UNRESTRICTED REPORT

Prepared for:

Annex I of IEA Implementing Agreement on Electricity Networks Analysis, Research and Development (ENARD)

ENARD Annex I Information sub-Task - regulatory frameworks and business models conducive to the development of Smart Grids Issue 2.0

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Report No: 6447
Project No: 46022

October 2009

Project No: 46022

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Issue 2.0

Note: Issue 1.0 of this report was originally published, for the benefit of the ENARD Executive Committee, October 2009.

The present Issue 2.0 is released into the public domain, May 2010, at the request of the 8th ENARD Executive Committee Meeting, held April 2010.

The content of the report remains as that in the original Issue 1.0 version and takes no account of the subsequent considerable developments in the field, from October 2009 on.

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ENARD Annex I Information sub-Task - regulatory frameworks and business models conducive to the development of Smart Grids

Issue 2.0

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Summary

This report provides an overview of developments in relation to the regulatory frameworks and business models conducive to the development of Smart Grids.

To begin, some commonly used definitions of a Smart Grid are presented from the perspective of the two leading continents, Europe and North America. Definitions are also presented from other key countries around the world. Along with the definitions, a range of drivers are discussed with the major drivers highlighted.

Recent developments in technologies typically associated with the Smart Grid are presented along with an overview of current trials. The trials are grouped into some high level categories which represent existing technology areas commonly associated with the Smart Grid. A range of projects are listed along with a brief description of the scope and the country of origin. Major stakeholders are also noted.

The potential benefits of a Smart Grid are given along with an indication of primary and secondary beneficiaries. More detailed information on some proposed business models is provided in the Appendices along with associated financial information. The reviewed business models cover total Smart Grid rollouts and rollouts of individual Smart Grid components.

Lastly, an overview of regulatory and governmental involvement is provided along with an assessment of future regulation.

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1 Introduction

ENARD Annex I focuses on information collation and dissemination activities and also serves as an essential definition platform from which further R & D Annexes can be launched. There are provisions within the Annex I scope of work, for particular information collation activities (Information Sub-tasks) at the discretion of the Executive Committee (ExCo).

This briefing document was requested by the ENARD ExCo and provides an overview of developments in regulation and business models related to Smart Grids. Some commonly used definitions of a Smart Grid are also presented along with current developments and trials involving technologies typically associated with these definitions. This report draws on information and leads gathered at GridWeek 2008, CIRED 2009, the ENARD Annex I Experts' Meetings and Workshops Programme and selected 3rd party publications.

The report was formally adopted by the 7th ENARD ExCo Meeting, held October 2009, and, at the request of the 8th ExCo Meeting, held April 2010, is now released into the public domain.

2 Definitions and Drivers

The concept of a Smart Grid or Intelligent Network can have many interpretations. The Smart Grid concept is often described in terms of both employed technologies and enabled functionality. Although the employed technologies may differ from one stakeholder to another, the general characteristics of a Smart Grid are typically similar. The major differences between stakeholder interpretations tend to occur as a result of differences in their perceived value chain. Interpretations also seem to be influenced by commercial biases and lobby group interests.

A common interpretation is that the scope of the Smart Grid is restricted to distribution networks. Another is that the Smart Grid is the integration of information and Communication Technology (ICT) into the electricity gird. The term Smart Grid is also commonly used to describe the various manifestations of smart metering systems (e.g. AMR - Automatic Meter Reading, AMM – Automatic Meter Management, AMI - Automatic Meter Infrastructure). These interpretations may or may not have been correct in the past, nevertheless the emerging descriptions tend to encompass the electricity supply system as a whole and see smart metering and ICT as two of many potential technologies and applications. As shown in Section 4 below, the Smart Grid has a wide range of stakeholders from Generation to the Consumers, Suppliers, Manufacturers and Society at large.

2.1 Europe

2.1.1 Definitions

Most European stakeholders recognise the definition outlined by the European Technology Platform SmartGrids (EU TPS)[1].

[1] http://www.smartgrids.eu/

"A SmartGrid is an electricity network that can intelligently integrate the actions of all users connected to it – generators, consumers and those that do both – in order to efficiently deliver sustainable, economic and secure electricity supplies."

This definition was first published in their initial Vision and Strategy document and was reiterated in their recent draft Strategic Deployment Document (SDD).

The SDD describes the major function of the Smart Grid as using innovative products and technology to:

- *better facilitate the connection and operation of generators of all sizes and technologies;*
- *allow consumers to play a part in optimizing the operation of the system;*
- *provide consumers with greater information and choice of supply;*
- *significantly reduce the environmental impact of the whole electricity supply system; and*
- *deliver enhanced levels of reliability and security of supply.*

The EU TPS definition is widely accepted and commonly referred to in European documents such as recent publications from the Union of the Electricity Industry (EURELECTRIC)[2] and the Commission of European Energy Regulators (CEER)[3]. The Department of Energy & Climate Change in the UK (DECC) recently published a document[4] which outlines the national strategy for climate and energy. The document describes the UK Smart Grid in terms of key elements which are in alignment with the functions described by the EU TPS.

2.1.2 Drivers

The EU TPS defines the driving forces behind the move toward Smart Grids in terms of three themes:

- The European Internal Market
    - Liberalisation
    - Innovation and Competitiveness
    - Low prices and efficiency
- Security and Quality of Supply
    - Primary Energy Availability
    - Reliability and Quality
    - Capacity
- The Environment
    - Nature and wildlife preservation
    - Climate Change
    - Pollution

Although the initial EU TPS documents are quite dated now, the three high level drivers are still recognised today and are still referred to in more recent publications from a wide range of stakeholders. Market and Supply issues have always been key considerations, whereas Environmental issues, particularly Climate Change, have seen an increase in public and political attention in recent times. This is further demonstrated by the aggressive 20-20-20

[2] http://www.eurelectric.org/CatPub/Document.aspx?FolderID=1573&DocumentID=26620
[3] Smart Grids Scope, History and Prospects Update on Smart Metering Activities Note to the GA 2 July 2009 (v3)
[4] http://www.decc.gov.uk/en/content/cms/publications/lc_trans_plan/lc_trans_plan.aspx

European targets. The Smart Grid is seen as a key enabler to helping achieve these targets and as such the reduction of adverse environmental impacts has become one of the major Smart Grid drivers in Europe.

The EURELECTRIC report involved a survey of 30 DSOs from 16 European countries. Part of the survey included a section on the perceived major drivers for Smart Grids. Seven drivers were presented and the DSOs were asked to rate the significance of each proposed driver. The drivers suggested were:

- Improvement of customer service;
- Integration of Distributed/Renewable Energy Sources including Plug-in Hybrid Electric Vehicles (PHEVs);
- Utilisation of Demand Side Management (DSM) for improvements in overall system efficiency (avoiding investments in peak generation) and customer tariff systems with incentives;
- Need for investments in end-of-life electricity grid renewal (ageing assets);
- Progress in technology;
- Increase flexibility in network operation (DSM, etc.); and
- Optimization between profitability, regulation scheme and investments/operation.

The survey found that the DSOs strongly believed that the major driver for Smart Grids was the progression of technology. The Improvement of customer service was also seen as a big driver although this could be heavily influenced by smart metering.

A recent CEER[3] Report recognised that investments in the energy sector are significant and will increase substantially over the next 25 years. A significant proportion of expenditure will be targeted at the renewal of ageing infrastructure. It was suggested that the use of existing technologies for asset replacements would result in lost potential efficiency gains and failure to meet the EU energy targets, which supported a case for the development of Smart Grids.

The recently published, UK Low Carbon Transition Plan also supports the fundamental Smart Grid drivers described by the EU TPS. One of the highlighted drivers was the significant future investment in networks, particularly for the connection of new generation sources including renewables. Clearly the major long term driver was to help achieve the reduction in emissions required to meet the European 2020 targets.

2.2 North America

2.2.1 Definitions

In North America, particularly the United States of America, there are a number of related government bodies, regulatory commissions and strategic alliances involved with research and development of the Smart Grid.

Under Title XIII of the Energy Independence and Security Act 2007[5] (EISA), the Federal Smart Grid Task Force was established. The Smart Grid Task Force also liaises with the Energy Advisory Committee (EAC) and other Federal agencies and programs. The EAC advises the US DOE on implementing the Energy Policy Act (2005) and executing the EISA. EAC released a report[6] in December 2008 which describes the Smart Grid as using:

[5] http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi?dbname=110_cong_bills&docid=f:h6enr.txt.pdf
[6] http://www.oe.energy.gov/DocumentsandMedia/final-smart-grid-report.pdf

"digital technology to improve reliability, security, and efficiency of the electric system: from large generation, through the delivery systems to electricity consumers and a growing number of distributed-generation and storage resources."

Another frequently referenced definition is that provided by the Modern Grid Initiative. The Office of Electricity Delivery and Energy Reliability (OE) sponsors the Modern Grid Initiative which is a project run by National Energy Technologies Laboratory (NETL). The Modern Grid Strategy builds on the "Grid 2030[7]" and the "National Electric Delivery Technologies Roadmap[8]" and aims to foster a clear national vision amongst all stakeholders. The Modern Grid Initiative's "Vision Document[9]" and more recent US DOE publications[10] describe the Smart Grid as having 7 key characteristics, namely to:

- *Enable Active Participation by Customers;*
- *Accommodate All Generation and Storage Options;*
- *Enable New Products, Services, and Markets;*
- *Provide Power Quality for the Digital Economy;*
- *Optimize Asset Utilization and Operate Efficiently;*
- *Anticipate and Respond to System Disturbances; and*
- *Operate Resiliently Against Attacks and Natural Disasters.*

Along with these key characteristics, the Modern Grid Initiative also describes the Smart Grid in terms of 5 key technology areas:

- *Integrated Communications (open architecture for real time information and control, two-way communication);*
- *Sensing and Measurement (faster more accurate measurement, remote monitoring, ToU pricing, DSM);*
- *Advanced Components (superconductors, fault tolerances, energy storage, power electronics, diagnostics);*
- *Advanced Control Methods (monitor key components, enable rapid diagnosis, self healing solutions); and*
- *Improved Interfaces and Decision Support (support individual consumer choices, provide knowledge for grid operators and managers).*

The North American concept of the Smart Grid has evolved over time and has been described in terms of technologies and characteristics / functionality. Historically, the definitions have not differed significantly but have simply been either more or less prescriptive. The majority of previous descriptions and concepts are encompassed by the above stated characteristics and technologies.

[7] http://www.netl.doe.gov/moderngrid/docs/Grid%202030.pdf
[8] http://www.netl.doe.gov/moderngrid/docs/NEDTR.pdf
[9] http://www.netl.doe.gov/moderngrid/docs/A%20Vision%20for%20the%20Modern%20Grid_Final_v1_0.pdf
[10] http://www.oe.energy.gov/DocumentsandMedia/DOE_SG_Book_Single_Pages(1).pdf

2.2.2 Drivers

The drivers for the United States appear to be fairly similar to those stated in Europe. The high level drivers relate to:

- Economic Security
- Economic Stimulus
- National Security
- Energy Security
- Reducing Carbon Emissions
- Energy Reliability
- Energy Efficiency
- Optimising the substantial re-investment in Ageing and Congested Infrastructure
- Energy Affordability

As might be expected, environmental issues, in particular carbon emissions and climate change, are also gaining increasing importance.

One of the key differences to Europe is the inclusion of National Security as a driver. The existing grid is perceived as vulnerable to attacks which is considered a threat to homeland security. Furthermore, Cyber-security of any information system is seen as a significant issue, going forward.

Economic security is also seen as a major driver with wide-scale blackouts typically resulting in substantial losses in economic activity. More economically efficient network operation, job creation[11] and the potential introduction of new markets are further potential benefits of a Smart Grid and are welcomed, particularly in the current economic crisis.

Economic stimulus is also becoming a significant driver for Smart Grids in the United States. The recently introduced American Recovery and Reinvestment Act 2009 (ARRA)[12] provides stimulus for a range of sectors, including the Energy Sector. The ARRA provides funding for Smart Grid projects under the authority of the EISA.

2.3 Rest of the world

The Smart Grid concept is gaining interest in many countries around the world. The drivers and definitions seem to be consistent with those described in the United States and Europe. That being said, the priority of each driver may differ slightly due to differences in local industries and environments. In many countries, the Smart Grid concept is typically based on the EU TPS and/or IntelliGrid/GridWise platforms.

The review of available information showed varying degrees of interest and involvement. Some countries have coordinated efforts from multiple Smart Grid stakeholders along with Government support. In other countries with only relatively recent activity, the interest seems to be generated from a handful of pioneering organisations. Some of the more advanced countries are described further below, however, it is worth noting that signs of significant Smart Grid activity are also emerging from parts of Latin America and the United Arab Emirates.

[11] http://www.gridwise.org/assets/pdfs/KEMA_SmartGrid_Jobs_Creation_1_27_09.pdf
[12] http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi?dbname=111_cong_bills&docid=f:h1enr.pdf

2.3.1 China

The Smart Grid concept is just starting to gain interest in China, with developments to date limited to a few smart metering projects. Furthermore, given the scale of investment being undertaken in China every year, the consequence of inaction is quite high. China is therefore more determined to accelerate the development and rollout of Smart Grid technologies as soon as possible to avoid the unnecessary rollout of incompatible technologies and any additional costs of retro-fitting systems in the future.

The Joint US-China Cooperative for Clean Energy (JUCCCE) launched the China Smart Grid Initiative in late 2008[13] and it is aimed at jumpstarting the adoption of Smart Grids in China. The initiative calls for international cooperation and knowledge sharing and as such is less likely to develop a radically unique Smart Grid concept. Given the current initiative members and affiliations with JUCCCE, China is most likely to adopt the American concept of a Smart Grid.

According to a presentation given at GridWeek 2008[14], the drivers for the Smart Grid in China are predominantly related to the current interest in "going green". China has recently set the following targets for 2010:

- Decrease energy intensity per unit GDP by 20%
- Decrease emissions by 10%
- Renewable energy sources from 8% to 15% by 2010

The China Smart Grid initiative claims that the top reasons to invest in Smart Grids are:

- Energy efficiency
- Reduction in coal fired plants
- Reduce emissions
- Distributed generation

2.3.2 India

A presentation given in GridWeek 2008[15], highlighted the growing interest in the Smart Grid concept. In India, the Smart Grid is seen is seen as essential to meeting the challenges facing their energy sector. The Smart Grid was described in terms of three major functionalities:

- Real-time visibility of Energy movement
- Real-time optimisation of Energy utilisation
- Flattening of the national load curve

India is rated as having the Highest Energy Intensity in the world at almost 5 times that of other developed nations. It is also responsible for the third largest emissions of GHGs. These issues are seen as major drivers for a Smart Grid along with addressing:

- Current generation load factor of 76%
- Transmission Congestion
- Technical & Commercial Distribution Losses of 30 to 50%

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13 http://www.juccce.com/documents/JUCCCE_Smart_Grid_press_release_081110.doc
14 http://www.pointview.com/data/2008/09/24/pdf/Peggy-Liu-3604.pdf
15 http://www.pointview.com/data/2008/09/24/pdf/Kumud-Goel-3618.pdf

Further interest is demonstrated by North Delhi Power Limited (NDPL) involvement in IBM's Global Intelligent Utility Network Coalition[16]. NDPL is jointly owned by Tata Power and the Delhi Government and is responsible for delivering power to North and Northwest Delhi. NDPL describe the growing energy demand in India as a key reasons for using new technologies to provide a robust electricity network.

2.3.3 Australia

In May 2009 the Australian government launched the National Energy Efficiency Initiative[17]. Due to the relatively recent launch of the initiative, a single press release has been published which describes the Smart Grid in the following way:

Smart Grid technology uses sensors to monitor electricity supply across distribution networks using communications networks, such as broadband technology. Smart Grids help to more easily integrate renewable energy like solar and wind power into the grid, and enable energy generated in homes, schools and businesses to be stored and shared. Combined with smart meters in homes, this technology will allow consumers to access immediate information on how much energy they are using, at what cost, and how they can save money. It will also allow for more efficient and reliable network operation.

A recently formed alliance, Smart Grid Australia[18] was launched in 2008 and has members from a wide range of stakeholders, including the Gridwise Alliance. The alliance describes the Smart Grid as incorporating:

- *Intelligent communications networks*
- *Digital sensors and controls for remote monitoring and operation*
- *Tools for grid planning, design and operation to simulate, plan and automate complex transmission and distribution operations*
- *Better ways to connect next-generation equipment such as advanced storage, improved transformers, and superconducting wires*
- *Advanced meters to collect usage data electronically and automatically*
- *Load management/demand response technologies that help reduce peaks in electric demand and thereby reduce the need for standby power plants*
- *Smart devices ranging from motors to HVAC systems (heating, ventilating, and air conditioning) to home appliances with embedded intelligence which will empower end-users to actively participate in this process.*

In Australia, the major drivers for Smart Grid are:

- Energy Efficiency & Saving
- Environmental Impacts (Emission reductions and Integration of renewables (Solar & Wind))
- Control of distributed energy resources
- Network Reliability
- Increase Retail competition

[16] http://www-03.ibm.com/industries/utilities/us/detail/news/D400854Q47092I49.html
[17] http://www.environment.gov.au/minister/garrett/2009/budmr20090512h.html
[18] http://www.smartgridaustralia.com.au/

3 Review of Current Developments

3.1 Smart Grid Technologies and Trials

As described in the previous section, the Smart Grid concept is largely defined in terms of functionality and/or characteristics. These functionalities and characteristics can often be achieved with a wide range and mix of both existing and emerging technologies. Furthermore, the technologies and trials associated with current definitions of a Smart Grid are typically targeted at specific parts of the electricity supply chain. As a result, the scope of the trials and the level of advanced technology involved can vary quite significantly. Some of these technologies have been in various stages of development prior to the emergence of the Smart Grid concept and have subsequently been "rebadged" as Smart Grid technologies.

The results of this review are tabled below and have been grouped under some commonly accepted Smart Grid related technology categories. The summarised trials do not represent exhaustive coverage of all Smart Grid technologies as the review was limited to technologies demonstrated outside laboratory conditions. An exception to this is the inclusion of the Smart City trials, which have not been demonstrated but are considered to be noteworthy developments. There are a number of Smart Grid technologies and trials which are not covered in this review as they are in the research and development stage.

Smart Grid Technology Components	Project	Country	Description / Drivers
Active Network Management	MEREGIO - **M**inimum **E**mission **REGIO**ns	Germany	The project utilises an extensive information and communications infrastructure to facilitate communication and control between infrastructure and the E-energy market place, which consists of the three major components: • Producers of electricity • End customers • Intermediaries – coordinating energy demand/supply and complementary services The pilot will be used to understand the interactions between the three major components and will use the pilot findings to: • Develop emission certification concept • Optimize spinning reserves with battery storage • Reduce transmission losses with local production • Demand response -real time price information • Optimize consumption –home automation

Smart Grid Technology Components	Project	Country	Description / Drivers
Active Network Management (Contd..)	Model City of Mannheim	Germany	• Co-ordination of information, consumption and generation. • Consumers are also able to view real-time consumption and price information and also modify the consumption of their electrical loads based on prices.
	Skegness & Fens Registered Power Zone	United Kingdom	Innovative way to allow the connection of new generation assets without exceeding existing network capacity. The scheme uses real time measurement of current and voltage in all circuit elements to action generation groups according to predefined thresholds. The system also uses real time ambient temperature and load readings to determine the dynamic circuit ratings and hence the available generation capacity
	FENIX - **F**lexible **E**nergy **N**etworks that **I**ntegrate the e**X**pected 'energy evolution'	Various European	The project has four major objectives: • analysis and characterisation of the capabilities of distributed generators and loads and associated aggregation aspects; • development of economic and regulatory framework and complementary business models; • development of Information and Communications Technology (ICT) architectures; and • demonstrations of the FENIX concept in practice.
	ADDRESS - **A**ctive **D**istribution network with full integration of **D**emand and distributed energy **RES**ource**S**	Various European	Project aimed at developing technical solutions at the consumer and power system levels along with proposing recommendations and solutions to remove potential barriers. A key aspect of the project is to understand and develop the interactions between key components.
	Cell Controller Pilot	Denmark	Project was developed to help tackle the issue of controlling a network with 25% variable energy sources, as is present in Denmark. The project uses layered control hierarchy and distributed agent technology which allows parts of the network to be treated as a single entity or a “virtual generator”.

Smart Grid Technology Components	Project	Country	Description / Drivers
Automatic Meter Management	Smart Meter	United States of America	• Replace all existing meters with SmartMeters by 2011. • Electricity consumption in hourly intervals • Data transmitted from meter to access points via repeaters and other meters • Data aggregated and encrypted at access points and sent to PG&E's head end systems via commercial cellular network
	Telegestore	Italy	One of the largest implementations of Active Meter Management. Reference to May 09 ENARD Workshop Conference Proceedings
	The South Bend Pilot	Unites States of America	Rollout of gridSMART technology, aimed at: • reducing energy losses in distribution equipment • lowering operating costs • providing new services to customers • allow customers to have more control over energy consumption and associated costs
	Smart Meter Rollout	Australia	State Government mandated rollout of smart meters in Victoria. CitiPower and PowerCor planned a 4-year rollout to all customers which represents 40% of all customers in the state .
Other Smart Grid Technologies	Energy Storage Program	United States	Long standing DOE Program with defined mission *"To develop advanced electricity storage and power electronics technologies, in partnership with industry, for modernising and expanding the electric supply. This will improve the quality, reliability, flexibility and cost effectiveness, of the existing system"*
	HVDC Light	Various countries around the world	HVDC (High Voltage Direct Current) Light is an example of existing technology rebadged as Smart Grid technology. Possible applications include: • Connecting wind farms to power grids • Underground power links • Providing shore power supplies to islands and offshore oil & gas platforms • Connecting asynchronous grids • City centre in-feed
	Smart - A Residential Appliances	Various European	The Smart-A project is aimed at identifying any potential benefits that might be gained from the coordination of smart appliances and generation at both a local and network level.

Smart Grid Technology Components	Project	Country	Description / Drivers
Other Smart Grid Technologies (Contd..)	Grid Friendly Appliance (GFA) Project	United States of America	The GFA Project demonstrated the how the GFA controller could be coupled with household appliances to allow their loads to be adjusted in response to system underfrequency events.
	Sodium Sulphur (NaS) Batteries	Japan	• Stationary NaS technology co-developed by Tokyo Electric Power Company • System designed to predict wind generation 48 hours in advance • Primary use for renewables integration
	Sodium Sulphur (NaS) Batteries - Wakkanai Mega-Solar Project	Japan	• Stationary NaS technology co-developed by Tokyo Electric Power Company • Help smooth variable output from PV array • Primary use for renewables integration
	Sodium Sulphur (NaS) Batteries	United States of America	• Stationary NaS technology co-developed by Tokyo Electric Power Company • Defer capital investment by 2-3 years • Provide 2 hours of dynamic islanded operation
	Sodium Sulphur (NaS) Batteries - Wind to Battery Project	United States of America	• Stationary NaS technology co-developed by Tokyo Electric Power Company • Assess ability to provide spinning reserve and frequency response to compensate for variable wind output • Assess ability to provide Store off peak surplus for provision during peak periods
	Flywheel Storage	United States of America	• Flywheel based energy storage technology for use predominantly for frequency regulation. • Faster response than traditional regulation • 50% less CO2 emissions than traditional gas fired regulation plants • 85% less CO2 emissions than traditional coal fired regulation plants
	The ERDF Smartgrid Project	France	▪ The Smartgrid project is aimed at Improving Distribution Operation, Control and Development using AMM Data and Infrastructure ▪ First set of functionalities to be tested alongside "*Linky* Project" which is a 300,000 AMM pilot project

Smart Grid Technology Components	Project	Country	Description / Drivers
Smart City Trials	Energy Smart Miami	United States of America	• Development of multiple Smart Grid technologies in City of Miami • Create consumer savings through consumption control and energy conservation • Longer-term addressing climate change • Near-term generation of "green collar" jobs
	SmartGridCity	United States of America	• Implement multiple Smart Grid technologies • Have a positive environmental impact • Give customers choices from products to services • Enhance system reliability • Increase efficiency of power delivery • Extend asset life
	Masdar City	United Arab Emirates	Developers intend to use Smart Grid technologies to: • Control supply and demand (distributed generation, time of use tariffs) • Ensure the safety of utility staff • Integrate with local electricity grid (4 micro grids to be implemented separately with each project phase) • Foster implementation of Smart Building technologies/applications
	Intelligent Cites Framework 'Smart Cities'	Netherlands	• Develop a series of economically viable and sustainable projects aimed at reducing energy consumption in commercial/residential properties, public buildings/areas and transportation.

The table above gives a brief overview of some of reviewed Smart Grid projects. More detailed information is available in Appendix A – Trials & Technologies.

3.2 Stakeholders in Smart Grids

The full-scale rollout of a Smart Grid has the potential to impact a wide range of stakeholders. As the concept attracts more public and political attention, more companies are realising the potential business opportunities. In terms of manufacturers and technology providers, the major players tend to be early adopting metering companies. More recently, major global corporations have emerged particularly from the information systems area. Many of the principal power system equipment manufacturers have also been engaged both early on and in recent developments. The major utility activities and participation tends to stem from companies with interests throughout the value chain.

Some of the Major Players are listed below:

Category	Organisation
Government Agencies, Special Purpose Vehicles and Regulatory Bodies	• US Department of Energy • US Smart Grids Task Force • European Commission • Department of Energy & Climate Change (DECC), UK • California Public Utilities Commission (CPUC) • California Electricity Commission (CEC) • Federal Energy Regulators Commission (FERC), US • National Association of Regulatory Utility Commissions (NARUC), US • GridWise Alliance • Electric Power Research Institute • European Technology Platform SmartGrids
Metering	• Landis + Gyr • Itron • Elster • Siemens • GE
Meter Data/ Demand / Energy Mangagement	• Landis + Gyr • Itron • Smart Sync • Echelon • GE • Comverge
Electricity Network / Substation Automation	• ABB • SEL • Siemens • Areva • GE • Cooper Power Systems
Communications Networks	• Landis + Gyr • Silver Spring • Smart Synch • Current Group • Sensis
Data Systems Management	• IBM • CISCO • Oracle • Google
Smart Grid Platforms	• Gridpoint • ABB • GE • Siemens • Echelon • Cooper Power Systems • Landis + Gyr

Category	Organisation
Energy Storage	• NGK • Beacon Power Corporation • SAFT
Utilities	• Xcel Energy • ENEL • Florida Light & Power • EDF • Vattenfall • Energinet.dk

Many of the Smart Grid systems have natural synergies which are exploited by certain stakeholders. Typical examples include Smart Grid platforms, Data Systems /Management, AMM, Communication networks and end-point metering. As a result, some companies are involved with systems of varying levels of sophistication and comprehensiveness. Others are only involved with one particular area.

4 Review of Business Models for Smart Grids

The review of current developments in Smart Grids, revealed a number of demonstration projects with varying ranges of technologies and value chains. Consequently, the stated benefits from these projects also tend to differ. This section presents an overview of the perceived benefits from current and future rollouts of various Smart Grid projects.

A consistent theme throughout the reviewed material was the uncertainty surrounding identifying and quantifying the complete benefits of a Smart Grid. It is believed that many of the future benefits will come from the consumer side through innovative products and services that are not currently in existence. Given these benefits will involve consumer behaviour; it is difficult to gauge the degree of benefits and the potential for new markets. Other issues, such as regulation, environmental policies and electric vehicles are also projected to have a substantial influence on potential benefits. As a result, many of the proposed business models were presented with various uptake scenarios and/or stated assumptions.

Benefit(s)	Beneficiary(ies)	
	Primary	Secondary
Reduced Customer Interruptions[19] (SAIFI)	DNOs	Consumers, Suppliers
Reduced Customer Minutes Lost[19] (SAIDI)	DNOs	Consumers, Suppliers
Improved Fault Location	DNOs	Consumers
Deferral of Capital Expenditure	DNOs	Consumers, Generators, TSOs
Reduced Operating Expenditure	DNOs	TSOs
Reduced cost of DG connection/integration	DNOs	Customers, (distributed) generators

[19] DNOs are deemed to be the primary beneficiary under the type of SAIFI/SAIDI measures adopted by many Regulators (SAIFI: System Average Interruption Frequency Index; SAIDI: System Average Interruption Duration Index)

Benefit(s)	Beneficiary(ies)	
	Primary	Secondary
Increased Asset Utilisation	DNOs	Consumers, Generators, TSOs
Greater Network Awareness	DNOs	TSOs
Greater control over demand	DNOs	Customers, TSOs, Generators, Suppliers
Greater Consumption Awareness	Consumers	Suppliers
Greater Electricity Consumption / Production control	Consumers	
Increased Supply Security[20]	Consumers	
Increased Supply Reliability[20]	Consumers	
Increased Supply Quality[20]	Consumers	
Decreased Losses	DNOs	TSOs
Reduce Carbon Dioxide emissions	Society/Governments	Generators, TNOs, DNOs
Energy Efficiency	Consumers	Society
Energy Savings	Consumers	Society
Economic Stimulus (New markets & Job creation)	Society	Manufacturers, New Market Entrants

The table above gives an overview of some of the estimated benefits associated with different Smart Grid projects. Financial benefits have been highlighted in Appendix B – Business Models, wherever possible, however, the majority of quantified business cases covered one particular technology with very few estimates of a total Smart Grid rollout. This might be expected, given the level of uncertainty particularly surrounding benefits that are largely dependent on consumer behaviour and new market establishment.

5 Regulation in Smart Grids

5.1 Trials-Involvement of Regulators and Government

In recent times, the Smart Grid has begun to gain support from Governments. This is particularly evident with recent initiatives and stimulus packages made available for projects associated with demonstrating Smart Grids technologies.

The reviewed material did not highlight a great deal of Regulatory initiatives or incentives aimed at Smart Grids as a whole. That being said, there was evidence of regulatory support for smart metering systems (see Section 3) and general innovation projects. This support has typically been given to energy utilities by allowing cost recovery from customers.

[20] As perceived by the customer and also often implemented in regulatory frameworks as SAIFI & SAIDI; see previous

Government Initiative / Regulatory Incentive	Country / Continent	Description	Funding
American Recovery and Re-investment Act (ARRA)	United States of America	The Act was established to stimulate the economy, save/create new jobs and to progress solutions for long term challenges. One of the more recent challenges to be acknowledged under the Act, is the modernisation of the electricity grid.	$ 3.9 billion
Loan Guarantee Program	United States of America	Title XVII of the US Energy Policy Act of 2005 authorised the US DOE to provide guaranteed loans for projects that: "avoid, reduce, or sequester air pollutants or anthropogenic emissions of greenhouse gases; and employ new or significantly improved technologies as compared to commercial technologies in service in the U.S. at the time the issuance is guaranteed."	-
E-Energy: ICT-based Energy System of the Future	Germany	The project was advertised in April 2007 and called for projects that showed how the ICT could be leveraged in the electricity supply industry to achieve: • Environmental and climate compatibility • Economic viability • Security of Supply	€ 40 million
National Energy Efficiency Initiative (NEEI)	Australia	The initiative was designed to support the development of smarter, more efficient networks through the use of new technologies. The funding will be used to perform an implementation study followed by a demonstration project.	$ 100 million

Government Initiative / Regulatory Incentive	**Country / Continent**	**Description**	**Funding**
European Energy Program for Recovery (EEPR)	Europe	The program was established to provide financial support for projects in the energy area which would aid in economic recovery, lower carbon emissions and help to provide a secure energy supply. Eligible projects need to target one of the following areas: • Electricity & Gas Infrastructure (Interconnections) • Offshore Wind Electricity (OWE) • Carbon Capture and Storage (CCS)	• Interconnections - € 2,365 million • OWE - € 565 million • CCS - € 1,050 million
Energy Technologies Institute (ETI)	United Kingdom	Aims to invest in low carbon technologies over the next 10 years, including Networks. Energy Storage & Distribution Programme:- projects to be commissioned in relation “Smart” network technologies, year 2010	£ 1 billion
Research Councils	United Kingdom	Direct funding provided for collaborative (industry & academia) research into networks. Designed to support early stage development of trials of key technologies consistent with UK Vision document (to be published toward the end of 2009) Complementary funding available to supplement existing sources (such as IFI - see below)	• £ 30 million (direct) • £ 6 million (complimentary)
Innovation Funding Incentive (IFI) & Registered Power Zone (RPZ) Low Carbon Network (LCN) Fund	United Kingdom	Two incentive schemes introduced by the regulator to encourage innovative development of electricity distribution networks. To be introduced via DPCR5, April 2010 on.	• IFI - Up to 0.5% of the DNOs regulated revenue (to be increased under next price control regime, April 2010 on.) • RPZ - £0.5 million per DNO per year • LCN available as £500M fund, from April 2010 on, with 90% of eligible costs recovered in tariff structure
Plugged-in Places	United Kingdom	Programme to support development of EV charging infrastructure administered by OLEV (Office of Low Emissions Vehicles)	• £30M

The table above highlights some of the major initiatives and incentives covered in the review, which have allowed and/or will provide funding for projects that will aid in the development of Smart Grids. More detailed information is available in Appendix C - Regulation.

5.2 Assessment of Future Regulation

Current regulatory frameworks may have been adequate for the existing grid but a modern grid will require a modern approach. Existing policies designed to promote efficient and prudent expenditure will not support new solutions for new problems or new solutions for old problems.

Some existing policies do encourage innovation however in most cases it is not sufficient to support significant transformation or to mitigate associated risks. Furthermore, some existing policies actually discourage grid modernisation.

For example, system peak related issues are usually solved by investing in additional supply capacity. Under some current policies, this increases the available revenue which is obviously preferable to a demand side solution that would decrease revenue.

Dynamic electricity rates that reflect the real-time cost of electricity would also help to encourage the adoption of demand side solutions. Furthermore, electricity grid in-feed tariffs may also help to increase the penetration of Distributed Energy Resources.

Policies should be developed that incentivise expenditure in areas that provide social and/or environmental benefits but decrease revenue. Decoupling of profit and revenue streams may be a potential solution to this problem[21].

According to CEER, the ERGEG has plans to publish a document that outlines the Regulators' position on Smart Grids[3]. This position paper will be published toward the end of 2009. Following public consultation, a final decisions document will be developed prepared during 2010.

The UK Low Carbon Transition Plan indicates that the Energy Networks Strategy Group (ENSG) 'Smart Grid working group' has recently commissioned a study on Smart Grids from a UK perspective. The findings of this work will be published toward the end of 2009 and will be used to aid in the development of a UK Smart Grid "vision" document and an associated "roadmap". Likewise, Ofgem's Project Discovery is addressing various security-of-supply aspects in GB energy supply.

[21] Barriers to Achieving the Modern Grid – NETL – Modern Grid Initiative

6 Conclusions

6.1 The Smart Grid is still effectively a concept, albeit presently under serious consideration. As such it does not have a strict or unified definition. Government special purpose vehicles and strategic alliances, in both Europe and the United States, have been working to develop the concept and promote a common vision. Although developed separately, the descriptions coming out of Europe and the United States are quite similar.

6.2 The most common descriptions of a Smart Grid are in terms of functionality and therefore encompass a wide range both existing and emerging technologies.

6.3 The drivers for the Smart Grid are not dissimilar from those that underpin the existing grid. The Smart Grid retains the existing desires to achieve efficient, reliable, secure and affordable energy supply; however, it must perform against these measures in a modern and changing society. The reduction of adverse impacts on the environment has also become a significant driver in recent times. More recently, the ability for the Smart Grid to provide a platform for economic stimulus has also become a major driver, namely due to the global economic downturn.

6.4 The scopes of many of the reviewed trials were limited to the development and demonstration of individual Smart Grid components. Some of the trials involved multiple complementary technologies. However there are very few trials that include a wider range of Smart Grid technologies. A few planned projects were reviewed that intend to demonstrate the majority of Smart Grid technologies.

6.5 As the Smart Grid concept tends to encompass both existing and emerging technologies, the perceived benefits are quite extensive. Furthermore, the perceived value chain includes a wide range of stakeholders from Generation to the Customer, Suppliers and Society at large.

6.6 There was very little information available on current or proposed Smart Grid business models. Although many of costs associated with the Smart Grid can, in principle, be determined with time and effort, the perceived benefits are not so easy to quantify. This is partly due to the fact that one of the major perceived benefits relies on changes in consumer behaviour, which is difficult to predict. Furthermore, the development and uptake of future technologies and markets will also have a significant influence. Lastly, there is also a great deal of uncertainty surrounding future legislation and policy, particularly concerning the environment.

6.7 Given that the perceived benefits span a wide range of stakeholders, one of the major barriers is determining who pays. This problem is particularly difficult when the value chain has been separated. It is however still an issue in countries with vertically integrated electricity supply sectors. Existing regulatory frameworks are also a potential barrier.

6.8 In recent times, the Smart Grid has begun to gain support from Governments. This is particularly evident with schemes such as the American Reinvestment and Recovery Act (ARRA) which recently provided almost $ 4 billion to the development and demonstration of Smart Grid projects.

6.9 The majority of projects reviewed were coordinated by Utilities but supported by Government funding. The projects often included additional investments from industry, namely manufacturers and technology providers.

7 Recommendations

The Smart Grid is increasingly becoming an important area of interest internationally and there are a number of organisations and alliances around the world that are helping to develop and promote the Smart Grid concept. That being said, these alliances are typically focused on collaboration at a local, state and federal level. Some of issues are more appropriately dealt with at these levels due to inherent differences in the operational environments; however, there is much to be gained from international collaboration. From the reviewed material there does not appear to be an international forum for information exchange apart from a few conferences.

ENARD includes member countries from multiple continents and therefore bodes well for international collaboration. ENARD Annex I is specifically designed for information collation and dissemination amongst member countries, across a whole range of network related issues.

There is therefore the opportunity available to consider the development of a dedicated “Smart Grids” Annex, within the ENARD Implementing Agreement. Descriptions of the Smart Grid cross a number of existing and emerging technology components. Whilst some of these technology components already have exclusive Annexes, and indeed exclusive IAs; not all of the Smart Grid components are accounted for. A new Annex could be supported by input from existing Annexes and also cover remaining technology components such as distribution automation and smart metering systems. It could also provide a platform for sharing information on new and emerging technologies such as smart appliances and/or electric vehicles.

Another complementary option may be to simply hold a Smart Grids Workshop to allow the ExCo to gauge the level of interest and the potential workload.

Regardless of which option is chosen, the principal recommendations arising from the present work are to:

7.1 Adopt a high level Smart Grid definition based on those described by the European Technology Platform SmartGrids and/or the Modern Grid Initiative.

7.2 Create a clear definition for the Smart Grid in terms of technologies, specifically intended for Networks (TSOs & DSOs).

7.3 Create a register of all government funding initiatives for total Smart Grids, individual Smart Grid components, and Smart Grid drivers (energy efficiency, carbon emission reduction etc.)

7.4 Keep a watching brief on projects that receive funding under various existing government grants (ARRA, NEEI & EEPR).

7.5 Keep a watching brief on developments in regulation and legislature.

7.6 Promote Regulatory awareness, via

- the creation of an “essential reading” list for regulators
- the highlighting of Smart Grids through regulatory responses
- the invitation of regulatory bodies to Smart Grid working groups

7.7 Conduct demonstration pilots / trials, via

- partnering manufacturers, other DNOs / TSOs, suppliers, government
- persuing projects with integrated complementary technologies
- using information from trials to develop sustainable business models

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Appendix A – Trials & Technologies

Active Network Management Technologies

MEREGIO, Energie Baden-Württemberg (EnBW), Germany

MEREGIO (Minimum Emission REGIOns) was one of the six winners of the E-Energy[22] competition in Germany. The focus of this project was to develop a "Minimum Emissions" certification procedure which is used as a tool to represent the effectiveness of energy efficiency and greenhouse gas emission reductions schemes within the certified region. The project utilises an extensive information and communications infrastructure to facilitate communication and control between infrastructure and the E-energy market place, which consists of the three major components:

- Producers of electricity
- End customers
- Intermediaries – coordinating energy demand/supply and complementary services

The pilot project launched in Karlsruhe/Stuttgart region consists of 1000 households and industrial consumers equipped with smart meters with remote read functionality. The consumers also have access to a display unit which displays the price of electricity and allows consumers to adjust their consumption patterns based on these prices. The pilot includes 150 generators and 50 storage systems.

The pilot will be used to understand the interactions between the three major components and will use its findings to:

- Develop emission certification concept
- Optimize spinning reserves with battery storage
- Reduce transmission losses with local production
- Demand response -real time price information
- Optimize consumption –home automation

Project Stakeholders include:

- Energie Baden-Württemberg AG (EnBW)
- ABB AG – Network Manager – Energy management platform
- IBM Deutschand GmbH – CORE system – data handling
- Systemplan Engineering GmbH
- Universitie of Karlsruhe (TH)
- SAP AG

Model City of Mannheim, MVV Energie AG, Germany

The Model City of Mannheim project was also one of the selected winners of the E-Energy competition. The aim of the project is to develop an E-Energy marketplace that allows for

[22] "E-Energy: ICT Based energy system of the future" is a competition launched by the Federal Ministry of Economics and Technology in Germany. http://www.e-energy.de/de/143.php

more efficient supply and consumption of electricity, water and gas. It also aims to facilitate the integration of renewables and decentralised energy.

The project involves 3000 consumers with 300 Whispergen micro-CHP generators. The coordination of information, consumption and generation is accomplished through three major systems: Power PLUS, Energibutler and CORE. The Mannheim area was already extensively equipped with broadband power-line (BPL) communication systems and so it was quite affordable to extend the existing infrastructure with Power PLUS BPL communications system. Energiebutler is an energy management system which is used to control heating, appliances and generation. Consumers are also able to view real-time consumption and price information and also modify the consumption of their electrical loads based on prices. The data handling function is provided by the CORE platform.

Project Stakeholders include:

- MVV Energie AG
- DREWAG – Stadtwerke Dresden GmbH
- IBM Deutshcland GmbH– CORE data handler
- Power PLUS Communications AG – PLC Communication System
- Papendorf Software Engineering GmbH
- University of Duisburg-Essen

Skegness & Fens Registered Power Zone, Central Networks, United Kingdom

Central Networks, a UK Distribution Network Operator, developed an innovative way to allow the connection of new generation assets without exceeding existing network capacity. This project was supported through the UK energy regulator, Ofgem, under their Registered Power Zone (RPZ) incentives (see Appendix C – Regulation). Under the incentive scheme the project was considered to meet the novel system operation/control criteria and included active export control, real time load measurement and dynamic circuit ratings.

The amount of renewable generation that was requesting connection in a particular Skegness & Fens network area exceeded the capacity of the two existing 132kV (227MW) circuits. There was 191MW of existing wind generation in the area and a further 77.5MW of formal requests for connection. The Central Networks RPZ application for this area proposed the development of a control system that maximised the output of generation without exceeding the circuit ratings.

Central Networks developed novel software that extended the functionality of their existing ENMAC system. The scheme uses real time measurement of current and voltage in all circuit elements to action generation groups according to predefined thresholds. The system also uses real time ambient temperature and load readings to determine the dynamic circuit ratings and hence the available generation capacity (dynamic circuit rating minus the current load).

The cost of this solution was much less than the cost of the alternatives, re-conductoring the existing circuits or establishing a new circuit.

ADDRESS, Europe

The project title “ADDRESS”, represents an **A**ctive **D**istribution network with full integration of **D**emand and distributed energy **RES**ource**S**. The project aims to enable active demand by developing technical solutions at the consumer and power system levels along with proposing recommendations and solutions to remove potential barriers. A key aspect of the project is to understand and develop the interactions between key components:

- Consumers
- Energy Aggregators
- Markets & Contracts
- DSOs
- TSOs
- Centralised Generation
- Ancillary & Balancing Services
- Distributed Generation
- Renewable Energy Sources
- Retailers
- Traders

The project is an Energy related Seventh Framework Programme (FP7) under the "Development of interactive distribution networks". The project involves a consortium of 25 partners from 11 European countries:

- Research: University of Manchester, Universidad Pontificia Comillas, Università di Siena, Università di Cassino, ENEL Produzione, VTT, VITO, Fundación Labein, KEMA, Consentec;
- DSO and TSO: ENEL Distribuzione, EDF Energy, Iberdrola Distribución Eléctrica, Vattenfall
- Energy supply and retail: EDF-SA, ENEL Distributie Dobrogea
- Electric equipment manufacturers: ABB, Landis+Gyr, ZIV
- Home appliances and white goods manufacturers, consultants: Philips, Electrolux, RLtec
- Communication and ICT providers: Ericsson España, Alcatel, Current

This project was recently covered in the ENARD Annex I Workshop on "Communications & Control" and further information is available from the Workshop proceedings.

Cell Controller Pilot, Energinet.dk, Denmark

The Cell Controller Project was developed to help tackle the issue of controlling a network with 25% variable energy sources, as is present in Denmark. The project uses layered control hierarchy and distributed agent technology which allows parts of the network to be treated as a single entity or a "virtual generator". The layered control hierarchy consists of :

- Level 0 – Units (Generators, Wind turbines etc)
- Level 1 – Assets (with multiple subordinate Units)
- Level 2 – 60/10kV stations (with multiple subordinate Assets)
- Level 3 – 150/60kV stations (with multiple subordinate 60/10kV stations)
- Level 4 – Distribution Company / DSO (with multiple subordinate 150/60kV stations)
- Level 5 – Energetik.dk / TSO (with multiple DSO)

The project has just completed the first phase of three. The first phase demonstrated Level 3 control of a virtual power plant consisting of various distributed generators and two 60/10kV substations. The project also successfully demonstrated islanded operation through the use of synchronous condensers and secondary load controllers.

This project was also covered in the ENARD Annex I Workshop on "Communications & Control" and again further information is available from the Workshop proceedings and associated presentations.

FENIX, Iberdrola, Europe

The FENIX project represents **F**lexible **E**nergy **N**etworks that **I**ntegrate the e**X**pected 'energy evolution'. This FENIX concept was developed to aid with the integration of distributed energy resources (DER). The approach involves aggregating DER to create both technical and commercial virtual power plants (TVPP & CVPP). The four major objectives of the project are:

- analysis and characterisation of the capabilities of distributed generators and loads and associated aggregation aspects;
- development of economic and regulatory framework and complementary business models;
- development of Information and Communications Technology (ICT) architectures; and
- demonstrations of the FENIX concept in practice.

The project was coordinated by Iberdrola and included a range of stakeholders including other utilities, manufacturers and universities. The project partners are:-

- Areva T&D Energy Management Europe
- ECRO SRL
- EDF Energy Networks
- Electricité de France
- Energy Research Centre of the Netherlands
- Fundación Labein
- Gamesa
- Groupment pour inventer la distribution électrique de l´avenir
- Iberdrola SA
- Imperial College London
- Institut für Solare Energieversorgungstechnik
- Verein an der Universität Kassel e.V.
- Korona Inzeniring DD
- National Grid Transco
- Poyry Consulting Ltd
- Red Eléctrica de España SA
- ScalAgent Distributed Technologies
- SIEMENS Aktiengesellschaft Öst
- The University of Manchester
- Vrije universiteit Amsterdam
- ZIV PmasC SL

FENIX is a sponsored by the European Sixth Framework Programme (FP6) under "New technologies for energy carriers – Electricity". Through FP6 the FENIX project has funding of up to € 7.8 million.

This project was also covered in the ENARD Annex I Workshop on "Intelligent Distribution Networks, micro-Grids and Active Network Management" and again further information is available from the Workshop proceedings and associated presentations.

Automatic Meter Management Technologies

SmartMeter, Pacific Gas & Electric (PG&E), United States

The SmartMeter project in Pacific Gas and Electric began in 2006 and the objective is to replace all existing meters with SmartMeters by the end of 2011. PG&E is currently deemed to have the largest rollout of smart meters than any other utility in the US, with approximately 2.3 million electricity and gas meters installed by April 2009[23]. By the completion of this project, this figure will grow to approximately 9.8 million meters comprising approximately 5.3 million electricity meters and 4.5 million gas meters.

Initially the installed smart meters used a combination of both Radio Mesh and Power-line carrier for communications. However, the preference going forward is to communicate via two-way Radio Mesh communications network. The SmartMeters record electricity consumption in hourly intervals and then transmit this data to PG&E. The data is sent to access points via a mesh network consisting of repeaters and other meters. The data is aggregated and encrypted at the access point and sent back to PG&Es head-end system via a commercial third party secure cellular network. The meters can be remotely upgraded if further functionality is required in future.

Project Stakholders include:

- Landis+Gyr - next generation FOCUS™ advanced metering infrastructure (AMI)
- General Electric – Meters
- Silver Spring Networks – communication cards in meters and radio infrastructure.

Telegestore, ENEL, Italy

The Telegestore project is one of the largest implementations of Active Meter Management n the world and is fully operational on over 30 million customers throughout Italy. Telegestore was implemented by Italy's largest power company, ENEL, who is involved with generation, transmission, distribution and supply.

The Smart Meters communicate via Power-line Carrier to data concentrators situated on MV/LV transformers. These concentrators then communicate with a central control centre via GSM/GPRS or PSTN or Satellite TCP/IP. The central AMM system gathers data from the concentrators and manages the overall system.

The major benefits of the Telegestore rollout were described as:

- Invoices on Real Consumption
- Remote Contract Management
- Tailored Tariffs
- Savings in Billing
- Pre-payment of accounts
- Easier free market development and management
- Peak shaving
- Energy efficiency and CO_2 reduction
- Reduction of commercial and technical losses

This project was recently covered in the ENARD Annex I Workshop on "Communications & Control" and further information is available from the Workshop proceedings and associated presentations.

[23] http://www.pge.com/about/news/mediarelations/newsreleases/q2_2009/090414.shtml

The South Bend Pilot, American Electric Power (AEP), United States

Toward the end of 2008, AEP began the rollout of their gridSMART technology to around 10,000 of the customers in South Bend, Indiana. The gridSMART project is aimed at:

- Reducing energy losses in distribution equipment
- lowering operating costs
- providing new services to customers
- allow customers to have more control over energy consumption and associated costs

The pilot aims to modify consumer energy consumption patterns by providing time-of-day rates. The participants are able to view their consumption history via AEP's website. 500 customers have also allowed AEP to control central cooling systems during summer periods via adjusting the thermostat. Finally, the enhanced loading information and extensive communications infrastructure will allow AEP to install and test out new equipment on the distribution grid.

The experiment cost approximately $ 7 million and was approved by the regulator, Indiana Utility Regulatory Commission. The South Bend pilot is the first stage in a planned rollout of smart meters to AEP's entire service area, approximately 5 million metering points. The trial will provide information on the costs/benefits of large scale roll-out, which will support the case to attain regulatory approval for cost recovery.

Smart Meter Rollout, CitiPower & Powercor, Australia

The Victorian Government is the first State in Australia to mandate the rollout of Smart Meters. CitiPower and Powercor operate separate electricity distribution networks in Victoria but share the same owners and together represent over 40% of the network in the state. In early June 2009, CitiPower and Powercor announced their plans for a rollout of smart meters to all customers, over 1.1 million meters. The planned 4-year rollout is due to begin in late 2009 and is intended to be complete by 2013.

The smart meters will record energy consumption in half-hourly intervals. The data will be sent via wireless radio mesh networks to the respective DNOs. The data will be processed by the DNOs and forwarded on to retailers. The new metering package will include an in-home display to to provide real-time energy consumption and price information. It is also planned to introduce time-of-use tariffs in 2010.

The new meters will be owned, operated and maintained by the distribution network operators. The cost of the meter rollout will be recovered on behalf of the DNOs through electricity bills and will be spread over a 15 year period.

Project Stakeholders include:

- CitiPower & Powercor Australia – DNOs
- Landis + Gyr – Smart Meters and Meter Management Software
- PRI – Smart Meters
- Silver Springs Networks – Communications Infrastructure & Devices, Software for Integration into DNO systems

Smart Meter Rollout, Toronto Hydro Electric System Limited & Hydro One, Canada

The Smart Meter rollout in Ontario is driven largely by the ageing infrastructure, with the majority of the current infrastructure to be replaced by 2025. This includes the replacement of approximately 80% of the current generation assets due to both asset retirement and additional capacity requirements. To help address this challenge, Toronto Hydro & Hydro One are aiming to encourage more efficient energy consumption and a reduction of total energy consumption. To achieve these changes in consumer behaviour, a large scale rollout of smart meters has been implemented along with proposed time-of-use (TOU) tariffs.

The meters record energy consumption on an hourly basis. The meter then communicates to meter data collectors either by public networks, wireless mesh radio or the Internet. These data collectors provide the information to network operational systems. The operational systems interface with a consumer web portal along with customer information & billing systems. The Ontario Government's current plan is to have a centrally located meter data repository, which will also interface with operational systems.

By the end of May 2009, Toronto Hydro had successfully installed over 600,000 meters. The aim of the project is to have smart meters installed in all homes and businesses by the end of 2010. By the end of May 2009, Hydro One had installed close to 900,000 meters and also plan to have all meters for all customers (approximately 1.2 million meters) by 2010.

Project Stakeholders include:

- Toronto Hydro Electric System Limited
- Hydro One
- powerWISE

Other Smart Grid Technologies

Energy Storage System Program, Department of Energy (DOE), United States

The Energy Storage Systems (ESS) Research Program is run by Sandia National Laboratories[24] and is part of the Office of Electricity Delivery and Energy Reliability (OE) at DOE. The ESS program is long standing and has a number of projects currently underway[25]. One project involving flywheel technology is discussed later in this section. The Program involves collaboration with industry and government bodies, and currently has a string of projects through two major collaborative efforts:

- Californian Energy Commission (CEC) / DOE Collaboration on Energy Storage
- New York State Energy Research and Development Authority (NYSERDA) / DOE Joint Energy Storage Initiative

The ESS program is aimed at developing advanced energy storage technologies and systems to increase the reliability, performance and competitiveness of electric generation, transmission and use in utility tied and off-grid systems.

[24] http://www.sandia.gov/ess/index.html
[25] http://www.sandia.gov/ess/About/docs/fy09qu2_ext.pdf

HVDC Light, ABB

HVDC (High Voltage Direct Current) Light was introduced by ABB in 1997 and is an example of existing technology rebadged as Smart Grid technology. A key characteristic of HVDC Light is its ability to stabilise the AC voltage at its terminals which makes it ideal for the connection of volatile generation sources such as wind. Furthermore, this technology is more cost-effective for long distance connections, which makes it a particularly attractive for the connection of offshore Wind Farms. HVDC Light systems also claim to have reduced impacts on the environment due to neutral electromagnetic fields, use of oil-free underground cables and compact converter stations.

The HVDC Light technology is currently in commercial applications at a number of sites around the world, including:

- Long underground cable link (70 km Gotland HVDC Light) from a wind park ("Gotlight", Sweden)
- Nord E.ON 1 (128km submarine, 75km underground cable) from offshore wind park (due to commence operations in late 2009)
- Long underground cable links (59 km Terranora interconnector & 180 km Murraylink) between different grids (Australia)
- Undersea cable link (40 km Cross Sound Cable) to Long Island (NY, USA)
- Long undersea cable link (70 km Troll A) to feed power to an offshore gas production platform (Norway)
- Interconnection of different grids (Eagle Pass)(USA)

Smart-A, Smart Residential Appliances, Europe

The Smart-A project is aimed at identifying any potential benefits that might be gained from the coordination of smart appliances and generation at both a local and network level. The project is broken down into various work packages:

- Synergy Potential of Smart Appliances
- Local Energy generation Networks
- Energy Networks
- Consumer Acceptance
- Overall Potential
- Strategies

The project is supported under the European Commissions "Intelligent Energy - Europe" programme.

Grid Friendly Appliance (GFA) Project, Pacific Northwest National Laboratory, United States

The Grid Friendly Appliance (GFA) Project[26] was one of two major projects carried out under the Pacific Northwest GridWise Testbed Demonstration projects[27]. The other part of this project was the Olympic Peninsula Project Demand Response demonstration. The GFA controller developed by PNNL was central to the demonstration project, allowing household appliance loads to be adjusted in response to system underfrequency events.

The project involved:

[26] http://gridwise.pnl.gov/docs/gfa_project_final_report_pnnl17079.pdf
[27] These projects were noted in a presentation at the ENARD Annex I Workshop on "Intelligent Distribution Networks, micro-Grids and Active Network Management".

- 50 residential hot water systems
- 150 clothes dryers
- GFA Controller
- Load Control Module
- Invensys GoodWatts System (energy management system)
- Invensys GoodWatts Home Gateway

The project was run in residential premises in three separate areas for one year. The project demonstrated that the GFA controller could respond reliably over a large geographical area and was practically unnoticeable to the appliance owners. The results showed that the GFA controller could shed between 5 and 35 kW of load from 50 residential hot water systems and between 3 and 30 kW from the 150 clothes dryers.

Sodium Sulphur (NaS) Batteries, NGK, Japan & United States

NGK has developed large scale battery systems for application in electricity distribution networks. The Battery systems use stationary sodium sulphur (NaS) technology which is co-developed by Tokyo Electric Power Company. The battery systems have been installed both in Japan and around the world and are predominantly used for renewable integration projects.
The largest installation is currently with Japan where the batteries are used predominately to support the integration of Wind generation. The system consists of 34MW of installed NAS batteries alongside a 51 MW Japan Wind Development Company Ltd wind farm installation. The system was designed to predict wind generation 48 hours in advance but current predictions only allow 10MW of capacity to be utilised.

A 1.5 MW NaS installation has also been used alongside a 5 MW PV Solar Array in Japan. The batteries are installed as part of the Wakkanai Mega-Solar Project in Hakkaido which is supported by the New Energy and Industrial Technology Development Organisation (NEDO) program. The system has been designed to help smooth the variable output provided by the PV array.

In 2006, American Electric Power was one of the first utilities to install large scale (MW) battery storage systems into their electricity distribution grid. In 2007, AEP ordered a further three 2MW battery systems which represent the first of many installations of their plan to have 1GW of storage capacity installed by 2020. The 2MW installations are intended to both defer capital investment by 2-3 years and also provide up to 2 hours of dynamic islanded operation.

In 2008, Xcel Energy also ordered a 1 MW NaS battery system for use in their “Wind-to-Battery” project[28] which is one of the projects associated with their SmartGridCity project (see Section on Smart City Trials). The project was planned to assess the ability of large-scale storage to provide spinning reserve and spinning frequency response, compensate for variable wind output and store off peak surplus generation for provision during peak periods. The project uses the Gridpoint platform for system integration, remote control and data access. The battery system is connected to an 11MW windfarm owned by Minwind Energy LLC and is the first large scale installation in the US to be used for direct wind energy storage. The project is partially funded through Minnesota’s Renewable Development Fund with a grant of $ 1 million.

[28] http://www.xcelenergy.com/SiteCollectionDocuments/docs/wind-to-battery.pdf

Flywheel Storage, Beacon Power Corporation, United States

Beacon Power Corporation have developed flywheel based energy storage technology for use predominantly for frequency regulation. The technology was developed in conjunction with the US DOE, California Energy Commission (CEC), the New York State Energy Research and Development Authority (NYSERDA) and some Independent System Operators (ISOs).

According to a report[29] by Pacific Northwest National Laboratory (PNNL) the fast response flywheel-based regulation is much more effective at regulating frequency than the traditional slow response regulation. Another report[30] by KEMA suggests that the flywheels produce around 50% less CO_2 emissions than traditional gas fired regulation plants and up to 85% less than coal fired regulation plants. The combination of these two characteristics makes flywheel storage an attractive technology for reducing emissions, especially when used to regulate renewable energy sources.

In July 2009, the US DOE announced[31] that it would provide a conditional loan guarantee for $ 43 million (over 60% of estimated total project cost) to help Beacon Power with the development of a flywheel storage plant in Stephenton, New York. The conditional loan was provided under the 'Energy Efficiency and Reliability' category of the US DOE Loan Guarantee Program (see 5.1). The 20MW plant will consist of 200 flywheels along with control and communications equipment.

The SmartGrid Project, Electricité Réseau Distribution France (ERDF), France

The ERDF Smartgrid Project aims at improving Distribution Operation, Control and Development using AMM Data and Infrastructure.

A first set of functionalities will be tested alongside the *Linky Project;* the *Linky Project* is a 300 000 AMM pilot project ERDF deploys in Lyon and Tours in 2010.

This experiment is due to assess new technical solutions and their value for the distribution network.

The *Linky* communication infrastructure will enable to connect new MV/LV substation equipments, such as switches, fault passage indicators, sensors to the control centres, allowing to reduce supply restoration times and to enhance monitoring and control.

<u>A communication challenge</u>:

The MV/LV substation is expected to become a communication node with a major issue to address regarding interoperability and scalability: the new IEC standards (61850, CIM, …) now developed in primary substations will be used.

<u>LV Supervision</u>:

Regarding LV supervision, it will be possible to be informed of outages seen by the meters. The customer call centre will be able to ping the meter of any customer and detect if the fault in on the network or in the private installation.

[29] http://www.beaconpower.com/files/PNNL.pdf
[30] http://www.beaconpower.com/files/KEMA_Report.pdf
[31] http://www.lgprogram.energy.gov/press/070209.pdf

Network Optimisation:

The *Linky* load curves will open new applications for network optimization, reinforcement and development: the improved load models and the knowledge of singe-phase customer phases will allow to optimize phase connections, and therefore losses and voltage drops, to evaluate the network load and generation hosting capacity on any LV node and to optimize reinforcement investments by focusing the capital expenditure on the adequate networks.

Network Operation:

Existing measurements (mainly on HV/MV substations) are not sufficient to obtain real-time observability of the network and its users (loads and distributed generation). New measurements are needed, and can be provided by new field sensors connected through the *Linky* communication infrastructure and by real-time measurements given by *Linky* meters. State estimation is needed to feed advanced automation functions (optimal reconfiguration, Volt/VAR Control, situation awareness). Situation Awareness techniques based on state estimation will help the Network Operator to cope with critical situations or anticipate them, by providing him an advanced monitoring of the network, short term anticipation, and calculating robust restoration solutions (both real-time and short term).

Asset management:

Asset knowledge is presently mostly based on known past conditions. The *Linky* data and data uploaded from sensors and fault detectors will be used to enhance present asset conditions knowledge and to forecast future conditions. This will enable to elaborate failure rates, life-time forecast, leading to a prior knowledge of assets. This will eventually lead to new functionalities:

- Optimise maintenance by moving from planned preventive maintenance to targeted maintenance
- Optimise operation knowing network condition

Smart City Trials

Energy Smart Miami, Florida Power & Light (FPL), United States

The Energy Smart Miami project is a $ 200 million project aimed at developing Miami's Smart Grid. The project was developed on the back of the recent American Recovery and Reinvestment Act (ARRA) which provides federal matching grants for advanced electrical infrastructure and related initiatives that target energy efficient, energy reliability and renewable energy.

The project represents a holistic approach to modernising the electricity grid and encompasses a wide range of technologies and applications:

- Smart Grid Automation and Communications
- Smart Meters
- Renewable Energy Integration – Several Universities and schools to be fitted with solar panels to meet local demand with some complemented with energy storage devices (batteries).
- Plug-in Hybrid Electric Vehicles (PHEVs) – 300 vehicles added to FPL fleet
- Consumer Technology Trials

- In home energy display (eco panel)
- Smart appliances
- Programmable and Smart meter controllable thermostats
- Demand Management and Demand Response software to manage appliances, lighting and other devices through Smart meter

The project is backed by local government and energy industry representatives including:

- The City of Miami
- Florida Light & Power (FPL) – DNO
- General Electric (GE)
- CISCO
- Silver Spring Networks

Drivers:

- consumer $ savings through choice over consumption and conservation of energy
- longer-term addressing climate change
- near-term generation of “green collar” jobs

SmartGridCity, Xcel Energy, United States

The SmartGridCity project in Boulder Colorado is another ambitious project looking to implement multiple “SmartGrid” technologies over a three phased project:

- Phase 1: Quick-hit projects (March 2008 – August 2008)
- Phase 2: Smart Grid City (September 2008 – December 2009)
- Phase 3: Xcel-wide deployment of proven technologies.

Phase 1 is aimed at developing and demonstrating the core benefits for each section of the value chain. Seven key projects were developed involving some of the key Smart Grid Technologies:

- Wind Power Storage – a 1MW battery connected to a wind farm
- Neural Networks – State of the art system that helps reduce coal slagging and fouling in boilers.
- Smart Substation – retrofitting existing substations with cutting-edge technology for remote monitoring of critical and non-critical operating data (such as breakers, TXs, batteries, ambient temperature, wind speeds, security video etc.). Includes developing analytical engines to process significant amounts of data for real-time decision making.
- Smart Distribution Assets – Testing existing meter communication equipment that can automatically contact Xcel energy to reduce outage duration.
- Smart Outage Management – Test diagnostic software that uses various statistics such as maintenance history and real-time weather condition to predict network problems. This would increase response time and allow for dispatch of more appropriate skilled/equipped field crews.
- Plug-in Hybrid Electric Vehicles (PHEVs) – Team equipped with 6 Ford Escape Hybrids with Vehicle-to-grid technology to allow charging and discharging energy to the grid.
- Consumer Web Portal – allow customers to program or pre-set energy use limits (against both energy costs and environmental factors) and automatically control power consumption.

This initial phase involves full system automation, monitoring and smart meters for the initial test group of two substations, five feeders and nearly 15,000 meters (residential, commercial and light industrial customers). Phase 2 involves extending the installation of the Smart Grid to an additional two substations, 20 feeders and 35,000 premises. The final phase will be full scale deployment of the demonstrated technologies to the remaining Xcel Energy network.

The Xcel Smart Grid Consortium currently consists of:

- Accenture – Project managing the integration and management of data flow. Integration of systems such as diagnostic software, intelligent distribution assets and outage management software into Xcels existing IT infrastructure.
- Current Group – Advanced Metering Solutions – use of CURRENT Smart Grid solution to provide advanced metering, two-way communications, 24/7 monitoring and enterprise analysis software. Also provides consumers with information and control over their energy usage and enables deployment of renewable energy sources.
- GridPoint – Smart Grid Platform Developer – use of platform to develop an intelligent network of distributed energy resources that controls load, stores energy and produces power.
- Schweitzer Engineering Laboratories (SEL) – Protection, Monitoring, Control, Automation and Metering for Power Systems - focus on smart substation effort.
- Ventyx – Software Provider - Work management solutions for deploying Smart Grid technologies, management of any work/service requests triggered by the smart gird, planning/analytics for relating customer actions to trading and investment decisions in real-time.

Drivers:
- deliver reliable energy
- whilst, finding more environmentally friendly ways to meet growing customer demand

Perceived benefits
- Positive environmental impact
- Customer choice from products to services
- Enhanced system reliability
- Increased efficiency of power delivery
- Extended asset life

Masdar City, Masdar Future Energy Company, United Arab Emirates

Masdar City aims to be the first carbon-neutral and zero-waste city. The project is one of a suite of projects within the Masdar Initiative which aims to help tackle energy security and climate change whilst developing expertise in the area of sustainability.

The developers of Masdar intend to use Smart Grid technologies to:

- Control supply and demand (distributed generation, time of use tarrifs)
- Ensure the safety of utility staff
- Integrate with local electricity grid (4 micro grids to be implemented separately with each project phase)
- Foster implementation of Smart Building technologies/applications

To achieve the carbon-neutral target, the city hopes to use a combination of renewable energy sources and best practice energy efficiency measures.

A planned 220MW of renewable energy sources will be predominantly made up of 200MW of PV in the form of both concentrated thermal/electricity plants and a more extensively, rooftop panels. It is also planned to use PV to supply the base load during the construction phase. The Project will be constructed in 4 stages and each stage will establish its own standalone grid or “micro-grid”. Each “micro-grid” will be able to be connect with each other and the existing local distribution network. Excess capacity during the day will be stored for use at night, with any additional capacity exported to the main grid.

Intelligent Cities Framework ‘Smart Cities’, Alliander, Netherlands

The local municipal government in Amsterdam developed the Amsterdam Smart City to ultimately at reduce the city’s carbon footprint in line EU carbon emission reduction targets. The City of Amsterdam hopes to achieve this through the development of a series of economically viable and sustainable projects aimed at reducing energy consumption in commercial/residential properties, public buildings/areas and transportation. There are 70 pilots planned, with 25 planned for 2009/10.

The project plans to use the following technologies to help reduce consumption:

- smart meters
- smart electricity grids
- smart building technologies
- electric vehicles

Included in one of the projects are 700 houses equipped with new smart systems including PV, electricity sharing and storage. 500 of these houses will also be equipped with in home displays to help consumers understand and manage their energy consumption. Another project “ship-to-grid” involves the electrification of marine transportation. It is planned to connect commercial vessels, barges and river cruisers to the electricity grid while docked.

The Project Stakeholders include:

- The City of Amsterdam
- Accenture

Accenture is working together with Amsterdam Innovative Motor[32] (AIM) which is a cooperation between universities, companies and municipalities. AIM invests in all stages of the innovation process, providing support for new activities in a range of areas, including ICT.

[32] http://www.aimsterdam.nl/amsterdam-innovation-motor-2#

Appendix B – Business Models

Business Models Employed to Date (eg. to promote R & D, trials, etc.)

SmartGridCity, Xcel Energy, United States

Xcel Energy's has used its Utility Innovations funding model to fund their SmartGridCity project. The model requires either full or partial funding from investment partners, who are then entitled to any intellectual property, products and or services arising from the project. Xcel plan to invest $ 15 million in the SmartGridCity and are hoping for six to seven major strategic investment partners. Together with other minor investors, the total investment is expected to be approximately $ 100 million.

Xcel does not intend to recover their initial investment but aim to work with regulators to develop frameworks for recovery of future expenditure. A primary objective for the SmartGridCity is to demonstrate the benefits particularly related to grid optimisation and reducing environmental impact. It is anticipated that the demonstration of these benefits will support the construction of firm business cases and the education of regulators and legislators.

Impacts of Smart Metering / Demand Response Management in Spain

In 2007 the Spanish Government mandated the rollout of Smart Meters to all customers in Spain. In response to this, UNION FENOSA developed a business plan which included a 13 year rollout and an expected meter life of approximately 15 years. In the initial financial model, the costs of rollout were only balanced against income from meter renting, for which the price was fixed by law. As a result the initial business model provided only for income of €777 million in return for an investment of €764 million i.e. an IRR of 0.67%. As the meter renting income is fixed by law, UNION FENOSA had to find a way to reduce the investment costs. UNION FENOSA, Iberdrola and EDP/Hidrocantábrico have combined efforts to agree on a common meter specification that helps reduce investment costs through both standardisation and increased meter functionality (i.e. increased applications/benefits).

Smart Metering in California

Another presentation given in GridWeek 2008[33] summarised California's commitment to the Smart Grid. The two major regulatory bodies in California, the California Public Utilities Commission (CPUC) and the California Energy Commission (CEC) were noted to have recently launched key Smart Grid initiatives. The initiatives were established to help develop a state-wide Smart Grid vision and facilitate compliance to recent federal laws and potential state laws.

It was also highlighted that California had launched a statewide rollout of smart meters for customers and a summary of the associated costs was provided.

[33] http://www.pointview.com/data/2008/09/24/pdf/Dian-Grueneich-3491.pdf

	Pacific Gas & Electric	San Diego Gas & Electric	Southern California Edison
Number of Electric Meters	5.1 Million	1.4 Million	5.3 Million
Number of Gas Meters	4.2 Million	0.9 Million	Gas Utility may connect to AMI
Costs Approved	$ 1.7 Billion (July 2006)	$ 0.6 Billion (April 2007)	$ 1.7 Billion
Costs Pending Approval	$ 0.68 Billion to upgrade		
Deployment Schedule	2006 to 2012	2008 to 2011	2009 to 2012

A separate report[34] prepared for the CEC in 2007 discusses the projected AMI deployment benefits for each utility. These benefits are shown below:

	PG&E		SDGE&E		SCE	
Benefit Type	Benefit ($ Million)	% of Cost	Benefit ($ Million)	% of Cost	Benefit ($ Million)	% of Cost
Meter Reading O&M	1074	48%	455	72%	271	21%
Labor Overhead	221	10%				
Meter Operations	103	5%			4	0%
Meter Capital			8	1%	118	9%
Meter Reading	1,399	62%	463	73%	393	30%
Billing	215	10%	188		21	2%
T & D	189	8%	32	5%		
Service Start & Stops	102	5%			29	2%
Call Center Savings	40	2%			3	0%
Customer and Field Service	142	6%			32	2%
Demand Response	448	20%	351	55%	370	29%

Business Models for the Future, for Rollout and Concepts

Intelligent Energy Systems, Federal Energy Regulatory Commission (FERC), GridWeek 2008

The Commissioner for FERC, gave a presentation at GridWeek 2008 on Intelligent Energy Systems and the Road to enhancing Energy Productivity[35]. The presentation highlighted the cost/benefit business cases as being one of the major barriers and/or challenges facing the implementation of Intelligent Energy Systems. Nationwide estimates of potential costs and benefits were also presented.

[34] http://www.energy.ca.gov/2007publications/CEC-500-2007-028/CEC-500-2007-028.PDF
[35] http://www.pointview.com/data/2008/09/24/pdf/Jon-Wellinghoff-3396.pdf

Target Sector Costs	10-Year Investment Level ($B)
Residential	7-10
Commercial	13-20
Network Infrastructure	25-30
Total	45-60

Sources of Benefits	Potential Benefits/Year ($B, by 2015)
"Smarting up" of customer premises (smart homes, intelligent buildings)	6-8
Enabling of Demand Response and IMI deployment	5-8
Investments in Intelligent grid technologies	2-3
DG, interactive storage technologies and mircrogrids	1-2
Total/year	14-21

It was highlighted that these figures represented a relatively short pay back period and that this positive investment should be embraced by regulators and consumers. The presented benefits were viewed as conservative estimates with the real savings likely to be higher as consumers developed more awareness and control of energy usage. It was noted that the accuracy of total costs was unclear however, initial indications were that technology costs were reducing rapidly and that would result in lower actual costs.

Impacts of Demand Response in Europe

One of the presentations given in GridWeek 2008[36], outlined some of the potential benefits of Demand Response in Europe. The impacts are based on two growth scenarios and give the benefits in terms of both contribution to EU 2020 Targets and in terms of avoided investment.

	Moderate Scenario	Dynamic Scenario	Impacts on EU 2020 Targets
Energy Saving	59 TWh	202 TWh	50%
Reduction on CO2	30 Mt	100 Mt	25%
Peak Generation Capacity avoided	28 GW	72 GW	-
Avoided Investment	€ 20 billion	€ 50 billion	-

Modern Grid Benefits in North America

A report[37] by the Modern Grid Initiative outlined some of the potential benefits that may come from modernisation of the electricity grid in North America. The report quoted EPRI findings that the modernisation of the grid would cost around $165 billion but had the potential to return benefits at $ 638 to 802 billion. The report discusses a range of benefits falling under the following categories:

- Reliability
- Security and safety
- Economics
- Efficiency
- Environment

Some of the quantified societal benefits are shown below:

Category	Societal Benefit
T&D losses	$ 25 Billion
Congestion	$ 5 Billion
Energy inefficiency	$ 36 Billion
Unreliability/PQ	$ 100 Billion
T&D O&M	$ 40 Billion
Total	$ 206 Billion

The report also quotes some findings from a PNNL study into Grid Friendly Appliances (GFAs). The PNNL study found that the use of GFAs could significantly reduce the required electricity infrastructure upgrades. The calculated NPV benefits over 20 years are presented below:

Category	NPV Benefit of reduced Infrastructure Expenditure
Generation	$19 -$49 Billion
Transmission	$5 -$12 Billion
Distribution	$22 -$56 Billion
Total	$46 -$117 Billion

[36] http://www.pointview.com/data/2008/09/24/pdf/Spero-Mensah-3535.pdf
[37] http://www.netl.doe.gov/moderngrid/docs/Modern%20Grid%20Benefits_Final_v1_0.pdf

Appendix C – Regulation

American Recovery and Reinvestment Act (ARRA), United States

The American Recovery and Reinvestment Act (ARRA) was developed as part of the US Government's response to the global economic crisis. The Act was established to stimulate the economy, save/create new jobs and to progress solutions for long term challenges. One of the more recent challenges to be acknowledged under the Act is the modernisation of the electricity grid.

The ARRA has made $ 3.9 billion available to develop Smart Grid technologies and electricity infrastructure. Approximately $ 3.3 billion will be provided in the form of federal matched grants which can be accessed to help cover costs associated with manufacturing, purchasing and installation of existing Smart Grid technologies. The remaining $ 600 million is available for projects which demonstrate how emerging technologies can be deployed in an innovative and economic manner.

The Energy Smart Miami project was one of the first large scale Smart Grid projects to propose using the ARRA federal stimulus funding to support their initial $ 200 million investment in Smart Grid technology. The project proposal was developed to meet the criteria for matched funding grants.

Loan Guarantee Program, Department of Energy (DOE), United States

Title XVII of the US Energy Policy Act of 2005 authorised the US DOE to provide guaranteed loans for projects that:

"avoid, reduce, or sequester air pollutants or anthropogenic emissions of greenhouse gases; and employ new or significantly improved technologies as compared to commercial technologies in service in the U.S. at the time the issuance is guaranteed."

With this authorisation, the US DOE established the Loan Guarantee Program[38] to help accelerate the commercial use of qualifying technologies. The first round of loan applications accepted projects that fell into the following technology categories:

- Biomass
- Hydrogen
- Solar
- Wind and Hydropower
- Advanced Fossil Energy Coal
- Carbon Sequestration practices and technologies
- Electricity Delivery and Energy Reliability
- Alternative Fuel Vehicles
- Industry Energy Efficiency Projects
- Pollution Control Equipment

The Loan guarantees will be supported through the ARRA.

[38] http://www.lgprogram.energy.gov/

E-Energy: ICT-based Energy System of the Future, Federal Ministry of Economics and Technology, Germany

E-Energy is a Technology Competition that is run by the Federal Ministry of Economics and Technology in Germany. The project was regarded as part of the German government's High-Tech Strategy and the "Information Society Germany 2010" programme and followed on from a study by the Ministry of Economics entitled "Potentials of Information and Communication Technologies to Optimise Energy Supply and Consumption".

The project was advertised in April 2007 and called for projects that showed how the ICT could be leveraged in the electricity supply industry to achieve:

- Environmental and climate compatibility
- Economic viability
- Security of Supply

In 2008, an independent panel selected six winning research projects from a total of 28 submitted proposals. The winners were given access to government funding from an inter-minesterial partnership between the Ministry of Environment, Nature Conservation and Nuclear Safety (BMU). The Ministry of Economics and Technology would provide € 40 million to be split between four of the projects, with the other two funded by the BMU.

National Energy Efficiency Initiative (NEEI), Federal Government, Australia

In May 2009, the Australian government announced a new National Energy Efficiency Initiative[39] which together with other initiatives will help Australia to reduce carbon emissions. The initiative provides AUD 100 million dollars to develop smarter, more efficient networks through the use of new technologies. The funding will be used to perform an implementation study followed by a demonstration project. The initiative will have close links with the planned National Broadband Rollout and the advisors for the National smart metering program.

European Energy Program for Recovery (EEPR), European Commission, Europe

The European Commission has recently called for proposals to be submitted under the European Energy Program for Recovery (EEPR)[40]. The program was established to provide financial support for projects in the energy area which would aid in economic recovery, lower carbon emissions and help to provide a secure energy supply. The program has offers support for three classes of project:

- Electricity & Gas Infrastructure (Interconnections) - € 2,365 million
- Offshore Wind Electricity (OWE) - € 565 million
- Carbon Capture and Storage (CCS) - € 1,050 million

The major priorities for the program are the infrastructure projects with a focus on particular interconnections and storage infrastructure. The OWE funding will be available to support the connection of particular wind farm energy systems. These projects will need to provide a range of innovative solutions including new technologies, installation, operation and maintenance practices. The CCS projects will support the development of various CCS sites throughout Europe.

[39] http://www.environment.gov.au/minister/garrett/2009/pubs/budmr20090512h.pdf
[40] http://ec.europa.eu/energy/grants/docs/eepr/eepr_call_for_proposals.pdf

Energy Technologies Institute (ETI) & Research Councils, National Government, United Kingdom

In July 2009, the Department of Energy and Climate Change (DECC) released the UK Low Carbon Transition Plan[4]. The plan details the national strategy for climate and energy and also discusses a suite of initiatives to help achieve emission reduction targets. One of the approaches involves taking action to build a UK Smart Grid. Various Government programmes aimed at develop the Smart Grid are discussed, including:

- Funding for the Energy Technology Institute (ETI)
- Funding for Research Councils

The UK Government aims to provide direct funding for innovation through the ETI. The ETI has recently established a panel whose focus is on networks. The panel is currently scoping the objectives for a range of projects which will be called for in future. Submitted network related projects will have the opportunity to gain access to the £ 1 billion pounds on offer through the ETI. The funding will be provided over a 10 year period and will be available for low carbon energy technologies, including networks.

The UK Government is also funding collaborative research between academia and industry. The funding will be available for projects which will aid the development of key technologies to be described in a "vision" document to be published in future. The research projects will have access to direct funding of up to £ 30 million through the Research Councils. The government will also provide complementary funding for existing network innovation initiatives such as Ofgem's Innovation Funding Incentive discussed below. Up to £ 6 million will be available for complementary funding.

IFI & RPZ, United Kingdom

The Office of Gas and Electricity Markets (Ofgem) is the energy industry regulator for the United Kingdom. As part of the current price control period[41], Ofgem introduced two incentive schemes to encourage innovative development of electricity distribution networks. These two schemes are:

- Innovation Funding Incentive (IFI)
- Registered Power Zones (RPZs)

The IFI allows Distribution Network Operators (DNOs) to recover the costs for projects that pass certain criteria. Essentially, the projects must demonstrate a new innovative approach to any aspect of the asset management activities (design, construction, commissioning, operation, maintenance, decommissioning). The DNOs are allowed funding to cover the costs of approved IFI projects up to a maximum cap of 0.5% of the DNOs regulated revenue (and to be increased in the next 5 year price control regime, commencing April 2010)..

The RPZ scheme is specifically targeted at encouraging new innovative and more cost effective approaches to connecting and operating generators on distribution networks. Approved RPZ projects give the DNO access to an additional incentive of £3/kW/year or up to 5 years after commissioning. The DNOs were able to claim for two RPZ projects per year for the first two years of the price control period and the incentive was capped at GBP 0.5 million per DNO per year.

[41] http://www.ofgem.gov.uk/Networks/ElecDist/PriceCntrls/DPCR4/Documents1/8944-26504.pdf