ICT FOR ENERGY-EFFICIENT URBAN COMMUNITIES: THE IREEN ROADMAP AND THE CASE OF A DEVELOPPING CITY

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ABSTRACT

The main objective of IREEN is to support developing a comprehensive strategy to maximise the take up and use of ICT to improve energy efficiency and performance in large areas with a view of promoting the creation of neighbourhood and district energy communities. The paper provides key outcomes from the IREEN project, including its roadmap discussed in the context of a case study of fast developing European city.

Keywords: districts and cities, sustainable development, energy efficiency, ICT (Information and Communication Technologies) and information management

1. INTRODUCTION

The concept of smart districts and neighborhoods, and by extension smart cities, is today developed as a potential answer to the challenges generated by a more and more urbanized world, with growing global populations and migration from rural areas to cities, along with the need to maintain necessary supplies of water, energy, communication and transport to meet growing demands in urban centers, and in parallel a mandatory evolution of old and established city infrastructures. It encompasses the idea that, along with all the constituencies of today and tomorrow cities (homes and buildings, energy grids, transportation, water networks, etc.), information management is to be the key asset that will sustain the smart (knowledge informed) city of the 21st century: "digitalizing" cities' buildings and infrastructures would allow them to collect and analyze data in order to respond intelligently to all domestic needs, allowing cities to grow with their infrastructure overloading, based on comprehensive information-driven strategies, with city sustainability as the ultimate goal.

ICT solutions provide a promising solution to address the challenges related to the overwhelming and conflicting transactions associated with management of sustainability in cities: many core enabling technologies are being deployed today, for instance in the case of energy efficiency, from advanced building controls, energy management systems, smart meters, grid automation and optimization, to city infrastructures that bring these together. Tomorrow, energy-positive buildings, neighbourhoods and districts will be empowered by electronic (embedded) components and ICT systems and infrastructures. As far as energy is concerned, for instance, these will not only meter the energy consumed and/or generated, but have the potential to provide real-time information to city planners and managers to save energy while maintaining comfort and security levels.

The main objective of the IREEN (ICT Roadmap for Energy-Efficient Neighbourhoods) Coordination Action is to develop a comprehensive vision and roadmap for European-scale innovation and take-up in the field of ICT for energy efficiency and performance in districts and cities. This encompasses the identification of drivers and gaps, future policies and operational support for the development and deployment of holistic ICT-based information systems in neighbourhoods, offering options for a technology infrastructure that are flexible and adaptive to the context of deployment in different types of neighbourhoods and cities, to residents and local authorities. It includes collecting a number of independent demand-side visions from the building and

neighbourhood communities, and identifying the key aspects within these visions towards sustainable urban development.

This paper will introduce to the IREEN objectives and the methodological approach leading to a European vision, scenarios and roadmap, but also how the own ICT-driven plans of a city (in this paper, the city of CARDIFF) feeds and maps the IREEN roadmap in terms of envisaged scenarios and projects, identified market drivers and barriers, and technology implementation.

2. TOWARDS KNOWLEDGE-INFORMED AND ICT-EMPOWERED DISTRICTS AND CITIES

The so-called smart cities concept includes many artefacts like smart homes and buildings, smart grids, smart mobility and transportation, smart healthcare and ambient assisted living, smart education, and smart security – supported by smart industry products/solutions and services. Test beds for various smart city technologies are present around the world, with projects such as the smart grid smart city project in Australia [1], the Jeju Island smart grid project in Korea [2], Amsterdam Smart City Project in Netherlands [3] and Energy Smart Miami in the US [4], helping to develop a state-of-art and competitive urban infrastructure – with attractive incentives and funding arrangements from governments are helping utilities to implement their smart city projects.

One of the key aspects of smart cities is related to the built environment (homes and buildings, infrastructures and large equipment): indeed modernising this built environment in Europe' cities presents a huge potential for advancing towards the European '20/20/20' energy and climate goals. Such a modernisation is at the crossing of many themes and challenges: integration and management of local and renewable energy sources; ICT solutions for design as well as operation of urban districts or corridors with different building typologies; high efficiency heating and cooling (in homes, buildings, infrastructures and large facilities); development of green infrastructures to reduce heating and cooling needs and reduce air pollution; construction of nearly zero-energy buildings and positive energy buildings and neighbourhoods; deep retrofitting of existing buildings and sustainable building materials, etc..

Another key aspect is in connection with the huge amount of data that is going to be generated and managed for future smart cities. ICT knowledge and technologies for data and information management are for most of them available today: the challenge is indeed to integrate them, from a technical point of view as well as form an organisational point of view, based on a shared and agreed political, business and customer consensus. There is a need for a global strategy allowing to collect and aggregate data available at a urban level on energy, transports, services to customers, etc., considering that these data belong to public but also private entities: developing smart city services requires having access to those data, and relying on new algorithms to develop new integrated services, in addition to the social acceptance by the users / citizens. Typically, efficient management of energy in the city will require high performance communication solutions between buildings and districts, up to some new cloud-based solutions integrating, synchronising and linking huge amount ("Big data") of city data, provided from public ("Open Data") and private sources, to tangibly deal with the deployment of more distributed renewable energy sources and the energy production and distribution mix, increasing electrification of transportation, enhanced comfort management as expected by the customers, etc.. Therefore, in terms of energy control and optimisation paradigm, new solutions need to be developed that will match our distributed and bottom up energy future, and the smart city has to be seen as a "system of systems" empowered by both a strong but flexible ICT backbone, as well as high computing systems to link and process urban data.

Eventually, this raises the question of the governance of data and information related to smart cities: there is a need for a transformation of a silo-like situation in terms of applications and services (transports on one side, built environment on the other, energy a third one, water on a fourth one, etc.) in an orchestrated process, with identification of responsibilities for such an orchestration, and of all and each data/information, characteristically between local authorities, energy providers (e.g. ESCOs), telecom operators, etc.

3. THE IREEN CONTEXT AND OBJECTIVE

The built environment in the future will have evolved into an adaptive and responsive organism, with buildings developing into interactive changeable structures producing energy, providing clean air and water, and maybe able to deal with their own waste management. As such, it will play the role of a "living" asset in an integrated sustainable urban solution: reacting to the environment and having its own function in the district/city, engaging with and responding to occupants in terms of comfort, assisted living and protection. It is expected to be:

- Sustainable: homes and buildings could produce more resources than they consume, e.g. buildings may generate energy through e.g. photovoltaic surfaces and on-site fuel cells. Water could be manufactured from humid air using modified wind turbines. Waste water will be recycled.
- Smart and integrated: Buildings will be linked to the surrounding infrastructure to provide an integrated "continuum" of living spaces, transport modes and utilities. Optimisation of resources will be achieved by collecting data on each individual building energy consumption and combining it with data from other buildings. Moreover, buildings will be flexible over their lifetime to be adapted to cope with occupant-specific change of use.

In this context, the main objective of IREEN is to support developing a comprehensive strategy to maximise the take up and use of ICT to improve energy efficiency and performance in large areas to create neighbourhood and district energy communities. Among the key priorities for IREEN are:

- Providing the domain stakeholders and the research communities (ICT, construction, energy, districts/neighbourhoods) with a short-term focus on the state-of-the-art in ICT solutions, enabling early access to results which complement on-going medium-term initiatives such as individual RTD projects, clusters and networks.
- Assembling a coherent supply-side view of the state-of-the-art by adding value to discrete summaries obtained from RTD projects and, to a lesser degree, from the vendors of software and services and the suppliers of technology;
- Collecting a number of independent demand-side visions of relevant state-of-the-art to the building and neighbourhood communities, and identifying the key aspects within these visions –leading to "innovative scenarios";
- Providing a path to future market-oriented innovation and usage centres, focused on large-scale pilots and preparing process-oriented ground for in-vivo large-scale pilots and future transfer to markets. Demonstrating, validating and certifying ICT solutions and packages for energy efficiency in neighbourhoods and cities and considering the potential transferability of lessons learned to regions and rural areas.

Utilising expert hearings, workshops, and networking activities (*as illustrated in Figure 1*), IREEN has developed a research and innovation roadmap for ICT supporting energy-efficient neighbourhoods. Ultimately it aims to stimulate the development of a large leading-edge market for ICT enabled energy-efficiency technologies and holistic systems in neighbourhoods (and by extension wider urban environments, such as city-regions and rural areas) that will foster the competitiveness of European industry and create new business opportunities. At the same time the aim is also to offer options for a technology infrastructure that is flexible and adaptive to the requirements of deployment in different types of neighbourhoods to residents, building owners and local authorities. The implementation of these objectives leads to a strategy to be further detailed in an innovation roadmap, linking and prioritizing all actions over the innovation life-cycle: RTD, experimentation and validation, transfer to market and deployment, and standardisation.

4. THE IREEN OUTCOMES

The main IREEN outcomes can be considered as follows: (1) the IREEN Taxonomy, (2) the IREEN innovative scenarios, and (3) the IREEN ICT Roadmap for Energy-Efficient Neighbourhoods.

For the development of the IREEN roadmap, a structured approach has been developed to manage the broad study area of the project. For this, an **IREEN taxonomy** has been developed based on REEB (Roadmap for Energy Efficient Buildings) [5], and modified to the neighbourhood level. The focus area of ICT enabled energy

efficient neighbourhoods includes the entire energy chain from energy consumption in buildings and transportation, to energy production and distribution in a neighbourhood. In addition, ICT have several different categories from design and energy management to decision support and integration technologies. The taxonomy is provided as a matrix in Figure 2.
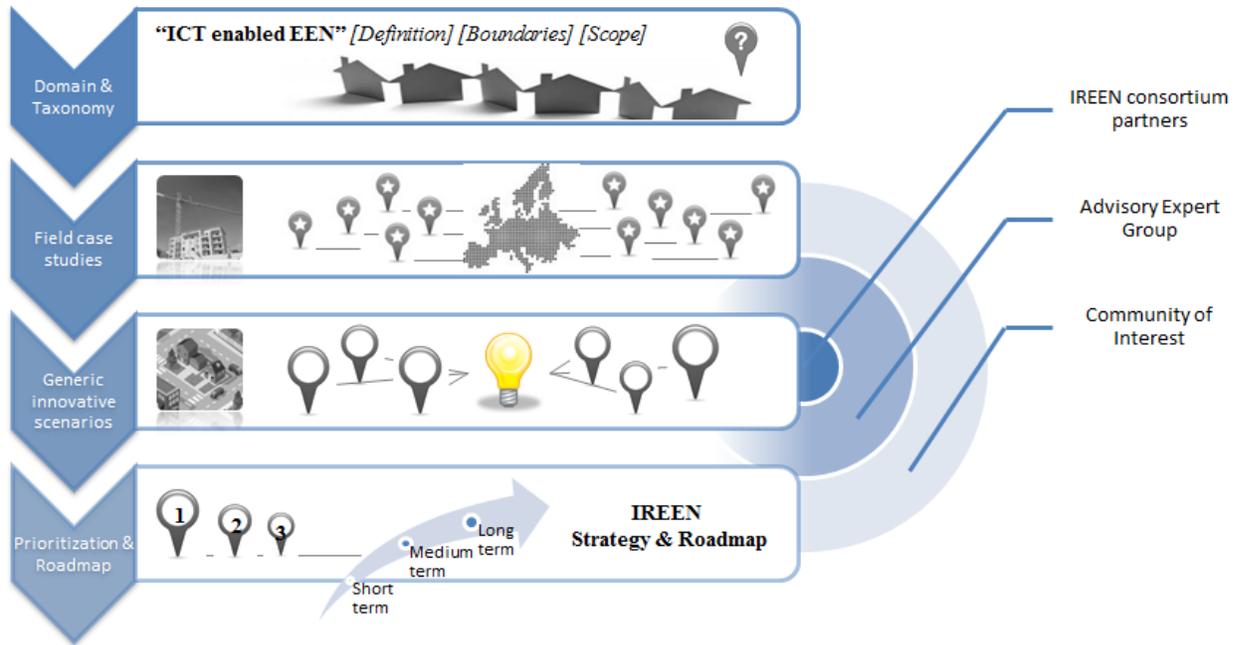
Figure 1: The IREEN methodology

The second step in IREEN has been the development of a set of **IREEN innovative scenarios**, describing situations expected to be common in a short, middle or long-term future (i.e. by 2015 and up to 2020-2025), based on an anticipated common usage of technology being proved as mature. The incremental assembly of state-of-the-art supply-side ICT projects, large-scale pilots and solutions, as well as the identification of demand-side objectives and strategies, is regarded in IREEN to be the basis of demand-side visions and innovative scenarios: the IREEN scenarios lead towards future large-scale trials to further allow appraisal of solutions from the ICT supply-side on how this can better meet demand-side needs and expectations.

The IREEN scenarios take into account elements related to regulation, costs, technology, security, standards, and energy supply structures. In the context of smart districts and cities, these scenarios and their IT-based support solutions try to address some overall complexity of expected functions, when addressing the entire value chain for energy production, storage, delivery, and consumption. IREEN advocates that this is to be done through integrated solutions, allowing stakeholders to share and exploit data and information generated by linking an unprecedented number of intelligent devices and systems. These include sensors, meters, IT-based equipments and components, distributed energy resources and energy assets, and software.

The IREEN user scenarios are to be considered as a functional basis for future large-scale deployments of robust technologies and their scalability in the neighbourhood / district context. They should also give provision for revisited and new business cases that work for all stakeholders, with the purpose of removing bottlenecks which stop ideas reaching the market, including lack of finance, fragmented research systems and markets, under-use of public procurement for innovation and slow standard setting. More than 20 innovative scenarios have been described in IREEN, presenting extrapolations on expected innovations in the field of ICT for Energy Efficiency in large areas (neighbourhoods and extended urban/rural communities) to appear in the next 10 years horizon.

Figure 2: the IREEN scoping matrix: Application and technology areas

Eventually, the last step is the delivery of the **IREEN ICT Roadmap for Energy-Efficient Neighbourhoods**. Such a roadmap has to rely first on a vision for ICT enabling energy efficiency at a neighbourhood level and needs and possibilities for its research, technology development and innovation in the near future. The vision is to identify how ICT can contribute and support improving energy efficiency and even energy positiveness in both urban and rural neighbourhoods – leading to a some well-identified desired state of our future so-called "smart districts". The IREEN vision has been developed as an iterative process strongly supported by experts from relevant fields of ICT, territories, energy and buildings from all over Europe and other countries, so as to get to a comprehensive, agreed and common shared vision. This vision gives an overview of the recognised RTD and innovation needs for ICT for energy efficient neighbourhoods by describing background, state of the art, needed new capabilities, vision (for each and all parts of the overarching vision), desired impacts, main barriers and drivers, and key stakeholders.

The elaborated vision is an essential basis for developing the ICT roadmap for European scale innovation and take-up for energy efficient neighbourhoods, with a focus on the complete innovation lice cycle of the domain. This includes identifying future RTD and priorities in terms of impact, as well as in terms of short, middle and long term research and technology development, experimentation and actual deployment in the considered market relying on evaluation and feedback, and fundamentally define the various paths for progress in achieving these

priorities. At time of writing of this paper, this is an ongoing process, with the identification of ICTs that are deemed to have the largest impacts, followed by balancing of anticipated impacts vs. required actions and time, which are required to achieve those impacts. The expected result will be the base for selecting priority topics for the IREEN roadmap development based on an analysis that will consider factors like technology maturity, drivers, policies, value chains, partnership, deployment challenges and stakeholder development.
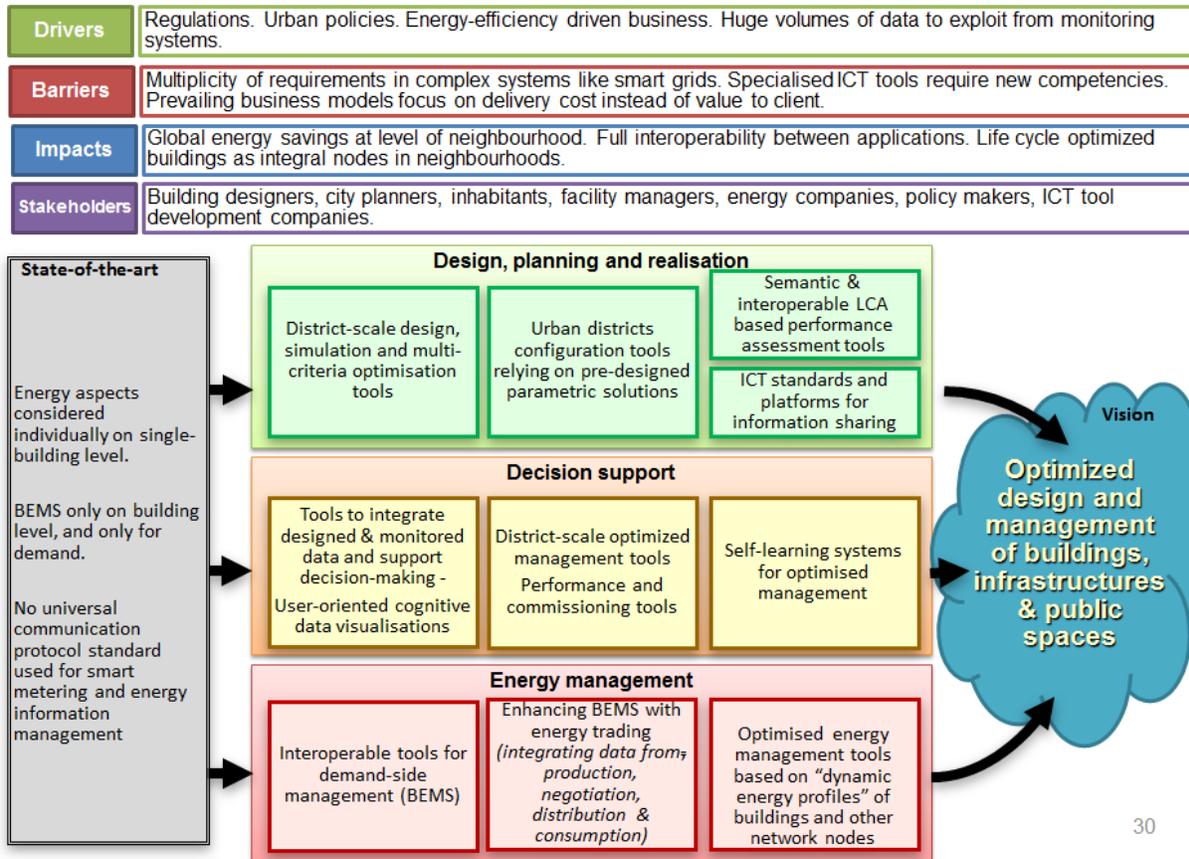
Figure 3: the IREEN sub-roadmap - *Buildings , infrastructure and public spaces*

The detailed outcomes of the IREEN project are detailed in the main IREEN actual deliverables:
- Report on state-of-the-art (International) ICT-based innovation projects;
- Structured Approach to Cases and innovative scenarios;
- Strategy for European-scale innovation and take up;
- Roadmap for European-scale innovation and take up.

The IREEN results will eventually be synthesized and consolidated through the IREEN Reference Guide, providing the final core findings of the project in the form of both an electronic and print reference guide for distribution to relevant stakeholders throughout Europe: such a guide is to be a fundamental public document being a cornerstone for future large-scale deployment and operation of ICT infrastructures for energy-efficient rural/urban communities. All these results are public and available at the IREEN Web site: *http://www.ireenproject.eu.*

5. THE "SMART CITY" CARDIFF CITY VISION

5.1 Background

Cardiff grew from a small town to become one of the largest ports in the world by 1880 due to the exporting of coal and iron. The decline and final ending of coal exports in 1954 and the closure of the East Moors steelworks in 1978 resulted in major changes to the economic activity and employment in Cardiff and the south-east Wales region. Cardiff has developed into a national and regional capital with a wide European and international reputation in arts, culture, education, economy and sports [6]. It has a key economic role in the south-east Wales region and in Wales as a whole and is ranked 4th in the UK Competitiveness Index 2010 for cities whereas Wales is 12th in the Regional index [7]. Of the 200,000 employed in Cardiff, 80% are employed in the service sector i.e. financial & insurance, business administration, public administration, health & education and the creative & digital industries. The 200,000 represents 32% of the total employment of south-east Wales and involves 74,200 people travelling into Cardiff to work, with 28,800 travelling out of the city. Cardiff has also become a major retail centre and attracted major private sector developments. The regeneration of Cardiff Bay, the construction of major landmark buildings and the heritage of castles, museums and cathedrals has also resulted in it becoming a major location for tourists and visitors [6].

Cardiff aspires to become a smart (knowledge Informed) 21st century sustainable city, in line with IREEN's vision. This vision involves contributing and paving the way to a wider UK based city digital platform that transcends the geographical boundaries of Cardiff city; Cardiff acting as a springboard for UK wide concept deployment and adoption. Various city stakeholders, including decision makers, will be able to draw on and share expertise across cities. Moreover, inter and intra city collaboration can take place via dedicated discipline-oriented hubs and organically formed communities of interest. Various city authorities can share real-time data (GIS maps, traffic videos, sensor data, and satellite imagery) of their city through these hubs. These hubs will be used as a mean to nurture city and community knowledge. Knowledge and discipline experts can collaborate seamlessly in resolving forecasted or unexpected incidents that span and have repercussion beyond city geographical boundaries (e.g. flooding). By synchronizing the processes of these hubs, the output of one analysis will feed to another and an expert from one hub can work with another to resolve a conflict or pursue a new plan in an informed and synchronized way. By balancing environmental, energy, economic and social impacts (the very essence of sustainability), systems engineering solutions can be advised and optimised. Total city management becomes a reality. Also relying on IREEN outcomes from an ICT R&D perspective, the vision of Cardiff City, as initiated in [6], will further detail a global blueprint, including the huge management of data and information required, through a comprehensive knowledge organization, storage and transmission between all the city stakeholders.

5.2 Threats and challenges

Cardiff faces a range of cross-cutting challenges that relate, at a basic level, to the problems of sustainability and evidence-based policy making. For example, key infrastructure will need to be renewed and developed to accommodate a forecast rapidly growing Cardiff population in the face of severe budget constraints given the ongoing economic issues. Education and health also need to be addressed to cater for the needs of the future population. Developments will need to be sensitive to potential implications on public health, such as air pollution from transport. Meanwhile, the growing and ever more immediate problem of climate change – and the related policy commitments – calls for a sustained and systematic attempt to reduce energy demand, improve efficiency, and increase the current production of renewable energy. Although the threats and challenges have been grouped (for convenience) in this section, many are interlinked and solutions need to address this aspect and understand the connections. A non-exhaustive list of threats and challenges is given below [6]:

- The development of 45,400 new homes by 2026 and the increase in the 20% population will create even more of a strain on city infrastructures and services. There is a lack of resources and capital funding to address the underpinning issues.

- Poor energy efficiency of existing building stock, requiring urgent energy retrofitting to address government carbon reduction targets.
- Expansion creates a shortage in energy supplies. Capacity and security could be an issue especially for electricity.
- Fuel poverty exacerbated by a continuous increase in energy costs.
- CO_2 emissions must be decreased from current levels, yet the city will be expanding. Risk of divergence between existing areas of Cardiff and new developments.
- Number of Council wards classed as being deprived communities will increase.
- Cost and environmental impact of food production and distribution.
- Flooding poses a particular threat to Cardiff due to its coastal location, low lying areas and rivers.
- Waste recycling with the objective of meeting targets of 70% household waste recycling by 2034.
- Transport, over 78,000 people commute into Cardiff (80% by car) from the region each day, projections show that to grow.
- 40,000 new jobs will be needed to accommodate the growth.
- Inability to retain well qualified people due to competition with other locations.
- Overloaded transport system which becomes gridlocked twice a day. Upsets existing firms and puts-off others from locating in Cardiff.
- Cardiff Bay seen as a separate area not linked to the City.

5.3 Strengths and opportunities

Cardiff's projected population growth coupled with its existing relatively young and skilled population represent a major opportunity for the city, and for the wider city-region. For this opportunity to be realised the development of the city will need to be taken forward with sustainability as a foundation principle. With its city-centre location, wrapped around the regional transport hub and the junction of the soon-to-be electrified national and regional rail-lines, Cardiff is well positioned to attract private sector investment and jobs which can be sustainably and easily accessed by the 1.4m citizens of the wider city-region. Cardiff has clear policies on the future development of the city and the vision for both 2020 and 2026. Key strengths and opportunities are summarized below [6]:
- Electrification of the Great Western Mainline and the regional rail network will enhance the city and Enterprise Zones' connectivity to both London and the regional labour market.
- The role of city as the economic driver for the wider region is being taken forward by Welsh Government and regional local authorities.
- The city's advance digital infrastructure can provide the platform for the delivery of new 'smart city' approaches.
- The city is wholly contained within the boundary of one local authority, and a strong partnership is in place between the City Council and the Welsh Government, thus leading to a simple governance approach and environment for inward investors and easy access to responsive decision makers.
- Within the city, an integrated approach to governance, planning and decision making (including integrated data collection and use) through the Cardiff Partnership Board is being taken forward.
- The potential for the new Energy from Waste Plant and district heating system for the city centre and communities in the 'southern arc' will increase the city's green credentials.

5.4 City planning and vision strategy

The Cardiff Local Development Plan (LDP) 2006 – 2026 clearly sets out the objectives against a range of social and economic needs and requirements [6]. The Preferred Strategy 2012 has been approved by Council and covers:
- The national, regional and local policy framework within which the Strategy has been prepared.

- The Council's vision for future development in Cardiff and its objectives for delivering sustainable development.
- The key strategic growth options.
- The key strategic sites and alternatives.
- Key strategic policies.

Within the LDP is a vision and outcomes section which was set out in the Integrated Partnership Strategy (Cardiff What Matters 2010-2020: The vision): "By 2020...Cardiff will be a world class European capital city with an exceptional quality of life and at the heart of a thriving city-region".

The Super-Connected Cities Cardiff Plan (August 2012) provides full details of the rolling-out of 4G and Wi-Fi across the whole of Cardiff a process which has already commenced. This brings a level of connectivity to Cardiff which is ahead of many other UK cities.

Specifically in relation to the sustainable development, a draft document has been produced titled Cardiff: One Planet City. The vision contained in this document is to make Cardiff an enterprising, prosperous, healthy, happy, clean and green city in the future, and a City which is renowned for sustainable thought and actions. Cardiff is currently a 3 planet city in terms of resources used and wants to be 2 planets by 2030 and 1 planet by 2050. The One Planet City approach sets out a number of objectives relating to energy, waste, transport, food, water, place and the need for people to be involved in all aspects if the vision is to be achieved.

5.5 Economic development

A large proportion of Cardiff's economic progress in recent years has involved major investments in leisure infrastructure together with a strong reputation as a tourist and retail destination. The leisure, tourism and heritage sectors have generated significant economic and cultural benefits, including the staging of major international events at world class venues such as the Millennium Stadium and the Wales Millennium Centre. In 2010 the city attracted a total of 18.3 million visitors [8] which was 25% higher than 2009. Building on this platform, Cardiff has set itself the goals of being the best small capital city for business in Europe and being a world class 'Quality of Life' city. There are also three key economic drivers:
- Enhance and expand the financial and professional services sector.
- Expand the creative and digital media sectors.
- Attract and retain talented people.

Cardiff is currently home to the largest concentration of media employed people outside of London and hosts major facilities for ITV, S4C and the recently completed BBC Drama Village in Cardiff Bay. A large cluster of other firms involved in the digital, design, animation, TV production and gaming areas are also located in Cardiff. In order to provide future facilities a new building for the Creative Industries, a Digital Media Centre will commence construction in Cardiff Bay in December 2012, and the Council is developing plans for the regeneration of Mount Stuart Square, adjacent to Cardiff Bay and the Central Enterprise Zone, as a district for innovation in the digital industries. The current plans in relation to super-fast broadband, connectivity, and resilience support these activities.

The Local Development Plan for Cardiff contains the objective of creating 40,000 new jobs by 2026. This total covers a range of opportunities and strategic sites are also identified to provide wider social and economic benefits across the Authority.

With an ambition to develop Cardiff into a leading European city of business, Cardiff Council has been working on the vision of a Cardiff Central Enterprise Zone to underpin and promote the financial and professional services sector and create a platform for investment. The Zone is a 56 hectare brownfield site wrapped around the central train and bus stations and will be transformed into a new business district with up to 380,000 sqm of office space and an International Conference and Convention Centre and indoor Arena. It will focus on enhancing Cardiff's growing reputation as finance and professional services cluster and is a key sustainable regeneration project. Integrated transport sits at the heart of the Cardiff Central Enterprise Zone with Central Square becoming the hub of the Enterprise Zone. The proposal represents the next phase of redevelopment of Cardiff city centre

and aims to create a modern and high quality gateway to the city whilst extending the function of the city centre south of the railway line, creating a better link between the city centre and Bay and provide a new convention centre to attract business, tourism and promote the city for business. The Cardiff Central Enterprise Zone is one of 7 new Enterprise Zones in Wales designated by the Welsh Government and the only Zone in the UK focused on financial and professional services. The Zone came into effect on 1st April 2012 and has a lifespan of 5 years.

5.6 IREEN and Cardiff City convergence

Allied to the growth challenge, resilience against environmental change, particularly flooding due to Cardiff's coastal location and low-lying areas and rivers, and an acute "health postcode" syndrome with a difference in life expectancy of nearly 12 years between the poorest and most affluent wards, must be tackled. For Cardiff to prosper it must develop approaches to managing this growth in a sustainable and resilient way. As noted above, Cardiff has the following key city issues that can be addressed through the IREEN framework via the deployment of scenario modeling and real life trials: housing, transport, waste, economic development, flooding, all set against a backdrop of significant population growth projects. Therefore, IREEN roadmap will address the integration of the above issues in a holistic multi integrated system approach, i.e. we will develop methods and practices to improve each of these issues, for instance improvement of the transport network, reduction of waste etc. However they will not be undertaken in isolation but in an integrated manner with other key issues, as illustrated in Figure 4.

Figure 4: Cardiff future cities challenges

6. CONCLUSION AND FUTURE WORK

21st century cities will increasingly rely on ICT solutions to deliver sustainable growth while increasing their level of citizen participation and overall social capital [9,10,11]. City sustainability is hence the ultimate goal [10]. Sustainability is in essence a multidisciplinary discipline (encapsulating engineering, environmental, management, economic and social sciences). Sustainability relies on knowledge and human wisdom as much as on data and information [11]. Moreover, sustainability requires localised (i.e. district / neighborhood) to larger scale (territorial and transnational) interventions [10]. Hence, it is dependence on data analytics to achieve informed decisions and larger scale impacts.

Finally, given that the concepts of sustainability are relatively new, it is impossible to allocate all required "human" expertise in one place; hence, sustainability analysis is by default "networked". Consequently, while it is important to develop new knowledge in sustainability, it is more important to "integrate existing knowledge" and

ensure this informs planned interventions. This is needed to handle the overwhelming and conflicting transactions associated with management of sustainability. In that respect, a number of place-related issues and research questions remain unanswered and need addressing, including:

- How can social and economic inclusion be achieved in cities and adjacent areas / suburbs?
- How can new forms of connectivity within and between communities and their broader physical and social environments help sustain the health of the local population?
- How does the physical environment complement the distinct social character of a community in creating a sense of place?
- How do we foster 'real' or 'strong' forms of sustainability practice?
- Why do so many community-led sustainability initiatives remain fragmented, marginal and disconnected and how can they become more joined and scaled-up to achieve real benefits?
- What are the rights, roles and responsibilities of each set of stakeholders involved – individually and collectively?

The above is currently being addressed by the authors in the context of IREEN and related projects.

ACKNOWLEDGMENTS

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