Intelligent Infrastructure:

Delivering the Competitiveness Benefits and Enterprise Opportunities

Forfás

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Executive Summary

This report explores the potential for the deployment of intelligent infrastructure in Ireland to optimise scarce resources, enhance competitiveness and create enterprise opportunities. The report focuses specifically on the core infrastructures of energy, water, transport and waste.

What is Intelligent Infrastructure?

"Intelligent infrastructure" or "smart infrastructure" is the application of technology to deliver a more effective and efficient infrastructure service. It uses a layer of technologies, which can be embedded in the design of new infrastructure or applied to existing infrastructure.

Intelligent infrastructure can apply to a system wide application, for example the development of smart electricity grids. It can also be targeted at a specific element within the infrastructure chain, for example the use of sensors to detect the presence of a toxin at a landfill site.

While the ability to apply technology to infrastructure assets has existed for some time, rapid advancements in sensor, communications and analytical technologies mean that intelligent infrastructure is a relatively new phenomenon. Research, development and deployment of smart technologies are ongoing in a wide range of infrastructures. Across the world policymakers, infrastructure providers, researchers and enterprises are working to develop solutions that use advanced technologies to address infrastructure challenges in more efficient ways. It is not surprising, however, that infrastructure solutions usually emerge in response to a particular issue or deficit faced by a country or region. For example, faced with crippling congestion, Singapore has become a world leader in intelligent transport systems.

Given the novelty and breadth of intelligent infrastructure and its rapid pace of development, it is difficult to capture all facets of its use and the benefits and potential opportunities which arise from these. It is likely that many of the infrastructure applications for smart technology remain to be developed. This report therefore focuses on the key trends that are materialising with regard to the application of smart technology to energy, transport, water and waste infrastructures. It highlights the uses and benefits these applications could have in Ireland and the emerging enterprise opportunities.

Why is intelligent infrastructure important to Ireland now?

Ireland has made substantial investment in infrastructure in recent years. However, further investment is required to ensure that our critical infrastructure can support economic recovery and enterprise growth. With significantly reduced capital budgets, it is vital that we get maximum value for money from existing physical infrastructure networks and that we fully exploit the potential value of future investments.

The significant economic challenges facing Ireland and the need to address infrastructure deficits have focussed attention on the potential for using smart technology to fulfil infrastructure objectives. By optimising the capacity of assets that are already in place as well as future assets, intelligent infrastructure can play a substantial role in reducing the burden on the Exchequer and freeing up scarce capital resources. In addition to reducing the need for capital expenditure, smart technology can be used to create revenue raising opportunities for the Exchequer and to improve national competitiveness through reduced business costs (e.g. less congestion) and more productive use of resources.

Intelligent infrastructure also provides enterprise development opportunities for new goods and services which can create jobs. The global market for the goods and services that are needed to provide intelligent infrastructure is growing rapidly. Ireland has a number of strengths which can be leveraged to realise some of these international opportunities such as a strong ICT base, a growing number of Irish SMEs translating into internationally renowned companies, a good research base in relevant areas (such as sensoring technologies, water quality monitoring and smart grids), a market size which is useful to test technologies and a number of existing advanced sites which can test-bed new intelligent technologies. To realise these jobs opportunities, it will be necessary for public policy to facilitate the development of new goods and services in Ireland which can be exported abroad.

Intelligent infrastructure can play a valuable role in achieving a number of national objectives including relieving the current strain on public finances, improving the competitiveness of our infrastructure systems and developing sustainable growth for Irish-based enterprises. The following list outlines the benefits of intelligent infrastructure and provides practical examples of how these can be realised.

Improve Public Finances

- Exploit existing infrastructure capacity and reduce the need for additional capital expenditure: For example, the projected cost of developing Grid 25 has been reduced from €4 billion to €3.2 billion largely through advances in smart technology;
- Reduce infrastructure operation costs: For example, using sensors to remotely monitor traffic flows and to reroute traffic where appropriate reduces the need to deploy personnel to monitor and direct traffic onsite; and
- Provide revenue raising opportunities for the Exchequer: Smart technology can be used, for example, to develop effective congestion charging mechanisms which can raise the revenues required to invest in improved public transport services.

Improve the Competitiveness of the Irish Economy

- Enhance management of infrastructure demand: Smart electricity metering, for example, enables electricity prices to be altered in order to align demand with system capacity and reduce supply costs. The ESRI has estimated that the rollout of smart electricity metering will result in a net gain to the economy over the next 15 years of €174 million through reduced energy usage and environmental benefits;

- Reduce usage of environmental resources and lowering of carbon emissions: For example, intelligent transport systems reduce congestion and travel times resulting in a reduction in carbon emissions;
- Assist in reducing costs that may arise from failure to achieve environmental targets: For example, Ireland has committed to ambitious emissions reductions targets by 2020. The EPA has estimated that the overall cost of failing to meet these could be in the order of €100 million to €600 million. Applying intelligent applications can help reduce emissions and the cost of failure to comply with the agreed targets;
- Improved safety and reduced system risks: The use of sensors on railway tracks and bridges, for example, can provide advanced warnings of track obstructions or structural weaknesses; and
- By developing a public agenda which explicitly recognises the importance of intelligent infrastructure, Ireland stands to gain reputational benefits as a country committed to competitive infrastructure provision and delivery and also as a prime location for the establishment of intelligent infrastructure enterprises.

Improve business productivity and create new business opportunities

- Improve insights into consumer preferences: Leveraging the information and knowledge derived from smarter technologies enables customisation of services as well as an increase in the range of services a business can offer, e.g. customised energy products;
- Reduce costs and improve productivity: Intelligent infrastructure can help businesses improve their resource demand management and thereby reduce resources costs (e.g. water, energy, transport). Improved data on resource usage can also help reduce services disruptions to essential water and energy supplies and help avoid production losses in key sectors which are energy and water intensive (such as food and drink, pharmaceuticals and ICT); and
- Enhance firm-level environmental performance: Improved demand management through smart applications can help companies reduce environmental liabilities, lower operational costs, improve brand image and gain competitive advantages.

What is driving intelligent infrastructure?

A range of factors are driving interest and enterprise opportunities in intelligent infrastructure both domestically and internationally.

- Technological change: Developments in technology such as new computer models, algorithms and improved sensor technologies have increased the potential and reduced the costs of intelligent applications for infrastructure;
- Fiscal constraints: The significant economic challenges facing Ireland and other countries, combined with the need to address infrastructure deficits with reduced public funding, has focussed attention on the potential of using smart technology to fulfil infrastructure objectives;
- Environmental considerations: Environmental pressures domestically and internationally are increasing the need to use technology to reduce water and energy

usage, improve water quality, increase the use of renewable energies and develop less carbon-intensive transport systems;

- Population pressures: Globally, rising populations and increasing urbanisation are placing increased pressure on infrastructure systems (such as electricity grids) and resources (such as water) which are driving global enterprise opportunities;
- International and domestic policies: A range of international and domestic policies are increasingly incorporating intelligent solutions. For example, intelligent infrastructure has a role to play in delivering on the EU 2020 Strategy priorities of "smart, sustainable and inclusive growth". Domestically, the Government's focus on identifying opportunities for sustainable economic growth and job creation and the need to improve national competitiveness through reducing business costs and improving productivity are also acting as policy drivers; and
- Customer expectations and preferences: As shown by the growth in the use of smart phones, consumers are increasingly demanding new smart technologies and solutions.

Intelligent infrastructure in Ireland: current uptake and future applications

Smart technologies have already been applied to a range of infrastructures in Ireland. In the area of electricity, for example, the development of a smart electricity grid is at a relatively advanced stage, and a large pilot study on smart electricity metering has been concluded with the results presenting a very positive outcome from the cost benefits analysis. A number of intelligent transport system (ITS) initiatives have also been established in Ireland such as barrier-free tolling on the M50 and the use of sensors to monitor traffic and sequence traffic lights accordingly in some urban areas.

Smart technologies are used to some extent in the monitoring and control of water and waste water, however, there is scope to expand their usage and reduce operational costs. For example, greater deployment of telemetry in the water distribution network could be used to reduce leakage rates and could reduce the need for investment in developing additional water treatment capacity. With regard to waste, sensors are used to monitor sub-surface and surface gases at landfill sites and sensors embedded in wheelie bins are used to collect data on the weight and time of each lift. The use of smart applications is expected to proliferate across the various infrastructures in Ireland quickly as the technology develops and the awareness of the costs and benefits increases.

Based on a review of current infrastructure challenges in Ireland, trends in smart technology development and consultations with stakeholders, Table 1 highlights target areas for the application of smart technology to infrastructure in Ireland. The deployment of intelligent infrastructure in these areas will deliver efficiencies and better quality infrastructure outcomes.

Table 1: Summary of Potential Target Areas for Development and Deployment of Intelligent Infrastructure Solutions in Ireland

Energy	Smart grid development Energy metering and energy management solutions
Water	Water metering Water distribution Water quality/ waste water monitoring Management of waterway levels and flows
Transport	Intelligent public transport Traffic management systems
Waste	Landfill gas monitoring

What are the areas of opportunity for Irish-based companies?

Ireland has a growing number of innovative small and medium-sized enterprises and a number of multinationals in key sectors such as ICT which are currently realising opportunities in intelligent goods and services domestically and abroad. Examples include companies which are developing programmes for online measurement and analysis of water quality; software systems for smarter transport; and street lighting products which optimise energy use. Ireland also has a strong base of relevant research and existing test-bed sites in areas such as sensing technologies, water quality analysis and smart grids which can be further leveraged to realise commercial opportunities. Ireland's small size is of particular benefit for test-bedding new technologies which can then be applied to much larger markets.

For example, the Marine Institute's Smart Bay Ireland project is a research, test and demonstration infrastructure project for monitoring and managing aquatic environmental data such as tidal flow, wave heights, and temperature via an integrated network of sensors, robotics and computational technology distributed throughout Galway Bay. This test-bed has the potential to create enterprise opportunities in the provision of ICT enabled products and services in a range of areas such as environmental monitoring, security, oil and gas, transport and shipping, aquaculture, coastal tourism, marine renewable energy and water management. Other important examples of test-beds that have emerged in Ireland include SEAI's Sustainable Energy Community Programme which is focused on energy efficiency, IBM's Smart Cities Technology Centre and ESB Networks Smart Grid project.

This report also looks at areas of potential opportunity for Irish companies to create jobs in developing goods and services for intelligent infrastructure. In this context, a range of these areas and examples of the types of goods and services that are expected to be required has been compiled following a review of current technologies and trends and consultations with enterprises in the relevant sectors. An overview of the enterprise goods and services

opportunities is provided in Table 2 and outlined in more detail in Chapter 4. It is important to note that these opportunities are likely to be global as many countries are making significant investment in intelligent infrastructure. Making sure that Irish-based companies are well placed to realise these emerging exporting opportunities should be an enterprise policy priority.

Table 2: Enterprise Opportunities in Intelligent Infrastructure

Area	Examples of potential enterprise opportunities for Irish companies (both domestically and abroad)
Smart Grid	Power system equipment, power system monitoring, software for grid management.
Energy metering	Data management, analytical services, surveys and meter installation and maintenance.
Energy management systems	Wireless building monitoring and control systems, street light monitoring and control systems and online software applications that allow for the identification and targeting of energy inefficiencies.
Energy efficient equipment	Smart heating, ventilating and air conditioning equipment, household/ industrial smart equipment, smart lighting solutions.
Water metering	Data management and analytical services, meter installation and maintenance.
Water Quality Monitoring, Treatment and Distribution Systems	Manufacture and export of smart sensors, development of water quality early warning systems, leakage control, small scale wastewater treatment technology for septic tanks.
Intelligent Transport Systems	Information display and monitoring devices, smart traffic management systems and software, smart vehicle monitoring systems and traffic control equipment.
Waste Management	Sensors for landfill monitoring, smart systems using radio-frequency identification (RFID) tagging.
System Integration Services	Joint supply of smart sensors and accompanying control and data management systems.
Software systems	Software applications in smart network monitoring and management solutions across different networks as well as smart data management (and billing) systems

What are the barriers to the deployment of intelligent infrastructure?

The report outlines a number of case studies (such as infrastructure initiatives, research excellence and companies) which illustrate the successful deployment of intelligent infrastructure to date in Ireland. However, a number of challenges must be addressed if Ireland is to benefit from the full potential of intelligent infrastructures.

- Investment strategy: Over the past 15 years, there was a tendency to prioritise investment in large scale projects throughout the country and across the range of infrastructures rather than to improve the capacity of existing assets. This was largely due to previous under-investment in infrastructure essential for sustaining economic growth and the need to add significantly to the net capital stock. New infrastructures were necessary to ensure infrastructure bottlenecks did not constrain economic or social development.

  Given the significant investments made over the past 15 years and the current economic difficulties facing Ireland, it is imperative that new, less costly, approaches to infrastructure provision are developed. Ensuring that policymakers, infrastructure providers and citizens are fully aware of the capabilities and benefits of intelligent infrastructure is a key challenge to be addressed.

- Investment appraisal process: Smart technologies are ideally suited to help resolve many of Ireland's pressing infrastructure problems (e.g. congestion in Dublin city, where there is limited potential for new roads, could be considerably eased through deployment of a sophisticated intelligent transport management network). The capital appraisal process currently in place was designed to assess proposals for traditional type investments in static assets. It may not be best suited for assessing the appropriateness of investment in intelligent systems and may not encourage public infrastructure providers to explore its potential to address or assist in addressing infrastructure deficits.

  In addition, when calculating returns on infrastructure investments there can be significant difficulties associated with capturing the role smart technology plays in avoiding system failures. This is because these calculations do not generally take into account the reliability of the system or the possibility of rare but substantial shifts in the operating environment. Other aspects that are difficult to encompass in routine return on investment calculations include the longer term benefits that might arise from better integrated systems and wider environmental and social benefits.

- Need for enhanced cooperation: The core elements of intelligent infrastructure are the same across all infrastructures. This provides scope for economies to be derived from cross-infrastructural or cross-institutional approaches. The costs of smart technologies could be reduced by bundling the procurement of systems. In addition, a failure of organisations to work together in relation to the design and rollout of intelligent infrastructure may mean that the longer term benefits that arise from better integrated systems are not realised.

- Consumer concerns and privacy: A lack of awareness of the benefits of smart technology and privacy and data security concerns among consumers may present significant barriers to wider adoption of smart technology. In addition, substantial consumer resistance may arise in the context of intelligent infrastructure applications

that facilitate the introduction or restructuring of prices (e.g. water, congestion charges).

Communications Infrastructure: The electronic communications infrastructure currently in place in Ireland is sufficient to enable the delivery of intelligent infrastructure in the areas of energy, transport, water and waste. However, significant Exchequer savings and enterprise opportunities are like to arise in the area of intelligent health and education services. Delivery of high quality remote services in these sectors will require advanced broadband capabilities that are high speed and symmetrical.

Ensuring the above barriers to deployment of intelligent infrastructure are dealt with will be key to realising enterprise opportunities. From a business's perspective, there are additional barriers which are impeding the development and growth of companies producing intelligent infrastructure goods and services in Ireland.

- Intelligent infrastructure goods and services often involve new or untested technologies. Demonstration of the practical feasibility of the application of the technology through test-bed and demonstration sites is crucial to achieving sales and internationalising;
- As the technologies involved are often new, unproven and require a longer-term investment, the potential market success of smart applications may be more difficult to predict. This increases the risk and uncertainty for financiers and makes access to finance for such firms more difficult;
- As much of our infrastructure spend is by the State, the importance of public procurement practices that support innovative and small firms is central. Some SMEs are currently experiencing difficulties in getting innovative intelligent infrastructure solutions recognised when procuring for Government business; and
- Skills shortages in areas such as electronic engineering, business analytics and software programming can act as an impediment to realising business opportunities.

How can these barriers be addressed?

This report puts forwards recommendations to overcome the barriers to the deployment of intelligent infrastructure in Ireland and the challenges to realising the enterprise and job opportunities that arise in this area. These actions are outlined below.

Actions to reduce public expenditure and improve the competitiveness of Irish infrastructure through the deployment of intelligent infrastructures

- The forthcoming Capital Expenditure Review (2012-2016) should explicitly outline the potential for intelligent infrastructures to maximise the value of existing infrastructure and its potential to enhance the value of future investments.
- An assessment of the potential for intelligent infrastructure to substitute or complement traditional capital investment should be required as part of the investment appraisal process. In addressing infrastructural deficits, there is a need, where possible, to utilise management and operational solutions rather than capital intensive investment solutions. The application of smart technologies to enhance the capacity of existing infrastructure is an example of an effective infrastructure management approach (e.g. using sensor technology to identify water network leaks

reduces the need for costly additional water treatment capacity). Appraisal methods may need to be modified to capture the benefits and costs of intelligent systems.

- Given the cross-infrastructural synergies of smart technology, institutional cooperation can yield significant benefits in terms of cost savings and other economies of scales. A more integrated approach to infrastructure planning would facilitate improved efficiency, effectiveness and competitiveness. Coordinating the rollout of different infrastructure services (e.g. roads, telecoms, water, and energy) has the potential to deliver significant cost savings, particularly where projects are undertaken simultaneously. Appropriate structures for exploiting these benefits should be explored in more detail. For example, the recently established Inter-Departmental Committee on Economic Infrastructure and the development of integrated utility agencies with a national remit (e.g. national water authority) could play significant roles in facilitating greater coordination.
- Ensure that consumer concerns regarding privacy, data security and costs are addressed through co-operation between consumer and citizens rights groups, the infrastructure providers, utility regulators and the Commissioner for Data Protection. In particular, where third parties are involved in the processing, management or usage of user data it will be essential that effective protocols are in place to protect the rights to privacy of individuals and households.
- The actions set out by Forfás to ensure the timely rollout of world class advanced broadband services in key urban centres need to be progressed quickly to support intelligent infrastructure deployment and the realisation of potential enterprise opportunities[1].

Actions to enable the realisation of enterprise opportunities in intelligent infrastructure

These actions will also address issues faced by enterprises working in other emerging and innovation intensive areas.

- Infrastructure providers, adjacent research facilities, core funders and the enterprise development agencies should cooperate to develop test-bed opportunities for Irish-based companies. Cross institutional structures should be established which will allow these parties to prioritise the development of key exemplar test-beds which can realise employment opportunities (such as Smart Bay Ireland, ESB Networks Smart Grid project and Smart Energy and Water Meter rollout).
- In terms of publicly-funded research, the current research priority setting exercise should focus on key areas of opportunity in intelligent goods and services for Ireland and identify priority research areas which can be commercialised.
- Policy measures that support financing of innovative SMEs generally should be rapidly progressed and specialist funds that are focused on innovative companies which apply smart technologies to improve productivity and reduce emissions and resource usage should be prioritised.
- Enterprise Ireland should continue to engage with the main lending institutions in Ireland to communicate the opportunity and specific funding requirements of smart technology companies. There is a need for financial institutions to develop expertise

1 Forfás, Ireland's Advanced Broadband Performance and Policy Priorities, forthcoming.

in investing in this high potential sector as a priority. Where this expertise is not available, financial institutions should develop networks of international experts which they can readily access for investment advice. There is also a need for Enterprise Ireland to continue to focus on promoting EU funding initiatives (such as the 7th Framework Programme) in the area of intelligent infrastructure to their client companies and support companies in the application process.

- The following public procurement practices should be used to foster market uptake of innovative intelligent infrastructure products and services:
  - Rollout of an innovative procurement model along the lines of the UK's Small Business Research Initiative which requires Government departments and agencies to implement innovation procurement plans, to identify procurements that have a significant technological and or innovative component and to ring fence a proportion of technological or innovative procurements for SMEs;
  - Immediate implementation of the draft Green Public Procurement (GPP) Action Plan in a way which promotes the development of new intelligent technologies and opportunities for SMEs; and
  - Upskilling of procurement staff within the public service around procurement which increases energy savings, improves resource usage and spreads innovative solutions.
- As the recommendations of the Expert Group on Future Skills Needs Green Skills report largely mirror the needs for the development to intelligent infrastructure enterprises in Ireland, they should be implemented as soon as possible. In particular, current 'green' education and training provision (approximately €25m – €30m per annum) should be aligned towards meeting the green and cleantech skills needs of enterprise generally, with a particular focus on the skills for 'Green' ICT Applications/Software as identified by the Group.
- The enterprise development agencies should continue to focus on scaling of companies involved in intelligent infrastructure, developing management development capabilities and helping these companies identify and avail of internationalising opportunities.

1. Introduction

1.1 Context

Ireland has made significant investment in physical infrastructure in recent years under successive national development plans, however, further investment is required to ensure that our critical infrastructure can support economic recovery and enterprise growth. Resources for capital spending will be limited and projects will have to be prioritised to obtain best value for money. "Intelligent" or "smart" infrastructure can play a substantial role in reducing the burden on the Exchequer and in freeing up scarce capital resources.

Intelligent infrastructure optimises the operation of infrastructural services and reduces infrastructure costs. It improves the productivity of infrastructure and by creating a better business environment can enhance national competitiveness. In addition, developments in intelligent infrastructure present opportunities for new products and services for the Irish enterprise sector.

1.2 Objectives

Forfás commissioned Goodbody Economic Consultants, in association with IBM Consulting, to investigate the potential benefits and opportunities arising from intelligent infrastructure in Ireland and the required policy actions to deliver them. Specifically, the study objectives were to:

- Identify what is driving intelligent infrastructure development and how it can promote enterprise development and competitiveness;
- Review what is happening and what is planned in the area of intelligent infrastructure internationally and in Ireland;
- Examine the potential for smart technologies and related public policies to enhance the productivity of existing and future infrastructure networks and services in Ireland;
- Identify the market opportunities internationally in intelligent infrastructure areas across telecommunications, transport, energy, water and waste. Evaluate which areas offer the best opportunities for new products and services for the Irish enterprise sector given existing enterprise capabilities and strengths; and
- Develop practical policy recommendations to speed up the implementation of intelligent infrastructure initiatives in Ireland and address barriers to realising the enterprise opportunities for both large companies and SMEs (small and medium-sized enterprises) across telecommunications, transport, energy, water and waste.

This report draws on the findings and conclusions of the study completed by Goodbody Economic Consultants and IBM Consulting.

1.3 Report Structure

The report is structured as follows:

- Chapter 2 provides an overview of intelligent infrastructure and sets out the benefits of applying smart technology to infrastructure systems.
- Chapter 3 looks at the domestic and international policies that are driving interest in the intelligent infrastructure agenda.
- Chapter 4 examines the extent of the deployment of intelligent infrastructure in Ireland both currently and in the future. It also looks at the activities of Irish based firms and the emerging enterprise opportunities.
- Chapter 5 looks at the barriers to intelligent infrastructure deployment in Ireland and to exploiting the enterprise opportunities in this area. It puts forward policy recommendations to address these issues.
- Chapter 6 highlights the key messages for policy makers regarding intelligent infrastructure.

2. Defining Intelligent Infrastructure and Why It Matters

2.1 What is Intelligent Infrastructure?

"Intelligent infrastructure" or "smart infrastructure" is the application of technology to deliver a more effective and efficient infrastructure service. It uses a layer of technologies, which can be embedded in the design of new infrastructure or applied to existing infrastructure. For example, some local authorities in Ireland have placed sensors in their water distribution pipes to enable speedy identification of leakages.

Traditional or dumb infrastructure is static, with limited ability to autonomously alert infrastructure managers of an occurring or imminent disruption. It is unable to respond automatically to changing conditions. Applying an intelligent layer facilitates improved monitoring and control of infrastructure systems and allows these systems to become dynamic, readily adjusting to conditions to ensure optimum performance levels are sustained. For example, standard traffic lights operate using a preset lighting sequence, however, in some urban areas in Ireland smart traffic lights have been put in place which adapt their sequencing in line with traffic flows to reduce congestion.

The benefits of applying smart technologies to manufacturing and services processes have been recognised for some time and they are now widely used across a range of industries (e.g. pharmaceuticals, software, food science, retail, logistics and security). They have been shown to deliver cost savings, improve efficiencies and quality and facilitate a better understanding of consumer preferences. However, the level of deployment of smart technologies across infrastructure has been slower than in other parts of the economy as it requires a greater degree of sophistication than within a private firm or single business process. Intelligent infrastructure is dependent on technologies which take account of infrastructure scales and the capacity for cross-agency cooperation in deployment. Other elements that need to be taken into account include the impact of any service interruptions required to install the technologies; security of data collected on infrastructure users; and given public access to many infrastructures, ensuring the security of the devices once they are installed.

While the ability to apply technology to infrastructure assets has existed for some time, rapid advancements in sensor, communications and analytical technologies mean that intelligent infrastructure is a relatively new phenomenon. Research, development and deployment of smart technologies is ongoing in a wide range of infrastructures. Across the world policymakers, infrastructure providers, researchers and enterprises are working to develop solutions that use advanced technologies to address infrastructure challenges in more efficient ways. It is not surprising, however, that infrastructure solutions usually emerge in response to a particular issue or deficit faced by a country or region. For example, faced with crippling congestion, Singapore has become a world leader in intelligent transport systems.

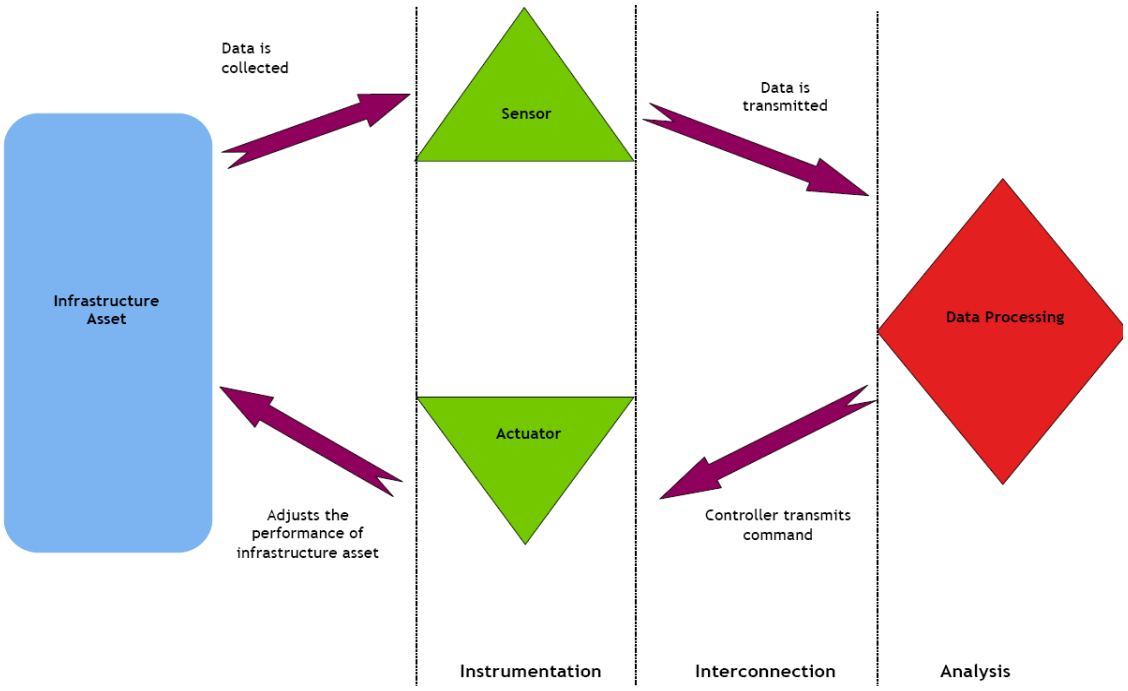
Given the novelty and breadth of intelligent infrastructure and its rapid pace of development, it is difficult to capture all facets of its use and the benefits and potential opportunities which arise from these. It is likely that many of the infrastructure applications for smart technology remain to be developed. This report, therefore, focuses on the key trends that are materialising with regard to the application of smart technology to energy, transport, and water and waste infrastructures. It highlights the uses and benefits these applications could have in Ireland and the emerging enterprise opportunities.

2.1.1 Elements of Intelligent Infrastructure

The first step in implementing intelligent infrastructure is to obtain information through sensing. Sensors include devices such as meters to measure flows of water, energy and traffic. This sensing is undertaken in an automated fashion and there is remote communication of the data to a central controller. This is in contrast to traditional approaches that employ manual data collection.

The controller subjects the data to analysis in order to ascertain the performance level of the infrastructural asset and the factors contributing to that performance. On foot of this analysis, the controller may make adjustments to the process. The process adjustments are made via actuators. Actuators are devices which are used to exercise control over a system; for example it could be variable message signage in the case of road transport, or pumps and valves in the case of water and wastewater systems. Figure 1 illustrates the various elements that constitute an intelligent infrastructure model.

Figure 1: Intelligent Infrastructure Model



In some applications, sensors and actuators are integrated: for example the proposal for electricity metering includes options whereby meters are used to control electricity appliances – switching them on when electricity is cheapest.

While the objectives of the application of smart technology to infrastructure may vary considerably (e.g. reducing the need for capital expenditure, provision of efficient payment mechanisms, improving safety or reducing environmental impacts), all intelligent infrastructures have three characteristics. That is intelligent infrastructure is instrumented, interconnected and analytical.

I. Instrumentation

Instrumentation enables infrastructure managers to gather large quantities of highly accurate performance data very quickly. The pervasiveness and low cost of existing devices and sensors offers the ability to measure the exact condition of every aspect of the operation and quality of service and operations of an infrastructure, as well as collecting data on the external environment which may impact the performance of the infrastructure.

II. Interconnected

Advanced communications technology offers the potential for governments, infrastructure businesses and citizens to link data, systems, services and people in ways that were not previously possible. The interconnectedness of intelligent infrastructure ensures speedy communication of data between infrastructure systems, managers and users.

The sensor devices that have driven the growth of instrumentation across infrastructures are increasingly integrated into broader networks through the development of smart applications and telecommunication networks.

The extent of interconnection means we now have an internet of increasingly interconnected objects for example roads, mobile phones, food crates, utility lines and water pipes[2]. Through this dramatic growth in both instrumentation and interconnectedness, the 'internet-of-things' offers huge growth opportunities in telecoms infrastructures and services but also as a growth platform for new and existing economic activities and to fuel productivity and efficiency improvements[3].

III. Analytical

The growth in analytic capabilities provides the key defining characteristic of "intelligent" infrastructure. The collection and integration of data, while necessary, are not sufficient to constitute "intelligent" infrastructure, technology or systems. It is only when analytics are

2 The number of internet connected devices is forecast to pass the 5 billion in 2010 and Ericsson predicts 50 billion inter-connected devices by 2020. Source: http://gigaom.com/2010/04/14/ericsson-sees-the-internet-of-things-by-2020/

3 IBM: Global technology Outlook: The Internet-of-Things, 2011

applied to this integrated data that insight can be derived to inform decisions and actions that can optimise systems and services.

Using advanced software to process large quantities of data, infrastructure controllers can optimise the links between data and systems and use predictive insights for decision making and action[4].

2.1.2 The Synergies of Smart Technology

At a high level, it can be seen that the use of smart applications by infrastructure give rise to the need for a selection of key generic technologies, regardless of the specific infrastructure in question. These include:

- Sensors;
- Actuators;
- Software systems for control; and
- Data management and analysis tools.

This suggests that there is scope for the integrated delivery of smart services across different infrastructural sectors. Similarly, the elements that make up intelligent infrastructure may have application across different sectors: smart meters for instance are used across a range of utilities. The CER has noted that the wide area network (WAN) communications infrastructure that would be put in place for a national electricity smart metering system could potentially be leveraged as a single communications infrastructure for electricity, gas and water smart metering[5]. Infrastructure providers may gain the benefit of economies of scale by working together to plan, develop and deploy intelligent infrastructure solutions. The level of integration can also extend across infrastructural systems. For example, there is a strong impetus towards viewing cities in a holistic way through an integrated approach to the introduction of smart systems.

Firms supplying goods and services in the intelligent infrastructure area may have an enterprise focus that extends across a number of infrastructure sectors or may focus on using generic technologies to tailor sector specific solutions.

4 Dencik, J., S. Dirks and M. Keeling (2009) How Smart is Your City: Helping Cities Measure Progress, IBM, 2009

5 CER, Smart Metering Information Paper 4: Results of Electricity Cost-Benefit Analysis, Customer Behaviour Trials and Technology Trials, May 2011.

Case Study: US Proposal for a Nationwide Intelligent Infrastructure using the Synergies of Smart Technology[6]

A report from the Centre for American Progress sets out a number of actions to take advantage of the cross-infrastructure synergies of smart applications. For example, under the American Recovery and Reinvestment Act 2009 billions of dollars are targeted at the construction of a smart electricity grid and at a broadband network. The Centre has recommended that, given the similarity in their structures (i.e. backbone, feeder lines, middle mile, and last mile), construction of the smart grid and broadband network should go hand-in-hand creating efficiencies with regard to planning, construction costs and procurement etc. The Centre recommends that the rollout of these core networks should be combined with other key objectives of the act in relation to weatherization of homes (retrofitting to reduce energy bills), ehealth and eeducation to create a nationwide intelligent infrastructure.

Given the synergies of smart technology, the Centre puts forward key principles for deployment of infrastructure. In pursuit of a nationwide intelligent infrastructure, it recommends establishment of principles to 'plan once' and 'only dig once'. That is, agencies should look for ways to deploy broadband, upgrade the electricity system and achieve other goals such as make transport improvements simultaneously to reduce the public expenditure requirement.

2.1.3 Enabling role of Electronic Communications

Electronic communications is a vital enabler of intelligent infrastructure applications as it provides remote and instantaneous communications between sensors and control centres and between those centres and actuators. Real time communications are vital to realising some of the efficiencies of intelligent infrastructure, for example through early warning of system failures. The communications infrastructure currently in place in Ireland is sufficient to enable the delivery of intelligent infrastructure in the areas of energy, transport, water and waste. However, significant Exchequer savings and enterprise opportunities are likely to arise in the areas of soft infrastructure such as health and education which will require advanced broadband capabilities with high symmetrical speeds. There is an opportunity to support the rollout of advanced broadband service while rolling out smart applications across other infrastructures. For example, there is significant potential to exploit costs savings arising from coordinating water network investment and fibre deployment as up to 80 per cent of the costs of telecoms infrastructure rollout is civil works.

2.2 Benefits of Intelligent Infrastructure

Application of smart technologies provides opportunities to improve Ireland's competitiveness by enhancing infrastructure service outcomes. Intelligent infrastructure can also develop the growth potential of Irish-based enterprises through improved productivity and demands for new goods and service both domestically and internationally.

Research by the ESRI has shown that the return on investment in infrastructure is linked to the relevance of the infrastructure to the wider economy. As core infrastructures provide the highest return on investment and are of most relevance to enterprise they are the focus of

6 Centre for American Progress, Smart Grid, Smart Broadband, Smart Infrastructure, 2009.

this report[7]. Energy, water, transport and waste infrastructure are key targets for the application of smart technologies. While communication systems are a core infrastructure, their role is generally to act as an enabler rather than a target for smart applications.

2.2.1 Economy-Wide Benefits

Intelligent infrastructure offers cost efficiencies and improved quality of services through system optimisation, operating cost reductions, demand management and reduced capital investment needs. In some instances, smart applications facilitate revenue raising (e.g. electronic tolls, water meters).

Exploiting existing capacity and reducing the need for capital expenditure
Greater application of intelligent infrastructure reduces the need for capital expenditure by identifying means to increase the capacity of the existing assets or system. Intelligent infrastructure seeks to maximise the return on investments already made. This is a major driver of smart applications in the current economic environment. For example, rather than building expensive new water treatment plants, the amount of treated water available would be greatly increased by deploying sensors throughout the distribution system to identify leaks quickly. Likewise, the use of smart water meters can promote water conservation. Smart electricity systems, by reducing energy demand at peak times, reduces the need for new power plants to match spikes in demand. Similarly, rather than expanding a fleet of public transport vehicles, technology which tracks the location of public transport vehicles, traffic speeds and passenger flows can be used to develop inter-modular scheduling. This maximises the capacity of the existing vehicle stock, reduces commuting times and improves user experience.

The use of smart applications can also reduce the cost of developing new infrastructures. For example, the cost of developing Grid25 was originally estimated to cost €4 billion, however, largely due to the introduction of smart technology in the form of high-temperature-low-sag (HTLS) conductors, the total forecast cost of Grid25 has now decreased to €3.2 billion[8].

Reducing operation costs
Traditional operating systems rely on significant manual inputs and often data cannot be communicated to decision makers in as timely a manner as appropriate. With intelligent infrastructure monitoring of infrastructural performance and communication of this data occurs automatically. Advanced intelligent infrastructure systems use actuators that are controlled remotely, reducing the need for slow and expensive manual resetting of controls. Smart water quality monitoring, for example, can reduce the cost of manual grab sampling. Intelligent transport systems can reduce the need to deploy personnel to monitor and direct traffic.

7 E. Morgenroth, ESRI, Prioritising Investment in our Cities to Secure Sustainable Economic Growth.
8 Eirgrid, Eirgrid announces major reduction in the cost of delivering Grid25, April 2011.

Enhanced management of infrastructure demand
In certain instances, intelligent infrastructure offers opportunities to manage demand for infrastructure services through appropriate pricing mechanisms. This occurs where real time monitoring and control is in place. Where demand or supply is variable by time of day, advanced smart systems can implement variable prices to ensure that demand is brought in line with system capacity or reflects the availability of supply. Examples include electronic road pricing where road tolls are varied with the degree of traffic congestion and smart electricity metering where electricity prices are altered to reflect demand levels. In this way intelligent infrastructure can be used to adjust demand to match system capacity and reduce supply costs.

Energy, Environmental and Resource Benefits
Climate change concerns, increasing population levels, water shortages and urbanisation globally are driving demand for technologies that reduce emissions and improve resource use. At EU level, Ireland has committed to achieving a range of energy targets relating to emissions reductions, renewable energy and energy efficiency by 2020. The latest projections published by the EPA from April 2011 show that even if all currently planned emissions mitigation measures are delivered to the full, Ireland will exceed its emissions limits from around 2015. There are public Exchequer implications for this as Ireland will have to purchase credits or allocations to bridge our gap to target. The EPA has estimated that the overall cost of doing so could be in the order of €100 million to €600 million.

Optimisation of infrastructure and enhanced demand management can lead to reduced resource use and emissions which are particularly important in areas such as:

- Promoting energy efficiency and carbon reductions in transport which is a major source of Ireland's emissions.
- Smart electricity grids which can accommodate the increasing deployment of renewable energy and use real time system information to match generation to demand.
- Smart metering which can contribute to demand management leading to reduced resource use and greater opportunities for use of alternative power sources.
- Smart hydrometric monitoring can help reduce the use of scarce water resources and support flood prevention and mitigation, through early warning of rising water levels.
- Real-time monitoring of water-based pollution can also alleviate adverse effects of natural and man-made pollution.

Improved Safety and System Risk Reduction
Increased demand for infrastructure services puts strains on infrastructure that mean the system failures have more profound negative impacts. Thus, gridlock on roads may be avoided by early detection and re-routing of traffic through variable message signage and the health and other adverse impacts associated with pollution of drinking water supplies may be avoided through early detection and temporary shutdown of water supplies.

Case Study: Smart Technology and "Black Swan" Events

System failures such as "black swan events" carry huge public and private costs that spill over to the economy as a whole not least through reputational damage. A black swan event is one that deviates from normal expectations and previous patterns. Once it has occurred a black swan event will have a significant impact.

Smart applications provide real time monitoring of infrastructures that can provide an early warning system to circumvent black swan events or to ensure quick responses and reduce the costs and service disruption arising when such events occur. The use of sensors on railway tracks and bridges, for example, can provide advanced warnings of track obstructions or structural weaknesses . Had this advanced sensor technology been in place along the Malahide Estuary railway bridge, authorities may have received an early warning of the potential of a bridge collapse and been able to reinforce the structure before passengers were endangered and avoided the lengthy service disruption which followed the collapse.

Reputational Benefits

Although intelligent infrastructure is a relatively new phenomenon, it has attracted significant interest from policymakers and infrastructure providers around the world. To date, countries have approached intelligent infrastructure in an opportunistic manner seeking to address specific infrastructure challenges in their country or region. There has been little attempt to adopt a strategic approach to the deployment of smart technology across infrastructures or to target the enterprise opportunities that arise with regard to intelligent infrastructure. In this context, by developing a public agenda which explicitly recognises the importance of intelligent infrastructure, Ireland stands to gain reputational benefits as a country committed to competitive infrastructure provision and delivery and also as a prime location for the establishment of intelligent infrastructure enterprises. In addition, it should serve to further enhance Ireland's reputation in the growing green and cleantech sphere.

2.2.2 Firm Level Benefits

A number of related benefits of applying a smart approach to infrastructure can also be seen to apply to firms.

Improved Productivity

Improvement of the efficiency and effectiveness of infrastructural services creates significant productivity benefits for firms and individuals – for example as intelligent transport systems reduce congestion. Utilities that use smart approaches can be expected to face fewer blackouts and services disruptions to essential water and energy supplies and help key Irish industries which are energy and water intensive (such as food and drink, pharmaceuticals and ICT) avoid production losses.

Reduced Business Costs

Where system improvements reduce the costs of the supply of infrastructural services, these costs may be passed on in lower prices to businesses, for example through reduced gas or electricity prices. In addition, smarter approaches which provide more information can help businesses understand how much energy or water their business is consuming and result in

improved resource demand management. Within the UK an estimated 2.7 million businesses have their meters read manually, with approximately £6.5 billion per year savings once these are converted to smart meters[9].

Gaining Consumer Insights and Meeting Consumer Preferences

Smarter technology enables infrastructure service providers to gain an insight into customer's profiles and preferences so that they can provide greater choice and high quality services. Leveraging the information and knowledge derived from smarter technologies enables customisation of services as well as an increase in the range of services a business can offer. In addition, as intelligent infrastructures and devices (in particular smart phones) become more widespread, consumer expectations for smart products and services is increasing.

Environmental Performance

Businesses are under increased pressure to reduce their environmental impact from legislation (such as the EU Emissions Trading Scheme Directive), carbon tax (currently at €15 per tonne), the "greening" of consumer preferences and higher environmental standards being demanded of sub-suppliers by large multiples (such as Tesco and Wal-Mart). Improved demand management through smart applications can help companies reduce environmental liabilities, lower operational costs, improve brand image and gain competitive advantages.

Development of Irish suppliers of intelligent infrastructure

The rollout of intelligent infrastructures in Ireland creates opportunities for Irish firms to design and deliver appropriate hardware and services. Given that intelligent infrastructure arise from the convergences of a range of technologies (ICT, energy, water, etc.) smaller countries are ideally placed to move more quickly. Ireland is well positioned as a host for sectoral convergence. This convergence is facilitated by access to a range of skills and expertise and the proximity of the collaborating firms to one another. As a base for some of the world's leading multinationals and being home to numerous innovative firms in the key convergence sectors, Ireland provides an ideal location for developing relationships and commercial partnerships between research institutes, infrastructure providers, ICT and financial services companies.

9 ESB, Smart Metering Project 2005, http://sustainableneighbourhoodspool.files.wordpress.com/2009/06/esb-board-06-smart-metering-appendix-one.doc

3. Policy Drivers of Intelligent Infrastructure

There are a number of issues driving interest in intelligent infrastructure. The potential to realise cost efficiencies is a key driver given the current economic environment, however, other longer term macro trends are also stimulating demand internationally for smart applications for infrastructure. At an EU and domestic level, legislation and strategic policies are encouraging policy makers and infrastructure providers to consider their potential.

3.1 International and Domestic Trends

Fiscal Constraints

The global recession has impacted on public finances in a number of countries. A host of countries are increasingly applying smart applications to optimise networks and manage demand in order to reduce the burden on the Exchequer and free up scarce capital resources. Ireland in particular is experiencing a deep recession at a time when public finances are under stress and an unprecedented banking crisis has unfolded. Achieving fiscal stability is a key objective of the Programme for Government and the EU/IMF Programme of Financial Support. In tandem with improving the quality of Ireland's physical infrastructure, intelligent infrastructure applications have a role to play in terms of:

- Reducing the cost and improving the productivity of public infrastructural services;
- Opening up revenue-creating opportunities; and
- Reducing infrastructural capital requirements.

The Programme for Government expects infrastructural investment to play a major part in Ireland's economic recovery. However, resources for capital investment will be limited and prioritisation of investments in the Capital Expenditure Review 2012-2016 will be essential to deliver the critical infrastructure to support sustainable economic growth and ensure the best value for money.

Technological Change and Consumer Preferences

A range of technological changes are combining to increase the supply of technology facilitating and enabling smart systems. Developments in technology such as new computer models, algorithms and improved sensor technologies are allowing for ever growing amounts of data to be gathered and processed. Growing levels of internet connections are also contributing. Technological change is also acting to create demand by consumers for new technologies and services, as exemplified by smart phone technologies and their applications' platforms.

Environmental considerations

At a fundamental level, many infrastructural services are concerned with energy use either directly through electricity and gas supply or indirectly through transport services. This energy use gives rise to emissions of greenhouse gases and local pollutants that are of

increasing concern to national policy makers. There is a worldwide view that current trends in energy supply and use are unsustainable. Increased fossil fuel demand has heightened concerns over the security of supplies and energy related emissions of carbon dioxide (CO2). The Kyoto agreement set international targets for the reduction in emission of CO2 and other greenhouse gases.

Energy Policies

Optimising the use of infrastructures and demand management have been identified as two of the key benefits of intelligent infrastructure. Both of these lead to reduced resource use. Smart electricity grids have perhaps the most potential to contribute energy and environmental goals. As the extent of deployment of alternative energy sources increases, it becomes more difficult for traditional grid systems to accommodate such power sources. The greater flexibility of smart grids in terms of real time system information and control supports operators in matching generation to demand. Smart metering can contribute to demand management leading to reduced resource use and greater opportunities for the use of alternative power sources.

Water Management

Sustainable water use based on the long term protection of available water resources of sufficient quality, is a key driver of intelligent infrastructures. Pressures on water supplies and quality are being felt around the globe, exacerbated by changes in climates and increased urbanisation.

Domestically, Ireland is faced with a number of challenges such as high levels of water leakage, water quality difficulties (with a recent EPA report identifying an E.coli presence in more than 50 public water supplies) and septic tanks monitoring. The Water Services Investment Programme is the primary investment vehicle for water and waste water services. In light of the issues identified above, the programme prioritises projects that target environmental and public health objectives as well as critical infrastructure to support enterprise development. The National Recovery Plan 2011-2014 envisages that by 2014 water services investment will be part funded by domestic water charges.

Population pressures

Globally, rising populations and increasing urbanisation are placing increased pressure on infrastructure systems (such as electricity grids) and resources (such as water) which are driving global enterprise opportunities. As the pressure on these systems increase, there is a need to develop innovative ways to manage existing assists and maximise the potential of future investment. As intelligent infrastructure can enable increased levels of integration across systems, city authorities across the world are exploring the potential to use smart technology to manage cities in a more holistic way and develop ‘smart cities’.

3.2 EU and Domestic Policy Drivers

EU Legislation and Policy

At an EU level 'The EU Strategy 2020: A European Strategy for Smart, Sustainable and Inclusive Growth' sets out a vision for Europe's economy over a ten year period. Intelligent infrastructure has a role to play in delivering on the priorities of smart, sustainable and inclusive growth. The use of technology to better manage infrastructure will boost prospects for long term growth and create jobs and enterprise opportunities. The European Commission has put in place seven flagship initiatives which have a number of synergies with the intelligent infrastructure agenda. For example, in the area of transport policy, the Commission has set specific objectives in relation to the development of intelligent transport systems. As part of the Resource-Efficient Europe, another of the flagship initiatives, water policy has been identified as a key mechanism for reducing resource usage.

The EU's energy policy commits member states to a variety of targets in relation to emission reduction and increased use of renewable energies, namely to reduce greenhouse gas emissions by 20 per cent, to increase the share of renewable energy to 20 per cent and to make a 20 per cent improvement in energy efficiency. Within the EU's *Strategy 2020*, smart meters and power grids are seen as the keys to full exploitation of the potential for renewable energy and energy savings as well as improvements in energy services.

Domestic Policy

The National Competitiveness Council in its *Statement on Competitiveness Priorities* recognised that significantly increasing exports will be central to Ireland's recovery, but that this will be dependent on the ability to enhance Ireland's competitiveness[10]. Improving national competitiveness will require action on a number of fronts, including reducing the costs and improving the performance of public and regulated infrastructures.

Ireland is faced with a number of infrastructure challenges such as high levels of congestion in cities, high degree of variability from renewable energy sources and an extensive water distribution network with significant levels of leakage. Intelligent infrastructure offers effective means to resolve or assist in resolving these issues.

The Government's focus on identifying opportunities for sustainable economic growth and job creation and the need to improve national competitiveness through reducing business costs and improving productivity are also acting as policy drivers. Unemployment has risen sharply and has been recognised as the most pressing economic and social challenge facing Ireland[11]. In June 2011, the standardised unemployment rate in Ireland stood at 14.2 percent[12]. In May 2011 the Government announced the Jobs Initiative, a set of measures that aim to improve the economy's international competitiveness and promoting job creation. These include

10 National Competitiveness Council, Statement on Competitiveness Priorities, 2011, Forfás.
11 National Competitiveness Council, Annual Competitiveness Report, Volume 2: Ireland's Competitiveness Challenge, 2010.
12 CSO, Live Register, June 2011.

actions in the area of tax, social welfare, training and enterprise development. Underpinning the Government's strategy is an emphasis on innovation and commercialisation. Of particular relevance is the commitment in the Programme for Government to make Ireland a centre for cloud computing and the application of technological innovation in sectors like energy generation and supply and transport. Intelligent infrastructure developments could contribute to enterprise development and jobs growth in these areas through the creation of opportunities for new products and services (Chapter 4).

The international growth in demand for intelligent infrastructure has the potential to drive demand in the Irish labour market. Employment opportunities in this sector are likely to be high value and knowledge-intensive. Firms will require employees with world class education standards and skills to develop technologies and deployment of such technologies will generate demand for continued skills improvements. Greater efficiencies and productivity gains arising from the rollout of intelligent infrastructure will help to facilitate growth across a range of key sectors, supporting sustained jobs creation throughout the economy.

4. Status of Intelligent Infrastructure in Ireland

4.1 Deployment of Intelligent Infrastructure in Ireland

4.1.1 Energy

Smart Grid

Intelligent infrastructure approaches can be applied to the transmission and distribution of electricity. This is often referred to as the "smart grid". Ireland is at a relatively advanced stage in implementing this approach.

The effective capacity and reliability of an electricity transmission or distribution grid can be significantly improved by adding sensors, high quality two-way communications and distributed computing power to the network. This can:

- Improve the usable capacity and reliability of the grid: Real time monitoring of the temperature, and hence actual capacity, of electricity transmission lines allows maximum use to be made of their capacity. If damage occurs to one part of the network, the system operator can react to this and can usually maintain continuous supplies to all or most users. These technologies are already in use in Ireland and the transmission system operator (Eirgrid) and distribution system operator (ESB Networks) are committed to maintaining this level of intelligent infrastructure into the future[13]. In contrast, where a grid is not actively monitored and managed a fault in one part of the grid can spread across the system and lead to blackouts.
- Increase the deployment of renewable energies: Wind generation is highly variable, as it depends on prevailing weather conditions. Meeting the target for the proportion of electricity generation from renewables could require up to 70 per cent of our electricity needs to come from wind at certain times when conditions for wind generation are ideal. At other times, output from wind generation could drop to negligible levels. Operating this type of system will require a high level of monitoring, communications and control.

Smart Electricity Metering

Smart electricity metering allows use of electricity or gas to be measured in real time and for this information to be recorded, analysed and communicated to energy suppliers and the customer. In conjunction with this, variable pricing can be introduced where the tariff charged for electricity or gas changes according to seasons, the time of day or even the availability of renewable power at the time in question. Customers can have real time information on the cost of their energy use and adjust demand or use accordingly. This type of technology can be extended to smart appliances where the customer devices that use power can be controlled automatically to optimise energy use and reduce costs for users.

13 See for example, Eirgrid "Grid 25 – A Strategy for the Development of Ireland's Electricity Grid for a Sustainable and Competitive Future" (2009). www.eirgrid.com

European legislation requires member states to implement smart metering for electricity and gas, subject to an economic assessment of its costs and benefits[14]. Ireland has recently published the results of the cost benefit assessment for smart electricity metering.

Case Study: Ireland's Smart Meter Rollout

A major pilot on the implementation of smart electricity and gas meters was carried out by a cross industry group led by the Commission for Energy Regulation. An active test of smart electricity meters in 5,700 homes and 800 small or medium enterprises took place throughout 2010. Results of the cost benefit analysis were published in May 2011 and found that the rollout of smart electricity metering is likely to result in a net gain to the economy over the next 15 years of €174 million through reduced energy usage and environmental benefits[15].
The gas meter pilot undertaken by the CER found that a national rollout of gas smart meters, taking account of the costs and benefits and leveraging electricity smart meter communications infrastructure, would yield a net benefit to customers and the country of up to circa €59 million over the next 20 years[16].

4.1.2 Transport

There have been significant investments in all forms of transport infrastructure in Ireland over recent years. The bulk of this investment has been in conventional transport infrastructure. However, a number of important elements of smart technology have been included in Ireland's transport infrastructure. The need to manage the enhanced infrastructure that is now in place is driving increased interest in smart applications.

Road Infrastructure
Smart transport infrastructure is already deployed in a number of parts of Ireland's transport infrastructure, particularly in or around the cities (see case studies below).

A potential application for smart technology in Irish road transport in the future might include the introduction of road pricing by tracking users' actual journeys and charging for their actual road use. This is more costly than more traditional methods of recovering the cost of roads such as fuel taxes. However, it allows the use of price signals to manage, and so optimise, the use of road infrastructure. Moneys raised from congestion charging can then be channelled into funding better public transport services, further improving the efficiency of the transport network. The Netherlands is preparing to introduce road charging based on satellite tracking of all vehicles through on board units. This type of technology is already used to charge HGVs for use of the motorway network in a number of jurisdictions including Germany. This level of instrumentation and communication with vehicles allows monitoring of vehicle performance, tracking of deliveries and a range of other value added services.

14 The Third legislative package for further liberalisation of the electricity and gas markets, in particular Directive 2009/72/EC on Electricity and Directive 2009/73/EC on Gas.

15 CER, Smart Metering Cost-Benefit Analysis and Trials Findings Reports, 2011.

16 www.cer.ie/en/information-centre-newsroom.aspx?article=6bd2c194-d597-4210-a309-e6274c5b0fa8

Eventually, this technology will allow automatic or semi automatic operation of vehicles optimising safety and efficiency of vehicle operation. The timing of this will be driven by advances in vehicle design and the level of technology included in vehicles. This in turn will be based on decisions made by vehicle manufacturers worldwide

Case Study: Barrier Free Tolling on M50 and Urban Traffic Management

Barrier free tolling has been implemented on the M50, which has significantly decreased journey times. This was achieved by replacing physical toll barriers with smart technology to recognise number plates and automatically bill motorists. Using sensors, communications and analysis technology had a similar effect of improving capacity as would have been obtained from more conventional infrastructure investments but at a lower cost.

Similarly, the effective capacity of roads in Dublin and Cork city centres has been increased by the use of traffic management systems. Traffic sensors and number plate recognition systems are used to monitor traffic in real time and to manage traffic signals to optimise the flow of traffic on roads.

Public Transport

Some smart approaches are also in use for public transport in Ireland. This use of instruments on public transport vehicles and the provision of real time information provide real improvements in the quality of service for passengers. The Dublin City Bike Scheme has been recognised as a world class model for smart urban bike initiatives.

Integrated ticketing is a cornerstone of intelligent public transport. A smart card ticket system acts as an instrument to gather information on the journeys taken by users, and as a communication system to centralise this data. Once traffic is being tracked, the resulting data has a wide range of potential uses including the application of analytics to further improve and optimise the transport system. This level of data can be used to optimise the use of the whole transport network. The potential of this approach is shown by the smart card system in Singapore which is used to pay road charges, parking and public transport fares. The data gathered on all use of the city state's transport infrastructure is used to optimise use of these assets through variable pricing and dynamic scheduling. The development of integrated ticketing in Ireland has taken an inordinate amount of time.

Case Study: Automatic Vehicle Location

Dublin Bus has an automatic vehicle location system that tracks each bus in its fleet using an onboard unit and satellite technology. This allows real time management of the bus network, and integrates with the traffic lights at major junctions to ensure that buses are given appropriate priority. Dublin Bus is in the process of rolling out real time passenger information displays across its network based on this technology. Displays at bus stops indicate the time to arrival and route of the next buses. It is hoped this will attract additional passengers to public transport in the same way as an investment in conventional infrastructure such as building a quality bus corridor (QBC) or upgrading the bus fleet. The data has been used to develop applications which communicate the data on vehicle locations and arrival/departure times to passengers via their smart phones. Similar technology is used by private

operators such as Aircoach. Having remote mobile access to real time information regarding public transport enables passengers to choose the most efficient transport mode and route to complete their journey. The main barrier to this type of service is devising a business model where data generated by the public infrastructure can be used by private service providers.

4.1.3 Water and Waste Water

Water Supply and Distribution

Water supply and distribution involves the treatment of raw water to make it fit for human consumption and the delivery of that water via a piped distribution network. Unaccounted for water (UFW) amounts to 43 per cent of the volume of treated drinking water produced in gateway and hub towns in Ireland[17]. Leak detection in water supply is undertaken by inspection, using listening devices or other technology or through district audits that isolate parts of the system with a view to detecting usage in that district. These methods are labour intensive, costly and less effective than the deployment of sensor technology. To reduce these costs, in recent years, authorities worldwide have installed permanent flow meters connected telemetrically to a SCADA (Supervisory Control and Data Acquisition) system, to help narrow down the search area for leak detection. The transmitted flow rate data are automatically analysed to detect unusual increases in flow patterns. Based on experience with the water system, it can then be determined whether an increase in flow rate is due to new leaks.

This type of system has been in use in local authorities in Ireland for a number of years. It is likely that, in the near future, these smart water supply monitoring systems will be expanded in terms of both the range of assets covered and the degree to which they are networked or connected, and the extent to which analytics will be applied. However, even though the costs of these basic systems are relatively low, the financial position of the local authorities is hindering take-up of smart applications.

Case Study: Leak Detection in Dublin and Meath

In Dublin, a sophisticated telemetry system for remote monitoring has been put in place to assist in identifying those areas where leakage is highest, giving Dublin one of the lowest levels of UFW levels in the country.

Some local authorities are moving to integrated monitoring systems to address the twin objectives of compliance with EU water quality monitoring requirements and reduction in leaks. For example, Meath County Council has introduced real time monitoring via a web connected SCADA server which covers water treatment and distribution assets at over 200 sites. Equipment failures are reported almost instantly, with reduced downtimes, and water quality monitoring has improved.

17 UFW is the loss of water through the distribution networks which cannot be accounted for through known usage. Forfás, Assessment of Water and Waste Water Services for Enterprise, 2008.

Operational monitoring of the water supply involves the sampling of water entering and leaving a treatment plant, as well as at points in the distribution network. Recent failures to maintain the quality of drinking water are a powerful impetus for more frequent monitoring of drinking water quality, particularly with a view to implementing early warning systems. The range of parameters to be tracked in real-time is expanding. Smart applications are likely to be the only viable means by which this enhanced monitoring can be implemented. The Department of Environment, Community and Local Government has committed financial resources to local authorities to support increased monitoring, for example, with respect to chlorine monitoring, however, the cost of implementing smart monitoring has inhibited widespread deployment.

Water Metering

In line with commitments in the EU/IMF agreement, the Government is considering the establishment of a national water authority to rollout domestic water metering on a national basis to 1.2 million households. While there are substantial economic benefits associated with metering in terms of water conservation, leakage control and fair pricing, there are significant obstacles to be overcome in terms of recovery of capital costs and the ongoing costs of meter monitoring and billing systems. Smart metering has the potential to overcome the latter problem. The experience of commercial water charging in the Dublin area is that a semi-smart metering process, that facilitates drive-by meter reading, yields benefits by reducing the costs of system monitoring over and above the traditional monitoring approach.

The most sophisticated water metering technologies delivers a number of benefits including providing consumers with a profile of use that enables them to better understand their water usage and take conservation actions, facilitating the water utility in the detection of household leakages and enabling the application of seasonal tariffs. A key consideration in the rollout of domestic metering is to ensure the level of smart technology deployed is appropriate. While caution is required to ensure that over-specification does not occur, the solutions should be future proofed in as far as possible, as it is likely that civil works rather than meter technology will be the largest cost component.

Waste Water

A number of local authorities have introduced real time monitoring of wastewater assets via a SCADA server linked to these assets. This improves operational efficiency and reduces response times to plant failures. The addition of combined storm overflow monitors to such networks further reduces system risks[18]. There is evidence that application of such systems among local authorities is becoming more sophisticated with Remote Terminal Units (RTUs) being equipped to automatically control critical plant and allow staff execute remote control.

With regard to wastewater outflow quality monitoring, the major parameter monitored is Biochemical Oxygen Demand (BOD). Sensors to measure BOD in a speedy fashion have not yet

18 This involves structures where excess sewage can be diverted from the sewer system either directly into a receiving watercourse or indirectly via a storm sewer system. Monitoring of levels in the sewer provides early warning of problems.

been fully tested. However, if this obstacle is overcome, then the real time sensing of effluent quality will become a reality, providing implementation costs are not excessive.

Management of Water Levels and Flows

Water resource management is concerned with the management of water levels and flows in our lakes, rivers and streams and their water quality. With regard to water levels, float or pressure devices are used to record levels and data loggers used to retain the data, which is transmitted by phone link. Levels are recorded at 15 minute intervals and the information is made available at the EPA and OPW web-sites. Water flow rates are obtained through manual methods, which involve measurement of current speeds and water depths. Currently, the EPA and the Office of Public Works (OPW) are testing alternative water flow rate measurement methods, including ultrasound.

Surface water quality monitoring is achieved through spot/grab sampling, which involves visits by personnel with mobile testing equipment. In more recent years, sampling personnel have used handheld computers to record data. Underground water quality sampling employs sensors and data loggers at fixed locations. There is a strong view among practitioners that traditional monitoring does not provide a reasonable estimate of the true condition of water quality. When persistent fluctuations occur, it is likely only to be detected through highly frequent measurement. Sensors capable of continuous sampling would provide more up-to-date information, reduce costs, and ensure better coverage of fluctuations of pollutant concentrations[19].

Ireland appears to be relatively advanced in the monitoring of water levels in inland water bodies. Smart water quality monitoring is becoming more widespread internationally but, as in Ireland, can be said to be still at an early stage of development generally.

Septic Tanks

Ireland has been found to be in breach of EU law over its management of domestic waste water. The European Court of Justice ruled that every county in Ireland, with the exception of County Cavan, has failed to comply with the relevant EU Waste Directive. Work is underway to address the judgment, through the introduction of a registration, monitoring and inspection regime. As there are approximately 444,000 households with septic tank systems, the costs of such a regime could be very large, if manual inspection were to be adopted. This raises the possibility of the introduction of automated systems. However, where malfunction of septic tanks occurs, the detrimental effects are slow to accumulate. This suggests that infrequent inspection may be sufficient and that handheld sensing with a PDA device rather than fixed sensors may be the most economic approach[20]. There is also considerable research needed to develop appropriate sensing technology.

19 See: B.O'Flynn et al. Experiences and recommendations in deploying a real-time, water quality monitoring system. Meas. Sci. Technol. 21 (2010) 124004.
20 J Goldman et al. Distributed Sensing Systems for Water Quality Assessment and Management. Woodrow Wilson International Center for Scholars, 2007.

4.1.4 Solid Waste Disposal and Collection

The decomposition of the organic component of municipal waste in landfills produces landfill gases, principally methane. Methane is a greenhouse gas with a global warming potential 21 times greater than carbon dioxide. Landfill gas also contains trace amounts of other non-methane volatile organic compounds. These other compounds may cause odours or affect local air quality. Uncontrolled landfill gas can also travel underground affecting groundwater. As a result, landfill sites employ gas collection facilities.

With regard to gases, monitoring of sub-surface and surface gases takes place. Both fixed and mobile sampling occurs. Real time sampling occurs, but is usually focused on one pollutant only and is often less sensitive than laboratory analysis. There is considerable pressure to engage in more real times sampling, as interval sampling can result in missing significant releases of gases. Local authorities are increasingly making use of real time monitoring and sampling. At the same time, there is significant research underway to develop new sensors that can provide real time information. Ireland is participating in this research. The further development of a smart approach is contingent on technological development of multi-parameter and cost effective sensors.

Where domestic refuse collection uses wheelie bins, a radio frequency identity device (RFID) chip is usually employed in each wheelie bin. This feeds back the lift weight and time to a centralised database in order to facilitate pay per weight.

4.2 Intelligent Infrastructure Enterprise Opportunities for Ireland

4.2.1 Overview

In general terms, intelligent infrastructure gives rise to the need for smart sensors, smart actuators, communication systems, software systems for control, data management and analysis tools and services. Given that intelligent infrastructure is at a relatively early stage of its development, any prediction of the future market for smart goods and services must be tentative. However, most predictions are for a significant increase in demand for smarter goods and services over the medium term.

As demonstrated in this study, intelligent approaches to infrastructure are ideal for addressing the most pressing drivers and priorities facing decision makers across the globe, such as environmental pressures, fiscal constraints and population pressures. Ireland already has a strong base of knowledge intensive indigenous companies with a small number of large players and a growing number of highly innovative SMEs. Ireland also has a strong base of multinationals that are taking a lead in the development of smart applications in both the electronic, ICT and infrastructures sectors (including Siemens, IBM and Cisco). In addition, Ireland has developed as a base of research for key intelligent infrastructure areas (such as sensoring technologies, water quality and smart grids). As a small market, Ireland, presents an opportune location for new technologies to be tested for application on a larger scale and we already have a number of existing advanced sites to test-bed new technologies.

The growing demand for intelligent infrastructure goods and services domestically and abroad will provide opportunities for Irish based enterprises to support job creation in the medium term across a range of infrastructure sectors.

4.2.1 Energy

With regard to energy, smart products and services may include:			
Smart sensing, measuring and intermediate data storage devices	Smart energy meters	Smart tags	Information display and monitoring devices
Smart household appliances	Smart Heating, Ventilating, and Air Conditioning Equipment	Smart industrial equipment	Distributed energy generation devices

Smart energy infrastructure can create opportunities for Irish companies in a range of areas.

- Energy metering: In Ireland, a major pilot and cost benefit analysis of smart electricity meters has been carried out by a cross-industry group led by the Commission for Energy Regulation. While metering hardware is likely to be sourced abroad, there may be opportunities for Irish based enterprises to participate in the metering market through the provision of data management and analytical services. Surveys and meter installation and maintenance are also areas where indigenous firms will be well placed. Smart meters are a key part of EU's Energy 2020 Strategy and eleven Member States of the European Community have conducted cost-benefit analyses (CBA), with a further twelve intending to do so. A number of states in the US are currently deploying smart meters. The level of activity in this area in Australia would also suggest the emergence of a significant market.
- Smart Grids: Ireland is investing heavily to develop its national grid and is a natural test-bed for the early development and deployment of smart grid technologies[21]. Smart grid investment is growing rapidly internationally (for example in the US and Europe but also in developing economies such as India and China)[22]. Ireland has the potential to develop smart goods and services (such as power system equipment, power system monitoring, software for grid management and security of system operation and data management, etc.) within the global supply chain to meet this demand.
- Energy management systems: Smart energy management systems provide real time information on where and how energy is consumed in buildings. Such systems can include wireless building monitoring and control systems, street light monitoring and control systems and online software applications that allows for the identification and

21 SEAI, Your Smart Grid Opportunity

22 Significant investments are expected in smart grids for electricity. Pike Research estimates that $200bn will be spent around the world on Smart Grid Infrastructure between 2008 and 2015. At least one "crowd sourced" prediction estimates that the global market for Smart Grid will triple in value between 2009 and 2014, reaching a value of $171bn.

targeting of energy inefficiencies. These systems realise the potential for savings that arise from smart electricity networks. Standard Control, Wirelite, Zutec, Episensor, Resourcekraft and Enerit are examples of Irish owned companies all involved in the provision of energy management systems. There is also important research going on in this area in Ireland (for example, the International Energy Research Centre aims to be at the leading edge of developing integrated energy system solutions).

- Household/Industrial Smart Equipment: There are growing opportunities for smart appliances where customer devices that use power can be controlled automatically to optimise energy use and reduce costs for users. EU targets to improve energy efficiency by 20 per cent by 2020 are driving EU opportunities in this area. Other examples include the US which has announced its Better Buildings Initiative; India which has introduced the Indian Leadership in Energy and Environmental Design (LEED) rating system; China has set up 'low carbon zones' in eight cities and five provinces, covering over 300 million people[23], and investments in the Middle East in greener buildings are growing
- Smart Lighting Solutions: There are a number of small innovative companies which are producing energy efficient lighting control products and services which can be applied to the transport and broader smart energy appliances market. SELC is one such company (see case study).

Case Study: SELC

SELC produces street lighting products that optimise the switching on and off and dimming of street lights, optimise the intensity of lighting output based on prevailing conditions, power the street lamp with a unique waveform to increase its useful life, predicts in advance when the lamp will fail (thus assisting lamp maintenance and repair planning costs) and communicates (either via installed power lines or wirelessly) data about the street light performance to a central management/monitoring system which is web-enabled and remotely accessible. The company is presently in the process of bringing together a major international technology company, the ESB and a number of local authority customers to fund and support the implementation of a complete upgrade of a local authority's street lighting infrastructure. It is anticipated the project will then be used to rollout the company's intelligent street pole technologies as they are developed over the next 24 months, thus representing the 'living laboratory' or global exemplar model required by the company to market its capabilities globally.

Case Study: Smart Grid Research in Ireland

ESB Networks joined the smart grid demonstration initiative organised by the Electric Power Research Institute (EPRI) to collaborate during the development of the smart grid in Ireland, while learning from other smart grid deployments around the world. The project is a three year alliance focused on the R&D and demonstration of a number of the key innovations in the area of smart grids, including integrating large numbers of wind farms into the distribution system, novel methods of controlling volts, balancing the load with electric vehicles and influencing customer behaviour through the use of various

23 The implications of China's 12th Five-Year -Plan for Europe, E3G Consultants, http://www.e3g.org/images/uploads/E3G_Chinese_Challenge_or_Low_Carbon_Opportunity_updated.pdf

time-based rates. The UCD Electricity Research Centre, (ERC) is helping to coordinate and conduct the ongoing smart grid research[24] and Sustainable Energy Authority of Ireland and the Commission for Energy Regulation are also involved in the project.

4.2.2.2 Water

With regard to water supply and distribution, smart products and services may include:				
Flow and pressure meters	Acoustic sensors	Various water quality sensors	Data loggers	SCADAs (Supervisory Control and Data Acquisition Systems)
AMR systems (Automatic Meter Reading)	AMI systems (Advanced Metering Infrastructure)	Utility dashboards	GIS (Geographic Information Systems) and schematic tools	Smart pressure management
Asset management	Workforce tools	Alert systems	Water infrastructure monitoring	Water balance and leak detection software

Water is a key area where smart approaches have strong potential for job creation in Ireland. The continuing pressure to improve drinking water quality monitoring and to detect leakage will mean that increasingly sophisticated monitoring solutions will be required by an increasing number of purchasers at home and abroad. Integrated monitoring approaches will be demanded and eventually systems that include control features will be the norm. There will be ongoing opportunities for Irish-based enterprise in this area, in particular in:

- Water metering: Smart water metering applications are beginning to proliferate globally with Pike Research estimating smart water meters installed around the world will increase from eight million to approximately 32 million by 2016. As Ireland rolls its water metering programme out to 1.2 million households, there will be opportunities for Irish indigenous enterprises to participate in this market - particularly through the provision of data management and analytical services which are required by the companies who supply meter hardware. Site surveys and meter installation and maintenance are also areas where indigenous firms will be well placed. From this base, there will be strong potential for Irish companies to internationalise.
- Water Quality Monitoring: Robust sensors which can accurately calibrate the physical, chemical and biological properties of water in rivers, lakes, estuaries and coastal are in increasing demand. There is an opportunity for Ireland to play a lead role in the development, testing and application of such water quality monitoring technologies. There is scope for the manufacture and export of smart sensors in this area and

24 The ERC is funded by Industry Members, an SFI Charles Parsons Energy Research Award and other sources, including SFI Principal Investigator, Stokes, TIDA and Research Frontiers Programmes, EU FP6, IRCSET, IRCHSS and Teagasc.

ultimately for system integrators to sell their services abroad. Such products and services will be required across the EU, as Member States strive to comply with the Water Framework Directive. Water quality is also of growing importance further afield with opportunities for turnover growth particularly in the Middle East, Brazil and Asia (China and India) where some Irish companies are already realising opportunities. The relatively early stage of development of monitoring means that research and development activity and test-bedding are crucial to success in this area and will require significant resources.

- Water and Wastewater Treatment and Distribution Systems Monitoring and Control: There is an ongoing demand from local authorities for smart sensing solutions for the monitoring of water and wastewater treatment and distribution assets. The continuing pressure to improve water quality monitoring and to detect leakage will mean that increasingly sophisticated monitoring solutions will be required by water management authorities. Integrated monitoring approaches will be demanded and eventually systems that include control features will be the norm. Both Irish and foreign firms are engaged in meeting this demand. There will be further opportunities for Irish based enterprise in these sectors to meet both domestic demand and to internationalise.
- Septic Tanks: Ireland is unusual in developed countries in the extent to which reliance is placed on private wastewater treatment in the form of septic tanks and other small scale sewage treatment technologies. A new monitoring and inspection regime will be introduced for these facilities. Depending on the approach adopted, this could give rise to significant costs, which could be mitigated by a smart approach. Irish firms have a significant presence in small scale wastewater treatment technology, and opportunities may arise for them or for existing system integrators to expand their offer into this area.

Case Study Company: BioTector Analytical Systems Ltd

BioTector Analytical Systems Limited has patented technology for on-line measurement and liquid analysis. The company employs 17 staff at its manufacturing plant in Cork and has an extensive network of distributors worldwide including Europe, USA, Asia, Australia, Africa and the Middle East. It is continuing to invest in R&D to constantly develop and improve their products.

Case Study: Water Research

The Marine Institute's Smart Bay Ireland project is a research, test and demonstration infrastructure project for monitoring and managing aquatic environmental data such as tidal flow, wave heights, and temperature via an integrated network of sensors, robotics and computational technology distributed throughout Galway Bay. Smart Bay Ireland was selected as one of the first collaborative projects to be undertaken at the IBM Centre of Excellence for Water Management which was opened in Ireland in 2008. In association with Smart Bay Ireland, IBM are developing an advanced sensor network, using real-time monitoring technologies, data analytics and next generation content delivery in a bid to provide scientists, commercial fishing & aquaculture, monitoring agencies and the public with access to marine related environmental information. This test-bed has the potential to create enterprise opportunities in the provision of ICT enabled products and services in a range of areas such as environmental monitoring, security, oil and gas, transport and shipping, aquaculture, coastal tourism, marine renewable energy and water management.

4.2.2.3 Intelligent Transport Systems (ITS)

As outlined in section 3.1, there are important drivers (such as traffic congestion) which are encouraging the development of intelligent transport. In particular, at EU level, the EU-wide ITS implementation plan has the potential to facilitate an increased market for ITS products and services, resulting in enhanced employment and economic growth opportunities in Europe and further afield. They are also likely to be demanded in cities with severe congestion problems which can be identified across the globe from China to North America and Latin America. Irish enterprise has a significant presence in this area that can be built on to realise the opportunities both domestically and abroad in areas such as:

- Information display and monitoring devices: Irish companies active in this area are developing electronic display solutions and interfaces, and include companies such as Data Display Ltd and DHS Ltd;
- Smart traffic management systems and software: There are a number of Irish owned companies which offer specialised vehicle tracking and fleet management solutions, encompassing a driving style management element; and
- Smart vehicle monitoring systems and traffic control equipment: There are a small number of companies in Ireland actively producing smart vehicle monitoring and traffic control equipment.

Case Study: DHS Ltd.

DHS specialises in Human Machine Interface (HMI) for small screen interfaces on cars, mobile phones and other touch screen devices like ATM machines, medical devices and aeronautical seat interfaces. DHS has developed the personal energy management SNAPGLANCE software system for rapid interaction with small screen devices. The system is designed to enable the remote energy management of a range of personal products from home appliances to electric vehicles. They have key expertise in the challenging CAT telematic environment. DHS works mostly in the automotive sector where clients are Fiat Group, BMW, Toyota and their leading suppliers.

4.2.2.4 Telecommunications

As platforms rapidly advance, opportunities exist to develop telecommunications devices and infrastructure. There are already a number of innovative Irish companies working in this area (such as Bandwidth Telecommunications Ltd; EpiSensor; Firecomms; Taoglas; Convertec; Enersol; Bluebridge Technologies; Smarthomes and Powervation). Specific areas of opportunity that are emerging internationally include:

- Deployment of advanced business analytics to capture more data from customers, relevant to customer demand modelling (in order to provide better services, reduce service disruptions, control churn and convert loyal customers into service platform ambassadors);
- Open standard platforms that support growing engagement from other service providers;
- Co-sharing of platforms with other telecommunications providers, especially in the areas with low population densities;
- Integrating communications systems at the traditional telecommunication services levels with wireless data collection and transmission needs of large scale organisations, such as Wi-Fi platforms for integrated city services, and wireless data transmission for energy and water utilities; and
- Addressing the constraints in terms of data volumes imposed by existing 3G spectrum, with Long Term Evolution (LTE) platforms acting as the core best practice solution at this point in time.

Case Study: Intune Networks

Intune Networks is a fast growing "full-system" telecoms equipment design company based in Ireland. Their core technologies include fibre optic system design, burst mode tunable laser transponders, 10 Gigabit electronic design and network hardware platforms.

Intune's aim is to solve many of the key problems encountered in deploying next generation telecoms network services and to build a next generation telecoms platform based on dynamic optical technologies.

The company is very R&D intensive and works at the leading edge of network technologies, both optical and electronic. Intune has received €25m in private venture funding from Irish and international investors since it was founded in 1999 and the company has grown rapidly over the past two years and now employs 70 people spread over two R&D centres in Dublin and Belfast.

4.2.2.5 Waste

Smart solutions have potential in waste management, particularly to address problems associated with landfills emissions and to improve the efficiency in waste collection.

- Landfill Monitoring: There are opportunities for development of sensing products for landfill sites. In particular, there is a gap in sensing products that are capable of multi-parameter monitoring. This is also an area where establishment of a test-bed may be advantageous. There is significant research underway through the EPA's Strive

Programme[25] to develop new sensors that can provide real time information and facilitate more widespread application of remote real time monitoring.

- Waste Collection: Smart systems using RFID tagging is increasingly in use for weight or volume based pricing and for dispatching, routing and monitoring of waste collection vehicles. Embedded sensors are being used to track transport of hazardous waste. Further applications will include the use of sensors in recycling containers to indicate that they are full and thereby trigger collection.

4.2.2.6 System Integration Services

Systems integration services involve companies offering an inclusive package of goods and services across a number of sectors. For example, a service frequently offered is the joint supply of smart sensors and accompanying control and data management systems. The demand for system integration services particularly arises where infrastructure providers have sensors in place, but these have not been made to function in real time, remotely controlled or integrated into a monitoring or control network. It also arises where a fully automated, real time and remotely controlled system is in place but adequate fully integrated solutions are not available in the market place.

Case Study Company: EMR Integrated Solutions

From initial experience in the 1980s of telephone metering, EMR identified the opportunity to apply radio communications technology to monitor and control water treatment and distribution networks. EMR has become one of the leading providers of radio based telemetry and SCADA solutions for the water and electricity utilities in Ireland. EMR has deployed many systems for water and wastewater network management which include the real time management of the abstraction, treatment and distribution of drinking water and the collection and treatment of waste water. The EMR solutions encompass water quality monitoring, plant automation, minimisation of energy usage, provision of an audit trail to ensure compliance with EPA and EU regulations, identification of leaks and the analysis of data to allow informed decision making and long term planning.

4.2.2.7 Other areas of opportunity

Opportunities arise in a number of other areas which support or facilitate intelligent infrastructure deployment but their application is not specific to intelligent infrastructure.

- **Software systems:** A range of software systems applications are required to reap the full benefits of intelligent infrastructure initiatives. These include software applications in smart network monitoring and management solutions across different networks from telecommunications, electricity to water and waste networks as well as smart data management (and billing) systems.
- **Cloud computing:** Cloud computing is a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources (e.g. networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction. Firms that

25 Strive is the EPA's environmental research programme for the period 2007 to 2013.

need computing power can now use the facilities of remote data centres rather than acquiring and operating in-house computer equipment. Similarly, businesses can access development platforms or use software applications that are hosted at remote data centres. Such cloud-based services are a key area of opportunity for Ireland, particularly as the Government aims to position Ireland as a leader for data centre development and international companies including IBM and Microsoft have opened data centres in Ireland.

- **Smart analytical services:** Intelligent infrastructure applications often give rise to large volumes of data. This data is required for day-to-day monitoring and control functions, but the sheer scale of the data means that analysis is required to distil key parameters. There will be opportunities for specialist SME start-ups as well as more generically oriented multinationals in the area of smart analytics. Given the presence of major multinationals in Ireland providing analytical services, smart analytics should be a focus for inward investment promotion activities.
- **Consultancy services:** Increased opportunities for consulting companies in Ireland will arise in areas such as ICT related consultancy services (including cloud computing), building energy management related consultancy services, and infrastructure design services.
- **Smarter Healthcare and Education services:** The healthcare and education sectors are areas in which the application of smart approaches is expected to advance rapidly, for example in opportunities for specialised consultancies or system integrators to put together turnkey smart technology solutions for these sectors. Ireland has strong advantages in both sectors – with a strong basis in medical devices and a growing presence in elearning – which can be built on. Across the EU, increases in overall longevity, imply the need for significant adjustments in the core services, such as healthcare and education. These changes will put more emphasis on provision of specialised healthcare services to the work-active and inactive older population. Education, lifelong learning and training, will increasingly be delivered without interruption in careers of the students and will often involve mature student. Smarter healthcare and education services are reliant on the deployment of a world class advanced telecommunications infrastructure.

5. Policies to Support Intelligent Infrastructure

Analysis of the state of development of intelligent infrastructure at home and abroad has indicated that there are a number of barriers to further development of intelligent infrastructure. This chapter begins with a short overview of international approaches to developing intelligent infrastructure. It then looks at the barriers to the deployment of intelligent infrastructure in Ireland and puts forward recommendations to overcome these. Finally, the chapter sets out the challenges to realising the enterprise opportunities in intelligent infrastructure and proposes policy actions to address them.

5.1 International Approaches to Intelligent Infrastructure Development

A review of government policies internationally revealed few initiatives aimed at encouraging the rollout of intelligent infrastructure directly. This would seem to result from a view that intelligent infrastructure is not an end in itself, but merely a means of securing efficiencies and reducing risks. Additionally, many of the barriers are not specific to intelligent infrastructure, but apply to other technological developments and to firms in a wide range of sectors. Thus, few countries have set intelligent infrastructure objectives or developed strategic plans for rolling it out.

A review of the development of smart applications for infrastructure reveals that intelligent infrastructure solutions usually emerge in response to a particular issue or deficit faced by a country or region. For example, Singapore has become a world leader with regard to the implementation of intelligent transport systems because prior to their development the small city state faced crippling congestion which had a negative economic and social impact.

Within EU member states, smart electricity metering has been the main focus of government activity in relation to intelligent infrastructure. Most notably Finland, Greece, Italy, Spain and Sweden are proceeding to rollout metering, having adopted legal frameworks to address the barriers[26]. Having completed a cost-benefit analysis Ireland is at an advanced stage of planning for the rollout of smart electricity metering and is also making progress with regard to smart gas metering.

Internationally, Australia stands out for taking a strategic view of intelligent infrastructure. Infrastructure Australia was established in July 2008 to advise the Australian Government on infrastructure policy, regulation and investment[27]. This is the first time a whole-of-government national approach has been brought to bear on infrastructure planning in Australia. In 2009, the Infrastructure Australia Council resolved that all future infrastructure proposals would need to explicitly address the intelligent infrastructure dimension. In 2010,

26 The degree of functionality provided by the smart meters varies significantly across member states. For information of smart metering progress across the EU see CER, Smart Metering information Paper 4, 2011.

27 http://www.infrastructureaustralia.gov.au/about/

the Australian Smart Infrastructure Awards were established with two award categories: innovative technology based projects and intelligent infrastructure research and development.

The US has taken the most proactive stance on training the future workforce of the utilities sector, using the America Recovery Reinvestment Act 2009 (ARRA) as the funding vehicle. In April 2010, US$100 million of ARRA funding was directed through the Department of Energy for smart grid workforce training and development. Universities and colleges across the country are developing ARRA-funded training programmes as well as utilities, including Florida Power & Light, National Grid USA, Duke Energy, Edison, GE and Once. The US Department of Energy has also launched the Smart Grid Information Clearinghouse to share the lessons learnt from individual smart grid projects. Its focus is primarily on the US market.

5.2 Deployment of Intelligent Infrastructure – Barriers and Recommendations

Investment Barriers

Investment Strategy

The availability of a competitively priced world class infrastructure and related services are critical to enable the productive sector to continue to grow exports and support economic recovery and sustainable long term growth.

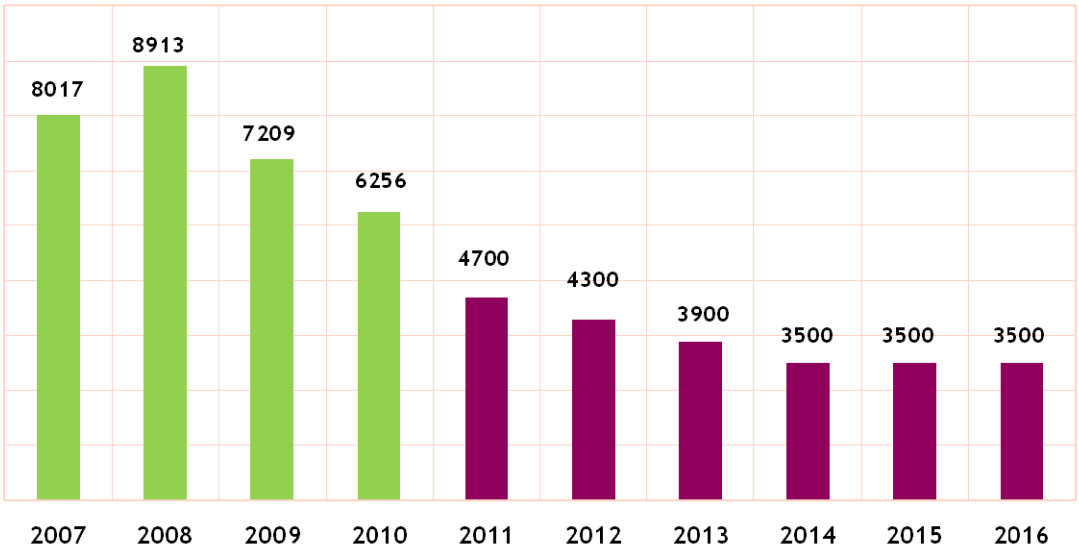
Ireland has made significant investment in physical infrastructure in recent years under successive national development plans. These investments programmes focussed largely on bridging the infrastructural deficits between Ireland and competitor economies through investment in 'big ticket' projects such as the construction of a national motorway network, significant water treatment capacity and energy networks.

During the era of strong economic growth in Ireland, there was often a need for policy makers and infrastructure providers to prioritise investment in large scale projects throughout the country and across the range of infrastructures rather than seeking to improve the capacity of existing assets. This was largely due to previous underinvestment in infrastructure essential for sustaining economic growth and the need to add significantly to the net capital stock. New infrastructures were necessary to ensure infrastructure bottlenecks did not constrain economic or social development.

As shown in Figure 2, in 2009, direct capital expenditure by Government amounted to €7.2 billion. Reflecting the economic difficulties, capital investment fell to €6.3 billion in 2010 and is to decline further over to €3.5 billion per annum between 2014 and 2016[28]. A capital review exercise is currently underway within the Department of Public Expenditure and Reform to prioritise capital investment over the period 2012 to 2016.

28 Department of Finance, Department of Public Expenditure and Reform.

Figure 2: Total Capital Expenditure (2007-2010) and Capital Budgets (2011-2016) (€m)



Sources: Department of Finance, Department of Public Expenditure and Reform.

Following a decade of significant infrastructure investment and given the recent fall in demand, many assets will have significant spare capacity. Despite this, there remain significant infrastructure gaps. A limited number of large scale capital investment projects are essential to ensure the necessary conditions for sustainable growth are in place. However, in light of the current economic difficulties facing Ireland, it is imperative that infrastructure providers seek to maximise the capacities of existing assets and networks.

In Ireland, a range of intelligent infrastructure projects have been undertaken or are in development. These initiatives are a response to sectoral needs and specific Government policies rather than being driven by an overall national strategy.

Recommendations

- The Capital Expenditure Review 2012-2016 should explicitly outline the potential for intelligent infrastructure deployment to maximise the value of existing infrastructure networks and its potential to enhance the value of future investments.

Infrastructure Investment Proposals and Appraisal

In addressing infrastructural deficits, there is a need, where possible, to utilise management and operational solutions rather than capital intensive investment solutions. The application of smart technologies to enhance the capacity of existing infrastructure is an example of an effective infrastructure management approach (e.g. using sensor technology to identify water network leaks reduces the need to construct costly additional water treatment capacity).

Smart technologies are ideally suited to help resolve many of Ireland's pressing infrastructure problems. Intelligent infrastructure offers innovative solutions to address issues such as a congested capital city with limited potential to build new roads, excellent but highly variable renewable energy resources and an extensive water distribution network with high levels of leakage. The capital appraisal process currently in place was designed to assess proposals for traditional type investments in "dumb" or static infrastructure. It may not be best suited to assessing the appropriateness of investment in intelligent systems and may not encourage public infrastructure providers to explore its potential to address or assist in addressing infrastructure deficits.

Given the importance of managing future investments to ensure the highest potential return, it will be important too that all public infrastructure providers take into consideration the potential for intelligent infrastructure to overcome or to assist in overcoming infrastructure deficits. In this regard, the approach taken by Infrastructure Australia, a statutory body, requiring all infrastructure proposals to explicitly address the intelligent infrastructure dimension merits consideration[29].

One of the key benefits of smart applications is the role they play in avoiding or mitigating system failures. This is particularly difficult to capture in return on investment calculations as they do not take into account either the reliability of the system or the possibility of rare but substantial shifts in the operating environment. Other aspects that are difficult to encompass in routine return on investment calculations include the longer term benefits that might arise from better integrated systems and wider environmental and social benefits.

Recommendation

- An assessment of the potential for intelligent infrastructure to substitute or complement traditional capital investment should be required as part of the capital appraisal process; and
- Capital appraisal methods may need to be modified to capture the benefits and costs of intelligent systems.

Institutional Barriers

As outlined in chapter 2, the technologies used to deliver intelligent infrastructure approaches are often the same across infrastructures. This provides scope for economies to be derived from cross-infrastructural approaches. For example there are potential synergies between the rollout of smart electricity, gas and water metering particularly in regard to in-home display and telecommunications.

In addition, the 34 local authorities are often required to make similar infrastructure investments to improve the quality of service or comply with official standards and

29 Infrastructure Australia, Better Infrastructure Decision-Making, 2010.

regulations. For example, the rollout of metering of commercial premises was implemented by each local authority. It is likely that a more centralised approach would have reduced the costs of implementation. The establishment of the proposed national water authority would facilitate economies of scale with regard to the procurement, delivery and operation of water services.

Recommendation

- Given the cross-infrastructural synergies of smart technology, institutional cooperation can yield significant benefits in terms of cost savings and other economy of scales. Coordinating the rollout of different infrastructure services (e.g. roads, telecoms, water, and energy) has the potential to deliver significant cost savings, particularly where projects are undertaken simultaneously. Appropriate structures for exploiting these benefits should be explored in more detail. For example, the recently established Inter-Departmental Committee on Economic Infrastructure and the development of integrated utility agencies with a national remit (e.g. national water authority) could play significant roles in facilitating greater coordination.

Consumer Privacy and Awareness Barriers

Consideration must be given to consumer concerns and awareness in the development of intelligent infrastructure in Ireland. These include a general lack of awareness concerning the benefits of smart technology, such as environmental and customer service, but also the advantages that smart technology has in supporting the delivery of better quality infrastructure services.

In addition, given the large amount of data which can be collected about infrastructure users, privacy and data protection considerations and data security requirements must also be closely considered in relation to the deployment of smart technology across infrastructures. For example, in the Netherlands the deployment of smart metering was significantly delayed due to issues surrounding privacy and data protection.

Substantial consumer resistance may arise in the context of smart infrastructure applications that facilitate the introduction or restructuring of prices. This is particularly relevant at the present juncture when electricity, gas and water metering reforms are under consideration.

Recommendation

- Ensure that consumer concerns regarding privacy, data security and costs are addressed through cooperation between consumer and citizens rights groups, the infrastructure providers, utility regulators and the Commissioner for Data Protection. In particular, where third parties are involved in the processing, management or usage of user data it will be important that a commitment to privacy by design is in place to ensure protection of the rights to privacy of users.

Intelligent Soft Infrastructure and Electronic Communications

The communications infrastructure currently in place in Ireland is sufficient to enable the delivery of intelligent infrastructure in the areas of energy, transport, water and waste. However, significant Exchequer savings and enterprise opportunities are likely to arise in the areas of soft infrastructure such as health and education. Delivery of high quality remote health and education services and development of the products and services to these sectors will require advanced broadband capabilities that are high speed, symmetrical and have low latency. There is an opportunity to support the rollout of advanced broadband services while rolling out smart applications across other infrastructures. For example, there is significant potential to exploit costs savings arising from coordinating water network investment and fibre deployment as up to 80 per cent of the costs of telecoms infrastructure rollout is civil works.

Recommendation

- The actions set out by Forfás to ensure the timely rollout of world class advanced broadband services in key urban centres need to be progressed quickly to support intelligent infrastructure deployment and the realisation of potential enterprise opportunities[30].

5.3 Enterprise Opportunities – Barriers and Recommendations

There are currently a number of barriers which are impeding the development and growth of companies producing intelligent infrastructure goods and services in Ireland. The barriers, which are outlined below, were identified through consultations with Irish based enterprises and are similar to those faced by enterprises working in other emerging and innovation intensive areas.

Test-Bedding, Research and Development

The delivery of smart products and services by Irish enterprise is related to their capacity to innovate. One of the barriers to innovation is the lack of absorptive capacity on the part of small indigenous firms. The availability of human capital is one of the issues that needs to be addressed in this regard. Additionally, the small scale of many enterprises means that they do not have the capacity to maintain a structured approach to innovation. This highlights the need for external supports that provide technological services to SMEs.[31]

Intelligent infrastructure goods and services are, to a large extent, intermediate in nature. This means that they are inputs to infrastructure development and customers are often in the public sector. For some intelligent infrastructure applications at least, purchases will be on a

30 Forfás, Ireland's Advanced Broadband Performance and Policy Priorities, forthcoming.

31 Forfas. Making Technological Knowledge Work. A Study of the Absorptive Capacity of Irish SMEs February 2005

large scale. Demonstration of the practical feasibility of the application of the technology is crucial to achieving sales. It is also key to internationalising as purchasers in foreign markets will look for examples of how the good or service worked in the seller's home market. Many small Irish companies who are developing smart goods and services do not have the resources to set up test-beds and find that R&D supports from Government do not extend to test-bedding. Addressing this need for test-beds for new technologies and services developed in Ireland is a key priority. Important existing examples of test-beds in Ireland which can be leveraged include: the Marine Institute's Smart Bay Ireland project, SEAI's Sustainable Energy Community Programme, IBM's Smart Cities Technology Centre and ESB Networks Smart Grid project.

As identified in this project, there is a range of important publicly funded research which can lead to commercial opportunities for smart goods and services in areas such as smart grids, sensors, water quality monitoring and energy efficiency. There is a need to continuously enhance the environment for business research and development in Ireland and to further strengthen the interaction between this research and businesses seeking to realise opportunities in smart goods and services. A prioritisation exercise is currently being undertaken by Forfás which will inform the priority areas and future focus of publicly funded science, technology and innovation (STI), taking into consideration Ireland's sectoral and research strengths and emerging opportunities[32].

Recommendation

- Infrastructure providers, adjacent research facilities, core funders and the enterprise development agencies should co-operate to develop test-bed opportunities for Irish-based companies. Cross institutional structures should be established which will allow these parties to prioritise the development of key exemplar test-beds which can realise employment opportunities; and
- In terms of publicly-funded research, the current research priority setting exercise should focus on key areas of opportunity in intelligent goods and services for Ireland and identify priority of research areas which can be commercialised.

Access to Finance

Access to finance was identified as one of the barriers facing firms seeking to develop intelligent infrastructure products and services. While this is a problem for SMEs generally, it may be more acute for smart technology firms as technologies are often new and untested, have a higher risk profile and the potential market success of smart applications may be more difficult to predict.

Smart technology is a relatively new area which often involves a range of different technologies (particularly where IT and energy interact) and unclear business models. Given its complexity, it is very difficult for investors to have the specialist knowledge they require

32 Department of Jobs, Enterprise and Innovation, http://www.djei.ie/press/2010/20100927.htm

as they make risky investment decisions. There is thus a continued requirement for specialised investors in this high potential sector.

Regulatory risk can also inhibit access to finance. For example, the development of products to support smart grids is complicated by the lack of clarity of the ultimate architecture of smart grids and the degree to which they will be embraced by electricity utilities and firms. Thus, there is a high level of uncertainty as to the demand for specific smart technologies. This means that the major problem for firms in the intelligent infrastructure area is that of accessing funding. Where the potential demand becomes clearer, venture capital support will arise.

Ongoing commitments to venture capital funding are particularly important for firms seeking to develop intelligent infrastructure products and services. Targeted competitive state funding in specific areas (such as Enterprise Ireland's recently launched dedicated fund targeting start ups in the cleantech, industrial and life sciences sectors) should continue to be prioritised. EU funding is also available for companies to engage in cross-border collaboration in key smart areas such as SET Plan European Electricity Grids Industrial Initiative[33]; the FP7 Energy Call on Smart Energy Networks (which is closing end October 2011); and other FP7 calls in ICT Research (where 11 smart grid projects and 27 smart building projects have been funded). Enterprise Ireland is the lead agency in the Irish support network for FP7 and provides financial supports for FP7 participants based in Ireland. Companies interested in developing an FP7 collaborative research project with other European partners can apply for a feasibility grant towards the cost of preparing an FP7 proposal.

Recommendations

- Policy measures that support financing of SMEs generally should be rapidly progressed (in particular the partial credit guarantee scheme). Enterprise Ireland should continue its efforts to enhance availability of venture capital for innovative start-up companies.
- Targeted competitive state funding for specialist funds that are focused on innovative companies which apply smart technologies to reduce emissions and resource usage (such as Enterprise Ireland's recently launched start-up fund which is focusing on cleantech projects) should be prioritised.
- Enterprise Ireland should continue to engage with the main lending institutions in Ireland to communicate the opportunity and specific funding requirements of smart technology companies.
- There is a need for financial institutions to develop expertise in investing in this high potential sector as a priority. Where this expertise is not available, financial institutions should develop networks of international experts which they can readily access for investment advice.
- Enterprise Ireland should continue to focus on promoting EU funding initiatives in the area of intelligent infrastructure to their client companies and support companies in

[33] http://ec.europa.eu/research/energy/pdf/smartgrids_en.pdf

the application process.

- Government should continue to provide clear strategic decisions which support investment in smart applications and clarify outstanding key areas at the earliest possible juncture (such as what form the smart meter rollout will take).

Procurement

Firms continue to have difficulties in having innovative solutions recognised when competing for government business. Too often, procurers opt for existing off-the-shelf solutions or for solutions that are least-cost but not best value. Similarly, procurement may be on a scale that precludes SME involvement. The issues here are complex, as there is a balance to be struck, for example, between solutions that have proved to work and solutions that add increased value.

Public sector buyers can play an important role in procuring smart technologies developed in Ireland which can be exported. Significant work to improve the procurement process for innovative companies and SMEs has already taken place such as the Procurement Innovation Group's handbook entitled "Buying Innovation – The 10 Step Guide to SMART Procurement and SME access to public contracts" and the Department of Finance's new procurement guidelines for SMEs are important steps but further measures could be taken to drive innovation in public procurement for SMEs.

The objectives of using procurement to increase energy savings, improve resource usage and spread innovative, less carbon-intensive solutions are part of the draft Green Public Procurement (GPP) Action Plan which is currently open for public consultation. The Action Plan is looking at the "greening" of procurement generally and is focusing on key sectors which may have intelligent infrastructure applications such as transport, energy and construction.

As an example of an approach which encourages the development of innovative solutions, the UK Government through its Small Business Research Initiative (SBRI), has required departments and agencies to establish innovation procurement plans to facilitate innovative responses to procurement requirements. The UK's SBRI programme allows government departments and organisations to procure innovative technologies quickly and with minimal risk by providing development contracts to businesses addressing their current needs. The contracts are generally short term in nature, with the business maintaining the intellectual property with certain rights of use held by the department in question. A similar approach in the Irish context would involve a process whereby:

- Government departments and agencies would implement innovation procurement plans;
- Government departments and agencies would identify procurements that have a significant technological and or innovative component; and
- A proportion of technological or innovative procurements would be ring-fenced for SMEs.

Recommendations

- Rollout of an innovative procurement model along the lines of the UK's Small Business Research Initiative which requires government departments and agencies to implement innovation procurement plans, to identify procurements that have a significant technological and or innovative component and to ring fence a proportion of technological or innovative procurements for SMEs;
- Immediate implementation of the Green Public Procurement (GPP) Action Plan in a way which promotes the development of new intelligent technologies and opportunities for SMEs is required.; and
- Upskilling of procurement staff within the public service should be undertaken around procurement which increases energy savings, improves resource usage and encourages the use of innovative solutions.

Skills and Education Needs

Consultations with companies, analysis of the enterprise opportunities arising from intelligent infrastructure and past work of the Expert Group on Future Skills Needs have identified a range of skills needs that are requireded to realise intelligent infrastructure opportunities in Ireland[34]. They generally relate to the requirement for high skilled professional engineering and science staff with the commercial awareness required to drive the development of existing and new products. Within this, specific reference was made to:

- The availability of skills in computer science, mathematics and statistics which are seen as key to realising software development and analytical services opportunities;
- IT systems developers and power engineers for the development of a smart distribution network for the electricity grid and for the rollout of smart meters; and
- Business analysis and cross-disciplinary skills between IT and business.

In addition, as many of the Irish companies producing smart goods and services are currently small, strong management capability will be required to drive growth in the innovative firm operating in an intensely competitive global market. Similarly, smaller businesses may have limited resources to identify international customers and new market potential in the growing global opportunities for smart technologies. These are two key areas for ongoing enterprise agency support.

34 Expert Group on Future Skills Needs, "Future Skills Needs of Enterprise within the Green Economy in Ireland, 2010.

Recommendations

- The recommendations of the EGFSN Green Skills report should be implemented as soon as possible. In particular, current 'green' education and training provision (approximately €25m – €30m per annum) should be aligned towards meeting the green and cleantech skills needs of enterprise generally, with a particular focus on the skills for 'green' ICT applications/software as identified by the Group; and
- The enterprise development agencies need to continue to focus on scaling of companies involved in intelligent infrastructure, developing management development capabilities and helping these companies identify and avail of internationalising opportunities.

6. Conclusions

Technology is increasingly being applied to the provision of infrastructure services to make these services more effective and efficient. This report has explored the potential for the deployment of intelligent infrastructure in Ireland across energy, water, transport, telecommunications and waste in a way which optimises scarce resources, enhances competitiveness and creates job opportunities.

In doing so, the elements of what makes infrastructure more intelligent have been drawn out, for example where data can be used to make informed decisions about the use of a particular type of infrastructure. The drivers and potential benefits of deploying smarter infrastructure both for the economy as a whole and for individual companies have also been looked at.

In deploying intelligent infrastructure solutions, Ireland is already embracing the potential benefits offered in by smarter solutions in a number of areas, such as the ongoing development of a smart electricity grid and the barrier-free M50 tolling system. In light of the reduced resources available to invest in the infrastructure required to support economic recovery and enterprise growth, we need to give serious consideration to the role that intelligent applications can play in:

- Reducing infrastructural capital requirements;
- Increasing the competitiveness and improving the productivity of infrastructure networks and services; and
- Opening up revenue creating opportunities.

Intelligent infrastructure is also creating a range of business opportunities both domestically and in a rapidly growing international market. Ireland has a growing number of innovative SMEs, a number of multinationals in key sectors such as electronics and ICT and a strong base of relevant research which can help realise the potential opportunities in intelligent goods and services and create jobs.

Examples of emerging goods and services are highlighted in this report and specific areas of opportunities for Irish based enterprises are identified. These include the development of: sensing devices, energy management systems, data management and analytical services, software systems, water quality monitoring technologies, information display devices.

Given the potential competitiveness benefits and market opportunities that exist, it is vital that the policy actions to address the barriers to the deployment of intelligent infrastructure and realising the enterprise opportunities are progressed quickly.

Appendix 1 - Recent Forfás Publications

The Games Sector in Ireland: An Action Plan for Growth Forfás	October 2011
Ireland's Competitiveness Scorecard National Competitiveness Council	September 2011
Research and Development Funding and Performance in the State Sector 2009 – 2010 Forfás	August 2011
Monitoring Ireland's Skills Supply 2011 - Trends in Education and Training Outputs Expert Group on Future Skills Needs	August 2011
Developing a Green Enterprise **Forfás**	July 2011
National Skills Bulletin 2011 **Expert Group on Future Skills Needs**	July 2011
Forfás Annual Report 2010 **Forfás**	June 2011
Costs of Doing Business in Ireland 2011 **National Competitiveness Council**	June 2011
Annual Employment Survey 2010 **Forfás**	May 2011
Response from Ireland to the European Commission Green Paper: Framework for Research and Innovation Funding **Advisory Science Council, Forfás, DJEI**	May 2011
The Expert Group on Future Skills Needs Statement of Activity 2010 **EGFSN**	May 2011
Business Expenditure on R&D 2009/2010 **Forfás, CSO**	April 2011
Developing Recognition of Prior Learning **EGFSN**	April 2011
Vacancy Overview 2010 **EGFSN**	March 2011
Statement on Competitiveness Priorities **NCC**	March 2011

Analysis of Ireland's Innovation Performance **Forfás**	March 2011
Progress Report on the implementation of the recommendations of the report of the High Level Group on Green Enterprise **Forfás, DETI**	March 2011
Staying the Course **Advisory Council for Science, Technology and Innovation**	January 2011
Research strengths in Ireland: a bibliometric study of the public research base - Extension Report: Public Research Organisations **Forfás, HEA**	December 2010
The Higher Education R&D Survey 2008 **Forfás**	December 2010
Profile of Public Research Activity in Ireland, 1998-2006 **Forfás, HEA**	December 2010
Research and Development Activity of Irish Based Enterprise **Forfás, HEA**	December 2010
Research and Development Activity of Irish Based Enterprise - Vol 2: Data **Forfás, HEA**	December 2010
Ireland's Priorities in FP8 **Forfás**	December 2010
Annual Competitiveness Report 2010 Volume 2: Ireland's Competitiveness Challenge **National Competitiveness Council**	November 2010
Future Skills Needs of Enterprise within the Green Economy in Ireland **EGFSN**	November 2010
An Enterprise Perspective on the Universal Social Contribution **Forfás**	November 2010
Review of Labour Cost Competitiveness **Forfás**	November 2010
Annual Business Survey of Economic Impact 2009 **Forfás**	November 2010
Enterprise Statistics at a Glance 2010 **Forfás**	November 2010

Appendix 2 - Forfás Board Members

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Forfás

Wilton Park House
Wilton Place
Dublin 2

Tel: +353 1 607 3000
Fax: +353 1 607 3030

www.forfas.ie