The OECD[48] estimates that demand for water will increase by 55% globally between 2000 and 2050. The increase in demand will come from manufacturing (+400%), electricity (+140%) and domestic use (+130%).

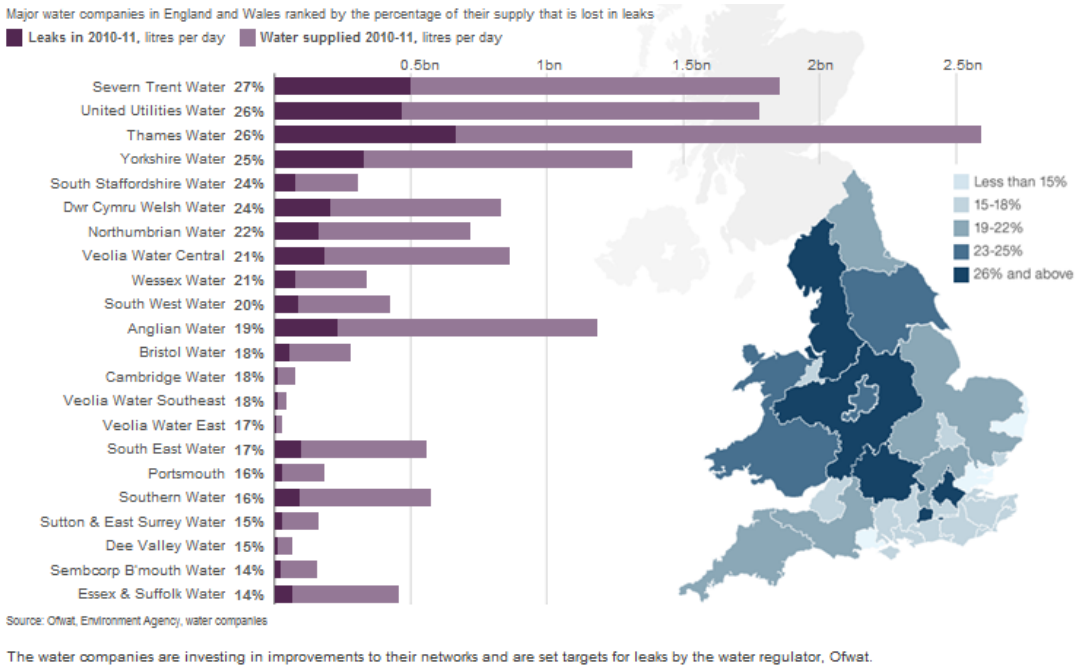

Figure 2.6: England & Wales Water Leakage - Source: BBC & Ofwat

Figure 2.6 shows the geographical regions in England and Wales where different water utilities operate and the leakage levels reported in these regions in 2011.

UK Water has noted that investment at the rate allowed from 2000 to 2005 means that it would take well over a hundred years to renew the entire network which clarifies that the present level of investment is not sufficient to manage the ageing network.

Climate change: Climate change is expected to cause significant variations in the hydrological regime of many regions, culminating in droughts and water crises in some areas. In other areas, climate change is expected to bring more intense and frequent storms and increase the risk of flooding and sea level rise, which combined may significantly overburden stormwater management systems.

The OECD estimates that the number of people at risk from floods is projected to rise from 1.2 billion today to around 1.6 billion in 2050 (nearly 20% of the world's population). The economic value of assets at risk is expected to be around €45 trillion by 2050, a growth of over 340% from 2010.

Increasing focus on micro pollutants: There is increased recognition that water utilities and regulators need to address the issue of micro pollutants, such as those from pharmaceutical and personal care products. Solutions need to be found to meet the emerging challenges arising from new micro pollutants that are becoming a problem in industrialised countries.

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48 Water Outlook to 2050: The OECD calls for early and strategic action by Dr. Xavier Leflaive, OECD Environment Directorate, Paris, 2012

Shifting water requirements: There is recognition that different uses may require water that meets different standards, and the industry needs to be able to match water supply quality (and quantity) to need. For instance, some commercial customers could use reclaimed water for certain uses, while some industrial customers may need water treated to the highest standard.

CSIRO Australia's Commonwealth Scientific and Industrial Research Organisation (CSIRO) is a national science agency. CSIRO research is enabling the water industry's transition towards integrated urban water management solutions in combination with climate change impacts. CSIRO believes that this integration has the ability to create a range of potential new public health, environmental, economic and infrastructure management issues which will improve the provision of services.

CSIRO research is developing and improving the utilisation of intelligent sensor network technologies for the water services industry. Sensor networks have the ability to improve safety, provide real-time information about water quality in drinking water and recycled water systems and enhance predictive control of network infrastructure degradation and risk of asset failure.

Regulatory and pricing reform: Water sector regulation is vastly different across the world, and depends largely on the institutional structure of the sector (for example whether utilities are operated by municipalities, quasi-independent corporations or are fully privatised). Water pricing is a highly contentious issue with significant socio-economic dimensions. In many parts of the world, water is seen as a basic necessity which should be provided at a free or low cost. Tariff regimes in which utilities only partly recover operating costs and lack capital to invest in asset replacement and renewal or system expansion, have led to mass underinvestment in the sector. Unlike the energy sector, tariffs generally aren't designed to encourage conservation through differential peak or seasonal pricing. Water utilities are required to keep up with ever increasing regulations and improve infrastructure; at the same time, they are restricted from passing these costs onto consumers. As a result, some rely on the public sector to plug holes in the financing. With recent austerity cuts, the focus is turning almost entirely to the utilities bottom line to finance projects and innovation. This means that water pricing models are now being examined on a whole new level in the UK.

Whole systems approach: Utilities are under pressure to take a more holistic perspective of water, considering its whole life cycle from abstraction to treatment, distribution, use and end treatment. This also means a stronger recognition of the role of green infrastructure and alternative mechanisms to manage stormwater runoff in urban areas.

Technology: The potential for service integration between utility sectors is enabling companies operating in the water industry to examine mechanisms by which technology and its usage can bring holistic improvements to the water network and bring potential reductions to their operating costs.

USA – Cities using Smart Water Technology

- DC Water had a 7% revenue increase after they installed a smart metering system and their call centre received 30% less calls.
- Leesburg, Virginia - 23% reduction in unaccounted water.

Source: Pike Research Smart Water Webinar 12th March 2013

Drivers of Change in the UK Water Industry		
Driver	**Trend**	**Water Sector Opportunity**
Technological Drivers		
Asset Base	Increased financial burden on maintenance. Ageing system not fully understood. Increased pressure through population growth and weather changes.	Improved asset management Provision of greater resilience to accommodate operational extremes. Greater resilience provided by more integrated approaches to the management of water.
Smart Technology	Cheaper sensors, potential for wider adoption and capacity within networks. Greater ability to engage with customers through real time interfaces. Technology enabling operators and providers to manage the sourcing, treatment and supply of water in a resource efficient and cost effective manner.	Wider adoption of real time technologies; water and wastewater. Potential introduction of smart meters.
Political Drivers		
Infrastructure cost review	Clear recommendation in the cost review what the UK needs to reduce the economic disruption of stop start investment cycles	Government looking to optimise work planning cycles in conjunction with Ofwat, DEFRA and water utility companies
Economic Development	Delivering an environment that supports economic growth	Fully integrating management across the catchment (£ per drop, how efficiently is the economy using water?) Delivering value through creative interventions across the water cycle (e.g. flood risk and regeneration)
Maximising resources	Full scale deployment of metering	Collect data which can be interpreted to promote and develop more efficient mechanisms of water supply and usage
Economic Drivers		
Competition	Increasing “noise” around competition in the water sector.	Liberalisation of upstream water markets Introduction of water trading
Funding	Growing pressure on availability of public sector funding. M&A in water is back on the agenda	Delivering wider value on investment Accessing private sector sources of funding More efficient delivery of capital investment

Customers (Value for Money)	Inequality and an ageing and changing population will lead to a more diverse customer base both in terms of demographics and in terms of their needs and expectations. Customers will have an increased understanding of the water cycle	Deliver operational efficiency savings; including energy and resources Manage the water cycle to deliver more sustainable solutions Look to join up interventions to achieve multiple benefits, adding value
Social Drivers		
Population Growth; increased water demand.	UK population likely to exceed 65m by 2018	Manage the water hierarchy, reduce per capita demand and manage existing resources and catchments better Look to local alternative sources to supplement demand and move water across catchments before looking to establish new resources.
Food and Water	Increased pressure within catchments on water resources Linking management of land and making space for water.	Delivering greater efficiency within systems Developing policy on energy and food that is aligned to the water cycle (e.g. links to water foot printing)
Social responsibility	Involvement of all water stakeholders to help manage and control water	More inclusive solutions to issues can be developed.
Environmental Drivers		
Climate Change Adaptation	Potential for more extreme events within the water cycle Increased stress on water systems	Provide resilience across the water cycle and within water systems
Flooding	Increased impacts of river and coastal flooding which can disable critical infrastructure including water networks and treatment plants	Flood risk management of critical assets Catchment and integrated responses to deliver cost efficient management of risk Opportunity created by management of the risk to socio-economic development
Energy & Carbon	Energy costs increasing New nuclear will come on line in 2025 and a huge rise in renewable generation is required to meet government targets	More efficient systems for managing the water cycle, looking at sustainable solutions within the wider catchment (reduce demand). Development of renewable energy sources Management of the land bank where appropriate Significantly reduce leakage

Water quality	Water Framework Directive looking to deliver good ecological status through sustainable interventions	Wider adoption of catchment wide interventions
Ecosystem Services	Increased recognition of the value of, and the benefits to, the economy of ecosystem services	Introduction of more catchment wide responses as a result of more transparent valuation of the role ecosystem services play in the environment

Table 2.4: Drivers of Change in the UK Water Industry Source: Arup

2.3 Smart Water Value Chain

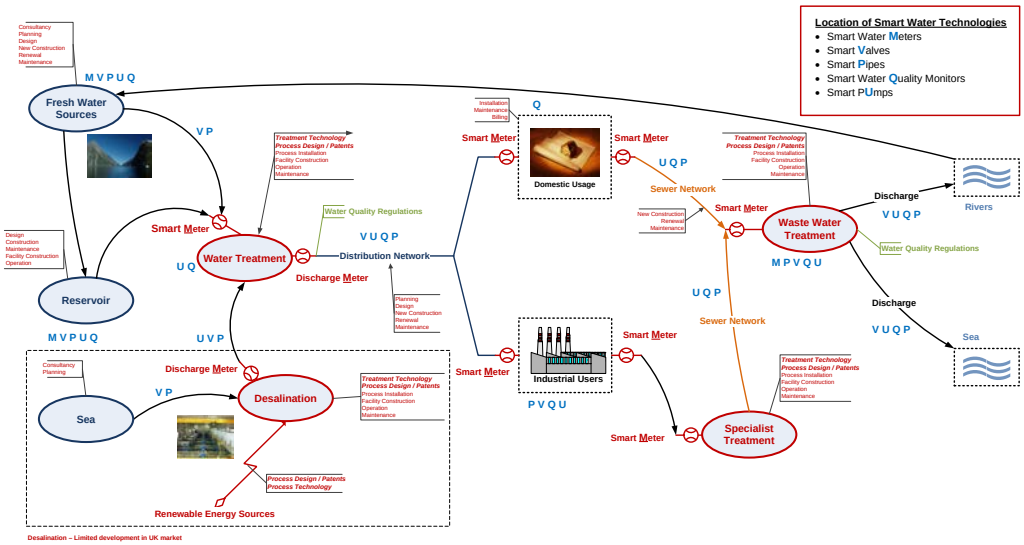

Figure 2.7: Smart Water Value Chain: Source: Arup

The illustration above provides an overview of the water cycle from water extraction, to its initial treatment, its delivery to domestic and industrial users, to its final treatment before it is discharged back into the water course. (The agricultural sector is not shown). It indicates where 'Smart Technologies' could be applied along the water distribution network.

Smart Water Companies, Customers & Clients

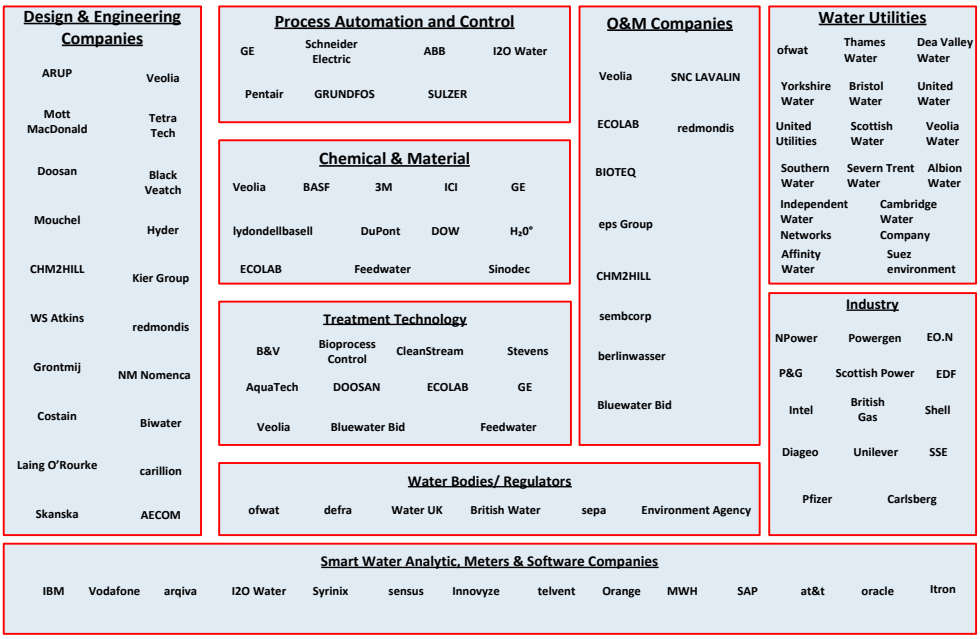

Figure 2.8: Smart Water Companies, Customers & Clients Source: Frost & Sullivan & Arup

Figure 2.8 denotes various different companies which operate in the different sectors in water industry.

Design & Engineering Companies: Develop waste strategy, policy, environmental compliance, design and manage procurement processes. These companies advise utilities, city councils, Governments, O&M companies, water bodies and industry. The goals of these companies is to design and build water networks and systems which are optimally designed, incorporate best practises to reduce leakage and breakdowns, improve quality of life, lower emission and increase efficiency of treatment plants. UK companies operating in this field are highly regarded globally.

Process/Chemical/Treatment Companies: Provide products/technical and financial feasibility studies, design of systems into project, liaise with vested parties to ensure their products integrate into overall design, commissioning of networks and facilities.

O&M Companies: Procure technologies for their water treatment facilities, operate and maintain the facility, finance the facility, responsible for performance of facility. Their products are aimed at making the water sector sustainable through the use of more advanced technology, some of which is smart technology. These companies will play a vital role in the development of smart water technologies.

Water Utilities: In the UK, 34 privately-owned companies provide water, sanitation and drainage services to 50 million household and non-household consumers in England and Wales. These are the key buyers in the ‘smart water’ market. Water utilities will come under increasing pressure from either end of the business spectrum, Ofwat and the businesses and public they supply to use better technology to improve efficiencies and reduce leakage.

Industry: These are companies which required large volumes of clean water from utility companies. These can have a huge influence on regulators and public regarding their use of new smart technologies and best practices.

Smart Water Analytics: These are companies which provide advanced analysis services of the water network along with information management, technology services, and business consulting capabilities. These are the key sellers and potentially the innovators and integrators in the ‘Smart Water’ market. The products/systems produced by companies operating in this sector aim to optimise water network management, improve supply and reduce leakage. These companies are at an early stage of being able to define which data they need to collect on the water network and how they can interpret it to develop smarter ways of managing the water network.

Water Bodies/Regulators: These bodies govern the water sector, the bodies whose laws have to be upheld by the water companies. The utility companies have to report to Ofwat.

2.4 Market Size

The value of the smart water market is considerable and estimated to grow at a rate of 20% per annum between now and 2020. It is estimated that the market will be in excess of $22.2 billion by 2020[49], four times greater than its present value This valuation of $22.2 billion includes an estimation of the smart technologies which will be used and directly affect the rest of the water industry. The valuation includes the amount which will be spent on innovation, on design consultancy and engineering services, on infrastructure development and installation, software and analytics and on automation and control to bring about smart management of the water sector. It includes all major sub sectors of water, where smart applications will be used to install technologies such as smart metering, development and installation of sensors and communication equipment.

This valuation of $22.2 billion by 2020 also considers ancillary industries and services, which will directly influenced by the investment in smart water solutions. These services include traditional services in the water network such as pipe network design, placement of new pipes, installation of new smart infrastructure, development of new software services, and integration of new technologies into legacy systems, development and deployment of data analytics which will interpret live data on rivers and reservoirs which will enable smart management of water within cities.

Our research has shown that the valuation of the smart water market varies depending on what sectors and degrees of infrastructure are considered. Different research experts such as Pike Research, Frost and Sullivan and IDC Energy Insights have different valuations for the smart water sector, which we discuss below.

Pike Research has based their valuation of the smart water market for cities on the use of technologies which use a smart layer of technology. These include technologies which have been developed to provide integrated network monitoring and management services, improve asset management to achieve longer design life of plant and equipment, enhance leak detection, provide real information to utility companies on water flow in river and sewerage systems[50].

Eric Woods, Research Director with Pike Research, noted when evaluating the transport sector that “differences in valuations in the smart transportation market reflect the difference in scope of the forecasts and also how they are related to the smart city concept. Three key distinctions can be made:

- The total spend on ‘smart’ transportation technologies and services
- The total spend on ‘smart’ transportation relevant to cities
- The market related specifically to smart city investments”.

[49] Unearthing the REAL value of water and the Industry, Fredrick Royan, Frost & Sullivan, Nov 2012
[50] Smart Cities by Pike Research, 2013

The same logic can be applied to the 'smart water' industry.

The valuation by Pike Research considers the investment likely to be made in smart water related to innovation and technologies which will be used in cities only. Other valuators (Frost and Sullivan and IDC Energy Insights) consider the wider aspects of the entire water network. This valuation by Pike Research can be described as the 'seed' money required to release the much wider potential of smart water solutions. These include the opportunities which the development and deployment of smart technologies could bring and the additional services and infrastructure required as a result of their deployment.

Pike Research - Smart City Technology Annual Revenue - Global Water: 2012-2020				
Water	**2012**	**2015**	**2020**	**CAGR (2012-2020)**
North America	$351m	$461m	$822m	11.2%
Europe	$108m	$132m	$239m	10.4%
Asia Pacific	$16m	$44m	$152m	32.2%
Latin America	$1m	$1m	$2m	8.6%
Middle East & Asia	$11m	$14m	$31m	14.6%
Total	**$ 487m**	**$ 653m**	**$1,246m**	**12.5%**

Table 2.5: Smart City Technology Annual Revenue - Global Water: 2012-2020 Source: Pike Research

The Pike Research report expects major growth in Asia/Pacific. Most of this is expected to take place in China. The high growth is due to their low starting point in using technology and the huge scale of development anticipated in China's Tier 2 and 3 level cities. Eric Woods, Research Director with Pike Research, noted 'The broader opportunities in Smart Cities could be 10 to 20 times greater than those noted in Smart Cities 2013 Research Report by Pike Research' and 'innovation after investing in smart ventures will open new possibilities'.

The European water utilities industry is forecast to be valued at $277.9 billion[51] in 2015. At present the UK has approximately 15% to 16% share of this market. The UK has the single largest individual market value. Based on this evaluation of the water market and the estimations provided by Pike Research for Europe, the application of smart technology in the water market in the UK could be worth $21m in 2015. Pike Research have based their valuation of the smart water sector on such technologies can help detect leaks, improve maintenance, and increase the efficiency of water use and waste treatment.

Smart City – Application of Smart Technology Annual Projection: 2012-2020				
Water	**2012**	**2015**	**2020**	**CAGR (2012-2020)**
UK	$17m	$21m	$38m	10.4%

Table 2.6: Smart City Technology Annual Revenue – United Kingdom: 2012-2020

[51] Water Utilities in Europe, Datamonitor, 2011

Global Water Utilities Industry: The water utilities industry consists of all water that is collected, treated and distributed to agricultural, industrial, and residential end-users. The global water utilities industry grew by 4.9% in 2010 to reach a value of $657 billion. In 2015, the global water utilities industry is forecast to have a value of $824.3 billion, an increase of 25.5% since 2010. Source: Global Water Utilities, Datamonitor 2010

IDC Energy Insights estimates that the worldwide utility industry for smart water technology spending will reach $3.3 billion by 2016, experiencing a CAGR of 18.7%. IDC Energy reports that this is a significantly higher growth rate compared with worldwide water utility IT spending, which will grow at a CAGR of 5% during the same time period[52].

Fredrick Royan, Research Director for Global Environment (Water) Markets at Frost & Sullivan estimated that the Smart Water Grid market was worth $5.8Billion in 2010 and that this would quadruple by 2020 to $22.2 billion[49].

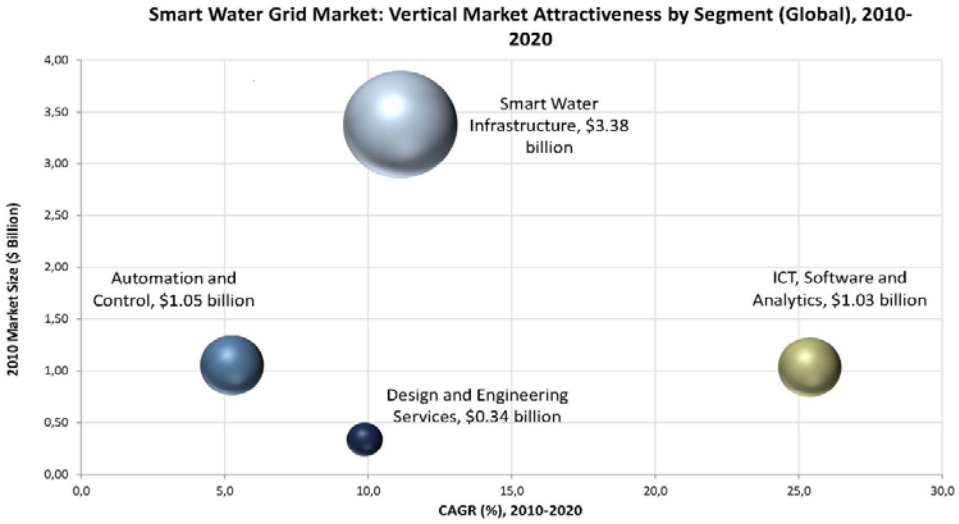

Figure 2.9: Unearthing the real value of water and the Industry - Source: Frost & Sullivan

Figure 2.9 provides a breakdown the water market into four segments, indicating the value of Design and Engineering, Automation and Control, Smart Water Infrastructure and ICT, Software and Analytics. Frost & Sullivan predict that between 2010 and 2020 the Smart Water Infrastructure will be considerable larger than any other sector and that returns in ICT, Software and Analytics with be around 25%. Analytics, the collecting and interpreting of data (Big Data), forms part of a market estimated to be worth $1.03bn in 2020.

52 www.smartgridobserver.com/n10-18-12-2.htm

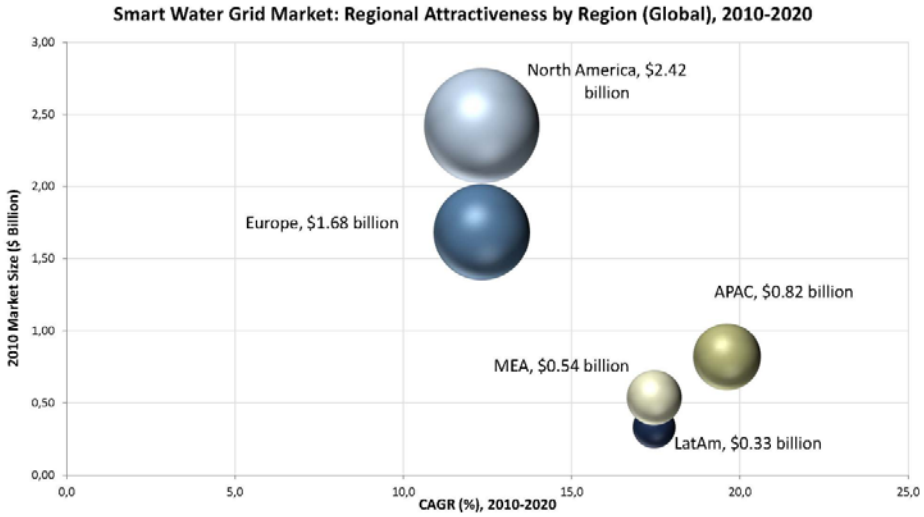

Figure 2.10: Unearthing the real value of water and the industry - Source: Frost & Sullivan

Figure 2.10 breaks down the water market into five geographical regions. The largest markets will be those in Europe and the U.S.A, while Asia and the emerging markets in Latin America, and Africa will yield return between 15% and 20%.

2.5 Route to Market, Market & Technology Trends

Route to Market: The route from most innovation comes from R&D. There are some great examples of UK based companies, developing products and capabilities and then selling them on a global market. Talking to a number of companies which operative in the innovation sector, there was consensus that not enough was being done by both UK government, utilities and SMEs to develop smart water technologies in the UK.

One SME interviewed felt that regulations in the UK meant that water utilities were conservative and risk averse. The SME noted that there were structural regulations which mitigated against water utilities using innovative means of managing their network. The company was able to gathered more traction, faster, aboard than in the UK and were able to establish a presence aboard before engaging with utility companies in the UK. Another SME noted it is easier to grow UK innovation overseas, where there can get more support from foreign utility companies. SMEs noted that they could not demonstrate new technologies to a level of reliability or performance which clients demanded in the UK, which led to clients (utility companies) being reluctant to specify them.

One leading water utility company felt that water utility companies were incorrectly demonstrating the requirement for innovation in the water sector and therefore did not apply to Ofwat for permission to innovate. The result of this was a lack of funding in innovation and the development of UK based technology on the home market.

Both SMEs and utility companies felt that the lack of testing and approval of UK based technology meant that internationally qualified technologies were being used in the UK market. SMEs noted that it was hard to continue funding

operations during the lengthy testing period. This placed a huge strain on their financial reserves of SMEs.

Adoption: The smart water technology would be considered to be in the early adapters stage, with countries like Israel, Australia and Singapore leading the way. Many new technologies have to be developed and installed before the any network can be recognised as being a fully smart network.

Water utility companies have been slow to adopt new technology in the UK. This is due to a number of issues; a lack of understanding of what benefits the technology will bring (tangible and intangible benefits), lack of available funding; lack of incentives being provided and no direct requirement from the Government requiring technology to be used to improve the network.

Approximately 65% of respondents to a SENSUS survey[42] cited a business case that fails to be compelling as a 'significant' or 'very significant' barrier to adopting smart water networks, while 74% and 62% of respondents said even given a compelling business case, lack of funding and of political support, respectively, would be challenges to adoption.

The water sector is one in which capital efficient investment opportunities are increasing. The small amounts of money being invested in the water and smart water industry demonstrates investors' fears of entering the water utilities market. Investing in the water sector requires a long term approach. Time is required to design and develop concepts before carrying out small scale and then full scale trials to prove their worth. Treatment technologies have long development cycles and potentially large capital requirements which discourages investors.

Useable data: Water utilities want to move from billing data to actionable knowledge. This is where water utility companies read more than that monthly or quarterly meter readings. This actionable knowledge enables a fundamental understanding of a customer's usage of the utility service. This information then allows companies to adjust their system management to provide a more efficient service. Smart water meters are in development. Knowing what information to collect, and how to interpret this information to maximises resources and efficiencies is still a couple of years away from being understood

Evolution of Smart Water Value Emphasis: Global & UK

Figure 2.11: Evolution of Smart Water Value Emphasis: Global & UK, Source: Itron

The UK is perceived to be at the first stage of the implementation of smart water technology.

Roll Out: The condition of the water infrastructure network needs to be improved before any smart water technologies control and operate the network. The network needs to be reduced into more manageble sections, damaged infrastruture removed, sensors and controlled valves installed. This is occuring on a picemeal rate at present and in most intances the upgrade works only take place after sections of the network have failed. Having a network which is in order would allow water utilities to upgrade infrastructure to a level which enables utilities to

carry out analysis, and then decide on further changes to the systems so as to enable the best returns. This has to be done on a stage by stage basis.

A smart water system will not be able to provide the stakeholders with all the necessary information on day one. Utility companies will not have the analytical experenice on day one to disect the data they receive. It may take up to three years to accumulate data (a comprehensive sample set). Only then will utility companies be able to predict and plan for opportunities to evolve and improve the network. After the intitial instalation and subsequent collection of data, a bedding in period would be required, (estimated to be between 3 and 5 years), utility companies would only then able to link and integrate into other systems, which is then considered to be a futher 5 to 10 years away. The smart water process and its development could be compared with the development of mobile phones, where the phones were allowed to develop as more functional mobile phones before developing and integrating into mini computers, etc.

Investment: The total revenue in 2011-12 of the water utilities in England and Wales was almost £10 billion. Only £12.7 million was spent by water utilities on innovation[53]. This equates to 0.13% of their revenue, which is significantly lower than those of top R&D companies.

Yorkshire Water noted that they spend on average 0.7% of their turnover per year on innovation and will spend £32million on innovation over the current AMP5 (5 year) period. They expect to generate returns in the order of 5:1 on this current investment.

James Kitson, Innovation Delivery in Yorkshire Water noted that 'Innovation has not been the main focus of water utilities since privatisation, however, water utilities are now recognising the value of innovation in the sector and the need to deal with long term water issues (25years +)' and 'Ofwat are proactive on matters relating to innovation, water utilities still have to present a strong business case for their investment in innovation, before gaining approval from Ofwat'."

UK 1,000 R&D-performing companies	No. of Companies	R&D expenditure (£m)	Average R&D spend per company (£m)	Turnover (£m)	R&D spend as % of turnover (%)
More than £5bn	54	13,755	255	1,161,781	1
Between £500m and £5bn	187	6,282	34	280,921	2
Between £50m and £500m	340	3,734	11	67,828	6
Less than £50m	419	1,491	4	7,167	21

Table 2.7: The 2010 R&D Scoreboard Source: BIS, 2010, Table 7, Page 32

[53] www.cleantechinvestor.com/portal/watertech/11350-innovation-in-the-water-sector.html

Lack of Venture Capital Investment in Water: Venture capitalists have identified business growth opportunities in the water market that seem obvious. The water market is:

- large and expanding
- in need of innovation and increased efficiency
- deeply enmeshed with energy usage
- in urgent need of a variety of new technology approaches

However, venture capitalists are of the opinion that they can't make sufficient returns; due to the length of the product development and implementation, the regulatory burden, and the market fragmentation. VC's have identified main players in water are large conglomerates like GE, Veolia, Siemens and realise that these companies dominate the market. Water is a €650 billion a year industry but it is only attracting around €105 million a year in venture capital funding according to Global Water Intelligence. This value is growing, but venture capitalists are reluctant to invest due to the size of the fragmented water industry and they have found it hard to identify opportunities which offer them appropriate economic returns. Returns by water utilities in the UK at present are in the order of single digit percentages, which may not suit their funding requirements.

Similar to other smart and Cleantech sectors, investment in water treatment technology requires patience. The product development stage is long and can potentially require large amounts of capital. This makes it unattractive to venture capitalist. Innovation in treatment technologies will continue through the advancement of IT-based technologies that will bring further efficiencies in existing systems.

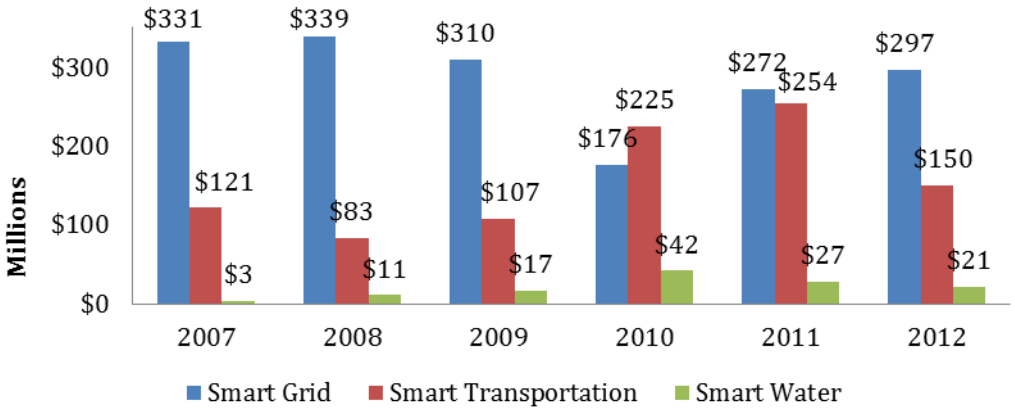

Table 2.8: Breakdown of Smart Investment: Source: Cleantech i3

New technology in the smart water sector will need to have:

- SCADA (supervisory control and data acquisition) which will allow modern controls and monitoring systems to interoperate with old, legacy infrastructure.

- To use analytics to model and to predict behaviour, where absolute measurements aren't possible but where probabilistic approaches can be used (e.g. leak detection)
- Use of real time data flows and analysis to enable much more prompt reaction (e.g. to stop pollution before its significant, etc.)
- Use of sensors to automate quality monitoring, again perhaps in real-time, to improve operational economy.

2.6 What is happening in the market

The following countries, cities and examples referred to in this section provides an overview of the contextual currencies which are affecting water and development of smart water on a regional and country basis. They are intended to highlight new and best practises around the world in smart water and water management.

Global: A 2012 report by SENSUS[42] on smart water, noted that gaining sufficient political support was a constant issue which was inhibiting the advancements of smart water networks globally. SENSUS noted that higher-level utility executives (chief operating officers and chief executive officers of water utilities) should be targeted for decision making and that key decision makers in utility companies needed to be convinced of the potential for smart water network solutions. SENSUS also reported that it was vital to have someone champion the cause within organisation. To change publicly owned water utilities, political support is required. Engagement is vital with local councils and politicians to help them understand how investment in water infrastructure helps the entire community. In the USA, city councils and mayors are seen as key stakeholders who need to be influenced.

Europe: In the European Union, the Water Framework Directive (2000/60/EC) is based on the idea that modern water management needs to take account of ecological, economic (including pricing) and social functions throughout the entire river basin. A mandate was issued to the European Standards Organisations (CEN/CENELEC/ETSI) in March 2009 to:

Figure 2.12: EU Countries

- Create European standards that will enable the interoperability of utility meters (in electricity, gas, water, heat)
- Permit fully integrated solutions, modular and multi-part solutions
- Ensure that its architecture is scalable and adaptable to future communications media
- Allow secure data exchange

Europe's Water Framework Directive requires countries to pursue water charges that reflect their costs and heavily promotes water efficiency. These policies in

Europe have reduced interest in metering from European regulators and governments[42].

UK: The water industry in England & Wales is divided into 10 regional Water and Sewerage Companies and 11 Water only companies. The industry was privatised in 1989 and the companies are now a mix of publicly listed and privately owned. The UK water utilities industry worth $36.6 billion in 2010 and this is expected to be worth $38.2 billion in 2015.

According to the UKTI the water industry in the UK comprises over 500 companies, employs around 80,000 people and generates over £3 billion of overseas business each year. Moreover, it:

- Provides 18,000 million litres of water every day to 58 million people
- Has 397,401 kms of water mains and 354,066 kms of sewers
- Has around 2,250 water treatment works and 9,620 sewage treatment works
- Carries out over 2.8 million water-quality tests every year.

In their 2012 report 'Smoothing investment cycles in the water sector', HM Treasury acknowledges that investment in the water industry has been cyclical since privatisation. The report denotes that cyclical nature of investment has led to a stop-start cycle developing within the water sector supply chain. It also leads to uncertainty and loss of productivity in the sector potentially costing 20,000 to 40,000 jobs in the industry.

The 2011 Government White Paper, "Water for Life"[54] describes the UK government's vision for future water management. The UK Government wants to make the sector more resilient and make companies operating in the industry more efficient and more customer focused through the better use of information technologies. The report denotes the importance of smart water metering and recommends that Ofwat establish a group to advise on the costs and benefits of intelligent metering. It also makes reference to possible synergies with the roll out of smart energy meters and notes the potential benefits which the use of smart water metering could bring by making the water system better managed and more sustainable.

Ofwat report that at present around 40% domestic properties in England and Wales are metered. Water companies in parts of the country which the Environment Agency has classed as 'water stressed' (refer to Figure 04), penetration is expected to reach at least 80% for most companies by 2020 and 90% by 2030.

[54] Water for Life – HM Government, Defra, December 2011

Government's Water White Paper and its impact on water companies:

The White Paper is intended to advance Defra's commitment to reforming the water industry; to enhance competition, improve conservation and to protect poorer households. The White Paper focuses on:

- Reforming the water industry to be innovative, efficient and customer focused
- Increasing the resilience of water supplies to future pressures such as climate change
- Ensuring bills are affordable in the future
- Considering the introduction of universal smart metering
- Reducing water wastage through leakage management
- Encouraging more responsible use of water - this needs to be developed through Building Control and further education of end users.

Responsibilities for Water Regulation:

- Ofwat introduced the Overall Performance Assessment (OPA) in 1999 to provide a comparative overview of company performance. In England and Wales activity in the sector is currently driven by the Ofwat five-year periodic reviews. Ofwat agrees an Asset Management Plan (AMP) with each of the water utility companies. This sets the price limits that consumers can be charged based on the costs of delivering the company's business objectives. AMP5 covers the period 2010 to 2015 and has established capital and operational expenditure across the sector of approximately £5bn per year for the period.
- The Department for Environment, Food and Rural Affairs (DEFRA) manages all aspects of water policy in England, including water supply and resources, and the regulatory systems for the water environment and the water industry.
- Environment Agency has responsibility for regulation of industrial pollution controls and is charged with preventing deterioration of water quality, seeking its improvement.
- The Drinking Water Inspectorate has responsibility to ensure that water utilities fulfil their statutory requirements for supply of wholesome drinking water.

North America: The water utilities industry in the United States was worth $156 billion in 2010 and this is expected to be worth $202 billion in 2015[55]. SENSUS reported that the existing regulations in the USA were not adequate for reporting and provide little incentive for water utility companies to adopt smart water technologies[42]. Water utility companies referenced the Energy Act of 2005, which instigated the development of the electrical smart grid in the U.S, and that a similar approach in the water sector may prove productive.

55 Water Utilities in the United States, Datamonitor, 2011

SENSUS noted that there is a lack of regulatory support for smart water networks and gaining political support to develop this market is required. Regulators are not in a position to either make key decisions or influence decision makers in relation to smart water. Utility companies in the USA have noted that regulatory support and incentives are critical to kick-start smart water management.

China: The Chinese water utilities industry was worth $49.3 billion in 2010 and this is expected to be worth $58.6 billion in 2015[56]. In comparison the UK water utilities industry worth $36.6 billion in 2010 and this is expected to be worth $38.2 billion in 2015. In Asia huge growth is anticipated in the smart water sector and in particular China. The high growth is due to their low starting point in using technology and the huge scale of development anticipated in China's tier 2 and 3 level cities. China has recently focused its attention on improving drinking water standards and wastewater treatment. In 2006, China's drinking water regulation was updated to those of the EU. Meeting these standards, however requires significant investment in Chinese water infrastructure, including upgrades to advanced water treatment technologies and rehabilitation of the water distribution network[42].

In 2011, a UKTI Water Sector Report on noted that the water market in China is big and demand is increasing year on year. Foreign investment in municipal utilities has been encouraged in order to improve efficiencies and reduce cost to local communities. UKTI advises companies to research the Chinese market and supply chain fully before entering. UKTI also advise UK companies on getting legal and financial advice before undertaking work in the country[57].

Only 70% of Chinese cities have wastewater treatment facilities. Many of its counties and towns are without sanitation services. As a result, 70% of China's lakes and rivers do not meet safety standards for human use. China's expanding urban demographics require modern sanitation services and access to drinking water: a challenge when 35% of untreated wastewater is discharged into drinking water sources.

Singapore: The Singaporean water utilities industry was worth $400.7 million in 2010 and this is expected to be worth $406.4 million in 2015[58]. Singapore has no natural aquifers or huge land mass to collect water and have been working on having a sustainable approach to water since their separation from Malaysia in 1965. Singapore's water challengers are being solved through the use of technology and integration of services. Singapore has been referenced as a model city for water management.

PUB - Singapore's National Water Authority

PUB (Public Utilities Board), has 158 water level sensors located around Singapore for monitoring of the drainage system. These water sensors provide data on water levels in drains and canals, which enable PUB operatives to forecast capabilities and potential response time for flash flooding. Using a number of different initiatives Singapore has been able to better manage its water network:

NEWater: High-grade reclaimed water is produced from treated used water which is further

56 Water Utilities in China, Datamonitor, 2011
57 Water Sector Report China, UKTI, 2011
58 Water Utilities in Singapore, Datamonitor, 2011

purified using advanced membrane technologies and ultra-violet disinfection. NEWater meets 30% of the nation's water needs.

Desalinated Water: Singapore has one of Asia's largest seawater reverse-osmosis plants, accounting for 10% of Singapore's water needs.

Reservoir in the City: Singapore has been creating reservoirs. The Marina Reservoir was formed in 2008 from the damming of the mouth of the Kallang Basin. These reservoirs have often formed part of greater developments which have helped develop the city state, such as the Marina Bay Sands Resort and Gardens by the Bay. In the case of the Marina Reservoir, it provides added protection against tidal flooding

Used Water Superhighway: Singapore has a network of tunnels to take wastewater from the northern and eastern parts of the city state to a centralised treatment plant where it undergoes NEWater treatment. The tunnel network is 48km long.

Israel: Israel's water demand outstrips their available conventional water resources. Rain falls only in the winter, predominantly in the northern half of the country. Irrigation and water engineering are seen as integral to the country's economic survival. A long drought between 1998 and 2002 led the Israeli government to build large-scale seawater desalination plants. Israel relies heavily on unconventional water resources, such as reclaimed water and desalination.

The Israeli government acknowledges that the country resides in an area suffering from a shortage of water. Israeli has managed, in collaboration with the private sector, to make full use of its limited water resources to develop a growing environment which compares to water-rich countries.

The development of their desalination program, the development of polices which promote and encourage the new of technology in the water sector, have led to Israel becoming a recognised world leader in water technology in a very short period of time.

Mekorot

Mekorot is Israel's national water company. It supplies Israel with 90% of its drinking water and operates the national water supply network known as the National Water Carrier.

During the 00's, Israel faced a growing challenge of managing its own water supply. Increasing demand, decreasing supply and growing energy costs were seen as challenges which the water network had to overcome in Israel. With the backing of the state government, Mekorot founded WaTech. Mekorot hoped that through developing technology and innovation in the water industry, WaTech would enable it to overcome Israel's water issues. Watech provides funding to help develop start-up companies in the water industry which nurtures innovation. Since founding WaTech in 2005, Israel has rapidly established itself as a world leader in water technology and innovation, exporting its technology and engineering services to numerous countries around the globe.

Mekorot has benefited from the establishment of Watech. Mekorot receives reduction on the costs of buying the developed technology developed through Watech supported companies. Mekorot also receives royalties, referral commissions and options from work carried out by Watech supported funds. Mekorot, WaTech and its subsidiaries have partnered with numerous countries around the world to solve water management issues.

Brazil: The Brazilian water utilities industry was worth $26.9 billion in 2010 and this is expected to be worth $46.5 billion, in 2015[59]. A 2011 report by UKTI[60] reported that increased government funding and changes in policy by the Brazilian Government in the water industry has encouraged companies in Brazil's water and sanitation sector to look at partnering opportunities on applicable technologies and products as a way of bringing in technology whilst minimising risk and capital investment.

The report also noted a perception of a knowledge and technology gap for sewage treatment in Brazil. The report concluded that there are three aspects of the water industry which need to be addressed in Brazil:

- Better planning and co-ordination
- Identification of appropriate projects for investment
- Ensuring that the re-engineering is appropriate and effective

Brazilian – Water Sector (UKTI Report)	
Industry Size	£2 billion p/a & 100 organisations
Industry Structure	State and large private organisations concentrated
Growth (5-year trends - output & investment)	15 to 20% per year
Short to medium term outlook	Very healthy for the supply chain
Main strengths	Strengthening legislation, policy and CSR
Gaps identified	Technology, skills, equipment, capacity to deliver

Table 2.9: Brazilian Water Sector Source: UKTI

On 05/03/2013, Brazil's President, Dilma Rousseff stated that Brazil would invest US$12.1 billion in waterworks projects to expand the potable water supply in the Northeast region. The Brazilian Government is keen to attract investment in PPPs and sees this as a stimulus to the country achieving the infrastructure development needed over the next two decades. Brazil's legal framework for Brazilian PPPs provides opportunities for UK environment and water companies and their professional advisers and lenders.

However, UKTI noted that some caution is still required since:

- Government officials need to be educated on the financing, management and operation of PPPs
- The legal system in Brazil is laborious and extremely slow.
- Standardising of legal documents is required.

[59] Water Utilities in Brazil, Datamonitor, 2011
[60] UK Environment and Water Opportunities in Brazil by UKTI, 2011

Australia: The Australian water utilities industry was worth $10.8 billion in 2010 and this is expected to be worth $16.7 billion in 2015[61]. In comparison the UK water utilities industry worth $36.6 billion in 2010 and this is expected to be worth $38.2 billion in 2015. Agriculture is the largest segment of the water utilities industry in Australia, accounting for 75.2% of the industry's total volume.

Australia is the Earth's driest inhabited continent where droughts are common, along with water shortages and resulting water restrictions. The Australian Government's Water Smart Australia Program has provided $1.5 AUD billion (£1billion) to fast track the development and uptake of smart technologies and practices in water use across Australia. The program also assists to advance the implementation of the National Water Initiative which is Australia's blueprint for national water reform.

The Australian water utilities industry is dominated by public-sector corporations, whose revenue streams may include state subsidies. For private-sector players, it is not possible to compete directly for end-user customers; instead, companies must usually bid for contracts to supply all customers within a geographical region.

FCubed

FCubed are an Australian company that have developed 'Carocell', a solar desalinating / purification technology which is extremely efficient and cost effective. Carocell solar desalination technology produces pure, clean drinking water on any scale from any water source. Carocell direct solar desalination technology emits no greenhouse gas emissions, uses no chemicals, no costly membranes, no filters, no electronics and no ongoing power source is required other than solar radiation. Carocell has been independently tested by ARUP who found Carocell to be almost twice as solar efficient as comparable products. When combined with ZLD, Carocell is also significantly cheaper than commonly used reverse osmosis technology. Source:Arup

[61] Water Utilities in Australia, Datamonitor, 2011

2.7 UK Strengths, Gaps, Opportunities and Barriers

Strengths:

The water industry is extensive and the UK has numerous experts in technology, consulting, engineering, legal and financial sector. These companies work on international projects providing products and services to deliver these important projects. Listed below are some of the sectors in which UK firms are able to offer their services:

UK Capability and Strengths in the water industry		
Regulation	Finance	Public Private Partnerships
Business Structure	Operations	Development and construction financing
Regulatory advisory work	Privatisation Advice	Feasibility Studies
Manufacture/Construction	Design Services	Dispute resolution
Competition	R&D	Mergers and Acquisitions

Table 2.10: UK Capability and Strengths in water

Gaps in UK supply chain:

UK based SMEs and utility companies spoken to noted that there was sufficient technology in the marketplace to enable a smart water network to become operational. However, these companies noted that there were a number of barriers which were preventing this from taking place

- **Lack of Research and Development:** There appears to be no direct progression for the outcomes of R&D in the UK. SMEs noted that they have to go abroad in order to further their business. SMEs noted that this slowed down their development significantly. A number of leading UK academic institutions (Universities of Cranfield Sheffield, Bradford, Imperial College London, Newcastle and Exeter) are endeavouring to develop technology to ensure that the UK is at the forefront of new water technology developments.

- The existing water networks do not provide sufficient information/data to enable utility companies to manage networks effectively.

- There are no British Standards specified for the development and deployment of smart water solutions.

- SMEs and utility companies spoken to noted that there was a lack of innovation in the water sector in the UK. Utility companies are slow to both SMEs and innovative technology on board.

- Funding – Utility companies have to comply with Ofwat regulations which run in five year cycles. This regime does not enable utility companies to invest in new innovation during an AMP which has not been approved for that AMP period.

- UK SMEs don't have direct access to financing. Furthermore, proposals by SMEs don't often adequately explain the proposal, risk and/or rewards to potential funders.

- Risk & Reward – The utility companies are regarded by some interviewees as being very slow to take on risk. This has been apportioned to the regulations imposed by Ofwat and the 'Old School' mentality which dates back to when the water utilities were in public hands.

- The UK is lacking tier one manufacturing capability (UK suppliers are not ready to supply parts in the development of new technology). From a product development perspective, this means that most of the equipment and technology required will not be manufactured in the UK. Smart meters are not made in the UK.

- Knowledge gap. Even with the introduction of smart metering, it will take utility companies time to ensure they are collecting the correct information before being able to interpret the information to manage the network for effectively. Analytics, the collecting and interpreting of data (Big Data) is still a couple of years away.

Opportunities:

Due to the presently ineffective nature of water management systems worldwide, many experts believe that technology and smart water management are the only real way to enable the huge reductions to the present capital and operational running costs currently incurred by the utilities. The table below identifies areas where smart water management could reduce cost significantly.

Smart Water – Identification of Global Opportunities to improve performance of Utilities Companies - Potential savings in the water sector	
Amount	**Water Sector**
$3,443m	Leakages and pressure management – reduction in leakage levels and exact detection of leaks, predictive modelling to estimate potential future leaks.
$4,348m	Strategic Capital Expenditure – improved dynamic assessment, maintenance, and replacement, planning and designing of network to optimise spending.
$431m	Water quality monitoring – automatic water sampling, testing and quality monitoring.
$1,557m	Network operations and Maintenance – Real time automated valve/pump shutoff to facilitate flow redirection and shutoffs; more efficient and effective workflow planning
Total = $9.8bn	

Table 2.11: Smart Water – Identification of Global Opportunities to improve performance of Utilities Companies Source: SENSUS 2012

The table above gives a breakdown of the potential savings which smart technology could bring the water sector globally. In order to achieve these savings, water utilities will have to invest in technology being developed by many SMEs operating in the water sector.

- The design services provided by UK consultancy are highly regarded globally. Opportunity exists for this field in the form of further trade missions by the Government and UKTI, which may help grow the national industry by unlocking new customers in developing regions across Africa, Latin America and Asia.

- Opportunities exist for wider distribution of income generated from the release of water related data.

Barriers:

For a smart network to become operational in the UK, a number of substantial barriers such as the fragmentation of the sector, slow adoption of new technologies, no holistic vision being set out for the sector, and lack of SME development needs to be overcome. An overview of the barriers in place hindering UK firms developing in this sector is provided below:

- Testing – SMEs are required to carry out full scale testing for each utility in order to get approved. This costs significant time and money.
- SMEs have a lack of access to funding which will allow them to bring their product to full scale development.
- The public have not been convinced by the utility companies as to the merits of Smart Water
- Technology and utility companies have not developed full business plans which demonstrate the true cost of smart water technology and who will reap the rewards. The initial costs of deployment and determining payback period need to be developed and explained.
- The fear of change by Governments, utilities and consumers in relation to the adoption of technology on a large scale needs to be overcome.
- There is no strategic, holistic vision set out by the UK Government for smart water solutions. This results in SMEs, utility companies, regulators and customers having different perspectives of what smart water is, and what it should offer cities. This lack of vision also acts to constrain legacy investments.
- Companies spoken to note that the water utility sector lacks a holistic view of the water industry, therefore they are reluctant to change what they don't know about and that there was a lack of understanding of how the network should look like in future by all.
- The utility companies and analyst companies don't have the correct level of data to make the water system fully smart. If metering was introduced they could have too much data being and not knowing what to analyse. Knowing what data to look for and interpret will take time, possibly 3 to 5 years after its installation.
- There is political pressure applied to Ofwat and the utilities companies to keep the cost of household bills low.

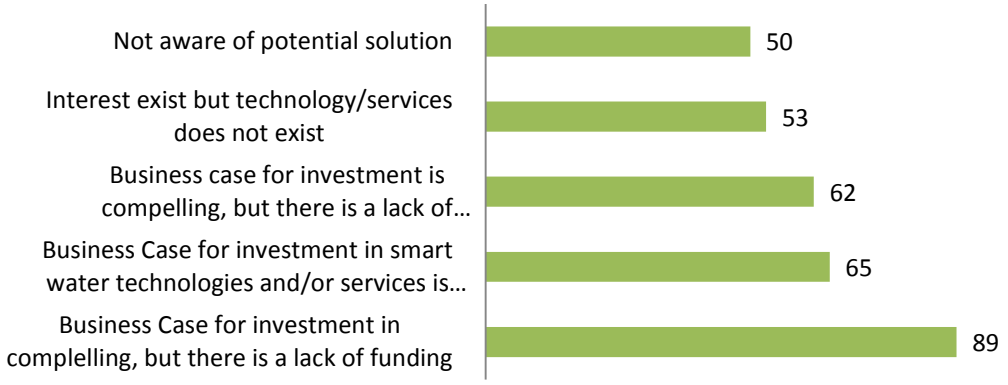

Table 2.12: Barriers to Smart Water Network adoption. Source: SENSUS 2012

The chart shows the factors which prevent companies from adopting smart water technologies. It is based on a study of 182 respondents who answered 'very significant' or 'significant' Total N=182 in a SENSUS report in 2012

2.8 What the UK Government is doing

In the recent White Paper 'Water for Life' by HM Government, the privatisation of water in the UK has been described as a success storey. Water utilities companies have spent vast sums of money, which the Government otherwise would have had to have spent. However the level of improvement presently required in the industry is huge. Since privatisation, the UK government have allowed Ofwat and the utility companies to handle water related issues. Industry expert have acknowledged that this is now hindering the development of the industry. The 2012 Draft Water Bill takes forward the proposal set out in the 2011 White Paper.

The UK Government have not been proactive in the industry; they have not been setting goals or visions for the utility companies to deliver. The Government's lack of involvement has damaged the industry. The water industry is fragmented and has no cohesive voice. There are five water bodies which claim to act for the water industry.

The Government has recently published it 'The Market Reform Programme' for water. It was developed to support delivery of the UK Government's vision for the future of water management in England, as it was described in the Water White Paper. The Government want to develop a resilient water sector, where companies are more efficient and customer focused, and one in which water is appropriately valued. The Governments wants to improve the range and quality of services offered to customers by fostering innovation and efficiency, and encouraging new businesses to enter the market.

There are some projects which are government funded and work across different parties in the industry:

TSB: Water: Innovation Opportunities for the UK

The TSB noted that conditions in 2011[62] did not warrant an innovation platform investment in water; however they did find other opportunities for the water industry. The TSB noted that the UK has many world class consultants, contractors and manufacturers who are already operating in the market and have the potential to expand and develop.

The biggest opportunities lie overseas. The UK has a vibrant water sector, including many world class consultants, contractors and manufacturers who are already serving this market and whom we think have the capacity to grow further.

The TSB noted that challenges and opportunities arose around the following areas:

- Flooding
- Water scarcity
- Water quality
- Water sector energy consumption and greenhouse gas emissions

Government Backed Projects

In November, 2012, The Technology Strategy Board (TSB), The Department for Environment and Rural Affairs (DEFRA), The Natural Environment Research Council (NERC) and The Engineering and Physical Sciences Research Council (EPSRC) provided funding to seven projects which will examine challenges in water security in the UK and overseas. £2.5 million of funding from the agencies combined with £3.1m from contributing companies will be used for research, technology innovations and an examination of how the participating companies can explore/expand/exploit opportunities in the UK and overseas. The companies involved have been set the challenge of creating a technology or process that will either save or recycle 1,000 million litres per day worth of water.

The Engineering and Physical Sciences Research Council (EPSRC) is providing £240,685 of funding to the University of Birmingham's Civil Engineering Department on a project for Smart Leak Detection Pipes. This project involves developing a leak detection system for existing and new water pipes which is easy to install.

Industrial Doctorate Centre: Skills Technology, Research, and Management (STREAM) for the UK Water Sector

The EPSRC's Industrial Doctorate Centre programme is a mechanism by which the EPSRC aims to plug the shortfall in advanced engineering skills within the water sector. The programme involves training engineering leaders to have a combination of business, engineering and academic knowledge. The proposal

[62] Water: Innovation Opportunities for the UK, Interim Strategic Assessment by TSB, 2011

combines together five of the UK's leading water research and training groups with the aim of securing the future supply of advanced engineering professionals in the water sector which of vital importance to the UK.

Led by the Centre for Water Science at Cranfield University, the consortium also draws on expertise from the Universities of Sheffield and Bradford, Imperial College London, Newcastle University, and the University of Exeter.

STREAM Project Partners:		
Anglian Water Services Ltd	British Water	International Water Association
JBA Consulting	Mouchel Group	MWH UK Ltd
Northumbrian Water Ltd	Severn Trent Water Ltd	South West Water Ltd
Thames Water Utilities Limited	Trojan Technologies	UK Water Industry Research Ltd
United Utilities Water Ltd	W R C Plc	Yorkshire Water
Starts: 01 October 2009	**Ends: 31 March 2018**	**Value: £6,423,636**

Table 2.13: STREAM Project Partners

2.9 Recommendations

2.9.1 What the UK government could do better

Follow through on previous recommendations

Many of the barriers and challenges the sector faces have previously been identified and recommendations have already put forward in previous papers by government. Government should ensure that the recommendations of ‘Smoothing investment cycles in the water sector’ by HM Treasury and the 2011 Government White Paper, “Water for Life” and the 2012 Draft Water Bill are fully implemented.

Leadership and Collaboration on standards and vision

National government (e.g. DEFRA) should set clear goals and visions for the future of the water market and the use of smart water technologies in the UK. BSI should be tasked with developing national standards for smart water solutions to provide a consistent definition and understanding within the industry. The vision and standards should be informed by the opinion of key stakeholders in the water industry.

Vested parties with different goals need to come together, to deliver one aligned vision. DEFRA and Ofwat can play a key role in driving this multi-party conversation and collaboration. It is essential that this vision is clearly communicated to the industry and the general public, once developed, to give confidence to investors by demonstrating government commitment.

Encourage and Drive Innovation through collaboration, regulation and open data

Ofwat should develop ways to encourage innovation in the water market. Yorkshire Water has been able to demonstrate to Ofwat that investment in innovation does provide considerable returns on investment. Ofwat should explore ways to actively support SMEs and water utility companies with the development, testing, approval and installation of new technologies which will greatly improve the level of innovation and development in the water industry. Ofwat should continue to build on the findings of its own paper titled *Innovation priorities for the water sector*, published in 2011, by reviewing the mechanisms by which they regulate the industry, learning from experience elsewhere – e.g. Ofgem's new RIIO price control scheme.

Ofwat and DEFRA should review examples of innovative funding methods provided by the State of Illinois, USA and Mekorot of Israel, to explore ways to ensure funding is available for innovative projects in which outcomes are often less certain than for conventional projects in the water industry.

DEFRA and Ofwat, along with the Open Data team in the Cabinet Office, and wider industry stakeholders, should explore the deployment of infrastructure to collect real time information on the UK water network and market. This information should be made publically available. As in other sectors this information can then be used by the private sector and others to provide innovative value-added services to industry and consumers. This could help drive competition and innovation between industry players.

2.9.2 UK Business has a responsibility

Alongside the vision set out in collaboration with government, UK businesses must develop a stronger vision of how a smart water system will operate and how it will benefit all - clients, utilities, Ofwat, Government, taxpayers and the environment. The tangible and intangible benefits will need to be identified, understood and valued.

These benefits will likely only be realised through innovation in business models and by developing incentives for consumers (e.g. advanced tariffs), and collaboration between all parties. Businesses must engage with government and Ofwat to help drive this collaboration forward. Utilities must also be more open to collaboration and engagement with innovative SMEs.

The public needs to be brought along on this journey, and public awareness campaigns are a crucial element, building the public case for the introduction of smart water technologies, engaging with the legitimate concerns around privacy and data security, and demonstrating and evaluating the benefit to the consumer. Customers need to be able to determine their return on investment.

3 Smart Transport Management

Increasing urbanisation means cities are facing more congestion and associated carbon emissions, while still needing to provide good quality of life. In particular, congestion costs the UK economy €24.5Bn a year in lost production. The growing demand for smart transport solutions to address congestion from city authorities and commuters means that the global 'Smart Transport' market, including digital and physical infrastructures, and associated design and advisory services, is expected to be worth over $100 billion by 2018.

UK businesses have the skills and experience to deliver and succeed in this exciting and growing market if certain barriers can be overcome. It is often difficult for innovative companies to deploy solutions in the UK due to a fragmented vision and market: there is little agreement between cities on requirements and standards for basic infrastructure, so there are few economies of scale for buyers or sellers. Cities are also reluctant to spend scarce funding on untested solutions. There is a role for national and local government to develop a common vision and roadmap for deployment, develop system wide pilots and facilitate collaboration between cities, academia and industry.

3.1 Introduction

The development of transportation systems is changing now more quickly than at any stage in the past 50 years. Advancements in communication technology combined with improvements in transport technology are now enabling cities to provide for more seamless movement of people and goods.

Increased urbanisation and population growth in cities, driving down energy costs, improving standards of safety, finding more sustainable methods of travelling and a desire for better integration of transport modes, are some of the challenges which confront city managers when they develop their transport policies. Advancements in technology are now providing global opportunities in smart transport management as cities try to reduce the burden of congestion and improve the lives of their residents.

Research organisations have different valuations of smart transport market depending on the extent by which they evaluate the many disruptive influences which smart transport solutions are likely to bring. Pike Research values the global smart technology sector at $1.3Bn in 2012, rising to $5.5Bn in 2020, however this is based on an evaluation of the technology which be used. Markets and Markets value the market at $26.7Bn in 2012 and expect it to be worth $102.31 billion by 2018, and their estimation encompasses the wider sectors of the transport industry which will benefit from the investment in smart transport solution.

Smart Transport

City managers and Governments are coming under increasing pressure from commuters and businesses to reduce congestion and to improve the quality of life of those living and working in cities. Smart Transport solutions are seen as a means of enabling these improvements.

A 'Smart Transport System' is one which enables people to take more control through informed choice of how and when they access transport, enabling the transport user to better manage their time, spend less time in traffic or waiting for

public transport. A smart transport system is one which integrates information from different modes of transport, including trains, buses, and tube, etc. It also facilitates the efficient movement of goods through a city, and ensures logistics do not become a burden on a city. A smart transport system requires control, operation and access to open data; it also requires people with the necessary skills to integrate disparate systems. Cities will have to build new services and open up existing systems (including data collection and data display) to cater for development of smart transport solutions.

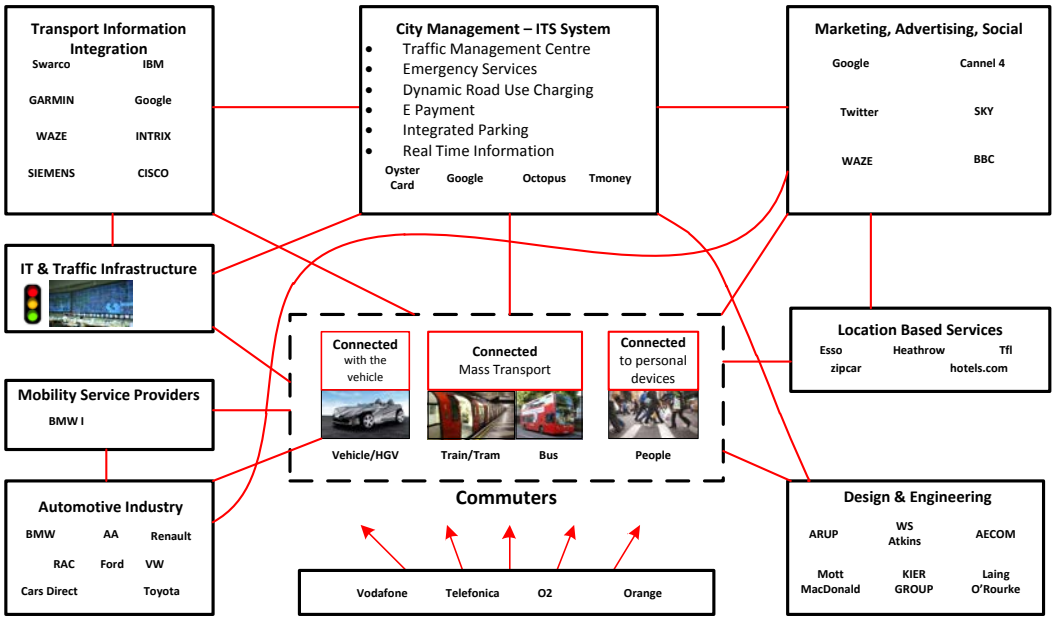

Figure 3.1: Connecting Transport - The Smart Transport value chain: Source: Arup

Figure 3.1 demonstrates the interaction between the different stakeholders and transportation services in a Smart Transport System. Refer to Section 3.3 for description of the stakeholders.

At the device end, Intelligent Transport Systems (ITS) are a key component of Smart Transport solutions. ITS solutions range from roadside devices, such as vehicle detection, to passenger carrying devices such as smartcards. In a 'systems environment' they can range from fleet management systems to integrated real-time management systems. Countries and regions of the world often group or define Intelligent Transport Systems according to their entry level into the market. Early adopters, such as UK, Japan, Australia and USA have in some cases been leapfrogged by new entrants, such as Middle East countries, parts of Eastern Europe, and China where legacy migration has been avoided. Legacy technologies and infrastructure are seen as the greatest barrier to a step change in ITS for many cities.

ITS consists of 'any technology, method or application that provides the traveller/client with added value, guidance, improved safety or efficiency benefits through information collection, storage, manipulation and subsequent dissemination'. Intelligent transport systems bring greater control and automation to road networks. They can be used to ease congestion and reduce carbon emissions and allow for more effective responses to planned to unplanned incidents. Whilst early systems were very much focussed on traffic rather than transport and the traveller, they looked to measure traffic conditions and act on

them, the current horizon for ITS is in the use of advanced analytics to predict and adapt in real-time to network perturbations. This is a step change from the use of SCOOT and SCATS adaptive traffic type control systems described below and deployed since the 1980s.

As with most new technology, the ability to accept change management in terms of changed roles and responsibilities by those operating (bus drivers, operators) in the transport system will be fundamental to the implementation of smart transport systems. Organisations will need to adopt a new approach of working to enable smart transport systems to operate successfully.

Opportunities

Smart transport management will be a critical component in 'Smart Cities'. At the technical layer, it involves the integration of technology and communication to a deliver a platform which provides users with a more encompassing view of transport. It provides the 'Smart City' owners with a system that allows for an all-encompassing system that enables a strategic approach to transport management in a city. A smart transport approach needs to be sustainable, citizen-centric, and support economic development. Pike Research estimates that from 2012 to 2020, $117bn will be invested worldwide on smart city infrastructures, and $31.2bn of this will be invested in the digital systems and infrastructure for smart transport solutions.

3.2 Drivers

Transportation is a sector which affects all city users, whether they are daily commuters, sporadic commuters, business owners, walkers, school users or cyclists. The requirement to improve this sector is being driven by numerous factors, which are governed by local, national and international influences. Improving the quality of life of those living and working in cities by reducing problems and efficiencies in the transportation sector are common goals set by cities throughout the UK.

Cost of traffic congestion: The estimated cost of traffic congestion to businesses and Governments is huge, estimated to be circa €111 billion per annum for EU member states[63]. The mitigation of congestion is the main priority of a number of cities and governments in the EU. Cities and governments want to improve productivity and reduce the cost of congestion.

The Technology Strategy Board[64] noted in a 2009 memo that:

- A 5% reduction in travel time on the roads could save businesses around £2.5bn; 0.2% of GDP.
- Eliminating existing road congestion would be worth £7-8bn of GDP each year to the UK.
- The cost of congestion could be an extra £22bn in 2025 if action is not taken.

[63] Measuring Road Congestion By JRC Scientific and Policy Reports, 2012
[64] Intelligent Transport Systems and Services – Innovation Platform by Technology Strategy Board, 2009

Annual cost of congestion per EU member state		
	Annual cost of congestion	**Cost of congestion as % of GDP 2009**
Germany	€24.2Bn	1.0%
Spain	€5.5Bn	0.5%
France	€16.5Bn	0.9%
United Kingdom	€24.5Bn	1.6%
Italy	€14.6Bn	1.0%
Total EU (available countries)	**€111.3Bn**	**1.0%**

Table 3.1: Annual cost of congestion per EU member state Source: JRC Scientific & Policy Reports, 2012

Quality of Life: Transport contributes to poor air quality primarily through the use of petrol and diesel and to a lesser extent, through brake and tyre wear. Many cities across the world are seeking to reduce air emissions from transport to improve air quality and reduce noise as well. Poor air quality contributes to;

- Loss of life expectancy, deaths brought forward, increased hospital admissions, soiling of buildings and damage to forests and other ecosystems.

Smart transport solutions aim to reduce all of the above to improve quality of life.

Energy use and carbon emissions: Globally, transport is the sector where greenhouse gas emissions are rising most quickly. Demand for oil is set to rise from 84.7m barrels per day (bpd) in 2008 to 105m bpd in 2030 with transport being 98% dependent on oil. The transport sector is predicted to account for 97% of this increase, as the global number of road vehicles is expected to double from over 1 billion in 2010 to 2 billion in 2020[65]. Transport systems have significant impacts on the environment, accounting for between 20% and 25% of world energy consumption and CO_2 emissions. With energy costs and pollution levels increasing, cities and governments have to find cost effective alternative means through smart transport solutions to improve their transport networks.

Increase in car use: Globally the number of vehicles is predicted to grow substantially over the next 20 years with the BRIC nations seeing the greatest increase in numbers. This will impact cities that already have inadequate transport infrastructure. The Boston Consulting Group (BCG) predicts that sales of vehicles in BRIC countries are likely to account for 30% of the global sales in 2014. BCG expects sales growth up to 15% per year. Cities and Governments have to find more effective methods of changing commuters' reliance on cars to encourage mass transport usage.

Optimisation of Transportation: A comprehensive ITS should enable network operators to realise maximum capacity from their existing transportation systems.

[65] International Energy Agency estimates – http://www.economist.com/research/articlesBySubject/displayStory.cfm?story_id=14790202&subjectID=381586&fsrc=nwl

ITS should facilitate the obtaining of the quality and type of data needed by decision makers to make sound performance-based investment decisions. An ITS should allow a performance-based cost benefit analysis as the basis for transportation investment decisions.

Urbanisation of population: In the latter half of the 20th century, the number of cities with more than 10 million inhabitants increased from 2 to 50. In 2007, urban populations surpassed rural populations. Ever increasing numbers of people living in urban areas places a greater strain on infrastructure networks. Transport for London estimates that by 2031 the population of London will have increased by 1.25 million inhabitants, and that 600,000 extra passengers will need to travel by public transport at peak times[66]. The London underground network is currently undergoing upgrade works to improve its capacity and deliver more efficient service.

Improve Safety: Reducing incidents involving vehicles as well as reducing the number of injuries to motorists and pedestrians is a goal of City managers and Governments.

Shift to Sustainable Transport: A sustainable transportation system encompasses a number of different aspects. It allows the basic access and development needs of individuals, companies and society to be delivered in a safe and affordable manner. It operates efficiently and offers a choice of transport modes. A sustainable transportation system limits carbon emissions and waste, uses renewable resources and minimizes land use. A number of cities are actively encouraging city dwellers to shift to pedestrian and cycling modes of transport to both ease congestion and improve levels of health.

[66] http://www.tfl.gov.uk/businessandpartners/20068.aspx

3.3 Value Chain & Route to Market

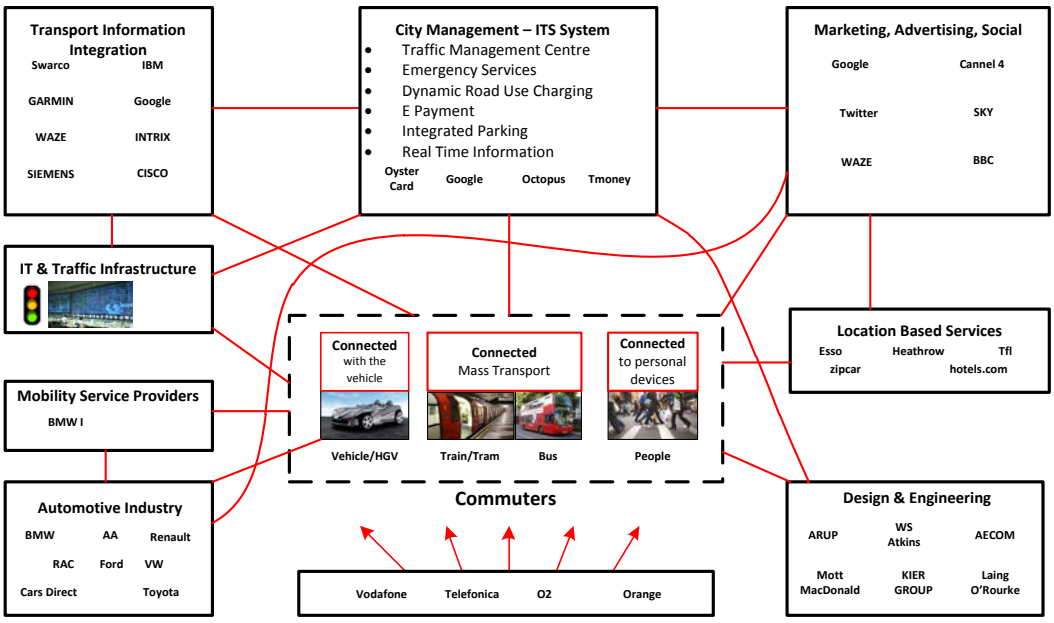

Figure 3.1: Connecting Transport - The Smart Transport value chain Source: Arup

Figure 3.1 demonstrates the interaction between the different stakeholders and transportation services in a smart transport system

The key actors are described below.

City Management: Personnel responsible for managing transportation systems within cities. These are the key buyers in the 'Smart Transport' market. City Managements are coming under increasing pressure from commuters and businesses to reduce congestion, improve the quality of life of those living and working in cities.

Transport Information Integration: These are companies involved in data collection and interpretation to provide traffic management solutions to City Management. These are the key sellers and potentially the innovators and integrators in the 'Smart Transport' market. The products produced by companies operating in this sector aim to optimise transportation, improve safety and reduce congestion.

IT & Traffic Infrastructure: Companies who manufacture technology related to traffic management solutions. These are the innovators in the 'Smart Transport' market. Their products are primarily aimed at companies involved with Transport Information Integration and with City Management.

Mobility Service Providers: Provide tailored transport solutions to city inhabitants. These are a small, but growing player in the industry offering services to commuters.

Automotive Industry: Companies who operates in the automotive industry (manufacturing, insurance, repair, recovery) and interested in providing

commuters with a more comprehensive transport solution. Their smart transport products are aimed at making transport more sustainable, greener and safer.

Design & Engineering: Develop transport strategy, policy and compliance. They design and manage the procurement processes and install the infrastructure network. These companies advise commuters, city management and transport information integration companies. The goals of these companies are to design and build transportation systems which are optimally designed, incorporate best practises to reduce congestion, improve quality of life, lower emission and optimise use of mass transport. UK companies operating in this field are highly regarded globally.

Location Based Services: Companies involved in this sector provide services such as beds, food, fuel, transportation to commuters. Commuters are informed of available services before, during or after their commute, through the use of smart technology which recognises their route or current location via GPS.

Marketing, Advertising, Social: Advertising companies will use the smart technology medium (smart phones, I Pad, etc.,) to connect with commuters to sell or provide a service. Commuters are targeted by tailored advertising techniques depending on their mode of transport, location or smart phones setup of companies or services which could strike a chord with commuters in that location. Revenues provided by advertising companies could greatly reduce the cost of development and installation of smart transport solutions for city management.

Communication Industry: Companies whose technology will be used to relay data to transport information integration companies, city management, and marketing information from advertising companies. Additional means of communication (data to and from measuring devices, transport information integrators and advertising companies) will be required. If vested parties come together early enough in the development of smart transport solutions, the sectors potential could be better developed to maximise revenue for all vested parties.

Route to Market

Andrew Everett, Head of Transport at the Technology Strategy Board noted ‘the challenge for an SME (operating in the transport sector) is getting into the eyesight of those making decisions. The challenge for SMEs is to showcase what they can do in the home market, however the Olympics was a springboard which should be developed’ and ‘that innovation and smartness will come from trying to do away with the infrastructure’. Optimising existing infrastructure is a key theme.

John Chipperfield, Chief Technology Officer of Swarco noted that ‘the UK is a crowded market, that there is not much innovation’ and noted that ‘It is easier for Swarco to approach a city in Europe and ask them they wanted to try them out a new ITS systems than a UK city. In a joint effort [between Swarco and City Council], the new traffic systems can be installed quickly, it could be done in a month…However in the UK, this process takes a bit longer, and is a bit tougher. City Councils in the UK need to be more proactive. Cities need to develop a common approach, where the architecture behind the ITS software is the same and at the same time allow for the city specific customisation’.

Darren Briggs, Associate Director in Arup noted that ‘UK Cities themselves are behind the rest of Europe in implementing solutions. Italy, France and Germany

each has over twenty Low Emission Zones in place and are pro-actively tackling urban logistics issues to reduce carbon emissions, etc. This is evident in the FP7 scheme called FR-EVUE in which 8 cities are implementing solutions, including ITS, to control urban freight. The scheme is led by Westminster but the London trials have no support from TfL or GLA, as opposed to all the other cities where the trials are being led by each City.'

3.4 Market Size

The value of the smart transport market is huge and presently growing at +20% per annum. The present value of the market is a quarter of what it is expected to be valued in 2018. It is estimated that the market will be in excess of $100 billion by 2018[67]. This valuation includes an estimation of the smart technologies which will be used, the amount spent on innovation, on design consultancy and engineering, on infrastructure development and installation, on ICT, software and analytics and on automation and control. It includes all major sub sectors of transport, where smart applications will be used to install technologies that will provide services such as parking management and guidance, real-time travel information, real time traffic management and other applications to bring about improvement in transport management.

This valuation of $100 billion by 2018 also considers ancillaries industries and services, which will be directly influenced by the investment in smart transport solutions. These services include traditional transport services such as road design, development of new software services, and integration of new technologies into legacy systems, development and deployment of business and data analytics which will interpret live data and better manage transport within cities.

Our research has shown that the valuation of the smart transport market varies depending on what sectors are considered. Different research experts such as Pike Research, Markets and Markets and industry bodies such as ITS America have different valuations for the smart transport sector.

Pike Research - Smart City Technology Annual Revenue - Global Transport: 2012-2020				
Smart Transport	**2012**	**2015**	**2020**	CAGR (2012-2020)
North America	$357m	$773m	$1,411m	18.7%
Europe	$320m	$757m	$1,535m	21.6%
Asia Pacific	$557m	$1,155m	$2,347m	19.7%
Latin America	$72m	$111m	$168m	11.1%
Middle East & Asia	$31m	$55m	$90m	14.4%
Total	$1,337m	$2,851m	$5,551m	19.5%

Table 3.2: Pike Research Smart Cities - Technology Annual Revenue - Global Transport: 2012-2020

[67] www.marketsandmarkets.com/PressReleases/smart-transportation.asp

Eric Woods, Research Director with Pike Research, noted 'The differences in valuations in the smart transportation market reflect the difference in scope of the forecasts and also how they are related to the smart city concept. Three key distinctions can be made:

- The total spend on 'smart' transportation technologies and services
- The total spend on 'smart' transportation relevant to cities
- The market related specifically to smart city investments'

Pike Research has based their valuation of the smart transport market on the specific opportunity offered by the growth in smart cities (defined as the integration of technology into a strategic approach to sustainability, citizen well-being, and economic development). These include technologies which have been developed to provide integrated traffic monitoring and management services, improve congestion management, to control road user charging, enhance emergency response, provide real times public information systems and provide smart parking solution[68]. Pike Research's numbers focus on the market related specifically to smart city investments. As the valuation by Pike Research of the smart transport market only considers the smart city aspects of the sector, it can be seen as a sub-set of wider forecasts for the entire transportation network provided by other valuators (Markets and Markets & ITS America).

The valuation by Pike Research considers the investment likely to be made in smart transport related to innovation and technologies by cities adopting a 'smart city' strategy. This valuation can be described as the 'seed' money required to unlock the much wider potential of smart transport solutions. These include the opportunities which the development and deployment of smart technologies could bring and the additional services and infrastructure required as a result of their deployment.

Eric Woods, Research Director with Pike Research, noted 'The broader opportunities in Smart Cities could be 10 to 20 times greater than those noted (in Smart Cities by Pike Research, 2013)' and 'innovation after investing in smart ventures will open new possibilities'. Eric Woods also noted that 'The other aspect of smart city investment to consider is that it is a catalyst for new opportunities around transportation technologies and services.' and that 'these broader opportunities would include economic benefits of investment in smart transportation in terms of the development of new businesses and services and the impact on local economic performance. For example, the European Commission has estimated that the cost of congestion to the European economy is around 100 billion euro or 1% of GDP annually.'

Pike Research estimate that the cumulative revenue for smart transport in 'Smart Cities' will be in excess of $31 billion between 2012 and 2020. This valuation is taken over the broad transport sector, which includes sectors such as passenger vehicles, roads, vehicle chargers, and transit fleets, controlled by various agencies or private entities and designed to achieve a range of policy and operational goals. Pike Research predict that most of this investment will be intelligent traffic

[68] Smart Cities by Pike Research, 2013

management systems, as this sector has room to expand and relevant to virtually all cities.

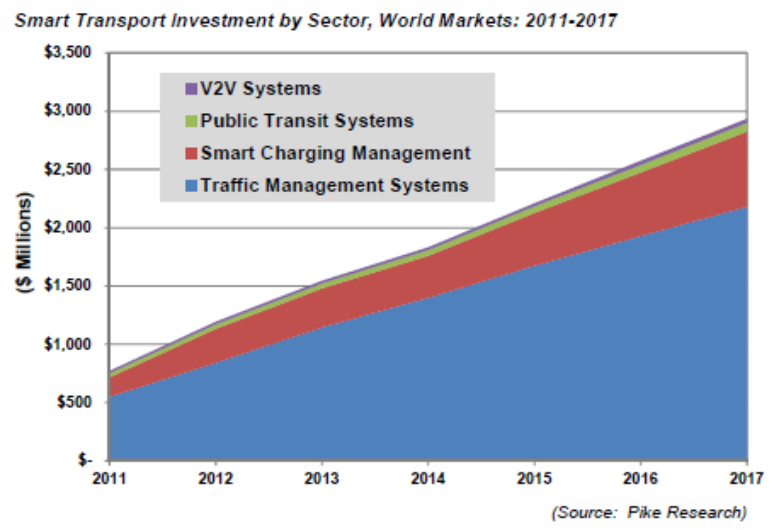

Figure 3.2: Smart Transport Investments by Sector. Source: Pike Research

According to Markets and Markets (M&M), the smart transportation market is presently worth $26.70 billion and is expected to be worth $102.31 billion by 2018, at a CAGR of 23.6%[67]. The M&M forecast includes a valuation of the market potential of the major sub segments of transportation, which include parking management & guidance, providing passenger information, integrated supervision of traffic, traffic management and smart ticketing. M&M's valuation also includes an estimation of the services which will be provided by those in the service industry (design and engineering), heavy manufacturing and business and data analytics.

M&M estimate that the global ITS market will be worth $24.75 billion in by 2017[69]. M&M consider North America to be the market leader in the ITS market. However, ITS America, valued the ITS market in North America at $52 billion in 2009, but considered the many business sectors and services which will be directly affected by the investment in smart transport solutions. ITS America expects the ITS market in North America to rise to $73 ($67 U.S. /$7 Canada) billion in 2015[69].

[69] Sizing the Intelligent Transportation Industry, ITS America, 2011

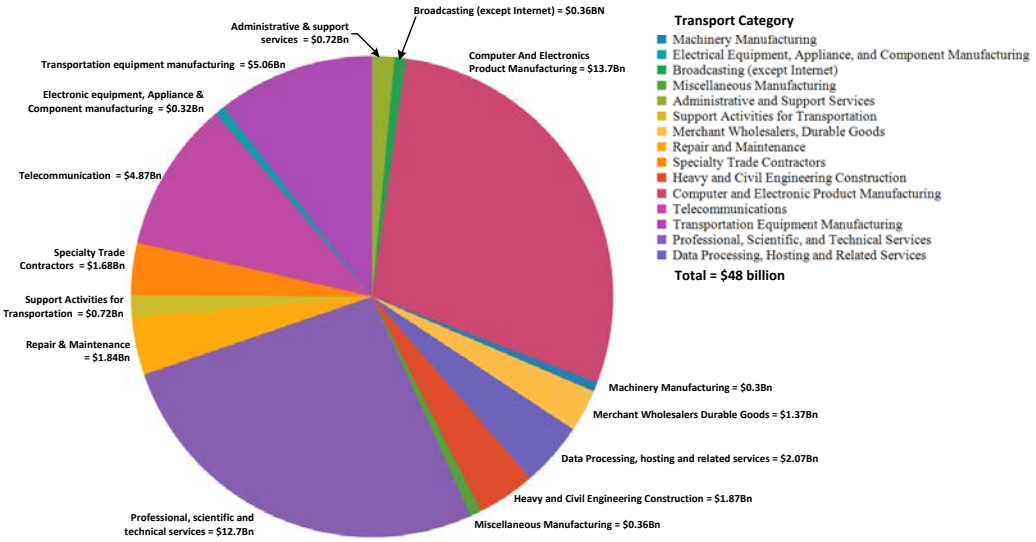

Figure 3.3: U.S ITS Market Breakdown 2009. Source: ITS USA

Figure 3.4 indicates the business categories and sectors involved in ITS in the USA which have been directly affected by investment in smart technology and indicates the amount by which each sector has benefitted as a result of the investment in smart transport solutions.

3.5 Market & Technology Trends

The list below gives an indication of the technologies being used in ITS. Recent Technologies include[70];

Transport Information Application developments (to reduce congestion, improve quality of life, reduce emission from traffic, improve safety and optimise traffic flow). These are used by technology companies and transport integrators to provide information to city management which enable better management of transport systems in cities.

- GIS/traffic management service application model integration and convergence
- GIS based mass traffic information management engine
- Traffic comprehensive information resources integration
- Traffic data centre and traffic flow data survey and analysis
- Traffic data collection, statistical analysis and presentation

Intelligent traffic features (to reduce congestion, improve quality of life, reduce emission from traffic, improve safety and optimise traffic flow)

- Dynamic traffic information acquisition, integration, processing, forecast and distribution

[70] http://www.chinatransinfo.com/

- Electronic toll collection
- Intelligent parking guidance system
- Vehicle licence plate automatic identification
- Traffic event automatic detection
- GPS monitoring/dispatching and information service

Digital City features (to reduce congestion, reduce emission from traffic, improve safety and security and optimise traffic flow)

- Video image based security and video image management

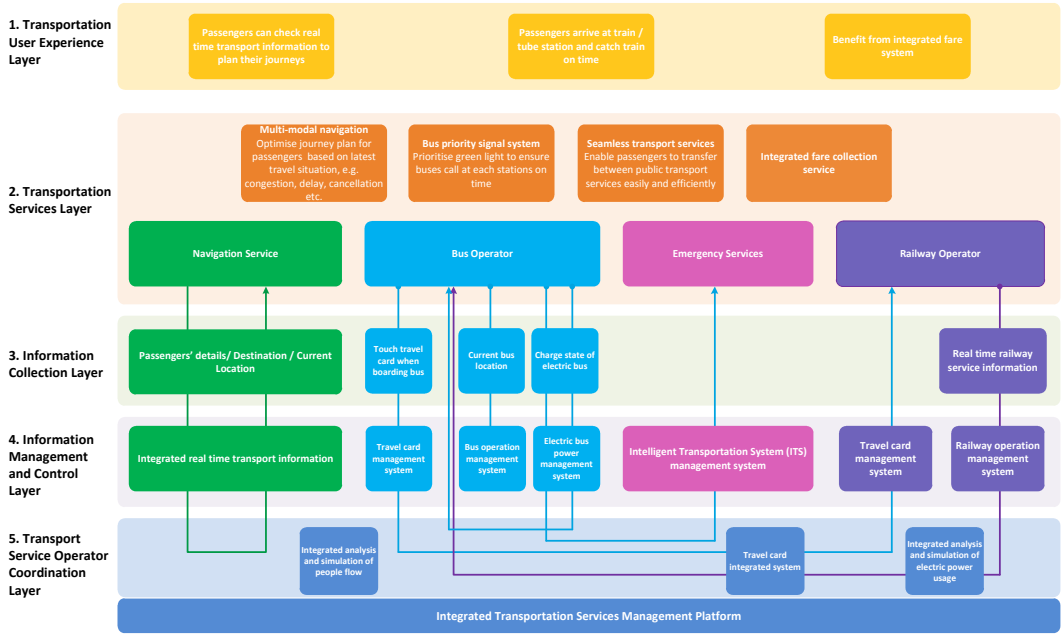

Figure 3.4: Smart Transport - Commuting Scenario and Solution – Based on Hitachi Relationship between Commuting Scenario and Solution

Figure 3.5 indicates that by having different transportation companies working together through urban management infrastructure allows for the provision of multi-dimensional services that could not have been achieved in the past by companies acting together[71]. The diagram also shows the different layers of information collection /interpretation and dissemination required in order to provide commuters with relevant information.

[71] Hitachi Review Vol. 61 (2012) No 3

3.6 What is happening in the market

The following countries, cities and examples have been cited in this report to showcase recent developments in smarter transport solution around the world. They are intended to highlight best practice and identify where there are opportunities for the application of smart transport solutions.

Global: Analysis by Arup and the C40 shows that cities are taking a wide range of actions to improve and expand mass transit and encourage more sustainable transportation. Of the 40 cities surveyed, about 23 cities have taken action on transport demand management, such as implementing zonal congestion charging, vehicular congestion charging, time/day restrictions on personal vehicle usage, restricting parking, and time/day restrictions on vehicle usage—initiatives which all require or benefit from smart transport technology[72]. Cities also exercise strong power over the transport sector. For example, in 26 of the cities surveyed, mayors own and operate city roads and have powers to regulate them – a critical requirement for congestion charging. However, only 8 have implemented either zonal or vehicle congestion charging[73].

Dynamic Tolling

Road pricing, under which 'Managed Lanes' has become an increasingly popular concept in recent years. Examples of road pricing at area level are the Singapore and London congestion charging.

Managed Lanes can include:

- Bus and truck lanes
- High occupancy lanes (HOV) or High occupancy toll lanes (HOT)- USA
- Temporary shoulder use - Netherlands
- Dynamic re-routing of trucks - Germany

Managed lanes may or may not be tolled for some or all vehicle types depending on public policy. Dynamic Tolling is one way of operating managed lanes. Dynamic tolls have become popular in the U.S.A in the last decade (SR-91 Express lanes, I-495 etc.). They are also in use in Israel. They are operated by concessionaires who take differing levels of risk on traffic/ revenue/ minimum performance specifications. Usually the key requirement is to maintain the managed lanes at a minimum speed, thereby increasing the toll in real-time (every 5, 10 or 15 minutes, or sometimes on a monthly/ bi-annual basis) to ensure that traffic flow is maintained at levels that meet the 'minimum speed requirement'.

There is some debate as to the 'larger social good' from dynamic lanes. They are designed to offer a reliable, faster (and more expensive) alternative to free alternatives. The revenue maximisation motive for private operators means that free lanes become more and more congested as you price people off the tolled lanes. Hence related issues like pollution may become worse, especially if new managed lanes were built, adding capacity to a busy corridor and thereby releasing suppressed demand as opposed to converting existing lanes into tolled lanes. If discounts or free travel is offered to vehicles with 2 or more people, some benefits may accrue by reducing the number of vehicles on the road but these will probably be outweighed by worsening conditions on the free lanes.

[72] Climate Action In Megacities: C40 Cities Baseline and Opportunities, C40 Cities Climate Leadership group and Arup, 2011
[73] Ibid

Europe: The EU is at the forefront of developments in ITS. In key areas of information technology and telecommunications, the EU has created the conditions for new products and services to spread all across Europe. The thrust of the EU strategy is set out in EU Directive 2010/40/EU ITS Action Plan[74].

Action Plan and Directive

A new legal framework (Directive 2010/40/EU) was adopted on 7 July 2010 to accelerate the deployment of these innovative transport technologies across Europe. This Directive is an important instrument for the coordinated implementation of ITS in Europe. It aims to establish interoperable and seamless ITS services while leaving Member States the freedom to decide which systems to invest in.

Urban Intelligent Transport Systems Best Practices

The collection of Urban Intelligent Transport Systems Best Practices was an activity coordinated by the Urban ITS Expert Group. Established in 2010 by the Directorate General for Mobility and Transport (DG MOVE) of the European Commission, as part of the ITS Action Plan. The group is made of 25 experts from public and private organisations, directly connected and concerned with urban ITS issues. The expert group was established to identify and exchange best practices for the key applications of urban ITS. The objective was to support cross-fertilisation among stakeholders through the setting up of an urban ITS database.

In 2011, the European Commission Transport White Paper; Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system was issued. Issues such as multimodal intercity travel and transport and clean urban transport and commuting are noted and a strategy to bring about changes is outlined. Innovation and smart pricing are seen being vital to the future success of transportation in Europe. The paper calls for the deployment of large scale intelligent and interoperable technologies to optimise the capacity and the use of infrastructure.

EU-Japan Cooperation in Intelligent Transport Systems: In November 2012 a member of the Japanese Ministry of Land, Infrastructure, Transport & Tourism joined the European Commission, DG CONNECT, for 6 months. This transfer is intended to enhance EU-Japan cooperation in the field of Intelligent Transport Systems research.

The objectives of the Cooperation in Intelligent Transport Systems have been outlined as:

- Identify benefiting research and development areas;
- Share information on research projects, results and benefits;
- Involve stakeholders in their cooperative activities;
- Support strongly the development of globally open standards.

[74] EU Directive 2010/40/EU Action Plan and Directive

Stockholm: IBM in partnership with KTH Royal Institute of Technology in Sweden has been gathering information on traffic flow in Stockholm. GPS devices have been fitted to 1,500 taxi cabs. The data collected gives city managers and inhabitant's real time information on traffic flow, travel times and best commuting options.

Oslo: Have a scheme where EVs can use bus lanes, do not pay congestion charge and can use council car parks for free to offload – all supported by a City IT platform.

Milan: Has free Wi-Fi across the city and is looking to use this platform to facilitate transport IT solutions.

European Initiative on Smart Cities – Strategic Objectives

Local authorities are encouraged to propose and implement holistic problem-solving approaches which integrate the most appropriate technologies and policy measures. The EU wants:

- 10 – 20 testing and deployment programmes for low carbon public transport and individual transport systems, including smart applications for ticketing, intelligent traffic management and congestion avoidance, demand management, travel information and communication, freight distribution, walking and cycling.

- Sustainable mobility: advanced smart public transport, intelligent traffic management and congestion avoidance, demand management, information and communication, freight distribution, walking and cycling[75].

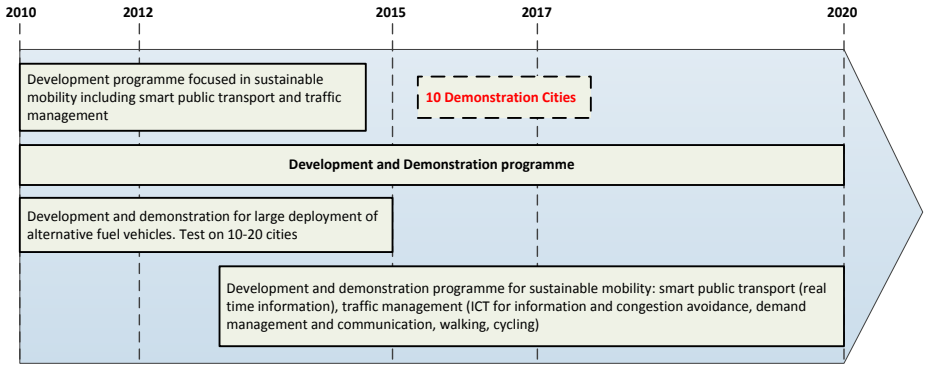

Figure 3.5: Timeline for European Initiative on Smart Cities Roadmap Source: European Initiative on Smart Cities Roadmap

UK: There are a number of important smart transport initiatives going on in the UK.

Central London Congestion Charging: Introduced in 2003, this system had reduced vehicle numbers in the central business district by over 70,000 per day. The success enjoyed by London has encouraged the cities of Stockholm and Milan, to introduce comprehensive congestion charging schemes.

[75] http://setis.ec.europa.eu/about-setis/technology-roadmap/european-initiative-on-smart-cities

Regent Street Consolidation Centre

In terms of delivering stock to the store, out-of-town consolidation centres, where goods are delivered in bulk and then sorted for local delivery by the most appropriate and resource-efficient means. An example of this approach is London's Regent Street retail delivery consolidation scheme. The Regent Street consolidation centre is located in Enfield. The centre acts as a first destination for deliveries from across the UK and continental Europe. The centre sends out electric trucks that collectively deliver all goods requested by Regent Street retailers on a specific day. The process has a number of advantages. It is more environmentally friendly due to the reduction in the number vehicles required for delivery; it eliminates the need for store-based storage and stock management; and it limits freight related traffic on the road. Since its introduction, the consolidation centre has helped realise a reduction in average deliveries from 650 to 75 each month.

The introduction of the Regent Street Consolidation Centre has reduced congestion and emissions, optimised delivery schedules and improved levels of safety for commuters in the Regent Street area.

FREVUE

FREVUE (Validating Freight Electric Vehicles in Urban Europe) is an EU funded project which is intended to demonstrate the benefits of electric vehicles operating the 'last mile' freight movement in city centres. FREVUE will see demonstrator projects running in eight countries and drawing on the expertise of over 30 partners. The aim of FREVUE is to deliver significant traffic reduction and improved air quality amongst the primary benefits.

FREVUE is funded by the European Commission's Framework Programme 7 and will result in a total investment of €14.2 million. The project is led by Cross River Partnership through Westminster City Council. FREVUE was launched on March 22nd 2013.

"Drawing on the significant experience we gained through our work on the Regent Street delivery scheme which has delivered an 80% reduction in delivery vehicles in the area, we are looking forward to working with other partners in London to deliver similar benefits." Darren Briggs, Associate Director, Arup.

Arup, along with The Crown Estate and Land Securities, is looking to establish new consolidation centres for end-users with significant logistics delivery demands. Potential end users who may take part in the demonstrator include St Bartholomew's Hospital, Imperial College London and Land Securities' tenants. The first 12 to 18 months of the project will involve the implementation stages, including initial investigation into suitable end users, setting up consolidation centres and procuring the appropriate electric vehicles. This will be followed by three years of monitoring and evaluation which will look to understand the challenges of these schemes as well as the quantifiable benefits such as the number of electric vehicles that can be deployed, the improvement in air quality, traffic reduction and potential cost savings throughout the supply chain. As part of the project, Arup will be developing an IT platform with ATOS to enable Consolidation Centre operations.

FREVUE intends to reduce congestion and emissions, optimise delivery schedules and improve levels of safety in cities for commuters.

The key ITS areas being developed on the FREVUE programme are intelligent routing systems that can change routes from traffic data, loading bay management systems, on board systems to locate and book charging points for electric vehicles (EV) and IT platforms to facilitate the operation of consolidation centres.

Efficient Consumer Response

Efficient Consumer Response (ECR) is run by The Institute of Grocery Distribution (IGD) in the UK. It is steered by a board group of experts drawn across the transport industry. The ECR is a joint trade and industry body working towards making the grocery sector as a whole more responsive to consumer demand and promoting the removal of unnecessary costs from the supply chain.

The ECR offers a self-assessment tool which has been designed to help and support all businesses in making informed decisions around technology and its relevance in solving specific issues within their distribution businesses. This is an excel-based tool which helps users establish the maturity of their current logistics technology, and make informed decisions on next steps. By benchmarking against current industry examples, company operations are examined in terms of technological development and what the next steps may be to improve efficiency and service.

Research and Education in the UK

- The Transportation Research Group (TRG) based at the University of Southampton is well known for carrying out research into all aspects of the development, application and impact of a wide range of Intelligent Transport Systems (ITS) across the globe.
- The Engineering & Physical Sciences Research Council (EPSRC): The EPSRC have recognised that with the ever-increasing demand on the transport infrastructure, the UK industry needs researchers and future leaders, who can provide solutions to reduce environmental impact and improve the energy and resource efficiency in the transport sector.
- The Industry Doctoral Training Centre (IDTC) in Transport and the Environment at the University of Southampton combines masters-level technical courses and MBA management courses with PhD-level research.
- Other leading UK Universities include; University of Newcastle, Leeds ITS Studies, and Imperial College London.

North America: The U.S. Department of Transportation's (US DOT's) Intelligent Transportation System (ITS) Program aims to bring connectivity to transportation through the application of advanced wireless technologies that enable transformative change[76]. Increasingly, funding investments by the Federal Government in the U.S are targeted at major initiatives that have the potential for significant payoff in improving safety, mobility and productivity. The main focus has been on the integration between vehicles and infrastructure and between modes of transportation.

The United States is considered to be not as advanced in ITS deployment as the UK or Japan in terms of urban traffic systems, although there is a lot of activity in fleet management and vehicle to vehicle (V2V) communications. It lags behind in relation to the provision of real-time traffic information by Government transportation agencies, adoption of computerized traffic signals, and maximizing the effectiveness of its already-installed ITS systems. The United States has pockets of strengths with regard to ITS in particular regions and applications,

[76] The U.S. Department of Transportation, Research and Innovative Technology Administration (RITA), ITS Strategic Research Plan, 2010 – 2014 Progress Update 2012

including use of dynamic and electronic tolling, certain advanced traffic management systems such as ramp metering. The private sector is proactive in the USA in telematics and the provision of travel information, however the use of ITS varies by state and region, thus leading the information to be sporadic and isolated. The systems between states are not connected at national level.

- The ITS market was valued at $52 billion in 2009. This is expected to rise to $73 ($67 U.S. /$7 Canada) billion in 2015[77].
- There are over 400,000 people employed in the value chain working in U.S. While overall patent applications in the U.S. were static, ITS applications grew 17%.
- 3,600 to 6,400 new employees are expected each year in the ITS sector in the U.S. up to 2015[77] and 73% of ITS revenues generated by U.S. companies have a workforce less than 500.

Green Light for Midtown

This was a significant transformative project on the streets of New York City. In 2009, the New York City Department of Transportation (DOT) closed 2.5 acres of Broadway to traffic in Midtown Manhattan and converted that space to pedestrian plazas. The aim of the project was to relieve congestion while improving mobility, safety and quality of life for several hundred thousand pedestrians and vehicles on a daily basis. The project began as a pilot using low cost surface treatments for initial, temporary interventions while the pilot's impacts were studied. In the analysis of numerous performance metrics and through surveys of dozens of user groups, the project was hailed as a huge success. The pilot was approved to be made permanent and construction of the redeveloped plaza spaces will begin in 2013.

The New York DOT analysis of the project noted the following:

- Traffic volumes increased but congestion levels dropped.
- Significant reduction in injuries to motorists and pedestrians.
- 74% of New Yorkers surveyed agreed that Times Square improved dramatically
- The number of pedestrians travelling in the area increased.

The technology used for the development of Green Light in Midtown has been in existence for over 20 years.

BMW i Ventures

In 2011, the BMW Group set up BMW i Ventures which it seeded with $100m. It offers high-potential short and midterm investments in the field of mobility services. BMW i Ventures has been set up to have access to vast corporate resources of the BMW Group and has the agility and speed of a start-up. BMW i Ventures want to develop solutions which are tailored to the specific demands of urban living and designed to make life in cities more pleasant both inside and outside the car.

[77] Sizing the Intelligent Transportation Industry, ITS America, 2011

The Department of Transportation's Research and Innovative Technology Administration (RITA) group have identified seventeen application areas which when combined offer a more integrated ITS. With different programmes and priorities required to administer each application, RITA has not developed a programme capable of governing all applications yet.

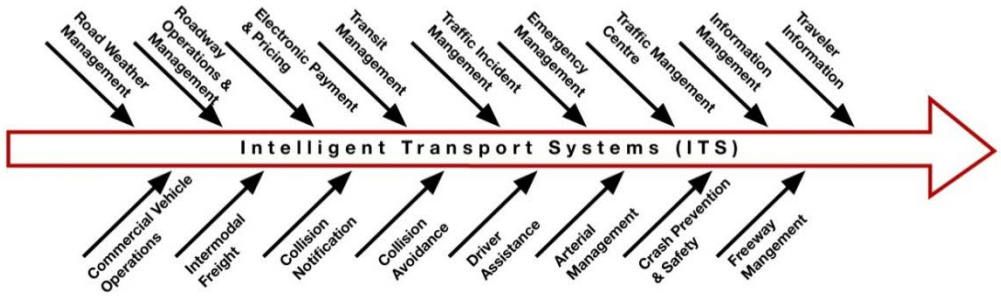

Figure 3.6: RITA: Intelligent Transport System applications

The above figure indicated the different layers of transport management which RITA consider part of ITS applications78

Hong Kong: In Hong Kong over 11.9 million passenger journeys are made every day, about 90% of are made on a public transport system which includes railways, buses, minibuses, trams, taxis and ferries. Hong Kong's roads are among the most heavily used in the world, with about 630,000 vehicles on 2,086 kilometres of roads. In 2001 the Government of Hong Kong commenced a $423m investment in ITS to improve the traffic management and control systems on Hong Kong's nationwide road network. The multi-phased development of ITS in Hong Kong was to undertaken to a common standard to ensure safety and efficiency in the country's transportation system when completed in 2010. The project was also intended to streamline the traffic operations on major highways, road tunnels and urban roads.

In 2006 the HK Government conducted a review on ITS in Hong Kong, and decided to establish a comprehensive Transport Information System and adopt a new Traffic Management Framework to make the transport system more intelligent. In 2006, the HK Government reported it would invest a further $3bn in traffic control systems over the next ten years. This would fund the integration of existing stand-alone control, information and toll systems (e.g. Octopus) into one system.

The Hong Kong Transport Department is also developing a Traffic and Incident Management System (TIMS) to enhance the efficiency and effectiveness in managing traffic and transport incidents, and in disseminating traffic and transport information to the public. TIMS has several functions including automatic incident detection, consolidation of traffic and transport contingency plans, provision of traffic information to stakeholders, dissemination of traffic and transport information to the public, and coordination of existing and future traffic control and surveillance systems. The project is scheduled to complete in mid-2015.

[78] http://www.its.dot.gov/application_areas.htm

T-money

T-money in South Korea is similar to Hong Kong's Octopus Card. It's a rechargeable series of cards and other "smart" devices used for paying transportation fares in and around Seoul and other areas of South Korea. The T-money System has been implemented and is being operated by Korea Smart Card Co., Ltd which is owned by the Seoul Metropolitan City Government, LG and the Credit Card Union.

Hong Kong's Transport Information System (TIS)

This is a centralised data warehouse for the collection, processing and dissemination of comprehensive transport information. It provides four key services:

1. **Road Traffic Information Service (RTIS)** integrates existing services of Special Traffic News, Traffic CAM Online and Traffic Speed Map for HK, Kln & NT (South) on the Internet.

2. **Driving Route Search Service (DRSS)** provides motorists with an optimum driving route search service based on options such as distance, time and toll on the Internet.

3. **Hong Kong eTransport** provides users with a one-stop portal for a multi-modal public transport point-to-point route search service on the Internet.

4. **Intelligent Road Network (IRN)** provides up-to-date information on traffic directions, turning restrictions at road junctions and stopping restrictions, etc. Value-added service providers in the private sector, including telecommunication companies, fleet and freight operators, logistic and IT organisations, can make use of the information for the development of ITS applications such as car navigation, fleet management systems and personalised information services to the public

China: In 2012 the Ministry of Transport in China has announced plans to develop an ITS strategy to be rolled out across the country by 2020. The Chinese Government hopes that an introduction of an ITS strategy will enable more economic growth for China. The Ministry of Transport estimates that there will be over 200 million vehicles in China by 2020, which means that China requires a more intensive use of smart transport technologies to optimize the traffic network and achieve lower-carbon emissions[79].

[79] http://www.trl.co.uk/trl-news-hub/transport-news/latest-transport-news/intelligent-transport-system-planned-for-china_801421169.htm

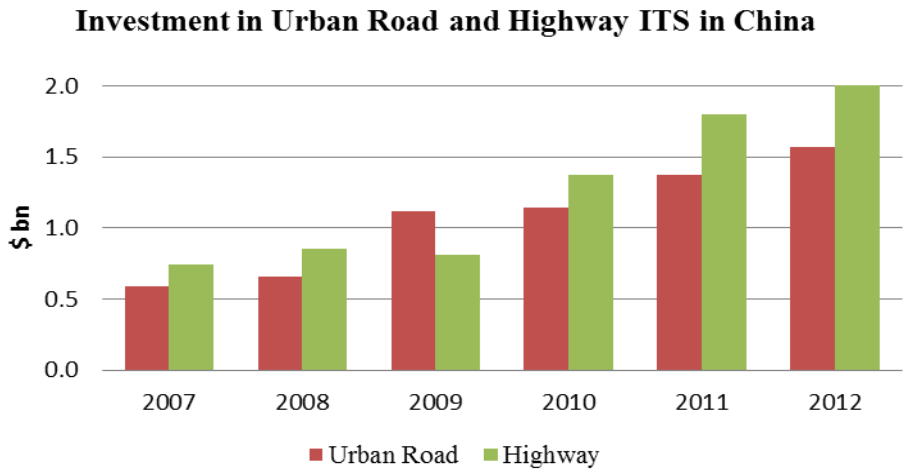

Figure 3.7: Investment in Urban Road and Highway ITS in China 80

Investment in urban road ITS was expected to reach £1.15 billion in 2012, this accounts for 1% to 1.5% of the total investment in new Chinese highway construction. Investment in highway ITS was expected to exceed £1.5 billion in 2012[80].

Brazil: Wasted time and fuel consumed in traffic congestion is estimated to have cost the city of São Paulo nearly US$21bn, or 10% of the city's economy, in 2008. Brazil was expected to invest $80bn in its infrastructure between 2011 and 2014. International experts estimate that this amount is well short of what will be needed to handle major international events such as the 2014 FIFA World Cup and the 2016 Olympics. The Brazilian National Confederation of Transport estimates that priority projects (rail, road, airport and port) need US$250bn in investment to get up to international standard.

In 2011/12 the US FCS which is the trade promotion arm of the International Trade Administration within the United States Department of Commerce undertook a number of trade missions to Brazil to promote the use of ITS in Brazil. In 2011 the U.S. Trade and Development Agency (USTDA) announced it was contributing $460,000 toward the modernization of Brazil's surface transportation infrastructure through a grant awarded by USTDA to EcoRodovias, a Brazilian private intermodal logistics and highway concessionaire company.

Rio – Centre of Operations

The Centre of Operations for Rio De Janerio was created to respond to natural disasters. In 2010, the second year of the current administration, a big landslide killed fifty people. It was originally in the Olympic plan for 2016, but the Mayor decided that it was required immediately. The operations centre was built from scratch in eight months in partnership with IBM and Oracle. The Centre of Operations is used by decision makers in the city to operate general, but especially to coordinate emergency response.

Over time, the administration has begun to develop routine operational uses for the operations centre. For example the garbage trucks are coordinated through GPS, so if something happens the trucks can be re-purposed for other tasks in an emergency situation. This helps them to manage resources and improve efficiency of response.

[80] http://www.researchinchina.com/Htmls/Report/2011/6268.html

India: There are many social and institutional issues facing the deployment of ITS in India; an underdeveloped road network, budget restrictions, huge urbanisation and growth, lack of resources, lack of interest amongst politician's and a lack of user awareness. A few ITS applications have been introduced in metropolitan cities like New Delhi, Pune, Bangalore and Chennai. These projects have focused on standalone deployment of parking information, area-wide signal control, advanced public transportation and toll collection. The projects are small scale pilot studies. However plans are in place to develop a national architecture and system for traffic and travel information.

Singapore: Singapore is regarded as having one of the most advanced traffic management systems in the world. The Singapore Land Transport Authority (LTA) uses ITS to maximise road network efficiency capacity as well as monitor and manage traffic flow. The Singapore ITS infrastructure covers 161 km of expressways and road tunnel systems. The Singapore LTA relies on innovative information gathering, communication and ITS solutions to make roads safer and keep traffic flowing smoothly. Singapore's ITS allows timely dissemination of traffic information which is vital in helping motorists take the best route to their destinations.

Traffic Prediction Pilot in Singapore

The Singapore Land Transport Authority (LTA) is constantly looking for innovative solutions to improve its range of traffic management tools. In collaboration with IBM the LTA recently invested in scheme to predict traffic flows in Singapore's central business district. Using historical traffic data and real-time traffic input from the LTA's iTransport system, IBM's Traffic Prediction Tool was able to predict traffic flows over pre-set durations (10, 15, 30, 45 and 60 minutes). Both speed and volume predictions covering the CBD were above the target accuracy of 85%. In addition, during peak periods where more real-time data was available, the average accuracy of the volume forecasts on the CBD was near or above 90% from 10 to 60 minutes into the future. With these predictions, LTA's traffic controllers will be able to anticipate and better manage the flow of traffic to prevent the build-up of congestion.

The Singapore LTA operates a number of ITS[81].

- **Expressway Monitoring Advisory System:** This monitors traffic along expressways, alerts motorists of traffic incidents ahead of them and ensures swift response to these incidents.
- **Green Link Determining (GLIDE) System:** This monitors, adjusts and optimises green time along main roads in response to changing traffic demand. A variation of SCTS specifically developed for the LTA.
- **Junction Electronic Eyes (J-Eyes):** Monitors the traffic condition at major signalised junctions.
- **Electronic Regulatory Signs (ERS):** Displays prohibited turning movements during specific time periods.
- **TrafficScan:** Uses taxis as probes on the road network to provide motorists with information on the traffic conditions island-wide.

[81]http://www.onemotoring.com.sg/publish/onemotoring/en/on_the_roads/traffic_management/intelligent_transport_systems.html

- **Signalised Pedestrian Crossing:** Facilitates time-sharing of road space between motorists and pedestrians.

- **Parking Guidance System:** Provides real-time information on parking spaces availability of participating developments.

Australia: Australia is considered as being as one of the leaders in ITS development. In 2011 the Standing Council on Transport and Infrastructure (SCOTI) was formed. SCOTI combines the Ministers with responsibility for transport and Infrastructure issues in Australia and New Zealand, and the Australian Local Government Association. Their objective is to achieve a co-ordinated and integrated national transport and infrastructure system that is efficient, safe, sustainable, accessible and competitive. Achieving this objective will support and enhance Australia's economic development and social and environmental well-being. National cooperation through the Council will seek to maximise the contribution of effective transport and infrastructure to Australia's productivity, quality of life and equity. SCOTI sees ITS as a means of delivering significant safety, environmental and efficiency benefits to Australian transport users.

The ITS Architecture framework in Australia intends to deliver more consistent and cohesive services to citizens and support cost-effective delivery of ITS services by Government and industry by:

- providing a common language for sectors involved in the delivery of cross-sector services

- enhancing collaboration and re-usable of sharable services

- assisting in describing and analysing ITS investments

- assisting in transforming Australia to be more citizen-centric, results-oriented and market-based

The national ITS architecture for Australia, will be applied across all transport modes, and is under development under the auspices of Austroads. The Australian ITS architecture is being developed to be consistent with global developments.

Australia are now looking at Cooperative Intelligent Transport Systems (C-ITS). C-ITS is seen an opportunity to considerably advance Australia's road safety through vehicles and infrastructure sharing vital information, which could avoid collisions. The C-ITS technology will also offer productivity and environmental advancements through improved traffic management and decision-making by drivers. In essence, C-ITS is cars communicating with one another. The National Transport Commission of Australia (NTC) is currently examining the policy implications of C-ITS to prepare a final recommendation to SCOTI.

Middle East: Cities in the Middle East are modelling their ITS on best practice from European and USA cities. Dubai has taken the lead in the deployment of ITS in this region. The ITS system in Dubai is capable of conducting hundreds of tasks simultaneously to advise motorist of traffic jams or alter routes, divert traffic away from blocked lanes, moderate speed limits during congestion of incidents, prioritises signal to assist support vehicles in accident and emergency cases.

In a bid to create a world-class transportation system for the Emirate, Abu Dhabi's transport authorities are implementing an integrated ITS strategy as part of their 2030 Plan. All stakeholders are tasked in coordinating and establishing a state-of-the-art multi-modal, multi-agency transportation management centre to ensure the number of road crashes is reduced, improve compliance to the speed limit and cut back on the emission of greenhouse gases. A state-of-the-art transportation management centre will be developed to incorporate a number of integrated intelligent transportation systems. According to research carried out in the UAE by the Roadway, Transportation and Traffic Safety Research Centre, injury crashes to cost the country £3.6 billion annually. In addition to safety issues, traffic congestion is estimated to cost the country £1.9 billion annually. To provide a more coordinated and integrated approach the Department for Transport has now taken over responsibility for the majority or roads external and internal to the cities in Abu Dhabi.

The Qatari Government has just released an ITS Master Plan which the first in a series of documents to standardise and proliferate the use of ITS in Qatar. Whilst a key focus is preparation for the 2022 World Cup, ITS is also be deployed to improved safety and reduce congestion of the road network.

3.7 UK Strengths, Gaps, Opportunities and Barriers

Strengths:

The transport industry in the UK is extensive and the country has numerous experts working within research, technology development, consulting, engineering and manufacturing industries. These experts work on national and international projects providing highly regarded services. Listed below are some of the sectors and skills in which the UK is demonstrating strength and innovation in respect to intelligent transport systems:

- The UK education sector is highly regarded around the globe for provision of world leading research, and development of innovative technologies for the smart transport sector. The University of Westminster is recognised as a global leader in the field of urban logistics and Cranfield University is a global leader in supply chain work.

- The Engineering & Physical Sciences Research Council (EPSRC): The EPSRC have recognised that with the ever-increasing demand on our transport infrastructure, UK industry needs researchers and future leaders, who can provide solutions to reducing environmental impact and improving the energy and resource efficiency in the transport sector. The Industry Doctoral Training Centre (IDTC) in Transport and the Environment at the University of Southampton combines masters-level technical courses and MBA management courses with PhD-level research.

- The University of Southampton: The Transportation Research Group (TRG) based at the University of Southampton has research links with other groups in the UK and overseas. Major activities have traditionally related to all aspects of the development, application and understanding of the impacts of a wide range of ITS. The principal sponsoring bodies for the research have been the European Commission (EC), the Department for Transport (DfT), the Transport Research Laboratory (TRL), the Engineering and Physical Sciences Research Council (EPSRC) and Transport for London (TfL).

- According to Andrew Everett of the TSB, the UK can be considered a world leader at early stage concepts and system integration, although leadership around full operating system may not yet be possible.

- The nation has strong capability in traffic management services through the experience gained during the 2012 Olympics.

- The UK (London Underground) has extensive experience in designing, managing and retrofitting underground transport systems.

- UK consultancies are highly regarded internationally and are well placed to help bridge the gap between Universities and industry, enabling faster development of research ideas.

Gaps:

UK based SMEs and expert companies spoken to, noted that there was sufficient technology in the marketplace to deploy smart transport systems in the UK, however, these companies noted that gaps in funding, manufacturing and standardisation of the market were not helping development.

- The existing traffic systems do not provide sufficient information to enable cities to manage traffic flow more effectively.

- There are funding gaps in deployment of ITS for City councils. City councils have to prioritise where they allocate funding and since the tangible and intangible benefits of ITS are difficult to define, the funding required for ITS is often allocated to other areas.

- There are no British Standards for the development and deployment of Smart Transport Systems or ITS.

- The UK is lacking tier one manufacturing capability (UK suppliers are not ready to supply parts in the development of new technology). From a product development perspective, this means that most of the equipment and technology required will not be manufactured in the UK.

- UK SME companies find it difficult to access financing. Furthermore, proposals by SME's don't often adequately explain the proposal, risk and/or rewards to potential funders.

Opportunities:

There are significant opportunities for the UK to develop the smart transport sector including developing its expert consulting services for export, the new opportunities which the Transport Catapult will bring and the collective bargaining the Government could use to drive down development costs:

- Cities such as Manchester have been very proactive in the development and use of ITS. Manchester has recently issued a request for a Dynamic Road Network Efficiency and Travel Information System Solution. Due to Manchester's success, the opportunity exists for knowledge sharing and transfer, which would enable other UK cities to follow Manchester's lead and develop a similar ITS.

- The design services provided by UK consultancy are highly regarded globally. Opportunity exists for this field in the form of further trade missions by the Government and UKTI, which may help grow the national industry by unlocking new customers in developing regions across Africa, Latin America and Asia.

- The basic infrastructure is in place for development of a strong smart transport market within the UK (e.g. educational institutions, R&D and ITS companies). Furthermore, the Transport Catapult should help bring about a more cohesive voice and approach to transport related issues in the UK and as such, the country is in a good position to adapt and use new technology (particularly if a proactive approach is adopted).

- London has the oldest underground system in the world and a wealth of knowledge in designing underground systems. This information can be better harnessed and utilised to drive innovation in the UK.

- There is an opportunity to utilise the Government's purchasing power to better procure ITS technology. The government and local authorities could use their purchasing power for better effect to enable cities to benefit from improved procurement.

- Opportunities exist for wider distribution of income generated from the release of transport related data.

Barriers:

For a smart transport system to be deployed in the UK, a number of substantial barriers such as the fragmentation of the sector, slow adoption of new technologies, the lack of a holistic vision for the sector, and lack of SME development need to be overcome. An overview of the barriers in place hindering UK firms developing in this sector is provided below:

- There is no strategic, holistic vision set out by the UK Government for ITS. This results in technology developers and customers having different perspectives of what ITS is, and what it should offer cities. This lack of vision also acts to constrain legacy investments.

- There are over 300 different authorities in the UK responsible for making decision on roads and transport. As such, there is no cohesive voice championing ITS and its benefits.

- Cities are slow to adopt new ITS. Industry experts noted that this may be a result of a lack of funding or the perceived risk of implementing a new system. The lack of speed with which city councils are adopting technology is stifling innovation and forcing UK businesses to seek revenue opportunities abroad.

- Industry experts noted that UKTI are looking for large opportunities, therefore there are fewer opportunities for small players operating in the market. UKTI need to develop a more cost effective way for UK SMEs to establish themselves in the domestic market.

- Collaboration and behavioural change is required from operators and end users in order to provide more efficient and cost effective transport services. Policies need to be developed that can drive better alignment among stakeholders.

- The public have a misconception of what 'Smart Transport' represents which stakeholders need to educate.

3.8 What the UK Government is doing?

Until recently, the UK Government hasn't taken an overly proactive role within the industry - it has thus far failed to set goals or a strong vision for the ITS industry. The Government's lack of involvement has hindered development and deployment of new technologies and as a result, the transport industry is fragmented and has no cohesive voice. Despite this, there are currently a few examples of Government development and investment in the smart transport system space. Examples of Government action which have been undertaken to date are included below.

Transport Systems Catapult: In March 2012, the Chancellor of the Exchequer announced the creation of a Transport Systems Catapult. This organisation, established by the Technology Strategy Board (TSB), is intended to become a technology and innovation centre which will enable UK businesses to benefit from the rapidly growing market for innovative transport systems and services. The TSB wants the UK to be the first place in the world where companies develop and deploy their next generation of integrated solutions for transport, and be a strong base for UK firms to secure global market share over the long term. Will Whitehorn was recently appointed as Chairman of the new Transport Systems Catapult.

The Transport Systems Catapult will form part of a network of world-leading technology and innovation centres. It is a long-term investment, which aims to open up global opportunities for the UK companies which will generate economic growth for the future[82].

UKTI: The UKTI have an automotive sector, however they do not have a specific sector on transport. Between 2005 and 2012, the Intelligent Transport Systems and Services (ITSS) Innovation Platform developed by the TSB invested jointly with industry and other funders in projects which promoted UK-based R&D in the field of ITS to strengthen relevant supply chains within the UK. ITSS was set up by the UK Government to develop innovative products and services in response to market opportunities that would result from UK Government led interventions in transport. The TSB's goals for innovation were aligned with the five goals contained in the DfT's 'Strategy for a sustainable transport system'.

[82] http://www.innovateuk.org/content/press-release/chairman-appointed-to-the-transport-systems-catapu.ashx

3.9 Recommendations

3.9.1 What could the UK Government do better?

Leadership and Collaboration on standards and vision

The UK Government, through the Department for Transport, should develop policy on how the UK's urban transport issues could be addressed using smart urban transport solutions and develop a roadmap and targets in collaboration with industry stakeholders, cities and local government. The TSB's Transport Systems Catapult will have a role in coordinating a common vision which could be a platform for policy development. It is essential that this vision is clearly communicated to the industry and the public once developed to give confidence to investors by demonstrating government commitment.

BSI should be tasked with developing national standards for smart transport solutions to provide consistent definition and understanding within the industry and those that procure smart transport solutions (cities and local transport authorities), in the UK and abroad. BSI should also take the lead in developing these standards internationally, potentially enabling British business to access more urban transport markets.

There is some disparity in levels of experience and expertise amongst UK cities and local transport authorities. The government should encourage better knowledge sharing between cities around topics such as the latest art of the possible, innovative procurement routes, and the intangible benefits, so encouraging more UK cities to explore smart transport solutions.

Encourage and Drive Innovation through collaboration, funding changes and open data

The Department for Transport should explore ways to encourage innovation in the transport market. This might include actively supporting local authorities, local transport authorities and SMEs with the development and testing, approval and installation of innovative smart transport solutions. Streamlining the approval processes to speed innovation and encourage more 'experimentation' by cities, perhaps introducing fast-track approval of environmentally sustainable projects. Currently slow bidding processes, dispute resolution and long licensing periods increase costs and the time required to transform transport patterns in major cities. New installation mechanisms and possibly funding should be put in place, encouraging City Councils to trial new smart transport solutions.

This might also include funding for technology development test beds and proof of concept demonstrations. This would be similar to the UTMS (Universal Traffic Management System) initiative in the mid-1990s, where the UK Department for Transport initiated a six-year programme to assist local authorities gain the most from ITS and achieve their transport objectives. In conjunction with local transport authorities, the Department for Transport should explore innovative funding models to ensure funding is available for the most innovative smart transport projects in which outcomes are often less certain than for conventional projects in the transport sector.

Cities should be encouraged to follow the example of Manchester in setting up Transport for Manchester and their recent proposal to procure a managed, hosted, multi-modal transport related Dynamic Road Network Efficiency and Travel Information System Solution.

The Department for Transport, along with the Open Data team in the Cabinet Office should also consider the development of infrastructure to collect and open up real-time information from across the UK's local transport authorities (much already exists), allowing more common open interfaces for the private sector to develop and expand innovative value-added services across more UK cities. This could also help drive performance improvements and innovations between local transport authorities.

3.9.2 UK Business has a responsibility

Alongside engaging and collaborating with BSI and with national and local government to help define visions and standards, UK business must also work to develop a clearer business case. Fundamental to this will be better understanding of the definition of smart transport solution and their benefits to citizens, cities, and industry. Companies need to be creative in how they measure the benefits of transportation systems. They should clarify and quantify the tangible value drivers of smart transport solutions such as reduce congestion and shorten commute time. Companies must also identify the intangible benefits of smart transport solutions, for example putting a value on how much a satisfied customer is worth.

In tandem with local transport authorities, companies should develop incentives for consumers to encourage engagement e.g. price reductions, modal shift reward schemes and bonus points. This should be combined with a more customer-centric approach and public awareness campaigns to build the public case for smart transport systems and engage with legitimate concerns around privacy and data security. This should include identifying the financial savings for consumers.

4 Waste Management

Our review of the waste management industry has indicated that there is not a significant amount of smart technology being used in the waste industry at present. Firms generally use technology to reduce cost and improve efficiencies. However, there are only a small number of examples where companies have used smart technology to create an economic benefit.

Current economic, regulatory and environmental conditions do not appear to be driving key players in the industry towards the adoption of smart technologies. The smart waste management is a nascent market, whose true economic value and wider environmental benefits require further research in order to be fully determined.

Waste is a by-product of economic activity and the smart management of waste will have economic implications, however waste has never seen the same level of research, innovation, product development or investment as the water or energy sector. Human behaviour towards waste, its generation and treatment, plays a significant role in explaining why the uptake in smart waste management is lagging behind those of other smart sector.

4.1 Introduction

Smart technology employed within the waste management industry focuses on enhancing the efficiency of collection and separation. The main driver behind these technologies has been cost reduction and the need for many cities to improve their recycling performance. Waste is a by-product of economic activity and the smart management of waste will have economic implications which will influence productivity, government expenditure and the environment.

The collection and disposal of controlled waste in the UK was estimated to be worth £8.9 billion in 2011. This market has grown recently through the implementation of EU Directives which are aimed at reducing the volumes of landfilled waste and increasing the levels of material recovery through recycling, composting and energy-from-waste[83].

The global waste management industry has annual turnover of $430billion and around 40 million workers. It is estimated that 60% of all waste generated in Greater London is currently exported for treatment or disposal outside of the area. This is contrary to a key objective set out by the UK Government's Waste Strategy for England 2007, which states that waste should be managed as close as possible to the point of production. To this end, London has set a target to achieve 85% self-sufficiency in the management of its waste.

Reducing the amount of waste being sent to landfill is a problem that unites cities with very different levels of wealth and across all regions, but large reductions can be made. For example, New York sends 64% of waste to landfill while Paris sends 11%. Copenhagen has put an integrated programme in place over many years, and now sends less than 2% of waste to landfill; in 1988, over 40% of its waste was sent to landfill. Half of Copenhagen's waste is now recycled and

[83] Waste Management Market Report - UK 2012-2016 Analysis, http://www.amaresearch.co.uk/waste_management_12s.html

maximum use is made of waste to generate heat for the city's district heating network. On the west coast of America, San Francisco leads the way with a landfill disposal diversion rate of 72% and the city has set itself a target of zero waste to landfill by 2020.

Figure 4.1 below shows the waste industry, from the generation of different forms of waste to collection and the different forms of treatment to waste. The application of smart technologies has been limited to a few areas of the industry to date.

Opportunities:

WRAP estimates that of the 600 million tonnes of products and materials that enter the UK economy each year, only 115 million tonnes is recycled. Between now and 2020, WRAP estimates that electronic waste in the UK will total more than 12 million tonnes with a market value of £7bn. WRAP estimate that the UK hospitality sector could save £724 million a year by tackling food waste. Through deployment of smart technologies such as RFID tagging and GPS tracking in the collection of this food waste, a significant saving could also be incurred in the movement of the waste.

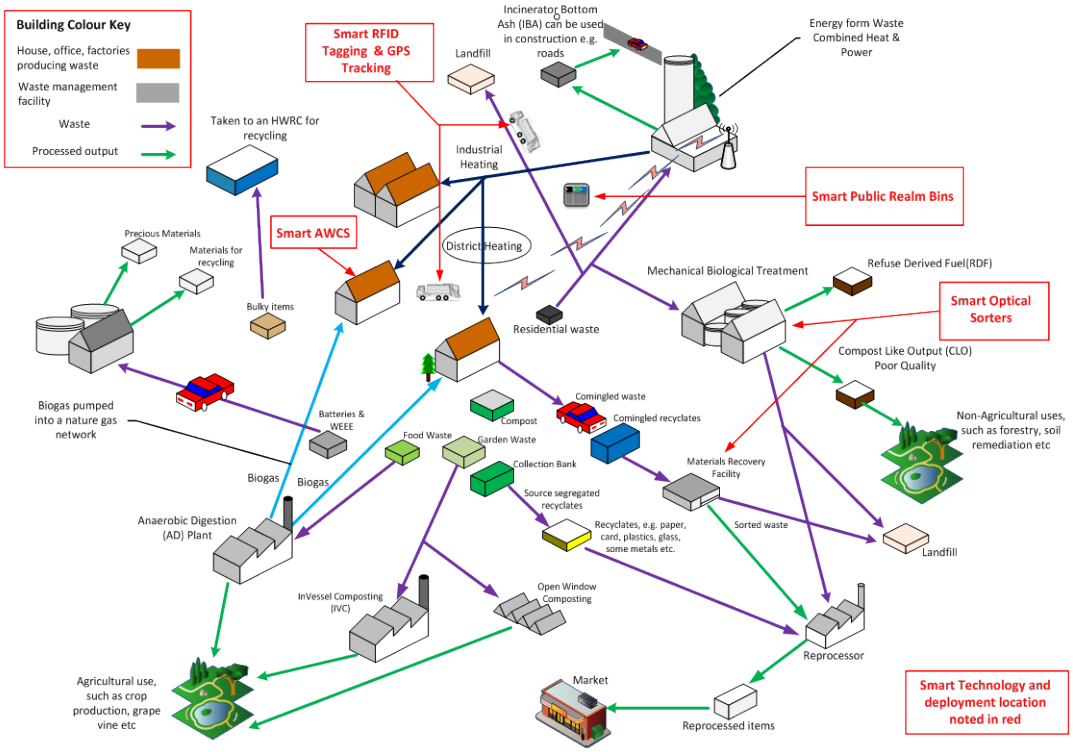

Figure 4.1: Waste collection and treatment Value Chain

4.2 Drivers

The management of solid waste has traditionally lagged behind those efforts to manage waste water or generate renewable energy. However, there are a number of drivers that emphasis why the UK should take the smart management of waste more seriously:

Urbanisation of population: In the latter half of the 20th century, the number of cities with more than 10 million inhabitants increased from 2 to 50. In 2007, urban populations surpassed rural populations. Finding cost effective, sustainable mechanism to treat waste is becoming an issue for a number of city councils. Waste management firms needs to be able to develop and deploy smart technology to reduce costs and improve efficiencies and also to deal with less space and resources.

Improve quality of life: Ever increasing numbers of people living in urban areas places a greater strain on waste management services. This can lead to increased pollution in city environments which could have a knock on effect on human health as a result of uncontrolled dumping and disposal[84].

Maximising resources: Many of the materials that are disposed of in the UK could be reused and recycled if markets were available. In many cases this does not happen, which contributes to a depletion of the world's natural resources. The UK needs to improve its waste recovery rates, particularly in the non-municipal sectors, and to develop waste treatment and recycling infrastructure. Smart waste separation, RFID tagging should facilitate this.

Landfill Directive targets: Major infrastructure investment will be required to meet the EU Landfill Directive targets set for 2013. This directive requires countries to increase their waste recovery rates. Further investment will also be required before 2020 to meet the targets set out by both the Landfill Directive and the EU Renewable Energy target.

Energy use and carbon emissions: The management of solid waste accounts for up to 3% of global CO_2 emissions. The cost of treating waste is also escalating. RFID tagging and GPS on waste collection vehicles should facilitate this.

Public perception: Deploying new smart waste management mechanisms is a means of enhancing a company's reputation.

Local community development: The detriment to the local amenity that results from the mismanagement of waste[85] have led to communities to spearhead new initiatives in managing their waste issues.

These drivers while important do not appear to be having a significant effect on the smart waste sector. The current economic, regulatory and environmental conditions have not had the same effect on technological innovation in the waste sector as they have had in other sectors examined in this report.

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[84] www.irishtimes.com/news/environment/street-cleaning-to-be-withheld-in-parts-of-dublin-due-to-illegal-dumping-1.1357615

[85] http://lovecleanlondon.org/Reports/Home

4.3 Market Size

A value for the smart waste management sector could not be determined. Market research companies do not have valuations prepared on the sector because the sector is so nascent. Globally, the market for waste management as a sector is expected to be worth $475 billion by 2015. The Asian market will account for $184 billion and the Canadian market for $4 billion in 2015[86]. The waste management industry covers a huge variety of operations for different waste streams and different phases of the waste life-cycle. The industry is expected to grow significantly in Asia and developing countries as the economic fortunes of developing countries in Asia improve.

In 2009, Veolia estimated that the total amount of waste generated annually worldwide (municipal, industrial, hazardous) is more than 4 billion tons. The waste management industry has annual turnover above $430 billion and around 40 million workers (including informal recyclers).

The smart waste management sector is a very small percentage of the global waste market at present. As economic parameters, regulations and public requirements changes, it will then start to have a significant role in the overall waste sector.

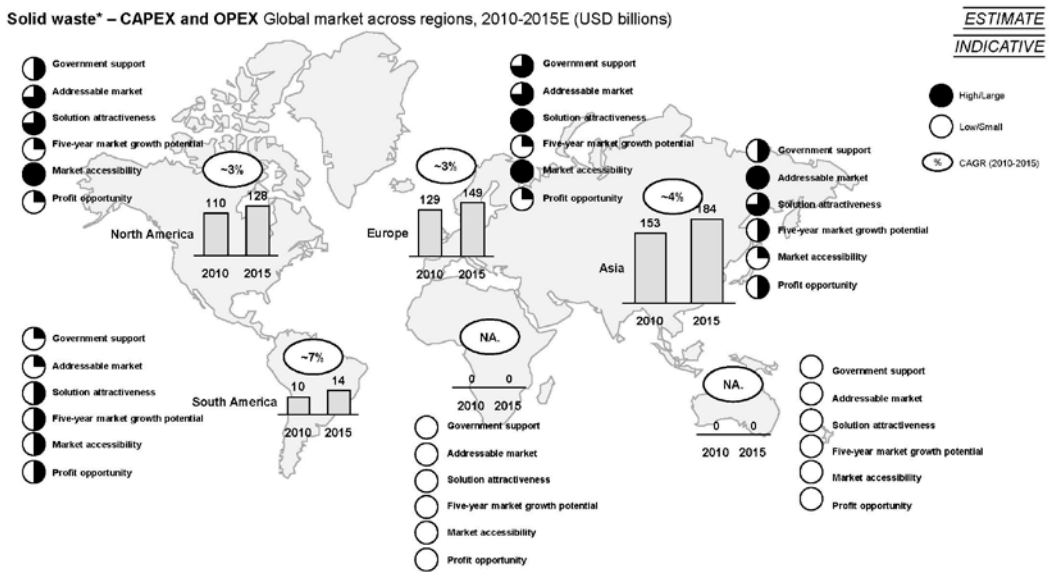

Figure 4.2: Solid Waste - CAPEX and OPEX - Global Market across regions, 2010-15, Global Cleantech Report 2012

[86] www.statista.com/statistics/246178/projected-global-waste-management-market-size/

4.4 Waste Value Chain

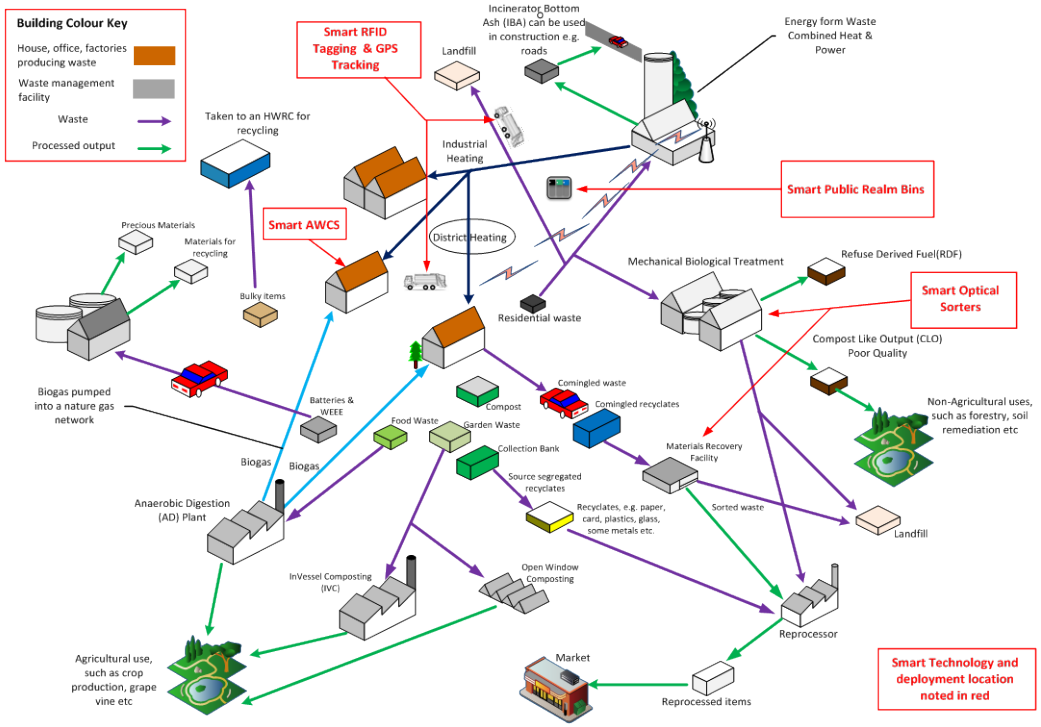

Figure 4.1: Waste collection and treatment Value Chain

The waste cycle is extensive and comprises of many different operators and stakeholders. There are many mechanisms to generate waste, which require separate and sometimes exclusive forms of waste collection and treatment. The application of smart waste technology solutions has been limited to a few areas of the industry to date. While there have been huge developments in treatment technology recently, the use of smart technology within these treatments has been limited.

Design & Engineering Companies: These companies develop waste strategy, policy and compliance. They design and manage the procurement processes which the present waste sector operates on. These companies advise communities, city management and technology providers, O&M companies. The goals of these companies is to design and build waste systems which are optimally designed, incorporate best practises to increase efficiency, be sustainable, lower emissions and optimise use of resources. UK companies operating in this field are highly regarded globally.

Technology Providers: These companies provide technical products and advice, they design systems into projects, liaise with vested parties to ensure their system integrates into the overall design and commissioning. These are the key sellers in the industry, the innovators and integrators in the 'Smart waste' market. The products produced by companies aim to optimise collection routes and treatment of waste.

O&M Companies: These companies procure technologies for their waste management facilities, operate and maintain the facility, finance the facility, they are responsible for waste collection and the performance of treatment facilities. These are the key buyers in the industry and are the likely recipients of the major economic benefits if smart technologies were to become more common place.

Automated Collection Companies: These companies are involved in automated waste collection and provide services to property developers and city management. Refer to Section 4.5 for further information.

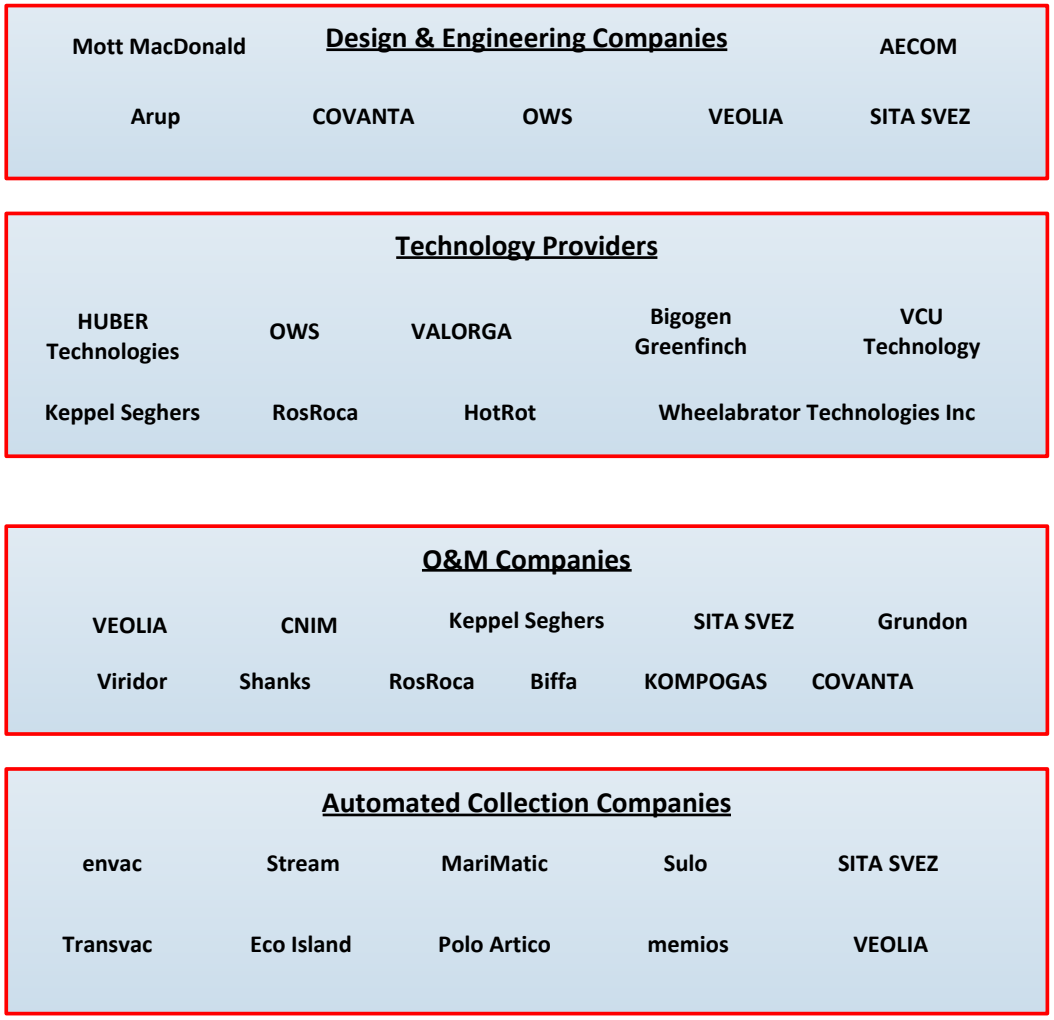

Figure 4.3: Waste Companies - Sector breakdown Source: Arup

4.5 Market and Technology Trends

Much of the "smart" technology employed within the waste management industry focuses on enhancing the efficiency of waste collection and separation. The main drivers behind these technologies have been cost reduction and the need for many cities to improve their recycling performance. The following is a selection of smart technologies which have been deployed.

- Smart Public Realm Bins
- RFID tagging and GPS
- Automated Waste Collection
- Mechanical Separation of Waste

Smart Public Realm Bins: Big Belly Solar UK is a company that produces a street waste collection bin that is a self-contained compactor powered by the sun. The bins can hold more waste than the average street bin due to the compaction feature. The smart angle is that when these bins are 85% full they send an email or text message alerting the collection contractor. This results in a reduced number of collections which saves on collection costs and GHG emissions from collection vehicles. As an added feature each Big Belly bin can transmit a Wi-Fi Platform providing local Council information and local retailer offers.

A study undertaken by Big Belly Solar over six years with 162 UK Councils shows that on average the frequency of bin collection dropped by 86% after the Big Belly Solar bins were installed.[87]

The city of Groningen in the Netherlands saved €92,035 after it installed public bins that could then sent text messages when they were full. Groningen city council reduced labour hours and petrol costs by only sending trucks out to bins that needed emptying.[88]

Refuse Collection Vehicle GPS Tracking: Many waste collection companies utilize GPS tracking on their refuse collection vehicles (RCV). GPS enables RCV fleet operators to track their vehicles with regards to their location, speed and historical routes. This information is useful for monitoring, analysing and improving the efficiency of their operations. GPS tracking enables the most efficient collection routes to be established and also enables operators to divert RCVs to locations that require immediate attention.

In Sevenoaks, Kent the Verdant Group Plc (a specialist municipal services provider) installed GPS tracking in 200 refuse and recycling vehicles[89]. The GPS system reported vehicle movements (authorised or unauthorised), tamper attempts, ignition state and a host of other data via eight input/output ports that were used for additional monitoring sensors. Verdant used these additional sensors to record time, location and process information for functions such as wheeled bin lifting and loading, street cleansing with powered brushes, travel speed and so on. This helped confirm that work is being carried out in the correct locations to mutually-agreed schedules and standards, a key performance element of Verdant's contracts.

Radio Frequency Identification (RFID Tagging): Waste reduction is primarily a behavioural issue but can be influenced through provision of new and existing information and communications technology, including: use of pay-by-weight mechanisms using RFID tags on waste bins; and use of smart-metering and swipe card access to monitor waste outputs and measure effectiveness of waste reduction initiatives.

RFID tagging of waste bins has been in use for some years now. The system works by attaching a unique RFID chip onto each wheelie bin. As the bin is lifted and emptied by the refuse collection vehicle, the RFID chip is scanned and the bins weight and contents are recorded. This is then stored in a central database that that can be used to monitor the quantity and types of waste people are disposing of. In addition to RFID chips on conventional wheelie bins other waste

[87] www.bigbellysolar.co.uk/about
[88] Maia Palmer, FT, Monday 28th Feb 2013
[89] www.enigmavehicle.co.uk/case-studies/waste-management/

systems are now using RFID swipe cards to control access to certain bins and also charge people for the type and quantity of waste they dispose of.

In South Korea, RFID swipe cards have been introduced for food waste bins. Food waste management in South Korea costs the government. The South Korean government is looking to reduce the amount of food waste that is generated. In response to this South Koreans have been issued with RFID swipe cards which debit their accounts according to the amount of food waste they generate, the swipe cards can also be used to access public transport.

Figure 4.4: RFID activated food waste bins in South Korea
Source: www.guardian.co.uk/sustainable-business/south-korea-swipe-card-food-waste

Automated Waste Collection Systems: Automated Waste Collection Systems (AWCS) have been in operation for decades. However, the first system in the UK only came into operation in 2008 at Wembley City in North West London. An AWCS can transport waste from each floor of a building/complex of buildings and communal area pneumatically through a set of pipes. An AWCS consists of a number of waste inlet points, linked together by a network of pipes that transport the waste to a central waste collection station for compaction and temporary storage.

Suppliers of this technology provide different variations and models that collect a broad range of waste. For example there are some systems that collect food waste only from commercial kitchens, linen from hotels and hospitals, mixed waste and recyclables from residential areas and also systems that have no collection station but instead are emptied by a special truck that sucks the waste out of the system at designated intervals.

AWCSs are being successfully used in many countries across the world (including the UK, Sweden, Spain, Germany, Korea, Singapore, Malaysia, Hong Kong, China, USA, Qatar and Dubai). The design life of the AWCS is about 30 to 40 years depending on the thickness of the installed pipes, the type of waste transported and the number of bends in the pipe network. There are no UK owned suppliers of AWCS technology however, there are several global providers. The smart aspects of this technology are:

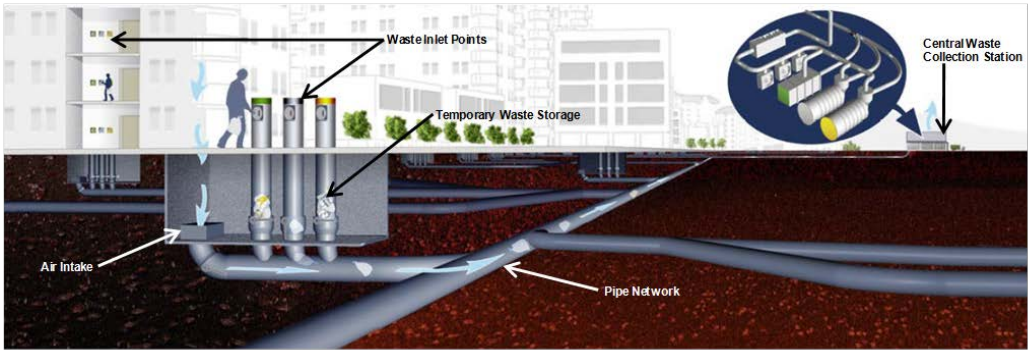

Figure 4.5: An illustration of an Automated Waste Collection Systems system
Source: Envac

- It enables the use of RFID tagging to track who deposits what type of waste in each inlet. The system can weigh the waste based on type is versatile and modular so it is future proof and easily expandable and adaptable

- The system is controlled by a computer system that enables easy control over how often and where the system is emptied. The system can be programmed to empty at set intervals or based upon how much waste is deposited in the inlets, this helps it adapt to special events when the waste generation rate can spike.

Mechanical Separation of Waste: Once waste has been collected from its source of generation (homes, offices, hotels etc.) it is often taken to a Materials Recovery Facility (MRF). These can be clean (for sorting recyclables) or dirty (for sorting residual waste). These facilities contain a number of different mechanical sorting technologies that can separate waste based on the following properties:

- Size & shape,

- Density,

- Magnetism,

- Electrical conductivity and

- Optical properties

The primary basis for their use is to extract valuable resources from the waste stream. A number of smart technologies have been taken from other industries and adapted into MRFs to separate material.

Mobile Phone Applications: There is potential to engage the public in better public realm management, especially around waste. The Love Clean London initiative uses mobile phone and 'apps' technology to enable members of the public to report environmental quality issues such as graffiti vermin, poor waste storage and fly-tipping to their local authority. Users can send a text, upload photographs online or use a free mobile phone application to submit reports to their local authority. Reports are shown on an online interactive map, which allows local authorities to prioritise clean-up operations where most needed, helping to maintain a clean and pleasant public realm environment for the community. It also enables photographs to be displayed to show where clean-ups have taken place and the results of the action taken.

4.6 Regional highlights

Most of the trends occurring in the waste management industry focus on enhancing the efficiency of collection and separation, however many of these recent developments and improvements would not be considered ‘smart’. The following countries, cities and examples referred to in this section provide an overview of the contextual currencies which are affecting waste management on a regional and country basis. They are intended to highlight new and best practises around the world in waste management and sometimes smart waste management.

Europe: Western Europe is recognised as world leaders in waste management. This is mainly due to legislation (EU Landfill Directive) being in place the longest and having more developed economies. There is no leading country which can be identified in this sector. Western Europe is moving away from landfill and is now using a combination of recycling, biological treatment and thermal treatment. In Europe 30 to 40% of the waste in now used in Waste to Energy (Anaerobic Digestion and Thermal Treatment combined).

The Netherlands recycles 64% of its waste and most of the remainder is incinerated to generate electricity and heat. Only a small percentage ends up in landfill. The Dutch approach is known as 'Lansink's Ladder' - avoid creating waste as much as possible, recover the valuable raw materials from it, generate energy by incinerating residual waste, and only then dispose what is left over – but do so in an environmentally friendly way. This forms the basis of the 'waste hierarchy' in the European Waste Framework Directive. The lack of space in the Netherlands and a growing environmental awareness forced the Dutch government to take measures early on to reduce the landfilling of waste. This in turn gave companies the confidence to invest in more environmentally friendly solutions.

UK: Department for Environment, Food and Rural Affairs (Defra) recently withdrew £200 million of Private Finance Initiative (PFI) credits from three waste infrastructure projects. Defra has already invested some £600 million in its Waste Infrastructure Delivery Programme, and will invest a further £3 billion in 29 PFI projects over the next 28 years in order to meet EU targets. The Chartered Institute of Waste Management (CIWM) has expressed their concern about the short and longer term impact of the Defra’s decision on the waste and resource management sector. The CIWM have called for a long term, joined up approach to resource management in the wider sense.

UK waste generation has been reducing since 2000, decreasing by 11.3% between 2004 and 2008. The industrial and commercial sector saw the biggest percentage change in generation with a decline of 17.3% over the period. In 2008 the UK total waste generation was estimated at 288.6 million tonnes (mt), down from 325.3mt in 2004. During the same period the quantity of waste recovered in the UK has increased by 50% from 95mt in 2004 to 143mt in 2008.

USA: In general the USA relies heavily of landfill disposal. There are however many variations between cities and states. The Rocky Mountains states and Midwest states depend mostly on landfill disposal, primarily due to the availability of cheap land. While the states in the west and north east have more of a balanced mix between landfill disposal, recycling and waste to energy. San Francisco leads the way with a current landfill diversion rate of 72% and a target to achieve zero waste by 2020.

Hong Kong: Hong Kong currently disposes the majority of its waste at three contained landfills located strategically throughout the territory. However, over the years the amount of waste that Hong Kong generates has continued to increase resulting in the lifespan of the landfills decreasing. To solve this problem Hong Kong is currently in the process of revolutionizing the way it manages its waste. This will be achieved through a combination of waste reduction efforts and recycling, the construction of two separate sludge and municipal waste power plants, organic waste treatment plants, construction waste management facilities and extending the existing landfills.

China: China is now the largest generator of waste in the world, producing approximately 190mt a year. In recent years, the Chinese central and local governments have made great efforts to improve waste management in China. New regulations and policies have been issued, urban infrastructure has been improved, and commercialization and international cooperation have been encouraged. However, China still only captures and treat approximately 60% of the total waste generated. The use of energy from waste technologies (incineration, anaerobic digestion etc.) is one the faster growing waste technologies in China.

India: India has a very under developed waste management sector. Open dumping is prolific and the environmental and human health impacts associated with this are endemic. India has however, made great strides in developing small scale organic waste treatment processes such as Anaerobic Digestion and Aerobic composting. There are huge opportunities for UK companies to offer their services to India.

Singapore: Singapore has set itself a target of 70% recycling by 2030. The Government is also placing more emphasis on waste generation reduction, source separation and education. There are great opportunities for Singapore to increase the recovery of resources from organic waste and prevent this from being disposed at landfill. Singapore is also investing in the next generation of thermal treatment plants to further reduce the need to dispose of waste at landfill.

Brazil: Brazil relies heavily on the informal Catadores (waste collectors) to collect and recycle materials such as paper, plastics and metals. In major cities such as São Paulo, the majority of the waste is collected by concessionaries. Brazil operates a very good waste collection network but lacks the infrastructure that can recover resources from the waste stream. Cities like São Paulo are looking at developing energy from waste thermal treatment plants but in addition to that there is good potential for organic waste treatment facilities as a large percentage of Brazil's urban waste is organic.

Brazilian Waste Market Summary (UKTI Report, 2010)	
Industry Size	$10 billion p.a. huge number of organisations (for instance more than 5,500 municipalities, several hundred hospitals, and many private waste generators, which are under increasing pressure to take more responsibility for their waste).
Industry Structure	Large and SME for municipalities, their contractors and independent firms large an SME for industry, construction, hotel & catering etc. some fragmentation growth
Growth (5-year trends - output & investment)	7 to 10% per year
Short to medium term outlook	Healthy

Main strengths	Latest legislation and policy towards optimising the 'waste hierarchy'
Gaps identified	Technology, skills, equipment, capacity to deliver

Table 4.1: Brazilian Waste Market Summary, UKTI Report, 201090

For UK companies seeking to do business in Brazil, UKTI advises that these companies should focus on exporting expertise and technology that is not available in Brazil. For lower-end solutions, UK firms should consider some form of joint venture, partnering with NGOs for design consulting advice.

Middle East: The Gulf States waste management services industry has developed into a multi-billion dollar market. Governments in the region are providing substantial investments. The GCC countries are using advanced waste management solutions for treating both domestic and industrial waste. Increasing urbanization and an influx of immigrants from other countries are leading to higher volumes of waste.

The GCC countries are using the latest alternative waste management solutions for recycling, composting, and waste-to-energy. The Gulf market offers more opportunities than the markets in developed regions. The scale of the projects in the Gulf States creates substantial prospects. The market in the GCC suffers from inadequate information being available in the waste market; however this is expected to change soon, which should allow for the full potential to be determined. Stringent environmental regulations are now in place in the GCC States which should also help develop the industry.

4.7 UK Strengths, Gaps, Opportunities and Barriers

Strengths:

The waste industry in the UK is extensive and the country has numerous experts working within the consulting, operational and engineering sectors. These experts work on national and international projects providing highly regarded services.

- UK consultancies are highly regarded internationally and are well placed to help bridge the gap between Universities and industry, enabling faster development of research ideas.

Gaps:

Our review of the sector shows that there is an insufficient understanding of how smart technologies could be fully deployed in the waste sector. There is a lack of funding for research, innovation development, and large scale trialling of innovation.

- Existing waste systems do not provide/gather sufficient information (data) to enable cities to develop/manage waste more sustainably.

[90] UK Environment and Water Opportunities in Brazil, UKTI, 2010

- There are funding gaps in deployment of smart waste technologies for waste management companies and city councils. City councils have to prioritise where they allocate funding and since the tangible and intangible benefits of smart waste management have not been fully developed, they find it hard to provide funding for the deployment of smart technologies.

- The UK is lacking tier one manufacturing capability (UK suppliers are not ready to supply parts in the development of new technologies). From a product development perspective, this means that most of the equipment and technology required will not be manufactured in the UK.

- There are no British Standards or guidance notes which will lead the development and deployment of smart waste management solutions in the UK.

Opportunities:

There are significant opportunities for the UK to develop the smart waste management solutions such as developing its expert consulting services to advise regulators/Governments and city councils on best practise in the UK and aboard. There are opportunities for city councils to gain economic benefits from the use of smart technologies which could then be put to better use to serve the public.

- The design services provided by UK consultancy are highly regarded globally. Opportunity exists for this field in the form of further trade missions by the Government and UKTI, which may help grow the national industry by unlocking new customers in developing regions across Africa, Latin America, India and Asia.

- The basic infrastructure is in place to develop smart waste management solutions within the UK (e.g. universities, R&D and waste management companies).

- There is an opportunity to utilise the Government's purchasing power to better procure smart technology for its deployment nationally. The Government should use their purchasing power for better effect to enable cities to benefit from improved procurement.

Barriers:

For smart waste management solutions to be deployed on a widespread level the UK, a number of substantial barriers such as the sector fragmentation, its slow adoption of new technologies, not having a holistic vision and lack of SME development need to be overcome. An overview of the barriers in place hindering UK firms developing in this sector is provided below:

- Understanding the problem: many counties/cities etc. have a poor grasp of the waste they generate and its composition.

- Realising the potential: secondary markets into which materials could be recycled/sold are often poorly defined, managed and regulated.

- Overcoming social concerns: waste management is often out of sight and out of mind and can have a generally negative reputation in the community.

- Optimizing production: many products today are designed for a short life and to be replaced. It is often difficult to disassemble these products for recycling. By incorporating end of life considerations into the design of products reuse and recycling can be made easier.

- Reducing consumption: as people get richer they generate more waste. Research and trialling of mechanisms which find a way of breaking this link while still maintaining economic growth need to be undertaken.

- Protecting the environment: the uncontrolled dumping of solid waste can have very negative impacts on the surrounding environment and human health.

- City councils may need to review their contracts with waste collection companies to permit them to trial smart technologies.

- While there have been huge developments in treatment technology recently, technology barriers which these technologies face will become barriers for smart technologies in future.

4.8 What the UK Government is doing

The UK Government has not seen the need to take an active role in setting goals or a vision for smart waste solutions. However, Government bodies and policies are in place to deal with waste management.

WRAP: WRAP was set up in 2000 to help recycling take off in the UK, initially by creating markets for recycled materials. WRAP is funded by all Governments across the UK. WRAP work with a wide range of partners, from major UK businesses, trade bodies and local authorities, through to individuals looking for practical advice from our websites. WRAP helps people recycle more and waste less, both at home and at work, and offers economic as well as environmental benefits. WRAP goal is a world without waste, where resources are used sustainably.

WRAP has a number of principles:

- Focus on preventing waste

- Getting value for money for the tax-payer

- They working in partnership and support the work of others

From 2011-15 WRAP aims to:

- Encourage better design and more informed consumption which will reduce waste generation

- Make it easier to recycle, repair and re-use as much of our waste as possible.

- To enable businesses to recover as much value as possible from the waste that's collected

- To assist business to keep resources moving round the economy.

DEFRA Government Review of Waste Policy in England (2011): This policy sets out the Government's overarching approach to work towards a zero waste economy. Central to this is the value of waste as a resource, both financially and environmentally, and working towards zero waste to landfill. The Government's review sets out a number of principal commitments designed to achieve these objectives, which are supported by a number of action plans. It also places greater emphasis on waste minimisation at the design stage where the largest environmental and financial savings can be made.

Planning Policy Statement 10: Planning for Sustainable Waste Management (2011): This policy sets out the Government's policy to be taken into account by waste planning authorities and forms part of the national waste management plan for the UK. All Planning Policy Statements have now been superseded by the National Planning Policy Framework; however the framework does not contain specific waste policies, since national waste planning policy will be published as part of the National Waste Management Plan for England.

4.9 Recommendations

What could the UK Government do better?

Leadership and Collaboration on standards and vision and research

The UK Government, through DEFRA and other bodies, should explore how smart waste management could help to address waste management issues in the UK.

Government has a role in convening and co-developing platforms that enable the waste industry, academic, associations, government entities utilities, SMEs and local groups to collaborate on the advancement of the waste industry. These platforms can contribute to the setting of vision and standards for smart waste management, as well as public engagement activities, and knowledge sharing on procurement, benefits and implementation aspects.

One outcome of the collaboration, vision and goals driven by government, should be a roadmap or strategy for deepening academic and industrial research into innovative applications of smart waste management concepts and their tangible benefits, in conjunction with BIS and RCUK (Research Councils UK). Supporting and encouraging R&D in areas of research that are currently under invested, such as dematerialisation, the restorative economy, new business models, and behavioural issues, will put the UK in a leading position regarding smart waste management internationally.

Encourage and Drive Innovation through guidelines, contracts and incentives

The public sector market for waste management in the UK is characterised by local councils signing performance-related contracts with waste management companies. Incentivisation models must shift to more outcome-driven models where citizens, waste producers and waste management companies are all incentivised to reduce waste and manage waste streams better. Local councils

must change the way they procure waste management services. Research and development is necessary to better understand what this model would look like, but national government has a role in developing guidelines for local authorities on local waste policies, procurement models and contracts, to encourage the use of smart technologies to deliver better outcomes.

UK business has a responsibility

Alongside government collaboration and R&D efforts, UK business must also work to develop a better understanding of the value of waste. The waste management industry in particular must work to develop new business models and a clearer business case. This will require a better understanding of the tangible and intangible benefits of smart waste management solutions and the vision of future waste management. The industry must also collaborate more closely with the wider material and value chains – i.e. with the industries that manufacture and sell products that currently end up in disposal. The waste management industry must articulate more clearly how real-time information from smart waste management solutions can be used further back in the manufacturing and design stages of the cycle. Business is best placed to lead this collaboration, though as described above, there is a role for government.

5 Assisted Living

Healthcare and social care systems around the world are seeing increasing demand as populations increase and more people live longer with long term conditions, disabilities, or the difficulties that come with age. There is an increasing need to help people live at home or in their communities longer.

Assisted living technologies can help these demographics to live independently for longer, increasing their quality of life and reducing the burden on core health and social care services such as hospitals and formal care homes.

However, technology alone cannot achieve this systemic change. Clinicians and the healthcare establishment must realign the established patterns of healthcare (care pathways) to take advantage of opportunities presented by technology.

The opportunity is large, with a European market worth £500 million by 2015 alone[103], and some healthcare systems are already benefiting, such as the US Veterans Health Administration saving almost $2000 per annum per patient with a 61% reduction in bed days of care. [108]

The Department of Health's 3MillionLives programme is a key cross-industry initiative for the UK market, and alongside the UK's strengths in product design, and life sciences and the role of the NHS, places the UK on a good footing. Issues around pricing and standardisation, disparity between regulation regimes, and low awareness amongst buyers (Clinical Commissioning Groups) and local authorities need to be dealt with. These obstacles can be overcome through industry collaboration, product and business model innovation, and the transformation of care pathways.

5.1 Introduction

There is mounting pressure on governments resulting from the need to provide the right living conditions for the elderly population in order to facilitate independent living, against a backdrop of rising retirement age and increased life expectancy. This is compounded by an increase in the prevalence of mental health conditions and long-term physical conditions among the ageing population. In the UK the Department of Health predicts up to 75 percent of people above the age of 75 will suffer from chronic disease, with the incidence of chronic disease expected to double by 2030[91].

Definition

Assisted Living for the purposes of this report is a philosophy of care promoting independence and dignity through the use of services and technology including instruments, apparatus, appliances, or materials, including software, necessary to assist people aged above 65, and those who are physically and cognitively impaired, in fulfilling daily activities towards independent lives and an improved quality of life.

Source: Adapted from Assisted Living Technology: A market and technology review (2012)

The global issue of an ageing population presents particular challenges for policy makers in terms of developing and maintaining health-social care systems that are

[91] Ageing population and long term conditions fact sheet, Department of Health, 2010

affordable, sustainable alternatives to some of the more inefficient models of care that currently exist.

Context

The environment for Assisted Living within Europe and globally is characterised by a significant economic challenge resulting from efforts to reconcile increasing demand for health and social care with constrained national budgets for public funding, compounded by the impact of the continuing recession.

There is also often a largely reactive approach to chronic condition management which is recognised as being increasingly unsustainable, evidenced by increases in emergency hospital admissions, increasing demand for primary care services, repeated handovers from professional to professional and inconsistent home-care provision. The market is therefore increasingly seeking more integrated solutions that are innovative, technologically advanced, and cost effective in order to maintain quality of care while coping with increasing demand and limited health and social care resources. However, while barriers to widespread adoption remain, these are surpassable.

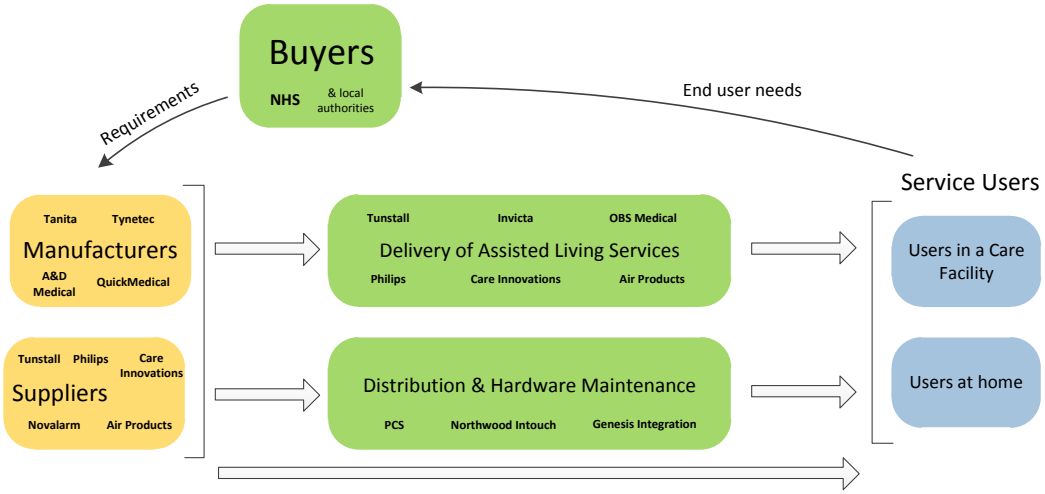

Figure 5.1: Overview of the value chain for assisted living technology products and services in the UK. Source: Arup

Role of Technology

This demographic shift and the need for better health-social care and whole system integration to keep people well and independent for longer, presents significant opportunities for technological innovation to make a tangible difference to people's lives. The development of assisted living technologies and assisted living services can efficiently enhance the living conditions of older people and those who are physically impaired, playing a crucial role in helping them to live their lives safely and independently.

As an emerging industry, the range of technology and applications is continually evolving, along with an array of technology jargon. This report looks at the range of technologies that might be categorised as telehealth, telecare, telehealthcare, ambient assisted living, assisted living services, and assisted living technologies.

As with the assisted living market, the meaning and use of these terms is continually evolving.

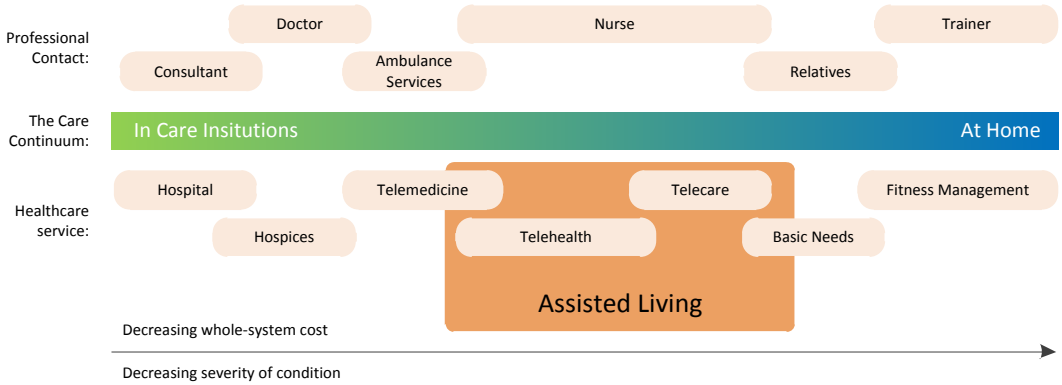

Figure 5.2: Diagram showing Assisted Living Technology products and services on a care continuum. Source: Arup

Opportunities

The developments in assisted living technology (ALT) and services create a significant opportunity for enhancing patient experience and quality of life while reducing cost through efficiency gains and improved health and care outcomes. This tied with demographic and socio-economic trends creates opportunity.

In the UK alone, the use of telehealth (only one of the core assisted living technologies) across the NHS could result in £1 billion in annual savings with hundreds of thousands of patients' lives improved significantly[92]. The 'Healthcare without walls' report also indicates that one of the greatest strategic issues facing the NHS is how we manage patients with long term conditions, such as chronic obstructive pulmonary disease, heart failure and diabetes, given that 70% of its budget is currently spent on the 15m people who have one or more of these conditions. With ageing population and increasing patient numbers in the UK, there are significant opportunities to radically change the approach to delivering care to people with long term conditions (LTCs) to make it more sustainable in terms of cost and quality of care.

In order to realise the benefits of applying technology in this area and fully exploit the opportunities, a significant amount of joined up working and collaboration is required within the healthcare supply chain, perhaps enabled through establishing greater incentives and strategic drivers for adopting ALT at scale. Crucially, these opportunities will only be fully realised when ALT is embedded directly into patient care pathways.

5.2 Drivers

The following summarises key market drivers, outlining the most significant factors likely to stimulate market growth for Assisted Living technologies and services:

[92] Healthcare without walls: A framework for delivering telehealth at scale, John Cruickshank, 2010

Demographic factors driving the market

The primary demographic challenge is that of an ageing world, especially one in which the aged are not necessarily healthy. It is estimated that by 2030 more than 1 billion people will be aged 65 years or older[93].

In the UK alone, in 2010 it was reported that there were 10 million people over 65. This number is predicted to rise to 16 million by 2034[94]. The fastest growing group is people over 85 years, often referred to as the 'oldest old'[95]. Their numbers are projected to rise from 1.4 million to 3.5 million (5 per cent of the total UK population) by 2034. The number of centenarians in the UK is also projected to rise from 12,640 in 2010[96] to 87,900 with one in four people born today expected to live to 100 years old[97].

Despite increasing life expectancy, these extra years are not always healthy. While global ageing shows evidence of humankind's great medical, social and economic advances; it also presents the whole world with significant challenges, not least in health and social care. In particular, age is a predictor of disability[98]. An estimated four million UK older citizens (40 per cent of all people over 65 years) reported having a long term condition or disability in 2009. This is predicted to rise to 6 million by 2030[97]. Such conditions can limit people's ability to undertake activities of daily living or attend to their personal needs.

Similarly, beyond the UK large increases in disability caused by age-related long-term conditions are predicted in all regions of the world, with non-communicable chronic diseases such as cardiovascular disease, dementia, arthritis and diabetes being the largest cause of loss of health and life rather than infectious diseases and accidents. In addition, the proportion of older people living alone is increasing, particularly in the most developed countries. This represents a huge social change which has taken place over the last 50 years.

Economic & Social factors: shifting customer demands

In terms of potential demand, by 2015 there will be 75 million people above 65 years of age living in Europe[99], creating increasing pressure on both working and independent populations and health and social care systems. This significant social issue will continue to drive potential demand, which could potentially be met by ALT that in turn, could indirectly benefit each regional economy.

The global increase in the elderly population is one of the key factors that support the case for funding key initiatives around ALT, not least as a result of pressure to address significant challenges presented by a rise in the retirement age and

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[93] Why population aging matters: a global perspective, 2011, US National Institute on Aging
[94] Later Life in the United Kingdom Factsheet, AgeUK, 2013
[95] Living Beyond 100 - A report on centenarians, November 2011, Serra V, Watson J, Sinclair D and Kneale D
[96] Number of Future Centenarians, 2010, DWP
[97] National Population Projections, 2010-based, ONS, 2011
[98] Vision Loss in an Aging Society, 2000, American Foundation for the Blind (Crews and Whittington)
[99] Assisted Living Technology: A market and technology review, 2012

increased life expectancy (reinforced by more effective medicines). These also provide new opportunities for social and healthcare providers aiming to meet increasing and different types of demand. The emergence of programmes such as AAL are beginning to enhance the profile of this sector and are helping to attract increasing investment and fuel market growth.

It is anticipated that the nature of demand from the ageing population is likely to change and this shift is likely to drive a vast expansion in product portfolio and the variety of equipment (and related services) required to meet service-user needs (increasing customisation of product and technology development). This will be driven by the elderly population's increasing emphasis on preventative medicine and healthy living (reinforced by greater social awareness and information sharing around risk factors and wellbeing promotion).

It is important to note, however, that within the next ten years these consistently high levels of demand, and diverse types of demand, are expected to help reduce the cost of equipment.

Technological

Technological progress and global market trends might expand the range of ALTs and ALSs which are in mainstream use over the next 20 years[100]. There are reportedly three major technology factors which will impact use of ALSs over the next 20 years:

- **Lower cost:** more efficient equipment offering greater processing speed and memory while consuming less power. The introduction of global standards in global markets could significantly reduce the price of most sensors, internet access devices and home hubs. Technological and regulatory factors of this kind could also lead to wireless sensors with a life of at least five years[100].

- **Commoditisation of broadband communication:** building on the UK government's existing pledge to provide basic broadband for all. Factors include the rollout of LTE-based mobile networks and fibre-based fixed networks that will enhance widespread availability of broadband to potentially facilitate real-time, video communication for all service users.

- Shift towards **mass-market device platforms** such as smartphones with software APIs, on which independent companies can design specialist ALT applications.

- **Big Data:** the transformative power of Big Data is emerging as a few healthcare systems begin to collect and mine their data, e.g. the recent announcements by the UK Department of Health to make some patient data available for research. The power of Big Data in healthcare is only just becoming apparent and is likely to have a positive impact on the effectiveness of ALTs.

[100] Assisted living technologies for older and disabled people in 2030, March 2010, Plum Consulting

European and Global political drivers

In order to enhance political and clinical collaboration and cooperation internationally and accelerate the establishment of this emerging industry (including addressing issues such as fragmentation of the supply chain) international Government policy and support will continue to play a key role.

Given the significant economic issues presented by the non-sustainability of current systems, the role of both political and economic strategies to fund and facilitate the wider application of ALT and service is fundamentally important.

Evidence of the importance of this within Europe can be seen through the establishment of initiatives that have significant government backing such as the European Commission DG-CONNECT Ambient Assisted Living Joint Programme[101] ("AAL") which is a scheme developed to enhance the quality of life for the elderly through effective use of information and communication technology.

5.3 Value Chain and Route to Market

The market for assisted living technologies and services fits closely with the healthcare sector structure. As such it varies with the different healthcare systems of different countries. Figure 5.1 reflects a generic view of these differing market structures.

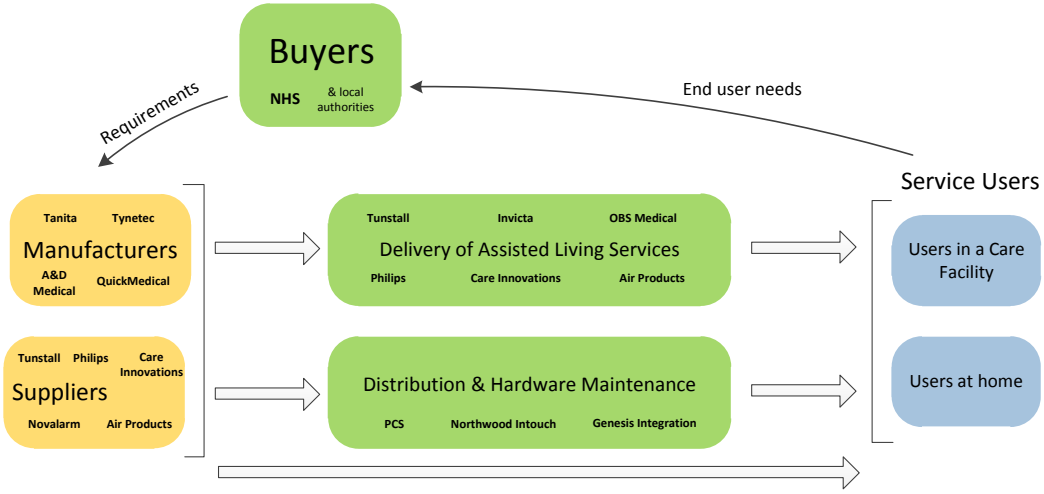

Figure 5.1: Overview of the value chain for assisted living technology products and services in the UK. Source: Arup

Route to Market

In the UK elderly and disabled patients are currently able to obtain assistive technologies and services through a combination of statutory provision, retail markets and a hybrid combination of both statutory (including NHS and local authorities) and private provision.

[101] www.al-europe.eu

A new framework agreement was constructed to address a revised set of needs and a greater understanding of the market, and following an EU compliant procurement process, the new framework agreement and its associated catalogues were established in August 2010. This enables contracting authorities to call-off goods and services across six different lots using standard terms and conditions. One of the major new developments of the framework agreement was the addition of new services such as telecoaching as well as a new lot for 'managed services' enabling a one-stop shop for a turnkey telehealth service.

Composition of the market

The figure below shows the number of companies by medical technology segment in the UK - the "stars" describe market segments closely associated with ALT:

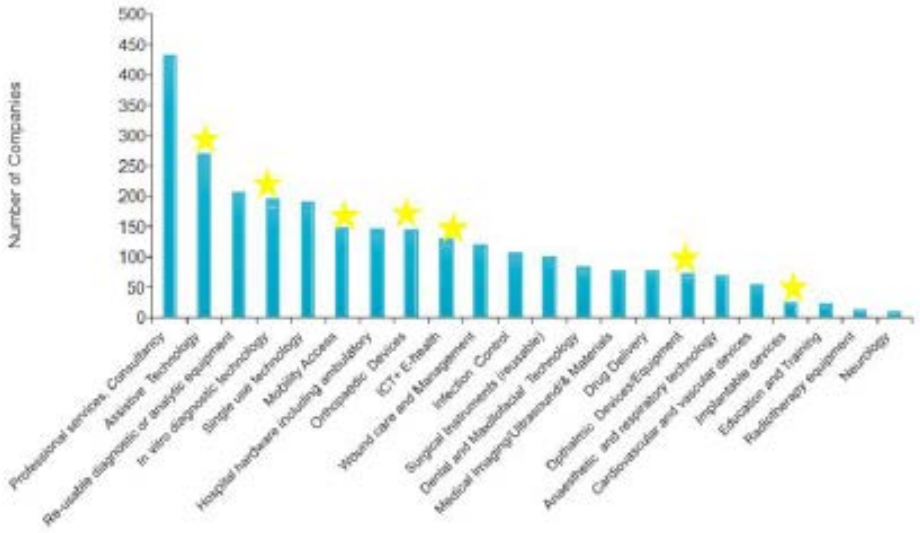

Figure 5.3: Number of UK Companies by medical technology segment. Highlighted segments are closely associated with assisted living technologies99 Source: Deloitte Health Solutions

5.4 Market size

In this section we consider the market size for ALT. As described earlier in this chapter, and shown in Figure 5.2: Diagram showing Assisted Living Technology products and services on a care continuum. Source: Arup, the definitions of assisted living technology and telehealth and telecare overlap to some extent. A recent report by Deloitte forecasts the global telehealth and telecare market to grow to £14.3 billion by 2015[102]. The following sections focus primarily on UK, European, and US markets as these are likely to be the initial focus for UK industry.

[102] Primary care: Working differently – telecare and telehealth, Deloitte Health Solutions, November 2012

UK & Europe

Table 5.1 shows projected market growth (to 2015) for the European assisted living technology market. The big markets for assisted living technologies in Europe are Germany, the United Kingdom, France and Scandinavia. These are also the larger markets for healthcare in the Europe.

Country	Estimated Revenue (m)		Forecast Revenue (m)	
	2007	2010	2013	2015
Germany	$24.7	$65.5	$120.4	$171.9
UK	$20.5	$55.5	$101.6	$141.0
France	$13.8	$31.8	$58.3	$85.8
Scandinavia	$7.8	$31.3	$62.1	$90.9
Italy	$3.8	$7.8	$12.7	$17.4
Spain	$2.6	$5.7	$9.4	$12.9
BeNeLux	$1.5	$2.8	$4.4	$5.8
Total	**$74.7**	**$200.4**	**$368.9**	**$525.7**

Table 5.1: European markets for assistive living technologies. Source: Frost & Sullivan 2010103

The growth in the ALT market primarily depends on receptiveness towards technology (for example by experienced community-based health professionals), price affordability and product customisation. The market dynamics appear to be favourable and are expected to influence a compound annual growth rate (CAGR) of 22.6 % by 2015[99]. In terms of the competitive environment, a large number of opportunities are expected to attract new entrants and support market development.

ALT in institutions: ALT is already prevalent due to the large number of community centres in use. Many aged people living in community centres and social care homes enjoy the benefits of personalised and regular care. The assisted living technologies market in institutions in Europe was valued at $115.5 million in 2009 and is expected to grow at an average rate of 20.2 % per annum between 2010 and 2015[99]. Germany, the United Kingdom, France and Scandinavia are again leaders here.

ALT in homes: The ALT market is shifting its focus towards home-based services and care. The ALT market for residences was valued at $39.4 million in 2009. Together Germany, UK, France and Scandinavia are again a huge market for home care assisted living (revenues in millions (market share) respectively: $8.3 (21%), $15.8 (40%), $6.5 (16.6%), $6.0 (15.3%)). The ALT market for residences is expected to grow at a CAGR of 28.5 % between 2009 and 2015 and reach a market size of $177.2 million in 2015.

[103] European markets for assistive living technologies, Frost & Sullivan 2010

US market

The U.S. Census Bureau indicates that there are almost 40 million people aged 65+ (almost 13% of the population). By 2030 there will be more than 72 million older persons making up 19% of the population. A study by Taiwan's Industrial Technology Research Institute predicts the US market for telecare alone (not including telehealth) to reach $337.2 million by 2015, growing by roughly 22% year-on-year[104].

5.5 Market and Technology Trends

Beyond the drivers set out in section 5.2 there are significant trends (within Europe and globally) behind market growth for assisted living technology and services, particularly within the next ten years. The report on European markets for Assistive Living Technologies[105] suggests that these trends are likely to include:

- **Market Driven Growth** - Increased private participation will lead to higher competition, and private sector investment will drive the growth instead of government-funded projects.
- **Private funding** - Will rapidly increase and overtake the government funds.
- **Diversification** - Strong market participants will expand into other lucrative regions, and there will be large-scale plans under execution.
- **Interoperability** - Equipment is likely to become globally interoperable and will use open platform software to enhance connectivity.
- **Shift in Demands** - There will be a vast expansion in product portfolio and the aged population are likely to change their demands. There will be specific suppliers for the variety of equipment.
- **Digital Communication** - The ALT market is likely to adopt c.100% digital communication and infrastructure for effective services to the elderly.

[104] Forecast data from Industrial Technology Research Institute Study, 2010
[105] European markets for Assistive Living Technologies, 2010, Frost and Sullivan

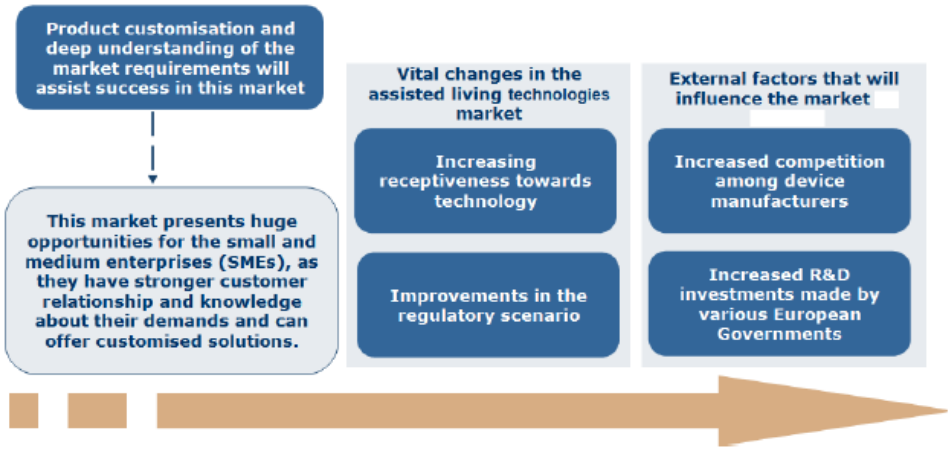

Figure 5.4: Overview of ALT technology opportunities and trends105, Source: Frost & Sullivan

These factors, together with the technological trends and drivers discussed in section 5.2, all have significant implications for ALT and related services, in particular by potentially driving down the cost of telecare and telehealth equipment due to high demand. The use of robust wireless connectivity could greatly accelerate and simplify the task of retrofitting individual homes or community-based care facilities.

As well as reducing production costs, technological trends and supply chain shifts will also help to make it easier to tailor ALSs to the specific needs of disabled people. In addition, the use of mass-market platforms will help to avoid the stigma which many old people perceive when using today's telecare and telehealth equipment.

Today telehealth services are focussed on providing better and more cost efficient management of common chronic conditions, using a combination of sensors, hubs and remote servers. As the decade advances this architecture is likely to remain broadly the same. However, in the short to medium term, new ALT developments could improve the management of chronic conditions, extend the range of conditions which are managed at home, and allow management while outside the home.

In the long term, increased use of ALT is expected to enable early home diagnosis of life threatening conditions and home monitoring of vital signs to be linked to real-time drug administration. All of these developments will be valuable to older citizens living independently at home.

Adoption: According to the 'Healthcare without walls' report[92], other countries and health systems (notably Spain, Italy, Japan, the US - Veteran Health Affairs and New South Wales) have developed a more strategic approach to adoption of assisted living technologies. This has led to significantly greater levels of adoption in some cases.

The macro-level landscape for ALT in Europe sits against a backdrop of austerity, with governments keen to adopt affordable, innovative and technologically advanced alternatives to traditional solutions.

Better visibility and collaboration: The assisted living market features a growing trend towards enhanced visibility in the value chain, with less fragmentation, improved collaboration between suppliers together with new supply chain/logistics technologies and information transparency.

Internationally, an increasing number of organisations are contributing towards stimulating more innovative technology solutions.

At the EU level, various initiatives exist, notably around FP7 (the Seventh EU Research Framework Programme - the EU's main instrument for funding research through to 2013) and the related Ambient Assisted Living Programme (i.e. where technology is hidden in walls). As part of its newly announced European Innovation Partnership, the EC's pilot project in the field of active and healthy ageing will be highly influential in the longer term.

Wearable skin-contact devices: At the moment, telehealth devices require user interaction to collect daily vital signs data, but there is rapid progress towards wearable and skin-contact devices using mobile and wireless technologies.

5.6 Regional highlights

England: According to the report "Workforce development for Assistive Technology, Telecare and Telehealth" a range of policies and policy agendas (e.g. personalisation, re-ablement, self-care and management, efficiencies, independent living, extra care housing, QIPP, housing) indicate a shift in policy in England towards the delivery of services which can offer greater control over lives, promote enjoyment of a good quality of life which is tailored to focus on prevention, an individual needs and low level support from social care and health when possible.

ALTs and services are apparent in this agenda at national and local authority level. Local authority discretion over delivery mode has resulted in a range of approaches to service set up. Associated costs of services and equipment also vary from free to paid-for.

While there is recognition of the importance of a supported and skilled workforce, there is less detail on how to develop and maintain practitioners in this area. The significant ALIP funded DALLAS programme will have important lessons for workforce development and system design.

Scotland: Scotland differs slightly from England in that personal care is free at the point of contact. As in England, telecare and telehealth are supported in policy. For example, Managing Long Term Conditions (Scottish Executive 2007), Better Health, Better Care: Action Plan (Scottish Executive 2007), Seizing the Opportunity: Telecare Strategy 2009-2010 (Scottish Government 2008), Caring Together: The Carers Strategy for Scotland 2010-2015.

The Scottish Centre for Telehealth and Telecare which sits within NHS 24 provides guidance, support, standards, protocols and processes to support telehealthcare solutions.

5.7 UK Strengths, Gaps, Opportunities and Barriers

Strengths:

The UK is one of the fastest growing markets in Europe for ALT[99], in part because the Government already recognises the importance and advantages of these technologies. This has resulted in significant improvements in the adoption rate of ALT in healthcare.

The market is expected to witness a CAGR of about 21.9 % from 2010 to 2015 and to achieve revenues of $141.0 million in 2015. Comprehensive deployment of pilot projects and government funding and the elder population growth are some of the reasons behind this market growth. This helps place the UK at the leading edge of the sector, addressing the challenges associated with an ageing population through the development of the next generation of assisted living products and services.

Scotland specifically has key strengths in this field because of its industrial and academic base but also due to proactive government policies. Medical technology is one of the key life sciences subsectors in Scotland with a significant company base in this sector that spans large companies such as LifeScan Scotland to small dynamic start-ups such as SureSensors. Scotland has also key academic strengths in this field with specialized institutes and groups (e.g. Strathclyde Institute of medical devices, The Institute for medical Science and Technology, The Care Technology Research group) but also a significant research base in areas of electronics, optoelectronics and sensors, and informatics.

Gaps in the UK supply chain:

In the UK, AL systems are invariably purchased by individual CCGs or local authorities which fragment the supply chain and drives up price of equipment. To counter this, there is a need for appropriate political and clinical collaboration. Such collaboration is also needed internationally, not least since the industry within the Europe and globally faces a common set of challenges, particularly in relation to long term conditions and the aging population.

Part of the supply chain stalemate derives from numerous telehealth initiatives remaining at pilot stage while suppliers' unit costs and therefore charges remain high. In contrast, economies of scale could be achieved if initiatives were able to be scaled up and further advanced in key areas, thereby also helping to spread costs more effectively in order to reduce unit costs. This could happen alongside the 3MillionLives initiative to accelerate the pace of change.

Installation & training gap

A range of health workers could potentially fill this gap by providing;

- The assessment and device training, provided they themselves are trained in specific telehealth skills and
- Technical installation to cover installation and configuration of the devices and hubs, establishing connectivity between devices/hubs, hub to centre etc.

The implications of this in supply chain terms include the need for visits and initial support to patient's home in order to cover both technical installation and initial training on the use of the equipment. Patients may need significant assistance over the first few days.

Opportunities:

As seen in previous sections the drivers and market for assisted living technology products and services create significant opportunity for UK businesses. Below we highlight some further specific opportunities:

Technology: Technology solutions are currently still fragmented, many using proprietary technology. Convergence and integration is beginning to happen, but opportunities lie in using and developing on existing domestic platforms e.g. smartphones, set-top boxes, etc.

Wider range of diseases and applications: Opportunities yet to be fully realised for ALT in tackling a wide range of diseases, and for use people with dementia, mental health needs, children and adults with disabilities, for expectant mothers with high risk pregnancies, and for palliative care. There is also the possibility to provide telehealth in different contexts other than the home for example, in nursing homes.

Market dynamics: Where feasible, join up telehealth/telecare initiatives through joint commissioning, exploring opportunities for common logistics and supply chain management. Explore opportunities to share template deliverables, e.g. commissioning models, project toolkits, pathway redesign templates, model business cases, template service specifications

The European advantage: The many European-funded projects in the field of ALT are designed to drive standardisation and interoperability and prove effectiveness in several European markets. UK industry's involvement in EU initiatives is likely to allow UK industry easier access to European healthcare markets (one of the largest as discussed earlier).

Barriers:

Some further key issues impacting the rate of growth for assisted living technology products and services include:

- Standardisation and interoperability of equipment and extent to which open platforms are utilised
- Disparity in medical regulation regimes globally (and even within Europe)
- Low awareness amongst CCGs, GPs, and their equivalents internationally, of the proven benefits and capabilities of assisted living technologies.

UK vs US SME perspective: There may be disadvantages for UK SME's compared to those in the US resulting from patenting of software and methods being perceived to be more difficult than in the US. In comparison with large corporations with resources to focus and optimise patenting strategies, UK SMEs have more limited resources to pursue a differentiated strategy for each of the UK, EU and US markets.

US SMEs (in medical devices and elsewhere) are also perceived to have an advantage when pursuing collaborations or licensing deals with global companies in the medical devices and Telehealth space. It is reported that the US dominance in this space, in relation to strategic patenting, may be at the expense of key emerging markets such as China and South Korea, which are known to be strong in telecoms and electronics[106].

5.8 What Government is doing

The UK as a whole is one of the fastest growing markets in Europe for ALT, as the importance and advantages of these technologies are already being recognised increasingly by the Government.

The combined impact of comprehensive deployment of pilot projects, increased government recognition, government funding streams and growth in the aging population results in increased market growth and improved adoption rates of ALT in healthcare. Some of the major government initiatives and funding mechanisms are outlined below.

WSD and 3MillionLives: The Whole System Demonstrator (WSD) programme was established in 2008 by the TSB and Department of Health as the world's largest randomised control trial for telecare and telehealth. The programme aimed to better understand the benefits, costs and barriers to the use of telecare and telehealth and involved over 6,000 people in England across 238 GP practices. Outcomes are still being analysed but WSD has already shown telehealthcare offers potential for significant reductions in bed days (14%), unplanned admissions (20%) and A&E admissions (15%) if "delivered properly"[107]. The cost of QALY (a measure used to assess the value for money of a medical intervention) from the WSD programme showed that the cost of telehealthcare technologies was still an obstacle to availability. The Department of Health "believes that to turn reductions in unplanned emergency admissions, elective admissions, A&E visits and mortality into savings, telehealth needs to be delivered at scale, with lower upfront costs and integrating the technology into a service offering. It is this philosophy that is driving the 3MillionLives initiative"[108].

3MillionLives (3ML) was established in January 2012 on the back of the WSD findings. 3ML is a pioneering partnership established by the Department of Health with NHS stakeholders, industry, trade bodies and third sector organisations. This cross-industry partnership is aimed at the whole-system transformation of health and social care through the use of telecare and telehealth technologies and services. The Department of Health has set the ambition to use telehealth to benefit 3 million people by 2017. The programme is currently establishing seven 'Pathfinders' – NHS and local authorities and CCGs – contracting with industry to deliver benefits to 100,000 people in 2013[109].

DALLAS: Announced in May 2012, and following on from the creation of 3MillionLives, the TSB's DALLAS programme (delivering assisted living

[106] Cambridge IP Ltd, 2011
[107] Whole System Demonstrator Programme, Headline Findings, DH, December 2011
[108] Making Connections, 2020health, March 2013
[109] 3MillionLives Press Release, 14th November 2012

lifestyles at scale) is designed to "explore ways of using innovative products, systems and services to create more independent lifestyles"[110]. The £37 million programme has commissioned four consortia who have added their own financial contribution. The TSB programme is joint-funded by the National Institute for Health Research and the Scottish Government. The four initiatives that make up the project will create several communities, working with existing statutory health care provision and will demonstrate how innovative technologies and services can be used to enable nearly 170,000 people to live independently and to expect a better future. Outcomes are expected by 2015.

Other Technology Strategy Board programmes:

- Assisted Living Platform Special Interest Group
- Smart Awards (previously Grants for R&D)
- Small Business Research Initiative (SBRI)
- Collaborative R&D is designed to assist the industrial and research communities to work together on R&D projects in strategically important areas of science, engineering and technology - from which successful new products, processes and services can emerge.

The scope of the collaborative R&D competitions has recently been expanded to support large collaborative R&D projects and smaller projects approved within faster timescales. These may vary with specific competitions and funding limits are specified by individual competitions but generally include:

- Feasibility studies - small projects lasting for a maximum of one year and often less than £100k; up to 75% funding
- Fast-track projects - projects lasting no longer than 18 months and having a maximum total cost of up to around £200k; up to 50% funding
- Larger Collaborative R&D projects – projects of around a few £100k to £m's to last up to five years; funding mainly for applied R&D; up to 50% funding.

The National Institute for Health Research (NIHR): The NIHR commission and fund NHS, social care and public health research that is essential for delivering their responsibilities in public, health and personal social services. For example the i4i Programme is an NIHR research programme that provides investment in, and improved identification of, promising healthcare technologies in order to accelerate the development of new healthcare products for the 21st century. It also funds translational research, extending between basic research and pre-clinical trials or health technology assessments.

[110] TSB Press Release, 23 May 2012

Other initiatives:

Several other public and NGO bodies are funding research programmes in the UK, including:

- Research councils through their general academic research funding, but also both EPSRC and ESRC are involved in the TSB's ALIP programme.
- The Wellcome Trust supports new health innovation, working with the Department of Health.
- The NHS National Technology Adoption Centre has looked at models around remote monitoring for heart failure.

5.9 Recommendations

The development of AL products and services should fit into an integrated care package, demanding genuine health-social care integration, rather than regarding ALT products and services as stand-alone. The government's 3MillionLives programme is a major step forward, and will foster growth in the UK marketplace.

Recommendations for government

The UK Government should aim to further support the growth of the assisted living market in the UK for the benefit of existing and emerging UK companies (including equipment, technology and service providers), by:

- Working to develop a solid market in the UK for assisted living services to increase uptake and help drive down costs – 3MillionLives is a step in the right direction, though perhaps more can be done sooner.
- Amending tariffs and incentivisation schemes to recognise and reward ALT-enabled services on a consistent basis across the NHS, based on applicable outcome measures[92].
- Continuing to provide evident policy commitment, leadership and guidance for ALT and its integration into care plans and pathways which interoperate across all healthcare sectors. This should build on the results of the major pilots results arising from 3MillionLives.
- Working to further "whole-system thinking" across wider sectors such as electricity, water, and transport. This has the potential to deliver further meaningful improvements to the quality of life of those who benefit from ALTs.

Recommendations for UK Industry

Individual businesses in this sector should aim to form collaborative partnerships, enhancing the international competitiveness of the UK in this market. This is especially the case if challenges around pricing and standards in particular can be addressed.

Specific industry recommendations include:

Collaborate:

- Industry players need to develop or collaborate to become capable of providing cost effective end-to-end system and service solutions to match the emergent commissioning requirements (including taking account of the establishment of CCGs)[92].

Innovate business models:

- Adopt innovative commercial approaches to large scale delivery to achieve in-year benefits for the NHS through collaborative partnerships[92].

- Develop a pricing model applicable to a consumer market – especially applicable to overseas markets where health systems are less structured. The global consumer market for assisted living technologies has strong growth potential with 1 billion people aged 65 years or older by 2030[93].

Innovate product and technology:

- Continue to integrate products and solutions, whilst specialising services for the different classes of end users; technology solutions currently are still fragmented and diverse, these will need to become more integrated at the location of care and fit for purpose. Convergence around interoperable platforms or better integrated platforms is fundamental to successful uptake.

- Capitalise on UK's world-leading skills and expertise around life sciences, bioengineering, service design and product design to deliver innovative products and services faster. Embrace the opportunity to address different diseases through different technology approaches more appropriate for lower cost, higher volume services.

Appendix A

Acknowledgements

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