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## Special Issue on Policy-Making: The Next Challenge in E-Government Research

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# Fostering Smart Cities through ICT Driven Policy-Making:
## Expected Outcomes and Impacts of DAREED Project

*Uthayasankar Sivarajah, Brunel Business School, Brunel University, Uxbridge, UK*

*Habin Lee, Brunel Business School, Brunel University, Uxbridge, UK*

*Zahir Irani, Brunel Business School, Brunel University, Uxbridge, UK*

*Vishanth Weerakkody, Brunel Business School, Brunel University, Uxbridge, UK*

## ABSTRACT

*The concept of smart city is emerging as a key strategy to tackle the problems generated by the urban population growth and rapid development. It is widely recognised that Information and Communications Technology (ICT) play a key role in addressing some of the urban societal challenges such as improving energy efficiency and reducing carbon emissions. Although there are various ICT tools providing intelligence and services relating to energy consumption and monitoring processes, they mostly tend to work in isolation. Therefore, this paper presents the outcomes and impacts of the concept of DAREED which aims to deliver an integrated ICT service platform to drive energy efficiency and low carbon activities at neighbourhood, city and district levels. Furthermore, the research highlights the need for ICT-driven policy making using platforms such as DAREED in the context of e-Government. This paper contributes to the current understandings of e-Government literature in terms of how ICT can help public authorities and stakeholders such as policy makers to achieve and drive energy efficiency. From a practical stance, the paper offers valuable insights to public administrations on how ICT can be used to address pressing societal challenges such as efficient energy use and facilitate better policy making.*

*Keywords:* *Decision Support Systems (DSS), Energy Efficiency, Information and Communications Technology (ICT), Policy Making, Smart City*

## 1. INTRODUCTION

Energy efficiency is at the forefront of energy policies in European Union (EU) (European Commission, 2012). According to the last European Commission's (EC) Energy Efficiency Directive that was published in 2012, all the member states of the EU are required to use energy more efficiently at all stages of the energy chain, from the transformation of energy and its distribution to its final consumption, with the goal to reduce energy consumption by

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20% by 2020. The strategy followed includes a mix of measures that involve efficiency in energy generation, new obligations for energy producers and distributors, new initiatives by the government, new roles and more empowerment to the consumers. As a result, cities across Europe are forerunners in the transition towards a low carbon and resource efficient economy. They are starting to plan and act for a more sustainable future characterised by investments in innovative, energy efficient integrated technologies and services such as buildings, heating/cooling, mobility, lighting, and other utilities to name a few (Caragliu et al., 2011; Nam and Pardo, 2011). A number of challenges are still open concerning energy management at city level, micro-generation from renewable energy sources, Combined Heat and Power (CHP) and its integration into the smart grid just to mention a few ignoring the needed change in private transport towards low emission and hybrid vehicle (Karnouskos, 2011).

Urban environment, cities and the construction sector are fully aware of their huge responsibility, being the highest energy consumers in the EU and main contributors to Green House Gas (GHG) emissions. The figures provided by the "Multi-annual roadmap and longer term strategy" of the Energy Efficient Building PPP (European Commission, 2010) claim that energy consumption from the construction sector accounts for the 40% of the total EU energy consumption and that contributes to the 36% of the total EU $CO_2$ (Carbon dioxide) emissions. Thus, fostering energy efficiency in the residential sector could play a fundamental role in achieving carbon emission reductions (European Commission, 2014). This will imply significant investments in the short term, but will provide long-term substantial savings in the future along with a much higher degree of sustainability as presently being tested in Cambridgeshire, UK. One of the fundamentals of the long term strategy is that energy efficiency will respond to climate change and energy issues, providing the stakeholders are able to focus on the proper working scale and are able to trigger concerted actions concerning all stakeholders involved in the process, namely citizens, energy providers and policy makers. Concerning the working scale, one of the pillars of the long term roadmap of the Energy Efficient Building (EEB) is the district level management. Only district scale intervention will permit the achievement of the much higher energy efficiency targets required by optimising the use of energy at different levels and involving all stakeholders in the process. This will involve the availability of adequate monitoring facilities and management tools that would enable local authorities to plan, execute and when needed enforce adoption of needed measures through better informed policy decision making.

It is broadly recognized that ICT solutions have the potential to be an enabler to reduce a significant part of total $CO_2$ emitted by non-ICT industries (Vasseur and Dunkels, 2010; Weber and Shah, 2011). At district or city level, ICT solutions might provide intelligence on the energy consumption process, the distributed micro-generation, the management of complex installations, their monitoring and control and also provide new business models and policy guidelines that foster good practices in energy consumption leading to significant GHG reductions. A number of ICT solutions have been described in the literature (e.g. González et al., 2012; Lazaroiu et al., 2012; Niemi and Mikkola 2012), developed and applied in practice for supporting energy saving, user engagement, user profiling, demand aggregation and energy management. Despite the fact that many ICT tools exist, they all work in isolation and mostly independently. Therefore this paper presents the concept of DAREED that aims to develop an integrated ICT platform by exploiting existing tools to support decision making for policy makers, citizens and other stakeholders in order to help them achieve energy efficiency. In doing so, DAREED seeks to foster smart cities through innovative application of ICT and informed policy decision making. DAREED (*Decision Support Advisor For Innovative Business Models And User Engagement For Smart Energy Efficient Districts*, www.dareed.eu) is a project co-funded in the seventh framework programme of the

European Commission. This paper reports the expected outcomes and societal, managerial and technological impacts of the DAREED platform and highlights the need for ICT driven policymaking through the development of effective decision support systems for driving energy efficiency at a city level.

## 2. ENERGY EFFICIENCY IN SMART CITIES: STATE OF THE ART REVIEW

The electronic government (e-government) era has enabled public administrations to become more efficient and effective through the delivery of digital solutions and services (West, 2004; Weerakkody and Dhillon, 2008). While the early emphasis of e-government led service transformation was highly focused on using technology to deliver improved and personalised services for citizens, more recent efforts have been focused on community and societal level impacts that are enabled through smart use of technology (Paskaleva, 2009). In this context, the emphasis has somewhat shifted from a service delivery focus to a smart ICT-infrastructure based eco-system that is sustainable. According to Lombardi et al. (2012), the application of ICT in the context of future cities is indicated by the notion of smart city. Smart city innovations are emerging as new approaches to holistic management of cities' physical, socio-economic, environmental, transportation and political assets across all urban domains, typically supported by ICT (*ibid*). Chourabi et al. (2012) argue that as the concept of a smart city itself is still emerging, this notion is used all over the world with different terminologies, context and meanings. As per Giffinger et al. (2007), a smart city is when a city is performing well and is forward-looking in terms of economy, people, governance, mobility, environment, and living, built on the smart combination of endowments and activities of self-decisive, independent and aware citizens. Toppeta (2010) highlights that a smart city is the combination of ICT and Web 2.0 (second generation web) technologies with other organizational, design and planning efforts to dematerialize and speed up bureaucratic processes and help to identify new, innovative solutions to city management complexity, in order to improve sustainability and liveability. Despite the variances in defining the term "smart city", most of the definition considers "smart" in this context as a city performing in a forward-looking way.

The management of energy efficiency in private, public and commercial buildings has become one of the key drivers in the transition to the smart city model (Chourabi et al., 2012). According to Lazaroiu and Roscia (2012), cities consume 75% of worldwide energy production and generate 80% of CO2 emissions. Thus, a sustainable urban model, the so called "smart city", is highly encouraged by the European Commission (European Commission, 2014). Hollands (2008) asserts that ICTs are key enablers of smart city initiatives and the integration of ICT with development projects has the potential to offer potential to enhance the management and functioning of a city. Similarly, World Wide Fund for Nature (WWF), an international non-governmental organisation considers ICT solutions to play a pivotal role in reducing a significant part of total CO2 emitted by non-ICT industries (WWF, 2014). Building Management Systems (BMS) as well as electrical appliances (including computers) are being used for achieving better and better energy efficiency levels at every new generation striving to reach the "A+" energy efficiency classification (Gonzalez et al, 2012). However, such contributions are still insufficient in the current energy context, where dependence from external decreasing energy and fluctuating, yet overall rising, prices cast doubt on the profitability of many solutions when compared to the appliance expected useful life and the related necessary investment. The surge in use and needs is causing energy saving measures and common recommendations (energy-efficient light bulbs, HVAC systems, awareness campaigns, etc.) to be increasingly ineffective in achieving a significant reduction of consumption, forcing to look for other and much more

advanced strategies. Therefore, the inclusion of monitoring and control systems in real time, BMS, and scalable solutions that are able to address the problem at a district level along with a substantial behavioural change is becoming a necessity rather than an option (Gonzalez et al, 2012). The integration of ICT and BMS facilitates the quantification of the energy status of a house, a building, etc. as they allow for the recording of the consumption parameters in order to characterize consumption profiles, detect patterns and potentially provide the means to change the urban landscape by deploying true Smart Cities (Vasseur, 2010). Such an approach can provide the "user" or final consumer the necessary information to understand, take into account, anticipate and minimize energy losses. As a result, this could help influence the policy making process by providing a starting point for discussion between stakeholders and citizens driving the final decision for adopting measures and best options knowing that they have been evaluated and verified.

The expanding application of Smart Grid and "clean" energy production technologies calls for the adoption of "intelligent" techniques to better coordinate and run the power production and distribution process (Ramchurn, et al., 2011; Vvtelingum, 2010). In this context, the task to keep it precisely balanced with supply at all times becomes especially challenging. Maintaining demand curve stability, in particular, can alleviate the risk of electricity network collapses and lead to financial and environmental benefits as then some generators can be run on idle, or even be shut down completely (MITEI, 2011). As a result, several load control programs have been proposed where electricity consumers are encouraged to limit their consumption, or shift it to off-peak hours in order to reduce the peak-to-average ratio (Davito et al., 2010). According to Nabona and Pages (2007), the energy utility or intermediary companies could define new business models, power planning procedures and pricing schema that on one hand are remunerative for the utility, but on the other hand are efficient for the grid, pushing consumers to consume energy in a way that a flattening of the demand curve is achieved.

## 2.1. Decision Support Systems for Driving Energy Efficiency and Better Policy Making

Apart from the development of new business models, sustainable energy policy making is also a fundamental driver for fostering energy efficiency at district and city level (Wang et al., 2009). Municipalities can play an important role by devising energy policies aimed at increasing citizen awareness toward efficient energy usage and consumption shift to off-peak hours. As far as policy making is concerned, the EU FP7 ePolicy project (ePolicy, 2007) has been highly influential for DAREED. ePolicy is a project aimed at devising decision support systems for policy makers at regional level. It is specifically devoted to the definition of sustainable regional energy plans, their strategic environmental assessment and in the definition of policy instruments that foster the adoption of renewable energy sources. ePolicy leverages techniques from Artificial Intelligence and Operations Research such as Constraint Programming (Apt, 2003), Integer Linear Programming (Schrijver, 1998), agent based simulation (Davidsson, 2002), opinion mining (Liu, 2010) and game theory (Myerson, 1997). DAREED will rely on these results, but extend them in order to cope with energy efficiency measures, and to downscale the ePolicy methodology to the municipality level instead of regional level. Table 1 provides a brief overview of existing software solutions related to decision support systems (DSS) to enable energy efficiency and presents the limitations of these ICT solutions in order to highlight the potential contributions of DAREED. The ICT solutions are drawn from both the academic literature and ongoing research and development projects.

In general these tools are developed and studied in isolation, with no tight integration of the different aspects is taken into account. An important element of DAREED is the integra-

*Table 1. Limitations of existing ICT solutions facilitating energy efficiency*

| ICT Solutions | Description | Limitations | Reference |
|---|---|---|---|
| RESURL Project | The sustainable rural energy decision support system (SURE DSS), a methodological package and software designed as part of the RESURL project builds upon technical and non-technical features of energy development in remote poor areas, drawing on a sustainable livelihoods approach as part of its rationale. SURE enables simulations and calculation of the disparities that may arise between current and potential livelihoods after specific energy solutions have been installed, as well as measuring potential trade-offs among alternative livelihoods. | Context is based on rural energy decision making and is focussed mainly on energy supply perspective. | (Cherni et al., 2006) |
| BESOS Project | The focus of BESOS (building energy decision support systems for smart cities) is on the development of integration technology to allow data sharing and communication between traditionally separated systems in a urban context (e.g. lighting, heating). This integration layer enables the development of higher-level applications for monitoring and analysis tasks. | No recommendation tools. Emphasis on integration and not on analysis, assessment, planning. | (BESOS, 2013) |
| ENRIMA Project | EnRiMa project aims to develop a state-of art decision support system for lowering the energy consumption and CO2 emissions of public buildings. | Focused only on building level and no recommendation tools | (Henkel et al., 2013) |
| OPTIMUS Project | The goal of the OPTIMUS project (OPTIMising the energy USe in cities with smart decision support systems) is to provide local authorities with on-line tools to devise (and monitor) city-level energy plans. The project includes the development of tools for automatic scenario recommendation, but the design of incentive and regulation schemes for the actual implementation of such scenarios is left to the policy maker. | No tools to define incentive schemes. | (OPTIMUS, 2013) |
| EEPOS Project | The EEPOS Project (Energy management and decision support systems for Energy POSitive neighbourhoods) aims at reducing the dependence of selected neighbourhoods on the external grid. The project plans to achieve such goal by several means and in particular by levelling peaks via automated load shifting and by exploiting differences on electricity usage patterns (e.g. households vs offices). | No recommendation systems. Limited predictive tools. | (EEPOS, 2012) |

tion of these tools, energy awareness policy making and the definition of business models for increasing citizen awareness. The concept of DAREED is now discussed in detail in the subsequent section.

## 3. PROPOSED SOLUTION: DAREED CONCEPT AND OUTCOMES

The DAREED project seeks to exploit existing ICT tools surrounding energy saving, user engagement, user profiling, demand aggregation and energy management systems and develop new ones that will be incorporated into a single ICT platform (Sivarajah et al., 2014). DAREED strives to foster the concept of sustainable energy district considering buildings not as an individual energy-consuming element but as a complex network element, allowing the introduction of macro strategies in the district level. The identification of new business models and the establishment of stakeholders' role according to building level (building manager), district level (district manager) and energy services companies is the other major project aim for driving synergies among them. The DAREED concept (refer to Figure 1) will consist of a multi-layer platform integrating a set of ICT tools that support Decision Support Systems (DSS) used for managing and optimise services oriented to foster Energy Efficiency (EE) and low carbon activities in neighbourhoods and city level. Working at district or neighbourhood level results in user and data heterogeneity. DAREED will therefore address a variety of user profiles and consumption rates as well as a variety of stakeholders involved in the process (urban planners, building's energy managers, citizens, and energy utilities).

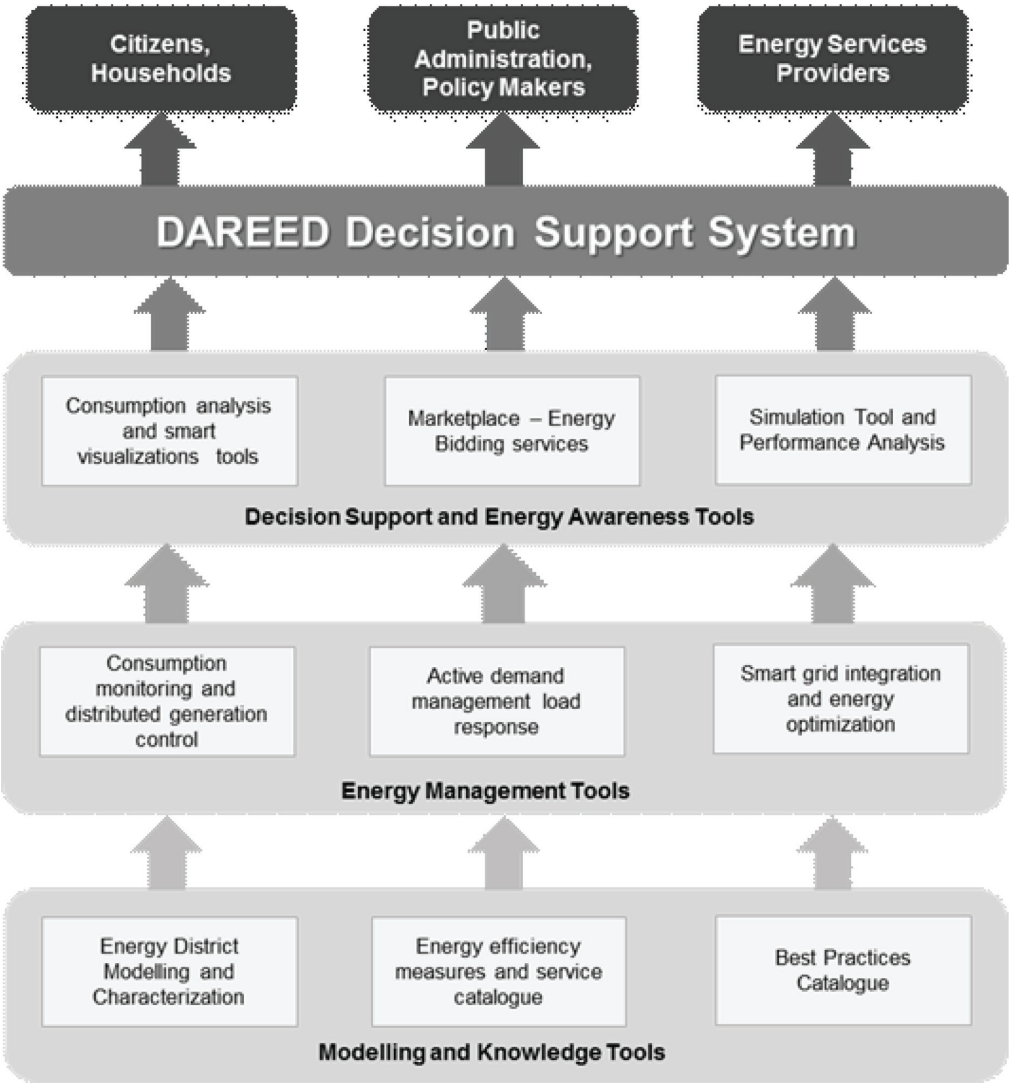
The ICT solutions integrated in the system address three main actors of the urban context and deliver three main products:

1. **Services for user engagement and awareness:** Services will be developed for engagement with citizens, building owners, energy managers and public administrators;
2. **Decision Support layer for City/District policy makers:** The decision tool will be available to help policy makers at municipality level to design and validate district and building level energy policies to enhance the user engagement and define best practices through a number of policy instruments like incentives, green certificates, simplified bureaucracy, etc.;
3. **Decision Support for energy and services providers:** The decision tool for consumer aware business models will be designed to aid energy providers in the definition and validation of new business models and pricing schema that are both economically sustainable, and are in line with the promoting of good energy practices.

The ICT platform will be based on service oriented system architecture of functional layers as reported in figure 1. The DAREED platform will be assessed and tested in three complementary pilots; (1) Cambridgeshire, UK (2) Seville, Spain and (3) Lizzanello, Italy. Some of the energy services to be tested are as follows:

1. **Remote energy management services:** An energy service provider will be able to manage consumption and distributed energy production, based on real time alert algorithms and communication with a local smart-grid at a specific location (grid and CHP integration). These services provide remote energy management with periodic reports that will support business cases for future investments;
2. **Energy bidding services/ Energy Marketplace:** This will be a place for citizens and building owners to exchange information and bids from energy suppliers, based on detailed real consumption data, and taking privacy issues into account;
3. **Demand aggregation and demand response:** For energy service providers to

*Figure 1. DAREED concept*

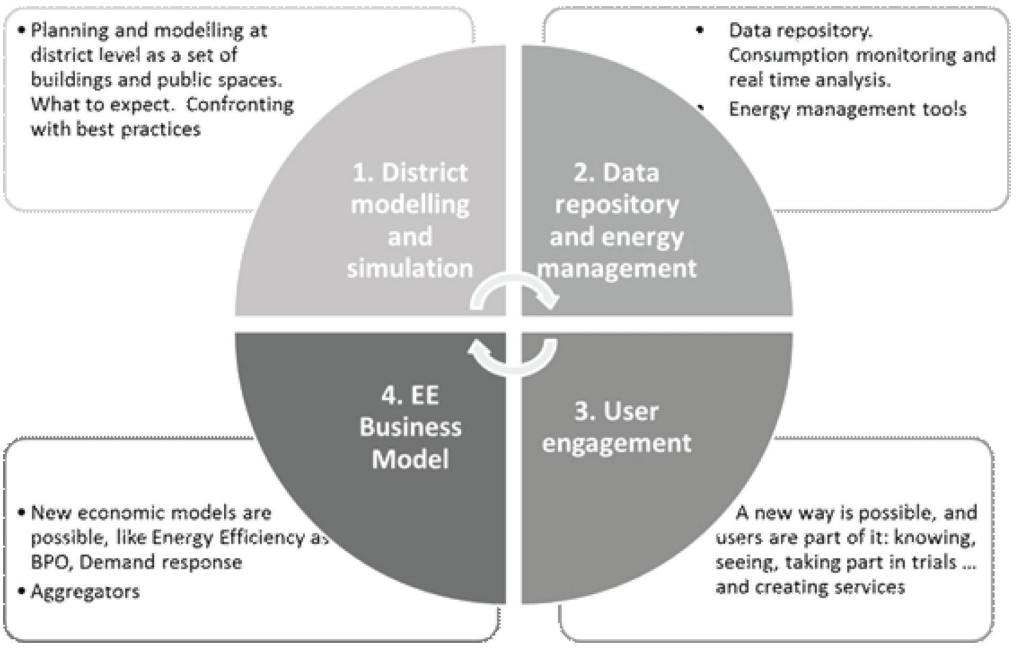



dynamically manage tariffs and request from Distribution System Operators (DSOs). The energy service provider acts as a demand aggregator for purchasing energy supply with dynamic tariffs, for instance an hourly pricing for the next 24 hours, and rewards from peak consumption limitations.

As control flow is concerned, the DAREED project proposes a model as illustrated in Figure 2 for continuously reducing energy consumption and increasing distributed generation in a district based on four main phases:

1. District modelling and simulation, especially to determine the diversity of consumers;

*Figure 2. Proposed model for monitoring and improving energy efficiency*




2. Systems for monitoring consumption and energy management;
3. Tools to facilitate user involvement;
4. Tools to support new business models based on energy savings.

These phases that form part of the improvement model are a continuous closed loop where at each cycle the impact of the preceding cycle on energy saving could be evaluated, conduct new simulations taking savings into account, and come up with new business models, policy guidelines and increased user involvement. It is worth noting that shifting from buildings to districts results in much higher complexity and heterogeneity of data requires a substantial paradigm shift in data harvesting and management. In fact, if a single building is concerned, complex simulation approaches are defined taking into account thermal models building areas and extensive consumption measurement by type (air conditioning, lighting and power in every area of the building). When a district is considered, a practical approach should be devised based on sampling of the area by type of consumption. For monitoring the consumption of the area we will consider representative sample consumption, meanwhile actions at district or city level will be made for awareness and validation of tools and services.

## 4. METHODOLOGICAL APPROACH OF DAREED PROJECT

The DAREED project relies on different methodological approaches to deliver the completed platform. These various approaches are outlined below.

### 4.1. Methodology for District Modelling and Infrastructure Planning

The definition of a methodology to simplify modelling of urban areas from an energy perspective is nowadays a challenge to the scientific communities (Yamaguchi et al., 2007). Thus,

different studies have been carried out but in many of these cases the particular methodology has been established ad-hoc, which means it cannot be applied in other scenarios or under different conditions. At least one (or two) existing methodology could be briefly described with their strengths and gaps in order to be able to make the difference with DAREED – the justification remains too general and unclear. The analysis of the existing methodologies is lacking actually. Some district, for instance, are modelled considering the energy flow as a sum of total energy flow in each buildings (Yamaguchi et al., 2003).

However, in those studies in which district modelling has been faced from a general approach the validation has been performed under controlled conditions so it cannot be ensured their applicability in other areas (Huber and Nytsch-Geusen, 2011; Pica et al, 2013). In this sense and considering the geographical scope of the DAREED consortium, the project aims to develop a common methodology for district modelling, based on energy models applicable under different conditions, amongst others; weather conditions, user patterns, national building codes, etc. Seville, Cambridge and Lizanello will ensure the reliability of the results taking into account the differences among them as well as the targeted districts in each location.

## 4.2. Methodology for Modelling and Simulation for Energy District

Moreover, in accordance with the proposed methodological draft, the monitoring over time will allow an online adjust of the initial modelling ensuring realistic results. It should be also highlighted that, contrary to other initiatives, DAREED aims to face district as a whole, instead of considering it as a set of parts (Policity, 2005); under DAREED approach energy demand and energy supply will be treated as a fully coupled system and a set of technologies will be modelled to meet different energy demand scenarios. To reinforce the gaps related to district modelling DAREED is facing (Keirsteada, 2012), there exist room for improvements in issues as sensitivity analysis and cloud computing, data collection and model integration that represent a challenge for DAREED platform as an integrated solution for modelling, data acquisition and energy strategies from district level.

Finally, for the evaluation of District performance, more topics are related especially on thermal district energy (USGBC, 2010). DAREED will contribute to define a scheme for a district energy rating, capitalizing previous lines of research, even devoted to Building performance and characterization (IntUBE Project, 2008) by exploiting the energy model that DAREED aims to develop.

## 4.3. Methodology for Knowledge Management for ICT Systems

Knowledge management is one of the essential methods in providing an intelligent ICT system. Knowledge management includes the phase to create the knowledge, to represent and store the knowledge, to use it, refine it, and finally transfer it (Edwards, 2001). The central point of knowledge management phases is the knowledgebase. In DAREED project, the knowledgebase formalizes the energy model as well as knowledge about the energy efficiency and production best practices. The knowledgebase makes this kind of knowledge more explicit, so that it can be shared among different stakeholders and systems. The common knowledge representation for the purpose is the OWL (Web Ontology Language) ontology (McGuinness and van Harmelen, 2004).

The OWL ontologies have been applied in different domains, such as in semantic web, product development (Wickasono, 2011), energy management in buildings (Wickasono, 2010), and energy management in manufacturing (Wickasono, 2012). In district level, OWL ontologies have been applied as knowledge base to support the e-government activities, connecting and integrating different information from different government offices (Oegov.

org, 2014). Furthermore ontology is also used as knowledgebase for ICT tools for supporting the urban development process. The knowledgebase contains knowledge about the land usage and the type and size of its population, following a customizable workflow (Gomes et al., 2012). However, there is still no OWL ontology that focuses on the energy efficiency in the district level. The DAREED project aims to develop a knowledgebase represented using OWL and focuses on the energy efficiency in district level. The resulted ontology is expected to be a standard knowledgebase in district energy management domain.

## 5. IMPACTS OF THE DAREED PROJECT

The DAREED platform will be implemented and tested in real end-user cases which will involve different district types and end-users. This will potentially result in feedback that is realistic early on in the process and will allow the refinement of the DAREED components in two different cycles with main goals, their improved applicability and enhancement of their actual added value to the European strategy for sustainable growth. The benefits and challenges in respect to the implementation of energy optimization actions for the main stakeholder are reported in Table 2.

Despite proclaimed benefits and challenges of ICTs use in cities, their impact is still unclear. Therefore there is a need to understand the key impacts of ICT solutions such as DAREED and these are reported below.

### 5.1. Adoption of ICT by City Authorities and its Impact for Policy Makers

One of the main stakeholders considered in DAREED is the *policy maker at municipality and investment level*. City authorities are in the position of pushing low carbon economy in general and energy efficiency and micro-generation in particular at district or city level. In general policy makers define a number of strategic objectives for a goal. These strategic and long term objectives should be achieved through a number of implementation instruments. In the energy sector, a number of them have been identified: investment grants, feed in tariffs, green certificates, financial incentives, tax exemption, simplified bureaucracy as well as information campaigns to increase citizen awareness with respect to carbon neutrality and energy issues. Deciding which portfolio of implementation instruments to apply and the budget to allocate to them is far from being trivial. The choice should be based on a number of data that are hardly manageable manually by an expert if at all. In addition, as implementation instruments should be perceived by the citizens, enterprises and stakeholders in general, the impact of these instruments on society should be measured in some way, possibly through simulation. The DAREED project promotes the adoption of ICT by City Authorities as it provides decision support systems specifically designed for policy making guidelines that aid the city expert in the definition of strategic objective that are feasible and in line with EU and national strategies and at the same time applicable from a social perspective. Easy adoption tools provided as a service can foster the public authorities' implication that, in turn, can be a behaviour model for citizens and building managers.

### 5.2. Quantifiable and Significant Reduction of Energy Consumption Achieved through ICT

The project will develop an ICT platform that will help achieve results for individual dwellings, buildings and public spaces, thus leading to a district level that will be on average leaning towards the same kind of values (although on a lower scale). These reductions of energy consumptions will come from several ways, as DAREED platform consist of an integrated set of innovative ICT based services designed to foster energy efficiency and renewable integration in buildings and at city level in a non-intrusive way interoperating with existing infrastructure. One of the most important change drivers to get

*Table 2. Benefits and challenges of implementation of energy optimization actions for the main stakeholders*

| Targeted Stakeholders | Benefits | Challenges |
|---|---|---|
| - Citizens, households in general<br>- Building Owners<br>- Public Authorities as major owners | - Sustainable environment for all city inhabitants<br>- Cost and energy savings for energy usage reduction maintaining comfort levels<br>- Minimizing the investment (i.e. providing services instead of traditional technology provision)<br>- Getting knowledge of where energy consumptions are can led to a habit change and to increase in savings | - Changing habits.<br>- Comfort levels are no standard for all citizens (and less for building energy manager)<br>- Legal contracting can be difficult. Regulatory frame for public administration contracting and procurement process<br>- Determining energy savings versus baseline consumptions<br>- Risks of vendor lock-in<br>- Change management needed |
| - Public Authorities<br>- Policy Makers | - Improving the corporate image: smarter cities for smarter citizens<br>- Meeting with regulation on greenhouse gas emission<br>- Economic development<br>- Energy planning | - Technological and financial risks.<br>- Resources for change management needed |
| - Energy Service Provider | - Sales increase in form of more services and a bigger market<br>- New EC directive on Near Zero Energy Buildings and the end of renewable subsidies can foster energy optimization services for self-consumption orientation.<br>- Lower commercialization costs as customers are more informed and have a clear idea of what they want through simulations<br>- Cost saving at deployment of remotely provided services<br>- New services in form of energy efficiency digital services not just financing traditional measures implementation<br>- Deeper knowledge of customers' energy behaviour<br>- Sales increase in form of more services and a larger market<br>- New services providing. Transforming technology providing to services providing | - Assumption of investments on services and developments<br>- Regulatory changes<br>- Financial and technological risk for not getting planned saving. Responsibility for investment |

the expected impact is knowledge: the usage of information that let user know exactly what is their energy consumption, how do other people get to use less energy with the same levels of comfort and what have they done to get the energy savings. Energy monitoring systems can reflect behaviour of citizens who have no idea of their potential negative impact on energy resources. Such systems that would allow the results being shown will raise citizens' awareness and adoption of different attitude with a change in behaviour and positive perceived feedback. Between 20% and 30% of electrical expenses come from not-desired consumptions (CYS Energy, 2011) like stand-by, failures, overloads and penalties, lack of regulation,

etc. It is therefore important to highlight that knowledge-based decision tools are core to the project.

### 5.3. Interoperability and Contribution to International Standards

The project will establish synergies with international standards worldwide known. In this sense, in accordance with the International Organization for *Standards (ISO) 50.001* the project will promote:

- Transparency and easy-communication on the management of energy from a district level perspective;
- Promotion of energy management best practices;
- Assistance in the evaluation and prioritization of most suitable energy technologies;
- Facilitate energy management improvements for greenhouse gas emission reduction projects, as mentioned above.

According to the objectives of the project, its outputs will facilitate the improvements in building energy behaviour as well as raise people involvement by offering accessible energy information. Final energy users will have the chance of identifying improvement options in their own buildings which contributes to comply with other standards and certification that beyond energy savings will offer energy added value to buildings. Of course, an important aspect of the project is the environmental issue. Therefore, energy savings promoted by this project means environmental impact reduction so DAREED will contribute to reduce environmental impacts in districts and satisfy requirements from ISO 14000 Environmental Management Standard. The project seeks to offer ICT tools to obtain energy and economic savings, continuous improvements and an awareness increase.

## 6. SOCIETAL, MANAGERIAL AND TECHNOLOGICAL IMPACT OF DAREED PROJECT

As with any development of ICT solutions there are potential challenges (e.g. technological, behavioural, financial etc.) that exist for stakeholders as highlighted in Table 2. These challenges need to be taken into careful consideration and addressed in order to justify the investments into such decision support systems and effectively satisfy any of the business case objectives set by the various stakeholders. Apart from the expected general key impacts of the DAREED project reported in the section above, the societal, managerial and technological impacts are now discussed below:

- **Societal:** From a society perspective, DAREED fosters the user-in-the-loop concept by involving citizens through visualization tools and user engagement tools. The evaluation of pilots will be conducted taking into account the interest and impacts of all involved stakeholders in their interaction with information systems including their effects and affects, appropriation or refusal. The consolidated experience in system evaluation and user engagement will be exploited in the field trials. Specific case studies will be conducted in order to analyse user engagement and collect suggestions, ideas and feedback to be provided to policy makers and other involved stakeholders. One of the key challenges that is expected to be met is the difficulty in the change of citizen habits or behaviours in pursuing the energy efficient practices recommended by DAREED platform. At times providing information to generate knowledge as intended by DAREED to citizens is important but not necessarily sufficient for changing user behaviour. Therefore, user behaviour will be further analysed to identify relevant factors affecting technology or service acceptance so as to better support long term

sustainability of introduced services and innovation. Social networks will be used for increasing energy efficiency awareness to citizens;

- **Managerial:** From a management perspective, DAREED is focused on defining innovative business models that take into account user profiling, demand management and renewables. The user involvement is studied to provide insights on user acceptance and user adoption of best practices. Consumers in the smart grid become "*prosumers*" and act as a source of innovation as they are modelled in the decision process at policy making levels and at energy service levels. Social networks are considered as a source of knowledge on user's opinion and sentiments as well as a mean for user engagement. A number of policy instruments might be implemented for promoting energy efficiency at various levels like investment grants, fiscal incentives, green certificates, feed in tariffs, to name a few. Clear rules and simplifying bureaucracy might greatly help citizens to apply for available incentives. Policy makers at municipality levels could play a fundamental role in promoting good practices especially if decisions are based on business models aligned with user engagement measures in place. However, in the municipality context, the regulatory framework for public administration contracting and procurement process can be often demanding (due to financial constraints, political agenda, etc.) and this is anticipated to be a key challenge for DAREED. Therefore, working closely with relevant stakeholders (e.g. the local administrations and municipalities, policy makers) is imperative when recommending business models and new policy suggestions to drive energy efficiency in cities;
- **Technological:** From a technology perspective, DAREED contributes to the objective of integrating ICT technologies by proposing an integrated platform putting together different tools and services for energy efficiency and $CO_2$ reduction. DAREED platform will not only provide intelligence to single aspects of energy production and management, but also to their integration. The key challenge for DAREED is the integration of various ICT tools into a single platform which is not often an easy task for the software developers. An important constraint of developing integration solutions is the limited amount of control the integration developers typically have over the participating applications. Moreover, despite the wide-spread need for integration solutions, only few standards have established themselves in this domain. However, the advent of XML (extensible mark-up language) and Web services certainly will help the application developers and mark the most significant advance of standards-based features in providing an integration solution.

## 7. CONCLUDING COMMENTS

Rapid urbanisation is creating a sense of urgency for cities to find smarter ways to effectively manage accompanying issues (e.g. traffic congestion, wasteful energy consumption etc.). As the literature review highlights, the concept of smart city is evolving around the world as cities are actively working on smarter initiatives such as ways to achieve higher energy efficiency for buildings, better transportation management, and stronger smart grids to address these urbanisation challenges. This paper has presented the concept of DAREED, an innovative ICT platform that aims to foster smart city initiatives and has highlighted its expected outcomes and impacts. Some of the key conclusions of this research are as follows:

- There is a need for the integration and orchestration of ICT tools required to improve energy efficiency in cities by involving multiple stakeholders (e.g. citizens, energy providers, policy makers). In doing so, allowing these stakeholders

to address challenges from different, yet tightly related perspectives and promote a uniform strategy for efficiently managing energy production and consumption through a single platform;
- This research highlights the importance of effective decision support systems such as the DAREED platform to address the challenge of improving energy efficiency in cities and encourage ICT-driven policy making for better informed policy decision making;
- It is emphasised that the adoption of ICT platforms such as DAREED by public authorities will better support policy making guidelines in order to help policy makers in the definition of strategic objectives that are in line with EU and national strategies.

In terms of contributions to e-government literature, this paper has highlighted how ICT solutions can help support stakeholders such as policy makers to achieve and drive energy efficiency at a city level. In addition, the DAREED project plans to contribute to the European Research Area (ERA), increasing the free movement of knowledge and contributing to the energy efficient semantics community by benchmarking the results of relevant research projects and existing scientific literature. From a practical perspective, the paper offers valuable insights into the policy making and how ICT plays a key role for public authorities in generating multiple stakeholder involvement in evolving the process of informed policy making. DAREED project strives to meet the varying needs of stakeholders (e.g. policy makers, citizens, and building managers) involved in decision-making in a complex environment such as a district or a city.

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*Uthayasankar Sivarajah is a Post-Doctoral Research Fellow at Brunel Business School, Brunel University London. He is currently involved in researching smart city technology and services through European Commission funded projects. His primary research and teaching interests are in the areas of Information Systems Evaluation, Web 2.0, Cloud Computing, Business Sustainability and e-Government. Sankar has a PhD in Management Studies Research from Brunel University and actively publishes in peer-reviewed articles. Prior to his PhD, he was awarded a MSc in Management (specialising in Entrepreneurship) with distinction from Cass Business School (CASS) in London and a first-class honours BSc degree in Business and Management (Computing) from Brunel University. Sankar is at present a member of British Academy of Management, Information Systems Evaluation and integration group (ISEing) research centre at Brunel Business School and an Associate Fellow of the UK Higher Education Academy.*

*Habin Lee is a Professor in analytics and operations management at Brunel University London, Business School. His research interests include business analytics in energy, public sector policy making, and business processes. He published articles on international journals including* Management Science, IEEE Pervasive Computing, IEEE Tr on Mobile Computing, Industrial Marketing Management, Technological Forecasting and Social Change *among others.*

*Zahir Irani is Dean of the College of Business, Arts and Social Sciences at Brunel University London. He used to be Professor of Operations and Information Management in the Brunel Business School, which he joined in August 2006 as the Head of School. Prior to his current role, he was the Head of the Department of Information Systems and Computing (now, Department of Computer Science). He completed a BEng (Hons) at Salford University before then accepting a research position where he completed a MPhil. He has a PhD from Brunel University in the area of investment evaluation before undertaking his leadership development at the Harvard Business School. Zahir's research interests are multidisciplinary in nature, and developed from early work on the area of evaluating investments in Manufacturing Information Systems through to more recent works in Transformational Government. He has received significant levels of funding from across the world as Principal Investigator, including from the UK Research Councils (EPSRC, ESRC), European Commission, Qatar Foundation, Australian Research Council and QinetiQ. He also publishes in leading scholarly journals. Zahir manages to find time to write press and thought leadership pieces on higher education and graduate employability that have appeared in* The Guardian, The Independent, The Wall Street Journal, Financial Times *(FT),* Thomson Reuters, University Business, Research Foresight and Times Higher Education *(THE). He is also a Senior Policy Advisor to Whitehall, where he advisor in the Cabinet Office (CSG).*

*Vishanth Weerakkody is a Professor of Digital Governance and Director of the Business Life Programme at Brunel Business School, Brunel University London. Prior to his academic career, Vishanth worked in a number of Multinational organisations, including IBM UK, in the area of software engineering, business systems design and process analysis. He is currently involved in several research projects which are funded by the European Commission and Qatar Foundation focusing on themes such as ICT enabled process transformation, social innovation and digital inclusion in the public sector. He has published over 100 peer reviewed articles, guest-edited special issues of leading journals and edited several books on these themes. Vishanth has many years of R&D experience in the field of digital governance and is currently the Editor-in-Chief of the* International Journal of Electronic Government Research*. A Chartered IT professional and a Fellow of the UK Higher Education Academy, he combines over 25 years of practical industry-based knowhow with academic and teaching experience. Vishanth is also an elected member of the University Senate and Disciplinary Committee.*