KEMA

Report.

RPI-X@20: Technological change in electricity and gas networks.

A Sample Survey of International Innovation Projects.

Final Report

London, 9th October 2009

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REVISION HISTORY

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GLOSSARY

AC	Alternating Current
ADA	Advanced Distribution Automation
ADSL	Asymmetric digital subscriber line
AEP	American Electric Power
AMI	Advanced Metering Infrastructure
AMSC	American Superconductor
ANM	Active Distribution Management
AURA - NMS	Automated Regional Active Network Management System
CCS	Carbon Capture and Storage
CCTS	Carbon Capturing, Transport and Storage
CERTS	Consortium for Electric Reliability Technology Solutions
CHP	Combined Heat and Power
ConEd	Consolidated Edison
DC	Direct Current
DCHP	Domestic Combined Heat and Power
DECC	Department of Environment and Climate Change, UK
DER	Distributed Energy Resources
DFIG	Doubly fed induction generators
DG	Distributed Generation
DNO	Distribution Network Operators
DOE	Department of Energy, USA
D-SMES	Distribution - Superconducting Magnetic Energy Storage
DTC	Distribution Transformer Controller
ECN	Energy Research Centre of The Netherlands
EDP	Energias de Portugal
EPRI	Electric Power Research Institute, USA
EPSRC	Engineering and Physical Sciences Research Council, UK
FACTS	Flexible AC Transmission Systems
FENIX	Flexible Electricity Networks to Integrate the Expected ' Energy Evolution'
FPL	Florida Power & Light Company
GE	General Electric
GenAVC	Generator Automatic Voltage Control
HVDC	High Voltage Direct Current
ICCS/NTUA	Institute of Communication and Computer Systems/National Technical University of Athens
ICT	Information and Communication Technologies

IFI	Innovation Funding Incentive (Ofgem GB)
ISO	Independent System Operator
LENS	Long Term Electricity Network Scenarios
LIFO	Last-in-first-off
LSVPP	Large Scale Virtual Power Plant
LTDS	Long Term Development Statement (Ofgem, GB)
LVRT	Low Voltage Ride Through
NECST	Networked Control Systems Tolerant to Faults
NGC	National Grid Company
NGG	National Grid Gas
NNFG	New Non Film Generation
PHEVs	Plug-in Hybrid Electric Vehicles
PNNL	Pacific Northwest National Laboratory
RPZ	Registered Power Zone (Ofgem, GB)
SCADA	Supervisory Control And Data Acquisition
SFCL	Superconducting Fault Current Limiter
SHDSL	Single-Pair High-speed Digital Subscriber Line
SP	Scottish Power
SSE	Scottish and Southern Energy
TRL	Technology Readiness Level
VAR	Volt Ampere Reactive
VPP	Virtual Power Plant
VSC	Voltage-sourced Converters

EXECUTIVE SUMMARY

Background: Effective and efficient innovation on energy networks will be crucial to delivering the needs of multiple stakeholders, including meeting the challenging objectives set by government for sustainability, energy security, and affordability. This report was commissioned by Ofgem, the GB Electricity and Gas Regulator, to review the current international status of innovation on electricity and gas networks, to understand what has encouraged that innovation and how it will bring benefits to customers and wider stakeholders.

Information contained within this report has come from a wide range of national and international sources and can be considered a sample of the types and maturity for leading innovation projects. Results from this global scan are not intended to be exhaustive but rather to provide representative examples of innovation and the business environment that facilitated fresh thinking and project delivery.

Scope: Some 200 innovation projects have been identified from the global scan and passed through a two stage filtering process. This has resulted in a shortlist of some 60 projects judged to be of interest and relevance to the UK context, and from this a subset of 20 case studies that have been analysed in greater detail. For completeness, the appendices to this report include details of the projects from the global scan and the shortlist. The report also includes a high level 'meta analysis' that draws out additional learning points. Focus has been directed to those innovation projects that have arisen in liberalised markets (i.e. in the absence of central planning), that are relevant to the GB context, and that have developed beyond the research stage.

Examination of the reported projects reveals that they commonly deliver multiple stakeholder benefits. For example a project to facilitate distributed generation (low carbon benefit) can also enhance network supply security and network investment efficiency.

Pace: Innovation on electricity and gas networks is now becoming more established after a period of relative inactivity and is exhibiting signs of acceleration, with electricity networks currently leading. Incentive schemes such as Ofgem's Innovation Funding Incentive (IFI), and to a lesser extent Registered Power Zones (RPZ), are showing demonstrable outcomes with greater volumes and more sophisticated levels of innovation activity over the five years since they were introduced. International innovation is not limited to purely plant and equipment solutions; there is a good range of projects that include network design, planning and operational support systems.

Breadth: The projects reveal examples where network operators have demonstrated excellence at implementing innovation. This encompasses a range of stages across the innovation chain from concept and formulation, through development and on to deployment. It includes attention to appropriate compliance and standards and effective management of the risks associated with connection to live networks providing operational service to customers.

It has been observed during the process of collating this report that there would appear to be a higher degree of innovation activity taking place on electricity networks, as compared with gas. Furthermore, within electricity networks, a higher degree of innovation activity has been observed at distribution voltage levels, as compared with transmission, in part led by higher volumes of distributed generation connecting on these networks.

Partners: A general observation from this survey is that the leading and most radical examples of innovation are commonly found where a partner (academic, manufacturer or research institute for example) has been actively involved with a network company. This supports the view that network operators benefit from the technical support, the critical mass, and the creative energy of partners when embarking upon innovation projects. For clarity, the term ‘partner’ is used here to suggest a close working relationship, beyond transactional purchases from a product supplier.

Sponsorship: The survey indicates that large scale Lighthouse projects[1], such as ‘smart cities’, require some element of regional or central government sponsorship that includes financial incentives and wider facilitation and profile. This facilitates multi-party engagement, mitigates some of the risk for the network operator, and allows long timescale projects to proceed through the stages from research to commercial deployment with the necessary regulatory and financial stability. Long term stability encourages participation from other partners who bring the necessary mix of skills to major projects, (including IT, smart technologies, research facilities, standards compliance, and telecommunications, for example) that are necessary to provide a complete project solution in an increasingly complex sphere.

[1] Lighthouse projects are ambitious innovation projects utilising multiple technologies and partners, usually involving high level sponsorship to mitigate risk and gaining leverage through high profile media interest and public engagement.

Risk: Adoption of innovative solutions invites greater business risk, by definition. Where there is no uncertainty, a solution might be described as new, but not innovative. It is unlikely that a commercial company will take avoidable risk without an expectation of due reward. Uncertainty is compounded by the longer lead times needed for innovation projects and the requirement to have new equipment types approved for use on energy networks. For companies to engage actively in these longer term projects and manage the associated risks, it is necessary to have stability of regulation, incentives and policy direction. Further, a longer term stable framework facilitates decision making and financial commitments that are needed to deploy innovation on a commercial basis across a network. A single innovation project, however successful, is unlikely to bring material benefit to customers and other stakeholders; innovations usually have to become 'business as usual' and be rolled-out across a network to gain material benefits.

Progression: The wider, general learning points in the report include a key observation that effective outcomes are built on 'learning by doing'. Every project has its learning points, some hard won. Companies need time to transition through the stages of managing innovation from simple projects to complex solutions. Time is needed to consolidate learning from smaller, or less radical innovations, prior to moving on to larger scale and more technically challenging projects. Experience also needs to be gained of working with partners and building trust. It would not be a reasonable expectation that network operators can commence engagement with innovation at the level of Lighthouse projects; to do so would invite additional and avoidable risk.

Regulatory aspects: in addition to the previously mentioned points about the evidence for the benefits of regulatory incentives and the importance of regulatory (and government) policy certainty, the following key points can be drawn from this report:

- successful network innovation can take place in liberalised markets in the absence of a 'central planner';
- the scale and pace of innovation is likely to benefit significantly where there are regulatory incentives, clear government policy objectives, and active facilitation by government departments and regulators;
- almost without exception, the timescale to develop and deploy innovation on operational energy networks is several years, and roll-out to achieve wide-scale benefits is yet longer; this is the nature of the activity and reflects the need for a methodical approach that integrates new with old, manages risks, and minimises hazards for staff and the environment;

- where innovation raises new issues in regard to legislation or regulatory frameworks, whether requiring clarification or more fundamental refinement, this can introduce uncertainty that delays project initiation and engagement with partners.

Innovation portfolio: To pave the way to the energy networks of the future, a company's or nation's innovation portfolio would be expected to have projects of different levels of size, impact and exposure. Some projects will have an exploratory nature to gather knowledge and some projects will provide incremental steps to increase for instance the functionality of efficiency of the current networks. But there is also a need for bolder, more radical projects. These projects will lead the way of innovation, capture the attention from the media, the public, and politicians and will enable other projects to arise; these are the so-called Lighthouse projects.

Figure 1 below shows a representation of the spread of the case studies selected for this survey with the x-axis project scale ranging from knowledge projects to Lighthouse projects, and the y-axis representing an assessment of level of innovation challenge.

Towards the upper right corner are larger scale, highly innovative projects including the Lighthouse projects. In the lower left quadrant, the plot identifies projects of a more incremental nature and more modest in scale. KEMA observation would be that IFI projects do not generally feature in the upper right quadrant, although RPZ projects are positioned closer to it. As the arrow on the plot indicates, there is a need to ‘upscale’ if GB networks are to participate in the Lighthouse category of developments. Recent proposals from Ofgem for a Low Carbon Networks Fund may be helpful in this regard.

The case studies set out in the body of the report show an indication of ‘regulatory fit’ for application in the GB context. In many cases this shows a good correspondence but in a few it is noted that further examination would be warranted. There are three main types of project that do not have straightforward regulatory fit, as follows:

- innovations that involve new energy transactions such as storage devices;
- innovations that involve new energy vectors such as hydrogen, and
- innovations that potentially create new commercial interfaces and service interactions between market players, such as micro-grids and virtual power plants.

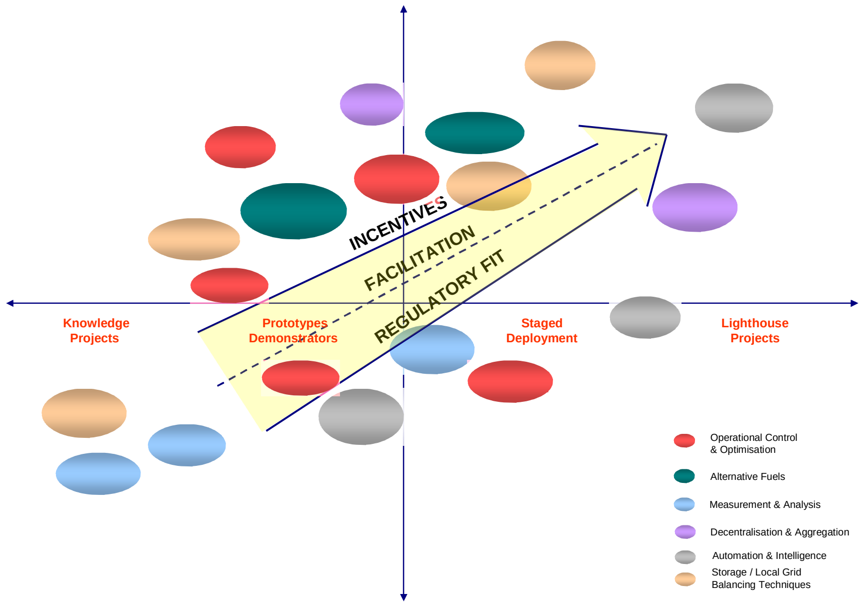


Figure 1 The spread of case studies

These innovative projects are described in the case study summaries in Section 3. Regulatory fit is a measure of how readily the innovations could be deployed in the GB electricity or gas networks environment within the current regulatory framework and incentive schemes.

In view of the foregoing observations, Ofgem's attention to innovation in recent Price Control Reviews and through the RPI-X@20 programme is commended. Mechanisms to monitor innovation progress (and hence the timely achievement of government policy objectives) and the early interception of potential regulatory issues and their resolution can be expected to bring considerable benefit by maintaining momentum and confidence in the complex domain of innovation implementation and the delivery of its benefits to customers, network companies and wider stakeholders.

1 INTRODUCTION

1.1 Background

Gas and electricity transmission and distribution networks in Britain have been regulated under an incentive-based revenue control ("RPI-X") since privatisation. This approach has delivered significant improvements in the operating efficiency of the companies, lower prices for consumers, improved network reliability and has facilitated new investment to maintain and increase network capacity and supply quality.

However, Ofgem identified a number of reasons why this approach should be reviewed. In particular, the recent Long Term Electricity Network Scenarios (LENS) project showed the significant impact that tackling climate change could have on the size and shape of future energy networks. With a range of new technologies being explored on both the demand and generation side, it is not clear whether larger or smaller transmission and distribution networks will be needed to deliver a low carbon economy and what their operational characteristics and requirements will be.

The primary focus of energy network regulation has shifted from achieving operating efficiency towards facilitating efficient delivery of the low carbon economy, continued security of supply, and other government social objectives. The delivery of a sustainable energy sector is likely to benefit from innovation, potentially involving changes in the business culture and the engineering practices of network companies. This will include for, example, testing and deploying new network technologies, utilising existing network assets in new ways, and interacting more closely with network users. Furthermore, this will need to be achieved through a cost-effective and consumer-responsive approach and may require reconsideration of established commercial and regulatory frameworks.

In this context, in March 2008 Ofgem announced the RPI-X@20 review, a two year project to examine the workings of the current approach to regulating GB's energy networks and to develop future policy recommendations.

The first consultation paper for RPI-X@20, that was published in February, addressed the principles, process and issues of the review.

It included the following key theme for energy network regulation:

> ***"Delivering a sustainable energy sector: achieving the environmental targets and ensuring security of supply requires innovation, possible changes in the role of networks, and increased investment"***

In addition to the ongoing drive for productivity improvement and commercial innovation, the energy networks are facing new challenges that may require a step-change in the technologies that are used, in order to deliver a low carbon electricity sector, to improve quality standards or security of supply and network resilience.

1.2 Context for this report

Ensuring continuing value for money is a key element of the RPI-X@20 review. In support of this objective, particularly in regard to future challenges, Ofgem commissioned this report to review, at a high level, the innovation that is taking place on gas and electricity networks worldwide, and to learn how this has been initiated and how it contributes to customer benefits.

Ofgem specifically requested an overview of innovation and, particularly, identification of those projects that are demonstrating a direct network benefit. Additionally, KEMA was asked to maintain a focus on those innovations that may be transferable to a GB network context.

The sample survey has focused on developments related to the delivery of a low carbon energy sector, security of supply, cost-effectiveness, and potential alternatives uses for gas networks. The analysis includes learning from international innovation projects and how these developments could be adopted by GB networks. This will help inform understanding of the potential for technological changes to be introduced. It will also allow understanding whether innovation by GB energy networks in the future will be about adapting technologies used elsewhere and/or whether they will need to focus on developing new ideas.

In support of these objectives the report describes those conditions that were conducive to innovation and technology development (e.g. regulatory arrangements, government support, private financing).

The information contained within this report has been compiled from a high level global scan incorporating an assessment of the types of innovation projects and how these sit within the research, development, demonstration and deployment timeline. A more detailed analysis on a number of representative case studies has been provided to examine in further detail how the innovation has taken place and the benefits that have been identified.

Case studies have been selected by a two stage filtering process to bring forward those that are illustrative of the types of innovation that are taking place on energy networks, and the circumstances that facilitated the development and introduction of network innovative solutions.

An initial global search using KEMA's international offices, customer contacts, and published materials identified some 200 unique innovation projects at various stages of development. Whilst there is some commonality in types of project reported, nevertheless the survey provides an indication of the international approach to innovative solutions to addressing business challenges. Projects in the early stages of research have been excluded from the search due to uncertainty of status and their likely long lead time to technology transfer and commercialisation.

Case studies that have been selected as representative examples in their class and have been chosen where there has been some stability in the development and deployment of the project and where adequate visibility was indicated for information that would enable analysis. A number of network companies have similar projects and KEMA used its best judgement to bring forward a representative cross-section of project types and host countries.

The survey indicated that there is at present more innovation taking place on electricity networks than on gas and this has been reflected in the mix of case studies. However, a number of leading gas projects were identified and it is likely that pace will gather in the gas sector as alternative fuels are developed commercially (e.g. bio gas) and as new techniques are identified for network optimisation (e.g. pressure management).

The global scan on electricity networks revealed greater innovation activity at distribution levels rather than in high voltage transmission. This would appear to be the consequence of the drivers for connecting renewable and distributed generation, supporting the view that innovation is commonly, but not exclusively, driven by factors external to the network companies[2]. It is observed that many successful innovation projects benefit from a partnership approach with a manufacturer, academia or other external party.

Network companies, in many cases, show excellence in developing and implementing innovation; however entrepreneurial activity is unlikely to be a core competence. The experience of other sectors shows (noting for example the trend towards Open Innovation) that it is problematic to achieve entrepreneurial activity in a company that is primarily a 'consolidator', seeking to minimise risk and optimise internal processes and unit costs. This is one of the reasons that partnering is a key to success. A primary competence to be developed by a network company becomes that of selecting and working with entrepreneurial partners, rather than being an entrepreneur it its own right. There will always be exceptions – and these should not be dismissed as innovation is known to be an inexact and fluid process.

[2] This reflects the current situation and does not preclude future on-shore renewable connections to the Transmission System, or initiatives such as OFTO which will enable direct Transmission connections for off-shore renewables.

2 GLOBAL SCAN OF INNOVATION

2.1 Introduction

KEMA has conducted an international search for innovation projects related to gas and electricity networks. A wide variety of sources have been utilised to maximise the potential for capturing the requisite diversity and to ensure that innovation projects in all stages of research through to deployment have been considered. It was possible, in the available time, to capture in excess of 200 unique projects that have formed the basis for this report. The projects demonstrate a wide range of type, scale and operational solutions.

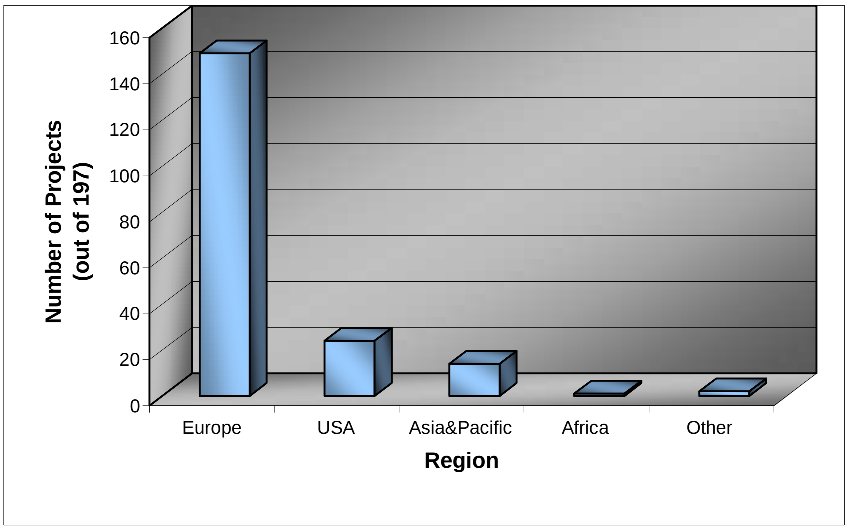


Figure 1 Geographical spread of innovation projects

The figure above highlights the dominance of projects located in Europe, with a major component coming from the UK. This would appear to be a direct result of Ofgem's innovation incentives that have been operating for some five years with increasing momentum. We show the impact of Ofgem's Innovation Funding Incentive (IFI) in section 4.2.

2.2 Scoring and ranking

To ensure that all projects were treated in an equitable way, and to support later analysis, project information was collected from industry participants using a standard pro-forma with structured data entry fields. Where information was collected from other sources (for example research papers, institutes, internal knowledge and others) the same process was applied to strive for consistency and impartiality of the output. Appendix C gives more details of the process undertaken to filter and select the case studies.

Consideration of the projects from the global scan based on the benefit delivered indicates the following disposition:

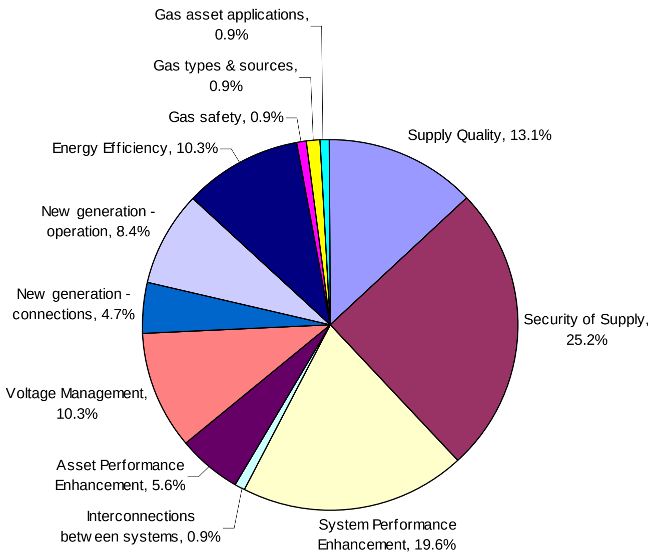


Figure 2 Target areas of innovation projects

Projects that have been selected for case studies based on the technologies employed are comprised of:

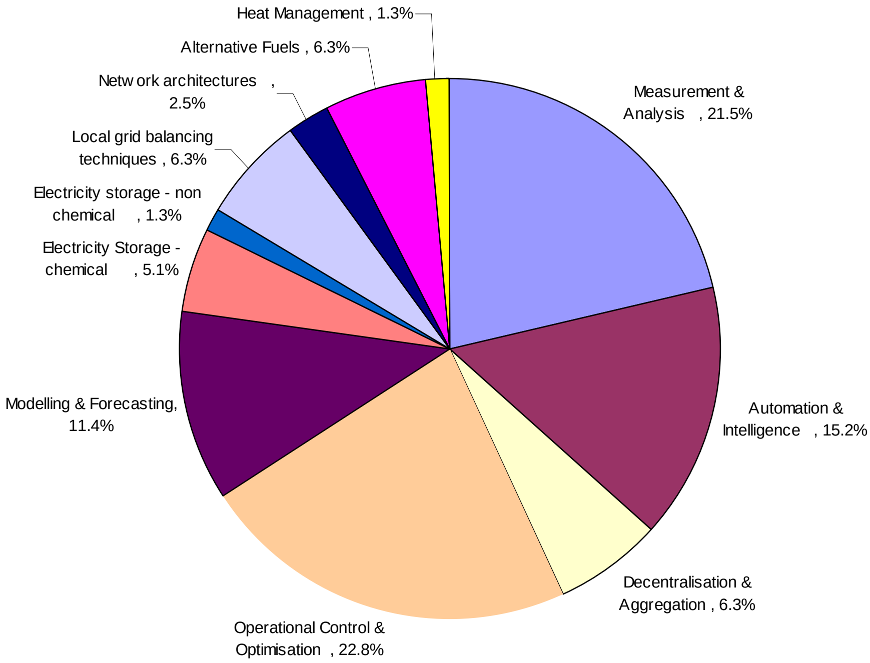


Figure 3 Technologies types used in the innovation

This is representative of the type and diversity of projects viewed in the initial global scan.

It should be noted that the innovation projects presented in the detailed case studies are often representative examples of such projects where a number of companies have either implemented, or are in the process of implementing, similar innovations.

Detailed case studies are presented in the next section of the report and have been selected to give a representative balance between gas and electricity, transmission and distribution networks. These case studies are reflective of technologies, systems and equipment that are suitable for implementation within a GB context, subject to suitable regulatory frameworks

It is not intended to promote one technology, or company, over another and KEMA has sought to be objective in the selection processes. The unavailability of sufficiently detailed information on occasion led to projects not coming through to the case study list (this included some high profile international projects). To make the report readable and provide a useful reference source, the names of commercial organisations have been included but this should not be taken to imply endorsement of particular products.

3 ANALYSIS OF CASE STUDIES

3.1 Introduction

The case studies have been selected against the criteria defined in the selection and filtering process (described in Appendix C). As previously mentioned, these are often representative of a number of broadly similar projects and have been selected on the availability of information, the maturity of the project, or relevance to the GB context.

Gas innovation projects are less well represented in the global scan and the case studies selected are included as examples of the innovation that is taking place.

Further technical details for the case studies is provided in Appendix B.

3.2 Case study dashboards

Each of the following case studies has an overview 'dashboard' that describes KEMA's assessment of the impact on the primary interest areas identified by Ofgem (Quality of Supply, Efficiency, and Carbon Reduction), the project status scored using Technology Readiness Level methodology (see Appendix A for the background and use of TRLs), the assessed degree of innovation challenge, the GB regulatory fit, and an assessment of the wider roll out potential for the project. Each project is introduced with a non-technical outline and the dashboard contains brief commentary, with the main description following.

Quality of Supply	Cost Efficiency	Carbon Reduction	Project Status (TRL)	Degree of innovation challenge	GB regulatory fit	Roll out potential
√√		√√√	6.5	√√√	√	√√
Comment: key observations **Regulatory fit in GB:** brief explanation						

Indication	Assessment
Blank	Not beneficial / very low impact
√	Some impact, or partial alignment
√√	Reasonable benefit, or largely aligned
√√√	Strong benefit, good alignment
TRL e.g. 6.5	An estimated TRL ranking between TRL 6 and TRL 7

The chosen categories reflect the areas of interest to Ofgem and GB network operators along with the KEMA assessment of the regulatory fit and roll out potential for the GB market. In the time available for this survey it was not possible to undertake detailed analysis of the projects and KEMA applied its best judgement to assign the assessments. In the cases where project status was uncertain, it was scored TRL 5.

3.3 Case Study Overview

No.	Location	Project title	Network	Benefit Statement
1	Greece	Micro Grid	Electricity Distribution	Enables stable electricity supply from renewable and other sources for a remote isolated electricity network
2	The Netherlands	PowerMatcher	Electricity Distribution	Facilitates the matching of distributed generation and demand on a devolved basis utilising economic and technical algorithms
3	GB	Active Distribution Management	Electricity Distribution	Maximisation of network capacity and accommodation of distributed generation employing active network management tools
4	USA	Energy Smart City	Electricity Transmission & Distribution	Providing a City wide solution for the adoption of smart technologies to maximise use of the network and support delivery of a low carbon solution
5	Portugal	InovGrid	Electricity Transmission & Distribution	Facilitates the development and installation of new smart devices for connection on electricity networks

6	GB	Distributed Generation Connection Planner	Electricity Distribution	Planning tool that facilitates the connection of distributed generation onto electricity distribution networks
7	GB	AURA-NMS (Active Network Management System),	Electricity Distribution	Planning and operational tool for maximising network connections and management of distributed generation
8	New Zealand	Intelligent Network Switching	Electricity Distribution	Active management switching system taking advantage of diversity in timing of peak demands between supply points
9	GB/Portugal /Spain/ France	Fenix	Electricity Distribution	Generation management tool that provides aggregation of distributed generation into larger virtual generators, facilitating access to ancillary service markets
10	USA	D-VAR system	Electricity Distribution	Implementation of power electronic devices at distribution voltages that enable enhanced active management
11	GB	Bankside Heat Transfer	Electricity Distribution	Utilisation of waste heat from transformers as an energy source for heating and air conditioning, minimising the use of other fuel sources
12	GB	Gen AVC Voltage Control on DG networks	Electricity Distribution	Maximising output from distributed generation whilst maintaining satisfactory voltage levels for network demand customers
13	USA	Distributed battery energy storage	Electricity Distribution	Devolved electricity storage system connecting multiple batteries on the lower voltage network, with potential to manage as a larger virtual battery
14	USA	Flywheel Energy Storage,	Electricity Distribution	Mechanical storage device utilising the inertia of a flywheel to provide electrical storage and system frequency control
15	GB	Carbon capture and transport	Gas Transmission	Utilisation of redundant gas networks for the capture of carbon at source and transport to expired gas fields for

				storage
16	The Netherlands	Biogas gate-keeper	Gas Transmission	Facilities the use of bio-gasses in traditional natural gas networks utilising a gate keeper device to maintain the requisite quality and safety standards
17	The Netherlands	Hydrogen injection in natural gas system	Gas Transmission	Facilities the use of alternative gasses in traditional natural gas networks
18	GB	Effect of Electric Vehicles on the Distribution network	Electricity Distribution	Impact and feasibility of allowing the connection of large scales electrical vehicle charging onto the electricity network
19	GB	Dynamic Line Rating	Electricity Distribution	Real time enhancement of circuit ratings talking account of environmental factors to maximise capacity
20	France/Germany	Minimal trenching	Gas Distribution	Technique for installing gas pipelines with minimum ground disturbance and interference with other buried services

3.4 Case study 1: Kythnos Micro-Grid, Greece

In Outline: *a micro-grid is a stand-alone power system that integrates renewable energy sources. So-called 'island systems' are not new, but traditionally are powered by controllable generation such as diesel units; in a micro-grid the power sources cannot be fully 'scheduled to order' and intelligent systems are combined with a communication infrastructure to achieve demand-side control and hence system balance between supply and demand. The principles being developed for micro-grids are of interest more widely than for application on geographic islands alone.*

Status: *Implemented*

Quality of Supply	Cost Efficiency	Carbon Reduction	Project Status (TRL)	Degree of innovation challenge	GB regulatory fit	Roll out potential
√√		√√√	6.5	√√√	√	√√

Comment: Whilst demonstrated on a physical island, the principles are applicable for wider smart grid applications including eco towns, private networks and possibly smart homes. The micro grid concept has potential in the longer term to assist the development of UPS (uninterruptible power supplies) say for vulnerable or remote customers on weak networks, or advanced network configuration management such as 'self-healing[3]' grids and intentional islanding[4].

Regulatory Fit in GB: a micro-grid is a complete power system and is likely to include storage of energy. In view of the multi-party involvement that this would require in a GB context and the contribution of storage, this has been scored as having limited alignment to current regulatory structures.

Description: Micro-grids are discrete electrical systems that have no connection to a main transmission or distribution system. Micro-grids are deployed where electrical networks are in the process of development, where there is no economic case for development of conventional electrical networks, or there are technical challenges, for connection to a conventional network. They potentially provide a route towards the development of highly robust, off-grid supplies as part of self-healing networks.

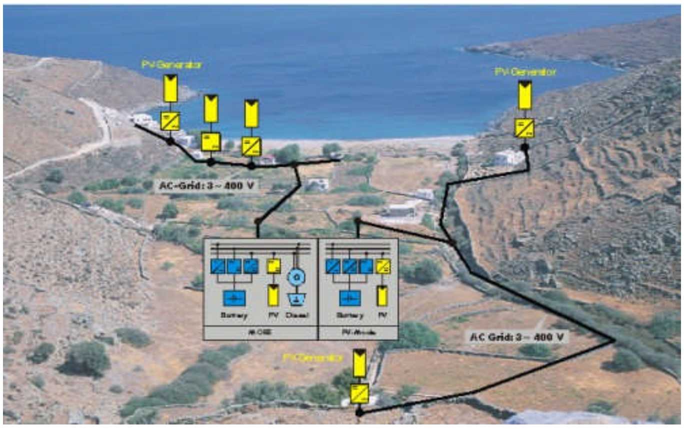


Figure 4: Kythnos Micro-grid [5]

[3] Use of artificial intelligent system to recognise network faults and automatically reconfigure to minimise impact.

[4] Used by network operators to safeguard larger portions of the network by deliberately islanding some sections during fault conditions.

[5] Source: www.micro-grids.eu

An interesting example of a micro-grid scheme that has been successfully deployed is in a small valley on the Greek Island of Kythnos. The system in Gaidouromantra, is a single phase micro-grid composed of the overhead power lines and a communication cable running in parallel electrifying 12 houses. This network is used to test centralised and decentralised control strategies in islanded mode as well as communication protocols that are a major challenge for such micro-grids.

The innovation was initiated by a combination of a manufacturer and research institutions. The manufacturer was developing products for the operation of power electronics for autonomous electricity supply systems and needed a field application to test and develop the hardware and control strategies. The research institutions contributed to the development of the micro grid concept, the control strategies, the monitoring and the analysis of the data.

The commercial driver comes from the social and environmental need for the electrification of small settlements in remote areas based on local renewable resources, mainly Renewable Energy Sources, where conventional power supply systems are too expensive to install, operate and maintain.

The benefits obtained from the project were technical, scientific and commercial for the involved institutions and local residents report they are satisfied from the electricity service provided. The power electronics manufacturer (DC to AC inverter[6]) gained experience for the developed products and owing to the publicity and good operation of the system has opened new markets. We understand that several hundred new installations of similar inverter systems have followed, which is an example of paving the way for roll-out. With the experience and knowledge gained, research institutions have gone on to participate in new R&D projects broadening their expertise.

It is reported that one of the challenges that occurred during the implementation was the fact that consumers were not adequately involved in the management of the micro-grid and as such they had the tendency to overload the system. This led to some shut downs in the summer period, when all the residents are present and increase the energy demand. It was found that the consumers do not have the necessary technical competence to take over the responsibility for managing the electrical micro-grid system even at a basic level. Currently there isn't a viable scheme for the operation of the system by the users, which may be a key issue to address for remotely located systems. The energy supply follows the model of the

[6] Conversion of electricity from battery storage to normal domestic alternating current supply

regular energy service provided by the local electricity utility, although the network conditions and the basis of the energy supply are very different.

The initial installation was financially supported by a European Union program (JOULE) followed by further financial support within the EU Framework Program VI. The investment cost in terms of hardware and installation of the infrastructure including a 3-phase low voltage grid with a total length of about 700 m for the electrification of 12 holiday houses was €280,000. This excludes the cost of monitoring equipment and the work of the engineers of the project consortium institutions that designed and implemented the project.

3.5 Case study 2: PowerMatcher, The Netherlands

In Outline*: this device is an example of using modern technologies to achieve interactive control of small scale distributed devices such as Distributed Generation (DG). It has been applied in practice and utilises industry standard communications and intelligent interfaces. Devices of this type will be of increasing interest for the implementation of smart grids.*
Status: *Implemented*

Quality of Supply	Cost Efficiency	Carbon Reduction	Project Status (TRL)	Degree of innovation challenge	GB regulatory fit	Roll out potential
√√√	√	√√	5.5	√√√	√√	√√√
Comment: There is high roll-out potential for technologies of this kind, depending on smart grid developments, including smart charging of electric vehicles. **Regulatory Fit in GB:** this project is scored as having moderate regulatory fit in GB. The interaction it potentially enables between customers and a number of market players (e.g. to generators for co-ordinating micro-generation sources, or with network companies for managing network constraints when charging electric vehicles) raise some issues that require consideration for the GB regulatory framework. Any such commercial arrangement involving end users, at small scale, will have to be suitably light-touch, simple to understand, and transparent.						

Description: PowerMatcher has been used to provide a devolved control solution for matching active power between distributed generation and local demand centres, utilising smart devices and standard communication protocols. The technology allows for communication between various smart devices that are managed locally without the need for input from a central control function This provides an optimised local management for a smart network and its energy consumption.

The Energy Research Centre of The Netherlands, ECN, has developed the PowerMatcher control concept for coordination of supply and demand in electricity networks that have a high penetration of distributed generation and allows implementation of a market-based solution in a local system. The device takes inputs, via smart interfaces, from generators and electrical loads to alter their operational profile to improve the overall match between electricity production and consumption.

The market parameters are modelled in the electronic systems and are implemented in a distributed manner via a communications infrastructure in which the PowerMatcher coordinate demand and supply in a defined cluster of devices.

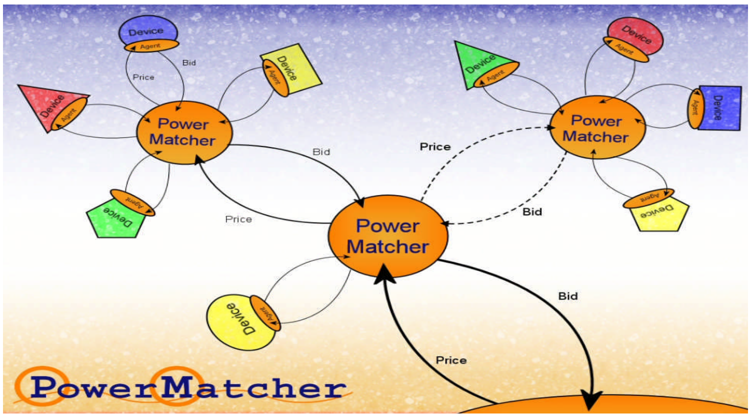


Figure 5 Relationships between the elements controlled by PowerMatcher

PowerMatcher has the ability to aggregate individual DG into larger 'virtual power plants[7]' that are able to be more readily managed as a single larger generating source. Without any infringement of users normal activities, the manufacturer claims that the market-based control can result in peak load reduction of 30% in summer and 50% in winter.

PowerMatcher can also exploit the use of a combined heat and power (CHP) booster mode in an optimal way, producing on average more electricity without consuming significantly more gas. Thus the PowerMatcher may also become a valuable tool as an alternative for demand side management programs.

[7] Refer to case study 9 that also takes advantage of this concept

3.6 Case study 3: Orkney Active Distribution Management, GB

In Outline: *this project is an example of an 'active network' making use of intelligent control logic and modern communications to control Distributed Generation so that available network capacity is not exceeded. It defers the need for expensive conventional reinforcement and so brings cost efficiency benefits in addition to enabling the connection of renewable generation sources.*

Status: *Implemented*

Quality of Supply	Cost Efficiency	Carbon Reduction	Project Status (TRL)	Degree of innovation challenge	GB regulatory fit	Roll out potential
√	√√	√√√	8.5	√√	√√√	√√
Comment: this project addresses network capacity optimisation and defers the need for expensive conventional reinforcement. It incorporates novel control logic and has been implemented over a relatively wide geographical area. It is a notable example of an 'active network' at distribution level. The principles have application for other constrained networks and are not limited to island situations. **Regulatory Fit in GB:** this has been implemented utilising existing regulatory frameworks and incentives.						

Description: Connection opportunities for distributed generation on the distribution network of the Orkney islands in Scotland is currently limited by network constraints. An increase in renewable energy generation is seen to be an important part of the plan to meet GB and international emissions reductions targets. Renewable resources are often located in remote areas where the connection to the national grid will be via weak distribution networks requiring substantial network infrastructure reinforcement.

The Orkney Isles are an area of abundant renewable resource with several wind farms and the European Marine Energy Centre. Orkney is connected to the mainland network by two 33kV submarine cables and network simulation and analysis has shown that this active network management scheme may be capable of releasing capacity for DG connections by up to three times the firm capacity of the existing distribution network.

To enable active management of the power flows on Orkney, the network has been segregated into control zones. Control logic has been designed to regulate the output or trip the New Non Firm Generation (NNFG) as required to optimise use of the available network. The inputs to the control logic are status indications from generators and network components, and analogue representations of power flows at zone intersections or 'pinch points'. Each zone has its own control logic. Measurement of power flows at intersections and other critical points informs the decision making process performed by the control logic.

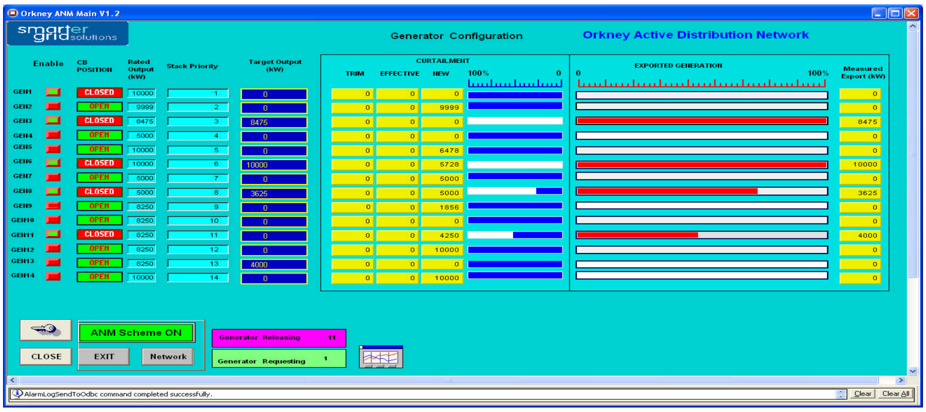


Figure 6 Screen shot of Orkney Active Distribution Network Control system

The system is partially commissioned with full operational use expected before the end of 2010, so it is too early to quantify the benefits. There have been a number of non-financial benefits, one of which has been avoiding a 'connections queue' that is awaiting primary reinforcement. SSE have only addressed generation projects on Orkney that have gained planning consent.

SSE engaged with Strathclyde University in Glasgow to develop the philosophy for this project; they were a natural partner arising from prior relationships. A government grant (DTI Technology Programme) in 2004 provided a helpful stimulus for the early work with Strathclyde. Also, SSE utilised the GB Regulator's innovation incentive mechanisms IFI (Innovation Funding Incentive) and RPZ (Registered Power Zone) which fitted well with the proposed developments. Approximately £500,000 has been invested in this project to date.

The project was conceived from within SSE's System Management team; it was 'need driven' arising from new DG being projected for the Orkney islands. Internal analysis soon revealed that this was an optimisation opportunity far greater than a simple inter-tripping scheme. Financial project benefits are derived from comparing the cost of the active network solution with the cost of extensive conventional reinforcement. This project will allow connection of further distributed generation on Orkney by use of novel techniques.

3.7 Case study 4: Energy Smart Miami, USA

***In Outline:** this high profile 'Lighthouse project' is one of several that are being reported internationally. Such projects are of particular interest because their boldness and scale can be expected to result in accelerated 'learning by doing', attract helpful political, media and public interest, and result in new ways of achieving energy engagement with end users which is key to energy efficiency and smart grid system benefits.*

***Status:** Development*

Quality of Supply	Cost Efficiency	Carbon Reduction	Project Status (TRL)	Degree of innovation challenge	GB regulatory fit	Roll out potential
√√	√√√	√√	3.5	√√	√√	√√√
Comment: A Lighthouse project that builds on smart metering technologies to enhance the efficiency of the power system and explore the best methods for customer energy awareness and interaction. The principles are being developed in a high profile Lighthouse project, but may have application at every level and scale. **Regulatory Fit in GB:** this has been assessed as at an intermediate level as application in GB would require careful evaluation of the potential interfaces required between multiple market players.						

Description: Energy Smart Miami is a city-wide design proposal for implementation of smart solutions on transmission and distribution networks and the scope includes industrial, commercial and domestic customers. Energy Smart Miami represents an alliance of local government and private enterprises. Miami is partnering with Florida Power & Light Company (FPL), GE, Cisco Systems and Silver Spring Networks to launch Energy Smart Miami, a model electricity system for American cities and a cornerstone for a broader $700 million state wide investment. Financial incentives and guarantees are provided from central and regional government low carbon economy initiatives.

Energy Smart Miami will require the deployment of more than 1 million advanced wireless Smart Meters to every home and most businesses in Miami-Dade County. These meters will give (FPL) customers more information and control over their electricity usage while also providing FPL with information that will enhance system efficiency and reliability. Implementation of the Smart Meters will be based on open network architecture, allowing other providers to develop and deploy new applications that could, for example, help consumers better manage the electricity usage of their air conditioning and appliances.

More background information can be found at http://www.itsyoursmartgrid.com/

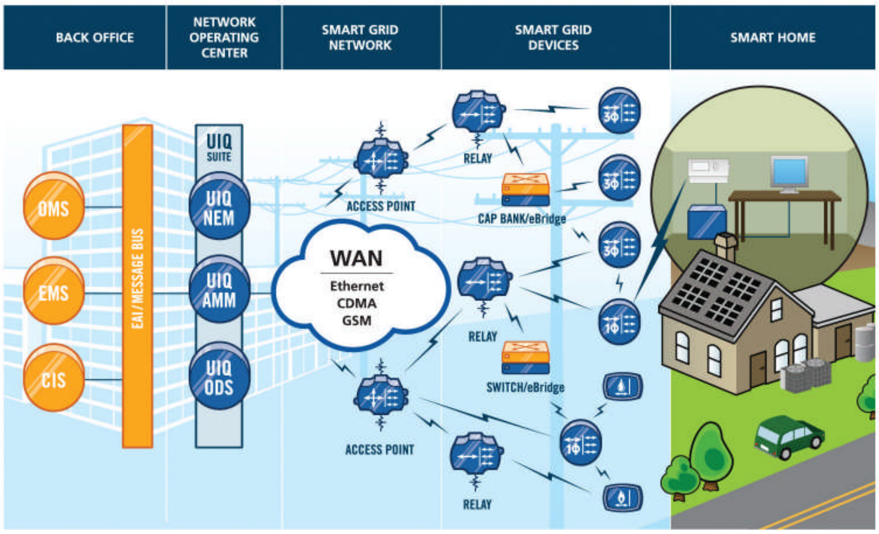


Figure 7 Illustration of the communication layers of the Smart Miami project

Using the capabilities of installed smart meters, the initiative will include trials of more advanced interfacing to approximately 1,000 consumers. The communications and empowerment systems will be assessed to determine which delivers the greatest energy savings and consumer satisfaction.

3.8 Case study 5: InovGrid, Portugal

In Outline: *This project is at an early stage in Portugal as a consortium of EDP, Efacec, Logica, Contar/Janz. It addresses network developments in a bold way to seek best use of the new concepts for smart grids. This can be expected to encourage the development of the liberalised market in Portugal as well as improve cost efficiencies.*
Status: *Research and early Development*

Quality of Supply	Cost Efficiency	Carbon Reduction	Project Status (TRL)	Degree of innovation challenge	GB regulatory fit	Roll out potential
√√	√√	√√√	4	√√	√√	√√
Comment: this is a bold project directed at distribution network optimisation. The principles it is addressing have general application more widely. **Regulatory Fit in GB:** many aspects of this project would fit straightforwardly in the GB regulatory framework, but aspects such as consumer demand interaction would require careful evaluation to address the multi party interactions.						

Description: Development and innovations in energy networks requires network operators to be responsive to changing operating conditions, equipment and customer behaviours. InovGrid proposes the development of technologies that seek to anticipate development and provide network management solutions. The project scope aims at developing a set of functionalities and new devices that can be installed on the network to facilitate a more active role for the management of the distribution system.

Provision of new market of opportunities arise from the new energy network paradigm offered with smart grids. The main objectives of this project include: i) bringing about the liberalisation of electricity markets in Portugal, ii) developing a customer-focused market, iii) inducing demand modulation, iv) improving security of supply and v) promoting the renovation of grids and their operation.

Constant requirements for capital investment optimisation and reduction and predictability in operating costs are leading the need for the development of a distribution grid with a level of intelligence to respond to the future challenges. Expected benefits from this project are that Regulators will see better implementation of conditions that support market developments, with positive implications on energy costs. Likewise, the Regulator should have access to a set of value-added information for greater visibility of how the market operates along with its operating conditions.

3.9 Case study 6: Distributed Generation Connection Planner, GB

In Outline: *this project is an example of innovation in the tools and services used for improved approaches to network design and planning, with particular regard to the connection of distributed generation. It uses modern on-line techniques and user-friendly interfaces. It has benefited from a partnering approach.*

Status: *Demonstration complete, deployment due*

Quality of Supply	Cost Efficiency	Carbon Reduction	Project Status (TRL)	Degree of innovation challenge	GB regulatory fit	Roll out potential
√	√√	√√√	4.5	√	√√√	√√
Comment: Interesting example of development of modelling and optimisation tools utilising modern Information Communications Technology (ICT) applications and has promise for enhanced customer service. **Regulatory Fit in GB:** this has been developed under the present regulatory framework and innovation incentive arrangements.						

Description: In the UK Distribution Network Operators (DNO) have experienced a significant increase in applications to connect distributed generation. Distributed generation is small scale generating plants, typically renewable energy, connected at lower voltages on the distribution system.

Figure 8 Screenshot of DG Connection Planner interface

Large quantities of distributed generation in close proximity, or individual generators on electrically remote parts of the distribution network, can present the DNO with many technical challenges to ensure compliance with licence and statutory obligations that ensure a safe and secure power system.

The Distributed Generation Planner is a distribution system planning tool that facilitates the modelling and required investment in assets and control systems needed to connect large volumes of distributed generation. The tool allows a DNO to assess fully the network impacts of connecting generation, minimising the impact on network capital development programmes and other users of the network, maximising transfer capacity within technical limits.

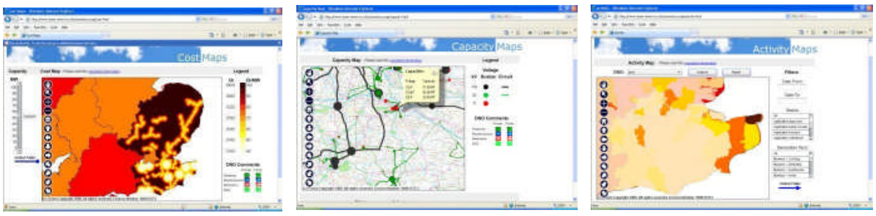


Figure 9 Examples: Cost Map, Capacity Map, Activity Map

This innovation is a leading example of non equipment focused innovation, but still supporting overall objectives of facilitating competition, the transition to a low carbon economy and achieving customer value for money. The project utilised Ofgem's Innovation Funding Incentive (IFI) and was developed in co-operation with partner organisations CE Electric, IMASS Limited and Senergy Econnect.

3.10 Case study 7: AURA-NMS (Active Network Management System), GB

In Outline: *AURA-NMS(Automated Regional Active Network Management System) is a multi party project addressing active network management to facilitate distributed generation connection and operation. It has a strong theme directed towards practical applications, including the 'real world' limitations imposed by the need to integrate new approaches with existing plant, equipment and controls.*

Status: *Implemented*

Quality of Supply	Cost Efficiency	Carbon Reduction	Project Status (TRL)	Degree of innovation challenge	GB regulatory fit	Roll out potential
√√	√√	√√√	4.5	√√√	√√	√√√–
Comment: this project has wide application beyond the case studies if successful in resolving the challenges that have been identified. It offers a range of potential benefits and practical application experience. It also build on the potential strengths of partnership working. **Regulatory Fit in GB:** depending on the nature of the solutions developed, this approach may fit within existing regulatory frameworks, but equally it may raise some issues for further consideration particularly if multiple parties in the supply chain are part of the solution.						

Description: This project will produce a control structure and set of control algorithms to realise the notion of an active distribution network and enhance the service a network operator provides to load and generation customers, improving network optimisation and de-carbonisation.

The scoping and development considers the following major areas.

- Distributed Generation and demand side management to facilitate the connection of DG to a network;
- Developing a controller to monitor electricity networks, isolate faults quickly and allow distributed generation to remain connected and operating.

This is a consortium project involving ABB, Scottish Power, EDF Energy and Imperial College London (leading 6 other universities). To take one aspect, the Scottish Power portion of this work focuses on constraint management techniques for use on new / existing generation connections, particularly considering the 33kV and 132kV networks. The principle focus in the case studies will be to overcome existing network limitations addressing:

- Overcoming complexity of existing hard-wired inter-tripping schemes,
- Determining a solution for managing multiple generation connections in a given locality,
- Developing and implementing a system that can work in harmony with existing SCADA infrastructure, and
- Overcoming communications / equipment limitations of existing systems.

3.11 Case study 8: Intelligent Network Switching, New Zealand

In Outline: *this is a project that has been implemented in New Zealand to defer primary capital investment for network capacity enhancement. It makes use of modern communications and logic processing, and utilises short term asset loading capabilities in an intelligent but secure way. It exploits the differences in peak load timing arising from different customer segments.*
Status: *Implemented*

Quality of Supply	Cost Efficiency	Carbon Reduction	Project Status (TRL)	Degree of innovation challenge	GB regulatory fit	Roll out potential
√√√	√√√	√	7.5	√√	√√√	√√√
Comment: Interesting to note the use of transmission concepts/technology on distribution networks. **Regulatory Fit in GB:** this project is seen to have good regulatory fit in a GB context.						

Description: Heavily loaded distribution networks usually require additional capital investment as the traditionally solution to provide increased network capacity. An alterative to capital investment is to take account of diversity within the network for types of demand (commercial, industrial, residential) and the different timing of the peak demands between supply points and utilising this to increase effective operational capability.

Vector, a New Zealand Distribution Network Operator, has developed a scheme to enable load to be rapidly transferred from one part of its distribution network to a neighbouring part of the network to deferring investment in network reinforcement.

The salient features of this load transfer scheme are:

- fully automated – when a fault is detected in a part of the network covered by the scheme, an automatic switching sequence will be initiated which will isolate the fault and rearrange the network to restore supply,
- fast response – the switching sequence is pre-programmed, and hence offers a fast supply restoration to customers, and
- high capacity – the fast operation of the scheme allows rapid off loading of substation transformers (which are usually operated in parallel) under post contingency conditions.

This level of automation allows equipment to run closer to its full load and short term overload limits with a suitable prearranged switching sequence determined to prevent any unacceptable overstressing of the distribution system. The logic of the automatic switching scheme takes account of pre and post fault thermal capacities to maximise network transfer capacity, commensurate with security and continuity of supply.

The project idea originated from the need to spend a substantial amount to reinforce an area with relatively low demand growth. The initiative was identified in the network planning team and encouraged and supported by senior management. The conceptual design was developed in house. Consultants were engaged to carry out detailed design of the control and communications schemes. This initiative enables a substantial capital expenditure in a network reinforcement project to be deferred for a number of years without adversely affecting the risks to the network or reducing the quality of service to customers. The decision was based purely on commercial (financial and customer service) drivers.

There have been a few, relatively minor, issues mainly concerning the quality of the equipment supplied (for example, failure of a control limit switch in one of the SF_6 switches, intermittent loss of radio signals) and the lack of coordination between suppliers in their equipment assembly and delivery. A key lesson learned from this exercise is that comprehensive upfront planning and risk assessment will help the smooth implementation of a project.

The cost of the project was about NZ$0.23 million (£97,000) at 2001 cost level and it was able to defer about NZ$7 million (£3.0 million) of capital expenditure (for building a new zone substation) for 7 years.

3.12 Case study 9: Fenix, GB/Portugal/Spain/France

In Outline: *this is a major consortium project supported by EU funding and having participation from across Member States. It is addressing the novel concept of aggregating many small generators to provide a service as a single 'virtual power plant'. This is a concept that does not exist in traditional power systems and is one of the hallmarks of smart grids thinking. It has the potential to add value for distributed generators and assist them engage in the wider electricity market.*

Status: *Demonstration complete, deployment due*

Quality of Supply	Cost Efficiency	Carbon Reduction	Project Status (TRL)	Degree of innovation challenge	GB regulatory fit	Roll out potential
√	√√√	√√	3.5	√√√	√√	√√
Comment: Ground breaking development that has the potential to enable an entirely new power system service. Roll-out potential will depend on DG penetration as well as the success of the project. **Regulatory Fit in GB:** there are aspects of this solution that will warrant careful consideration of regulatory frameworks, including the value chain and payment for services provided by the dispersed DG.						

Description: This four year project is a European consortium seeking to address the challenge of managing large scale distributed generation (DG) on a distribution network. By aggregating the DG into larger 'virtual power plants' it is possible to develop delegated control systems for real time management.

Continental Europe, Spain in particular, has high densities of DG which presents many technical challenges for management of the distribution network within the limits of voltage control, stability and operational monitoring and control of the generation.

The Flexible Electricity Networks to Integrate the Expected ' Energy Evolution' FENIX solution provides for commercial and technical communications between the individual distributed generators and a central monitoring point where decisions can be made for the most effective commercial and technical despatch of the generation.

The project is organised into three phases:

- Analysis of the Distributed Energy Resources (DER) contribution to the electrical system, assessed in two future scenarios (Northern and Southern) with realistic DER penetration,
- Development of a communication and control solution suitable for a wide range of network applications including normal and abnormal operation, including recommendations to adapt international power standards, and
- Validation through 2 large network deployments, one focused on domestic combined heat and power (CHP) aggregation, and the second aggregating large DER in Large Scale Virtual Power Plants, (LSVPPs) (wind farms, industrial cogeneration), integrated with global network management and markets.

Development of this project was driven by the need to manage a high density of DG on a network and then facilitate these generators becoming involved in the market with provision of commercial ancillary services.

Development costs for the project is €14m with an EdF Energy (UK) contribution of £250k. Funding from the European Commission has been essential to facilitate the consortium that engaged in this integrated project. Strong project management from Iberdrola (Spanish Transmission Operator) supported by Labein has ensured that the project partners worked together effectively.

3.13 Case study 10: D-VAR system, USA

In Outline: *power electronic devices (heavy current and high voltage versions of electronic components), coupled with intelligent controls, offer a range of new solutions to overcome power system capacity limitations. Over recent years similar devices have been used successfully at transmission level and with suitable redesign these can be applied on lower voltage, distribution networks., The advent of distributed generation, variable primary sources, and more active distribution networks presents an opportunity to transfer these power electronic solutions to a new context. The commercial product described here is one such application which has been used in the Orkney active network described in Case Study 3.*

Status: *Implemented*

Quality of Supply	Cost Efficiency	Carbon Reduction	Project Status (TRL)	Degree of innovation challenge	GB regulatory fit	Roll out potential
√√√	√√	√	7.5	√√	√√√	√√
Comment: Interesting to note the use of transmission concepts/technology on distribution networks. Fast-acting power electronics such as this may be expected to find increasing application on distribution networks as they become more active in character. **Regulatory Fit in GB:** this is an innovative network solution that aligns well with GB regulatory frameworks.						

Description: Wide spread connection of distributed generation results in distribution networks becoming more dynamic in their operating behaviour with an increased need for active network management. These changes require transmission-type solutions but at a much lower voltage levels.

The American Superconductor (AMSC) dynamic VAR (Volt Ampere Reactive) system is a powerful, cost-effective solution that dynamically stabilises and regulates voltage on networks and industrial operations. Utilizing AMSC's proprietary PowerModule power electronic converters, D-VAR systems detect and instantaneously compensate for voltage disturbances by adjusting reactive power at key points on the transmission and distribution networks.

D-VAR systems enable wind farms to meet network operator (and Grid/Distribution Code) connection requirements including the ability to remain connected during a network fault, and provide voltage regulation and power factor correction. Wind farms are required to comply with the grid or distribution code of the country they are in, and the GB code is a relatively onerous one, requiring a significant range of reactive power capability even at low or zero power generation levels. The D-VAR system is a solution that enables wind farm operators to comply with these requirements.

Figure 10 D-VAR system in practice

An additional benefit of fast-acting controls is that it enables generating plant to ride through brief low voltage events on its grid connection. This is of particular value and importance to wind farms and other generating plant that may be located in remote places where the local network can be exposed to storms and other disturbances.

This is a commercial application at distribution level of power electronics that is more usually associated with large scale transmission systems. It has been applied as part of the Orkney active network project (see Case Study 3).

3.14 Case study 11: Bankside Heat Transfer, GB

In Outline: *this is an unusual and interesting project to capture waste heat from power system transformers. It utilises specially developed heat exchangers to provide heat services to a major art gallery in Central London. If successful there are likely to be a number of potential applications elsewhere, especially where electricity substations are embedded in commercial buildings.*

Status: *Implementation during 2010*

Quality of Supply	Cost Efficiency	Carbon Reduction	Project Status (TRL)	Degree of innovation challenge	GB regulatory fit	Roll out potential
	√	√√	4.5	√	√√√	√√
Comment: It is interesting to see a heat-related network development: it shows the potential application to utilise network heat losses. It has a knock on benefit of carbon saving from heating derived from conventional means. **Regulatory Fit in GB:** this project utilised GB regulatory incentives.						

Description: An innovative solution for utilising waste heat from transformer cooling systems in heating the Tate Modern art gallery located in the decommissioned Bankside Power Station building at Bankside, on the River Thames in central London. Bankside Grid Supply Point was planned to be replaced and the replacement design would occupy a much smaller footprint. This provided the opportunity to look at other options. Discussion took place with the architects from the Tate Modern and agreement was reached to provide the waste heat from the transformers to provide heating and air conditioning. The scheme was agreed at the EdF Networks UK Board and the project will become operational during 2010.

Oil in an electrical transformer, which generates heat during the process of stepping up or down voltages, provides the dual function of insulation and cooling. It is this heat, which is normally lost to the environment, that is utilised via oil/water heat exchangers to provide the heating and cooling energy to the gallery. Utilisation of the waste heat provides an environmentally friendly solution with the gallery able to use the waste heat rather than other energy sources.

Figure 11 Location of Bankside Heat Transfer project

The project needed careful technical and commercial evaluation and project management to coordinate with the primary substation replacement and when commissioned will be monitored to ensure that the transformers are adequately cooled. Other applications of this technology are constantly under review where heat from Combined Heat and Power (CHP) or substation waste heat installations can be utilised in alternative situations.

Specially designed oil/water heat exchangers were designed to meet the needs of this installation but can be used as a template for other applications, subject to project viability. The main benefit from implementing this project is to demonstrate opportunities to use heat otherwise wasted in an effective way reducing the need for other energy sources to provide the necessary heating and air conditioning.

The incremental cost to the project, including R&D and construction, is approximately £750,000.

3.15 Case study 12: Gen AVC Voltage Control on DG networks, GB

In Outline: *this project is an innovative solution to maintaining acceptable voltages on the part of a network where DG is connected. It uses system measurements (which for distribution networks are commonly sparse) and combines them with a real-time system model to infer the voltages at points where measurements are not available. This technique (state estimation) has been used traditionally for control centre applications on large transmission grids and it is an innovative step to translate this methodology to an entirely new context. Devices of this type can be expected to find increasing application as distribution networks become more actively managed.*

Status: *Implemented*

Quality of Supply	Cost Efficiency	Carbon Reduction	Project Status (TRL)	Degree of innovation challenge	GB regulatory fit	Roll out potential
√√√	√√	√√	8.5	√√	√√√	√√√
Comment: An interesting example of migrating technologies previously reserved for control rooms (state estimation) to a field based application. The project utilises sparse data, a common feature of developments on existing distribution networks. **Regulatory Fit in GB:** this project utilised existing GB regulatory frameworks and innovation incentives.						

Description: The GenAVC (Generator Automatic Voltage Control) product has been developed by Senergy Econnect to manage power system voltages in situations where there is connection of Distributed Generation (DG) on lower voltage distribution networks. This system had demonstrated successful operation in a trial at Martham Primary (EdF Energy) substation. The trial demonstrated that the principles of voltage control can be applied to maximise the output from the generation at the same time as managing voltage control for demand customers.

Large amounts of DG connecting on the EdF Energy network need careful management to facilitate maximum generation commensurate with network performance remaining within acceptable limits. This necessitated an assessment tool to model the network and the generator parameters to assess the impact on voltage levels ensuring that demand customers quality of supply is not adversely affected, maintaining voltage levels within operational and statutory limits.

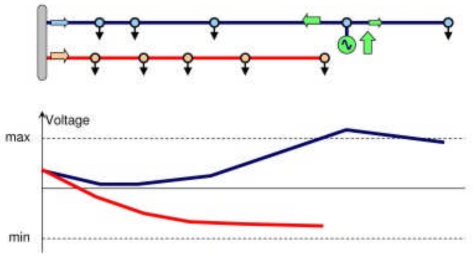


Figure 12 Voltage on a feeder with load only (red trace) against voltage on a feeder with generation (blue trace)

The project demonstrated that GenAVC provided a viable solution and a commercial grade GenAVC was subsequently installed at Steyning Primary substation. This demonstration provided the least-cost connection for DG when additional generation capacity was sought, making it possible for a landfill gas generator to increase its export capacity by 1.5MW (from 2.5MW) which would otherwise have required capital network reinforcement (4 to 5km of underground cable).

Generators that are remote from the primary substation need secure, digital, communication channels to provide the necessary control and monitoring systems. In some geographical areas this has proved to be a challenge as the telecommunications network may not be sufficiently robust and has to be upgraded to provide signal integrity.

The total project costs was £315,000 with an EdF Energy contribution of £160,000.

3.16 Case study 13: Distributed battery energy storage, USA

In Outline: *this project is the first MW-scale application of Sodium-Sulphur battery technology in the USA. It has been deployed to defer primary reinforcement but the utility sees a number of incidental benefits and wider commercial opportunities. This project provides a marker that battery technologies are now becoming available at an industrial scale suitable for deployment as solutions for network optimisation.*
Status: *Demonstration in service*

Quality of Supply	Cost Efficiency	Carbon Reduction	Project Status (TRL)	Degree of innovation challenge	GB regulatory fit	Roll out potential
√√√	√√	√√	5.5	√√	√	√√√
Comment: An interesting development of the use of storage at distribution level to mitigate congestion during peak hours. Possibly also micro-grid applications? **Regulatory Fit in GB:** storage applications at distribution level will benefit from closer consideration in the context of GB regulatory framework; this may be a matter of clarification or may require more substantive action. For example, it is unclear whether storage should be considered as demand or 'generation' or something in its own right; how this fits within licences, and whether regulation can made sufficiently light touch to encourage small scale applications and encourage commercial innovation.						

Description: Electrical storage solutions have previously been focused on relatively large schemes connected at higher network voltages. Distributed energy storage considers the use of multiple smaller units, that have the ability to be managed as a single larger virtual storage, which can then be connected at lower network voltages.

American Electric Power (AEP) installed a 1MW, 7.2MWh NaS (Sodium Sulphur) battery in an existing substation at Charleston, West Virginia during 2006. The battery is roughly 80% efficient at the point of connection to the network . However, when reduced transmission and distribution losses are taken into account this give the battery an effective 90% efficiency,

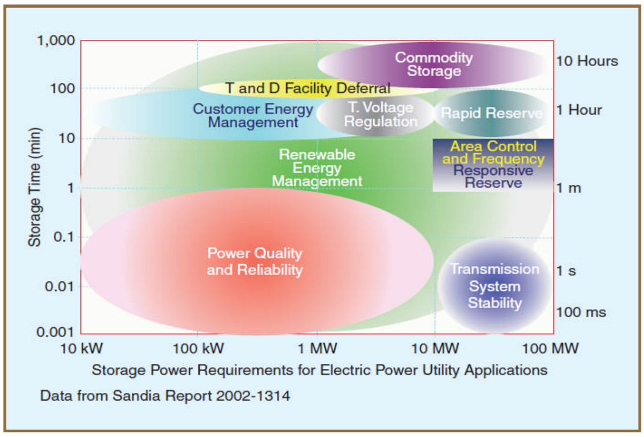


Figure 13 Ranges of power and discharge time requirements for different applications

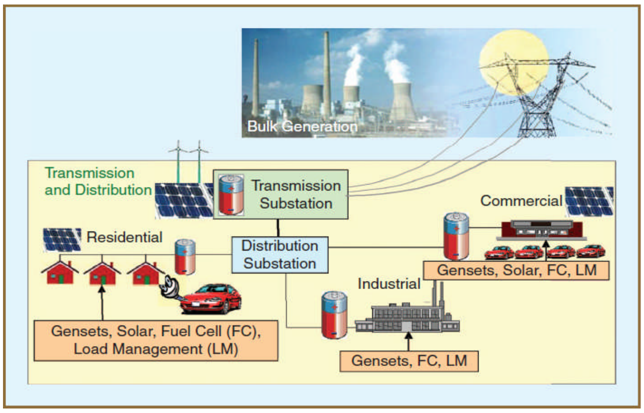


Figure 14 A vision of future distribution circuits

Installation of the battery has reduced the peak load on potentially overloaded equipment in the substation until AEP builds a new substation in the neighbourhood. By reducing the peak load, AEP planned to defer the cost of building a new substation for several years, until the load has grown, better utilising new substation capacity.

Commercial drivers have provided the primary business case for this project. If network operators were able to quantify all the financial benefits of energy storage, it would pay for itself, many times over. With the relatively high cost of current electricity storage technologies, the challenge for network operators today is to learn how to realise multiple benefits from the storage value stream. These benefits, however, are site and application specific, making them difficult to generalise across the industry. Service related benefits, such as improved reliability and load levelling, may have the support of regulatory bodies and may assist cost recovery. Commercial ancillary services such as financial gains from energy arbitrage and frequency regulation, appeal to investors.

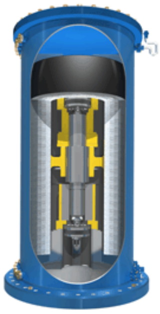
Partially funded by the U.S Department of Energy (DOE), the Charleston storage project was the first megawatt-scale application of NaS battery storage in the United States.

3.17 Case study 14: Flywheel Energy Storage, USA

In Outline: *this project is another example of storage technology that is now becoming commercially available at MW-scale. As with battery devices, it is modular and can therefore be scaled-up to greater capacities. Unlike batteries, this device uses stored rotational energy in a fast-spinning flywheel. The example quoted is from Beacon Power in the USA.*
Status: *Demonstration in service*

Quality of Supply	Cost Efficiency	Carbon Reduction	Project Status (TRL)	Degree of innovation challenge	GB regulatory fit	Roll out potential
√√√	√	√√√	6.5	√√	√√	√√√
Comment: Interesting project of modular storage technology that can be used to provide balancing services at transmission level, displacing fossil reserve generators. Potential for quality of supply and improvement at distribution level. Possibly also micro-grid applications? **Regulatory Fit in GB:** as described in the previous case study, storage applications will benefit from consideration in the context of the GB regulatory framework; this may be a matter of clarification or may require more substantive action. It may be less complex to consider this type of application which is primarily providing a transmission ancillary service.						

Description: Electricity storage in alternating current power systems has historically presented a significant technical and economic challenge. This project utilises flywheel modules in a mechanical solution that provides active power (with demonstration projects up to 20 MW installed) delivering an ancillary service for frequency control. A flywheel is a mechanical device with significant inertia that is run at high speed and has a high level of stored rotational energy. A typical example is shown in the figure below.



The flywheel system includes a rotating carbon-fibre composite rim, levitated on hybrid magnetic bearings operating in a near-frictionless vacuum-sealed environment. The rim itself is fabricated from a patented combination of high-strength, lightweight fibre composites, including graphite and fibreglass combined with resins, which allow the flywheel to rotate at high speeds (16,000 rpm) and store large amounts of energy as compared to flywheels made from metals. To reach its operational speed, the system draws electricity from the grid to power a permanent magnet motor. As the rim spins faster, it stores energy kinetically. The flywheel can spin for very extended periods with great efficiency because friction and drag are reduced by the use of magnetic bearings in a vacuum-sealed environment. Because it incurs low friction, little power is required to maintain the flywheel's operating speed.

Figure 15: Typical flywheel construction

Flywheel energy storage system is designed to respond to a regional transmission or distribution operator signal to quickly add or subtract power from the grid in a frequency regulation support mode. Using this concept, the flywheel recycles energy (store energy when generation exceeds loads; discharge energy when load exceeds generation) instead of trying to constantly adjust generator output.

Flywheel technology is driven by the economic needs of generators that are facing higher operating costs owing to increase fuel consumption and maintenance costs, caused by the suboptimal output caused by frequency deviations.

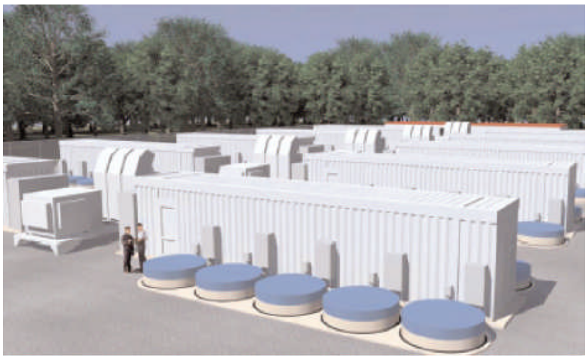


Figure 16 Illustration of the larger scale use of fly wheel storage

An important benefit delivered by the flywheel technology is the increase in available effective energy. Generators are often not able to provide their maximum output since they need to be operated below their maximum capability to provide frequency regulation. Typically generators need to operate below their maximum capacity by 2 times the amount of frequency regulation they are providing in order to provide for safe operation. The manufacturer calculates that if all regulation were accomplished by Flywheel Energy Storage system, then there would be an additional 2-4 % generation capacity without adding new generators.

3.18 Case study 15: Carbon capture and transport, GB

In Outline: *this is an innovative project that is taking first steps towards carbon capture, transportation and storage. It is necessarily at the early stages of modelling, scoping and knowledge creation. This technology could play a major part in electricity de-carbonisation at large scale.*

Status: *Research*

Quality of Supply	Cost Efficiency	Carbon Reduction	Project Status (TRL)	Degree of innovation challenge	GB regulatory fit	Roll out potential
√	√√	√√√	2.5	√√	√√	√√
Comment: An interesting case of alternative use of natural gas networks. Depending on Government policies and technology developments, CCS may have wide application.						

Regulatory Fit in GB: this is a new development beyond established electricity and gas paradigms. Consideration will be needed to create suitable regulatory frameworks. Existing frameworks for gas as well established and can be expected to form a helpful baseline for new thinking and adaptation.

Description: If and when gas networks reach the end of their effective life for transporting natural gas alternative uses may be found for the network that are consistent with a low carbon economy. National Grid Transco has developed a proposal for the alternative use of some sections of their gas network (post the transport of natural gas) to capture carbon at generation sites and transport it for underground storage in exhausted gas fields.

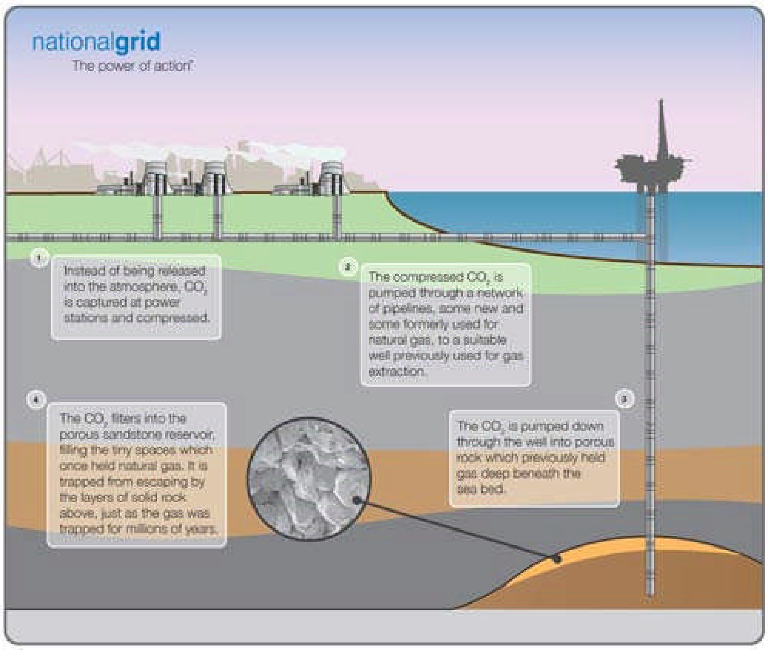


Figure 17 Schematic of National Grid's Carbon Transport and Storage project

Increased focus on carbon capture and storage allows gas network operators to look at employing their gas networks for carbon transport. Building CCTS (Carbon Capturing, Transport and Storage) infrastructure requires research efforts in many areas to gain the knowledge needed for commercial application. The knowledge required should include an understanding of the different processes (capturing-transportation-storage) and the influence of each one of these processes on the others.

Initial investigations have been carried out to identify the research topics in the different areas for the different project stages. This project provides a simulation tool that considers economic and energy aspects to create an optimized CO2 transportation system. Research, and engineering activities have been initiated to provide the necessary data for use in the models. The main benefit obtained from this project is the knowledge and skills to progress CCS research and development concerning CO2 transport.

3.19 Case study 16: Biogas gate-keeper, The Netherlands

In Outline: *this is an interesting gas innovation designed to enable gas created from biological sources (e.g. sewage digestion systems) to enter the public gas network. The gate keeper concept has wider application as biogas becomes larger scale.*
Status: *Implemented*

Quality of Supply	Cost Efficiency	Carbon Reduction	Project Status (TRL)	Degree of innovation challenge	GB regulatory fit	Roll out potential
√√	√	√√√	8.5	√√√	√	√√
Comment: this project demonstrates an innovative approach to bringing bio gas into the public network in a safe and secure manner. It recognises that are a number of uncertainties that require effective solutions and that these have to be carefully risk-managed. **Regulatory Fit in GB:** this is a new development beyond established gas paradigms. Consideration will be needed to adapt regulatory frameworks.						

Description: the programme has been fully operational since 2007. The 'biogas gate-keeper' is a concept for establishing a safe and effective interface between the biogas provider and the natural gas public network. Significant innovation challenges arise here including public safety issues (gas quality and flame behaviour), bio hazard concerns, and the significant recovery challenge if off-spec gas should enter the public network.

Figure 18 The BioGast Gate-keeper in operation

The project was developed by BioGast in The Netherlands and involved partnership with external parties STEDIN.NET (former Eneco Networks), ASN Bank, Cirmac, Hoogheem-raadschap Hollands Noorderkwartier.

3.20 Case study 17: Hydrogen injection in natural gas system, The Netherlands

In Outline: *Some commentators regard hydrogen as the energy carrier of the future. When hydrogen is ignited, the combustion produces heat but no greenhouse gases. In theory, hydrogen could replace natural gas (partly) as a source. This project explores through a real demonstration the potential and impact of blending hydrogen into the natural gas system.*
Status: *Demonstration in service*

Quality of Supply	Cost Efficiency	Carbon Reduction	Project Status (TRL)	Degree of innovation challenge	GB regulatory fit	Roll out potential
√√	√	√√√	6.5	√√√	√	√√√
Comment: this is an early development but an interesting practical step towards potentially greater application of hydrogen as an energy vector. It also assesses end-user reactions which is an important dimension. **Regulatory Fit in GB:** this is a new development beyond established gas paradigms. Consideration will be needed to adapt regulatory frameworks.						

Description: 14 houses in Almeland, the Netherlands, are being supplied with a mixture of natural gas and hydrogen (up to 20%). Hydrogen is produced locally by PV electrolysis and the main objective is to ascertain the effect of hydrogen on network equipment and customer reactions.

Figure 19 The hydrogen injection project in practice

The key trigger for the project was a financial one; the developer receives a government subsidy for injecting hydrogen gas into the network. The payment for injecting is higher than for burning the gas locally in a CHP, especially if the heat cannot be used. Without the subsidy, the project would not be viable, since it is expensive to procure and to run.

3.21 Case study 18: Effect of Electric Vehicles on the Distribution network, GB

In Outline: *Some observers believe that electric vehicles will be the 'killer application' requiring the wide scale implementation of smart grid distribution systems. This project explores the impact of charging electric vehicles on conventionally designed distribution networks and includes network modelling and demonstration and measurement phases.*
Status: *Later stages of research and early demonstration*

Quality of Supply	Cost Efficiency	Carbon Reduction	Project Status (TRL)	Degree of innovation challenge	GB regulatory fit	Roll out potential
√	√√	√√√	4.5	√√	√√	√√√

Comment: This is a notable example of a network company preparing itself for the potential impact of the large scale introduction of electric vehicles.

Regulatory Fit in GB: This project has been implemented utilising existing regulatory frameworks and incentives.

Description: The potential fuel vector shift in the transport sector from fossil fuels to electricity, required to achieve compliance with the Government Policies on Renewables Energy and Carbon reduction, means that the simultaneous charging of multiple electric vehicles is a foreseeable scenario.

The project is looking at the potential impact of Electric Vehicles on the existing UK Distribution Grid systems and considers how the energy in the car's battery might be returned to the grid at times of peak load or for system support. It aims to understand the requirements and limitations of the energy demands of a network-connected vehicle fleet when connected to a real distribution network.

A system-level network management strategy will be developed to level the demand loading and maximise efficiency, and a local management strategy to control individual vehicle network connections, along with further strategies implemented on board the vehicles.

The research will provide knowledge to overcome the barriers in the use of network-connected vehicles by the development of models to represent operating condition. It will also allow the creation of typical demand profiles and provide a greater understanding of typical diversity factors. In addition it will provide data on potential cumulative power quality issues, including harmonics and power factors.

The parties involved are E.ON Central Networks, ARUP, Warwick University & E.ON Engineering. The total project costs (collaborative + external + Central Networks) were around £90,000 for the year 2007-08. Phase 1 (Network Modelling) has been completed

3.22 Case study 19: Dynamic Line Rating, GB

In Outline: *This project involves the measurement and assessment of the operating conditions for a 132KV overhead line to determine its real-time maximum power carrying capacity. Real time measurements are made of ambient temperature and wind speed. This*

technique can permit additional line loading, depending on conditions, beyond the standardised ratings typically assigned on a seasonal basis.
Status: *Implemented*

Quality of Supply	Cost Efficiency	Carbon Reduction	Project Status (TRL)	Degree of innovation challenge	GB regulatory fit	Roll out potential
√√	√√√	√√	8.5	√√	√√√	√√√
Comment: This is an interesting example of a project that maximises the utilisation of existing network overhead lines. This is useful for deferring costly primary reinforcement and has additional value where connections to wind farms are involved (under windy conditions more generation is produced, and the line is better cooled and capable of carrying the extra power generated). **Regulatory Fit in GB:** this project utilised GB regulatory incentives.						

Description: Active ratings calculations are carried out at Central Networks' control centre as part of the DMS control management system. The scheme will curtail generation in the event of the line rating becoming exceeded.

The idea for this project was generated by engineers that recognised the need and the potential opportunity and was cultivated by the network management team who have been encouraged to be innovative in outlook and actions.

The RPZ regulatory innovation incentive provided the encouragement, or perhaps legitimised, such an activity. However, in practice Central Networks has so far only experienced costs, as the incentive is driven by actual generation connections which have been slow to come forward in the area concerned. To date, the 'PR' value has been the real benefit.

The social benefits obtained by the development of this project lie in the possibility for more renewable generation connected and in shorter timescales for achieving connection. What is more, significant financial benefits can be potentially obtained through the avoidance of capital investment and the extension of the principle to other situations.

The cost for developing the project was of the order of £500,000 in total, some associated with necessary network refurbishment.

3.23 Case study 20: New gas concepts: minimal trenching, France/ Germany

In Outline: *Research projects about the optimisation of the trench geometry in the gas networks in order to: i) improve the safety of gas networks, ii) limit the impact of works for neighbours, iii) reduce the environmental impact and iv) improve economic efficiency.*
Status: *Research and Development with field trials*

Quality of Supply	Cost Efficiency	Carbon Reduction	Project Status (TRL)	Degree of innovation challenge	GB regulatory fit	Roll out potential
√√	√√	√	5.0	√√	√√√	√√√
Comment: the requirement to achieve extensive gas mains replacement, while achieving safe working, minimum highway disruption, low environmental impact, and with effective cost control is a challenge for gas network companies. This group of projects demonstrates fresh thinking in hitherto a traditional sphere of activity. **Regulatory Fit in GB:** this project has utilised GB regulatory incentives.						

Description: Three R&D projects are in progress, co-ordinated by Gaz de France, DVGW – Bonn and S&P - Stuttgart. Two of them focus on the development of minimal intrusion into roadways while ensuring optimum quality and reduction of costs, when building gas networks:

- Placement in narrow trench with recycling of material (DVGW / Gaz de France project) for suburban or rural areas.
- Laying at Shallow depth (Gaz de France / ETDE project) for urban environment.

The essential aspects of these projects are the comparison of guidelines and required performances in France and Germany, the treatment of excavated soils for re-employment as backfill material and a long term study of the behaviour of recycled materials. These projects are expected to culminate in a ‘professional guideline with a view to harmonisation of French-German standards’. A technique in service is already tested internationally, in Switzerland and the UK.

The third project deals with the optimisation of GPR (Ground Penetrating Radar) in order to locate every distribution network under a street. The objectives are to characterise the performance of existing radar systems and develop new systems capable of satisfying user needs.

The main benefits obtained by these R&D projects lie in the opportunities to use, in Europe, new technologies with evolutions of laying rules for the distribution gas pipes.

4 META ANALYSIS

4.1 Introductory remarks

This meta analysis provides a high level overview, drawing out wider learning points and common factors from the global scan of innovation projects. It considers how these innovation projects are impacting on network operators in the current environment and how market and external factors will impact on them in the medium term.

Each reviewed project has demonstrated innovative resolution of a network challenge with differing degrees of uniqueness and technical, commercial and organisational approach.

Network innovations are in general responding to the underlying driver arising from government targets for low carbon economies, recognising that fresh thinking is needed to find cost-effective and practical solutions. This driver has for example led to solutions for connection of distributed generation, maximising network capacity, control and monitoring and adoption of smart technologies.

A number of common factors have been apparent in the process of collecting and analysing the projects and these are presented as a series of discussion points, around a number of topic areas relevant to how innovation impacts on regulators, network operators and how the energy business environment is changing.

It is observable from the global scan of innovation projects that the pace of innovation is accelerating with numerous projects in the early stages of research and development and significant ones that have been adopted organisationally or applied to operational networks.

With a significant shift in emphasis for network operators away from traditional solutions and the increased complexity and dynamic nature of network operations it suggests that the historic business model is changing with higher levels of uncertainty and hence risk.

Analysis from the global can of network innovation projects has shown some common themes as follows:

4.2 Regulation

Network operators rightly have a low risk tolerance and are not naturally inclined to embark on projects unless there is a perceivable return on the investment. Regulatory frameworks can reinforce innovative behaviours with network operators responding to policy directions and financial incentives.

This scan of innovation projects identified greater numbers of projects where regulatory incentives or government funding is available. Where Regulatory incentives have been implemented, such as IFI and RPZ in Britain, network operators have responded with a wide range of novel solutions to address network operational challenges. These incentive schemes have allowed network operators to identify areas where investment has contributed to innovation and provided enhanced customer service. The projects tend to be small and medium scale and these mechanisms have not to date brought forward large scale Lighthouse projects. We note that Ofgem has recently proposed a new mechanism to succeed RPZs (the Low Carbon Network Fund) and this may be effective in bringing forward large scale developments.

The impact of Ofgem's introduction of the Innovation Funding Incentive (IFI) is shown on the Figure on the following page.

External factors are observed to have been the driving force for a significant number of the innovation projects that have required network operators to respond and develop implementable solutions beyond those that would have generally been adopted. The single main factor has been the drive for a low carbon economy and the widespread adoption of renewable energy sources and distributed generation.

A number of interesting innovation implementations that have been reported from the USA were initiated before President Obama's financial stimulus package that designated smart grids as a target topic. An observation is that such projects have in the main been sponsored by the very large utility companies (e.g. AEP, ConEd, PJM) and there is little or no activity from the smaller utility enterprises. This indicates that a critical mass is probably needed before innovation can be established, at least in the absence of innovation incentives.

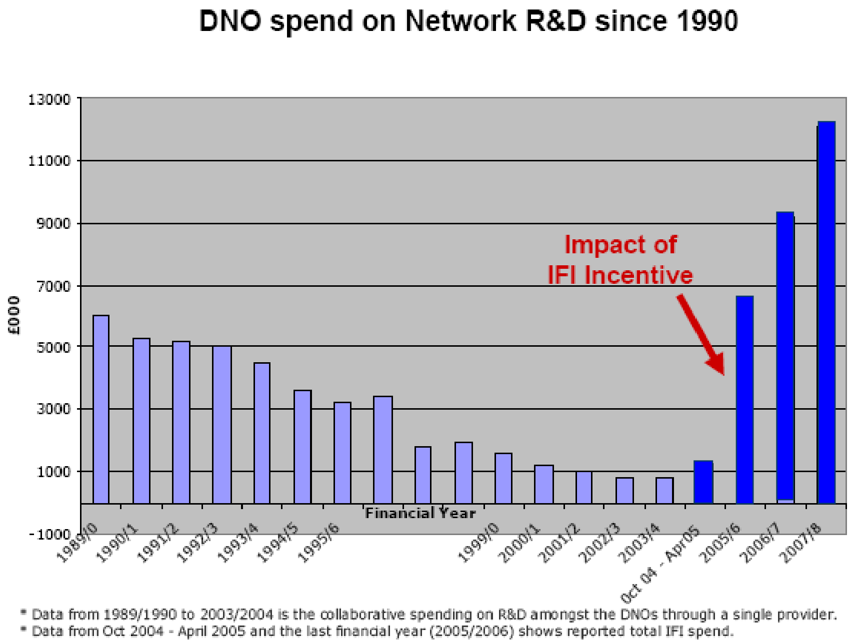


Figure 20 Impact of Ofgem's innovation incentive scheme on R&D spend by GB DNOs

In Europe a number of innovation projects have come from jointly funded Research & Development organisations allowing network operators to spread the costs and risks for R&D. Additionally, large Lighthouse projects, such as smart cities, have some element of government sponsorship to enable the project to proceed, whereas technical innovative solutions are often driven by need e.g. connecting DG, deferring capital expenditure and improving network efficiency.

Headline factors such as the project scale (e.g. Lighthouse projects) and the anticipated benefits are generally observable. However, critical aspects that are key to success are commonly not visible to observers; these include the development of standards that ensure open systems, the testing and certification of new equipment, first line support to field applications, and skills and risk management. All these aspects entail significant attention to details before projects can be accepted on to operational networks, in effect managing the technology transfer from research to commercial deployment.

Innovations appear to be more advanced in electrical networks, which is apparent from the greater degree of challenge brought about by renewable energy where technical innovations can be rapidly taken up and implemented as costs and implementation issues become known.

It was noted earlier that the pace of change is accelerating and networks operators and regulators will need in turn to be more responsive so that innovative solutions become business as usual and that wide area roll-out is achieved to bring about the benefits being sought to a material extent.

Clearly with increased uncertainty, and associated risk, for network operators any regulatory incentives need to be responsive to change but combined with sufficient regulatory certainty to ensure that network operators can take appropriate investment decisions for the medium and longer term.

4.3 **Organisational**

Throughout the review of innovation projects network operators have shown strong aptitude for implementing network innovations with a number of leading examples reported here. Where innovation has moved smoothly through the Research, Development, Demonstration and Deployment phases the involvement of a partner or partners has commonly been evident.

Partner organisations have been manufacturers, academia, or research organisations such as EPRI (Electrical Power Research Institute) in the USA and Europe, EATL (EA Technology Limited) in the UK, and ECN (Energy Research Centre of the Netherlands) in The Netherlands. These organisations would appear to bring significant value for network operators supporting R&D and can helpfully act as an interface with other network operators, manufacturers and research organisations. This approach supports innovation while at the same time mitigating risk for the network operators. Evidently for innovation to be successful it requires a level of creative energy, persistence and effective partnering with entrepreneurial organisations. These may be skill sets beyond recent experience in network companies. Where the most innovative solutions have been seen this appears to be aligned with effective partnership arrangements as well as good in-company policy direction and management attention.

When innovation is implemented on networks it commonly delivers more than a single benefit to stakeholders thus maximising the return on investment. There are examples of innovation for the connection of distributed generation (a low carbon benefit) that also defer capital expenditure and improve network security. In addition there may be gains arising from community goodwill or staff motivation. Sometimes the incidental or wider benefits are not easy to quantify, but are nevertheless real.

Deployment of innovation is incremental within companies with no evidence that network operators can adopt a high degree of innovation without first going through an entry level, building on learning by doing and then increasing the complexity that they address. It is the nature of innovation that there will be dead-ends and sub-optimal out-turns. The treatment of these from a regulatory perspective is an important factor; it can be argued that it is to the customers benefit that they share in a proportion of the losses as without these the successes will not come forward. Performance of an overall innovation portfolio is perhaps a better output indicator for success than individual projects.

Manufacturers are responding with the development of new products and in some cases anticipating market needs and developing appropriate technologies ahead of network operator requirements. However, practical hurdles need to be crossed in getting innovation pilots and demonstrators operating on real networks with agreements needed on technical standards, support, skills and risks. With the pace of innovative change accelerating, networks owners and operators need to be increasingly responsive to uncertainty.

Successful projects have been characterised here by the term partnership; this is intentional as it is intended to convey a joint-working approach. The alternative to this where the relationship is simply transactional, a form of ‘baton-passing’, rarely results in success. As sometimes described, ‘there needs to be both technology push and user pull’ for successful innovation.

Electricity networks are observed to have adopted a higher degree of innovation than gas and that rate of innovation is accelerating. This can be accounted for by the high level of renewable generation that has connected to distribution networks and the changes that have been implemented to facilitate the required generation capacity. Gas networks have been more focused on the use of alternative gases and other uses for the current network.

It was also identified that an increase in expenditure for innovation on electricity distribution networks was seen directly following the introduction of Regulatory incentives such as IFI and RPZ (Figure 20). These incentives have clearly stimulated some of the innovative solutions and could will be seen as anticipating similar trends for electricity transmission and gas networks

It has been demonstrated that technical innovations can be rapidly taken up and implemented as costs and installation issues are known and have become public. It is apparent that there is a high degree of information sharing once innovations have passed the initial research stage.

It is helpful to recognise that end users cannot be expected to manage any level whatsoever of technical complexity in energy systems; hence there is a compelling need for automation, simple user interfaces, remote monitoring, long time between routine maintenance interventions, and perhaps training of a local site technician who has access to deeper knowledge backup as needed. Such a situation can be envisaged for a remote location such as an island active network or micro-grid.

Companies new to innovation may not yet have innovation processes running as smoothly as in their core activities; successful innovation is known to be something of an organic process that benefits greatly from professional engagement, networking contacts, and informal feedback from other sectors or personal contacts. This unstructured activity is to be encouraged as valuable ideas for new business opportunities or risk management arise from such channels. However, vigilance is needed because it may result in contacts being made at a range of points across an organisation, with the possibility of, say, duplication or lack of co-ordination. The best advice is that there is more to be gained than lost though professional engagement, but that extra care is needed until the organisation streamlines its innovation approach.

4.4 **Low Carbon**

Non-network innovations such as the widespread uptake of electric vehicles are likely to trigger significant changes to network investment and operational management, with the necessity to have increased diversity (utilising smart technologies) at domestic voltages to accommodate home charging.

Increased connection of renewable generation and adoption of smart technologies in domestic and commercial properties will bring a fresh challenge for network operators. This will lead to new innovations and adoption of smart technologies to accommodate diversity and intermittency in the generation and demand.

Renewable and distributed generation, which predominantly connects at distribution voltages, has encouraged significant innovation on distribution networks to achieve a greater level of active network management. There has been significant investment activity on transmission networks in some countries, but from this survey it has not revealed significant innovation in areas that might be applicable to the GB context.

Transmission innovation investment has predominantly been in systems to support management of the system with higher levels of interruptible generation and to address increasing system utilisation. It is likely that greater innovation will be evident in the medium and long term as transmission systems reach capacity limits, as greater international connections are established, as off-shore developments take place, and as new services from the demand-side offer material opportunities for efficiency gains at transmission level.

4.5 **Security**

Network security is one of the key responsibilities for network operators with standards well documented and understood; the rapidly changing landscape that the low carbon economy is stimulating means that companies may need to manage risk in a more dynamic environment and some long-established standards will warrant review.

When non-network innovations e.g. widespread uptake of electric vehicles are taken into account this means that smart technologies integrated into the operational systems will be the tools needed to maintain the required level of security. A number of projects have been reviewed that demonstrate this need is becoming better understood with solutions matching the requirement available to be implemented.

A significant number of the innovation projects have been driven by external factors such as the low carbon economy where network operators have responded to help facilitate targets for new generation, network losses, capital optimisation and improved customer service standards. This is likely to grow in the future and have significant impacts for planning and the financial justification of network projects. For example carbon costing methodologies may become a normal part of business case evaluation.

4.6 Network efficiencies

With innovation investment attracting a higher level of risk and the resulting multiplicity of benefits it is difficult to disaggregate the cost benefit to each area of stakeholder value. A more holistic approach to evaluating targets and expenditure will enable enhanced monitoring of network operator performance for regulatory and customer service standards.

Adoption of network management tools, Flexible AC Transmission Systems (FACTS) devices and smart technologies will all impact on network efficiencies, investment decisions and have operational consequences. Many of the innovation projects have been instigated to assist network operators (particularly electricity distribution) in higher levels of dynamic management of their respective networks to maintain security standards at the same time of delivering network efficiencies.

Where wholesale uptake of new technologies are planned e.g. smart cities, electric vehicles, micro generation the impact on power flows, demand profiles and voltage levels will need careful planning and operational management. It is encouraging to see that a number of innovation projects that are in development are specifically designed to meet these challenges.

Funding and adoption for these projects will entail some practical hurdles to be crossed in attaining innovation pilots and demonstrators operating on real networks. Less direct correlation between expenditure and direct network tangible results will become more prevalent. In an innovation context some projects may be path-finders that de-risk later applications; a traditional cost/benefit case is less straightforward to apply here and company investment decision processes may need to be adapted for innovation projects.

4.7 Smart technologies

The term 'smart grids' encompasses a wide range of technical solutions to meet the current and future challenges for planning and operating energy networks. Some of the technologies have been singularly implemented e.g. smart meters and some have a much wider adoption of integrated solutions e.g. smart cities. The larger projects, and particularly those large Lighthouse projects, have some element of government sponsorship.

A number of examples of enabling technologies have been developed to facilitate higher level smart grid solutions with large investments in IT and data management systems often linked to the operational systems of the network operators. From the numbers and types of innovation projects it is observed that higher degrees of network operational complexity will become the norm for the future.

Design, adoption and the nature of the innovations, the use of ICT, power electronics, new materials, fast processing and simulation will all require higher degrees of sophistication in control, planning and risk management. Conceptual innovation projects in the early stages of research show a focus on solving some of the network management challenges faced by network operators in the medium term.

4.8 Boldness of innovation projects

To pave the way to the energy networks of the future, a company's or nation's innovation portfolio should have projects of different levels of size, impact and exposure. Some projects will have an exploratory nature to gather knowledge and some projects will provide incremental steps to increase for instance the functionality or efficiency of the current networks. But there is also a need for bolder, more radical projects. These projects will lead the way of innovation, capture the attention from the media and politicians and will enable other projects to arise; the so-called Lighthouse projects.

The figure below shows a representation of the spread of the case studies selected for this survey with the x-axis project scale ranging from knowledge projects to Lighthouse projects, and the y-axis representing an assessment of level of innovation challenge.

Towards the upper right corner are larger scale, highly innovative projects including the Lighthouse projects. In the lower left quadrant, the plot identifies projects of a more incremental nature and more modest in scale. KEMA observation would be that IFI projects do not generally feature in the upper right quadrant, although RPZ projects are positioned closer to it. As the arrow on the plot indicates, there is a need to ‘upscale’ if GB networks are to participate in the Lighthouse category of developments. Recent proposals from Ofgem for a Low Carbon Networks Fund may be helpful in this regard.

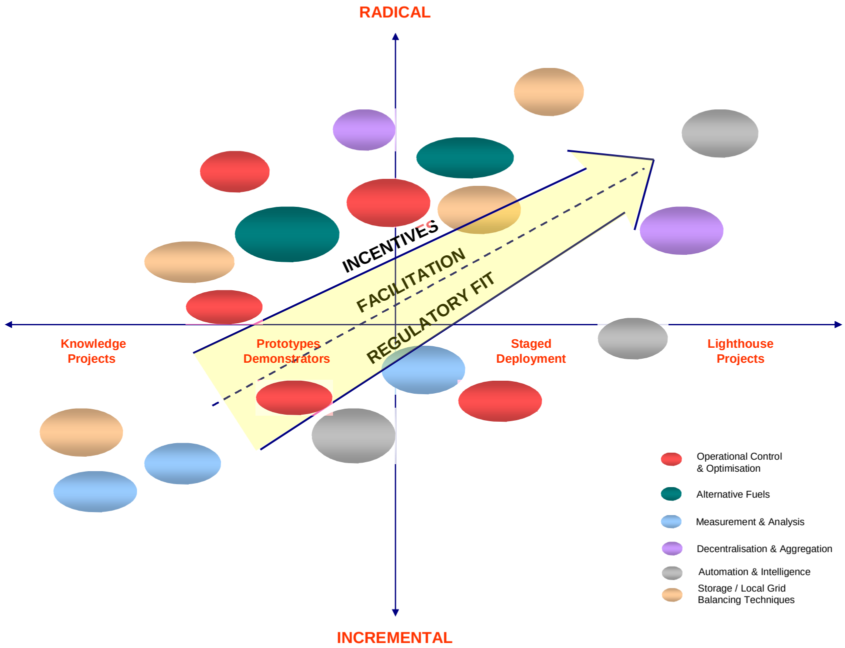


Figure 21 Relative size and impact of the selected case studies

The following figure provides a broader analysis:

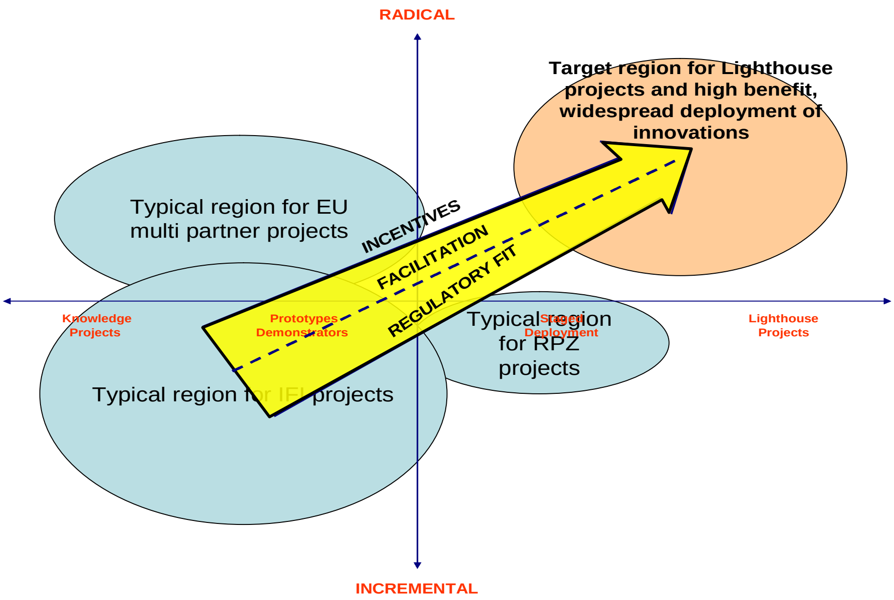


Figure 23 A broader classification

It is important to note that the above diagram should not be interpreted as suggesting that projects in the lower left quadrant are of low value. On the contrary, they commonly provide the technical foundations for the bolder projects. They also provide essential starting points for gaining innovation experience in companies who are relatively new to innovation, and for forging partnerships that are key to delivering large scale innovation.

4.9 Practical pointers

The following points were made by innovation practitioners who contributed to the survey and are noted here for interest.

- **where there is a concern for early obsolescence** or stranded assets, an approach may be to design innovative solutions to be relocatable e.g. trailerised or containerised (noting it is unrealistic usually for them to be fully mobile); this may be particularly apposite where primary network reinforcement renders an innovative capacity management solution redundant ;

- **build early devices with space for extra monitoring**, ease of access for de-bugging or fault fixing; optimise space later; this is an ideal reason for a prototyping stage

- **beware of knock-on effects** such as improving network utilisation through, for example, demand side management or the application of storage, but then losing the availability of cyclic ratings of network assets such as underground cables and transformers

- **some apparently modest-scale projects can have high liability risks** in the rare event that they go badly wrong; for example if off-spec gas gets into the gas grid there may be risk to the public, but purging the system would be a massive and costly task. This emphasises the importance of good risk management and, if necessary, ensuring that (perhaps existing) insurance arrangements cover the risk. An example of risk management in this case might be adding an additional length of pipework so that if off-spec gas is detected a signal can be sent to a remote valve to stop the gas flow before the gas from the prior sampling period reaches the public network.

- **when projects move down-scale from macro to micro, proven techniques may no longer be valid**; for example, odorisation is a well-established technique for adding the distinctive smell to natural gas and the equipment to do this is well-proven; however we understand that at a micro-scale (e.g. adding bio gas from a pilot installation to the public system), the standard odorisation techniques cannot be used as they do not down-scale sufficiently for the small quantities of odorant involved.

- **if a project is likely to attract public interest, build in some level of visitor facilities from the start;** if an innovation project may attract public concern, or there is a need to build public engagement, there may be considerable benefit in designing the installation to be 'visitor friendly'. For example, positioning so that information or displays can be read from the highway, or providing viewing ports or walkways that enable groups to be escorted round, or even a design that allows for a visitor centre to be accommodated on the site. This can be highly effective when interfacing for example with local communities, schools, media or politicians.

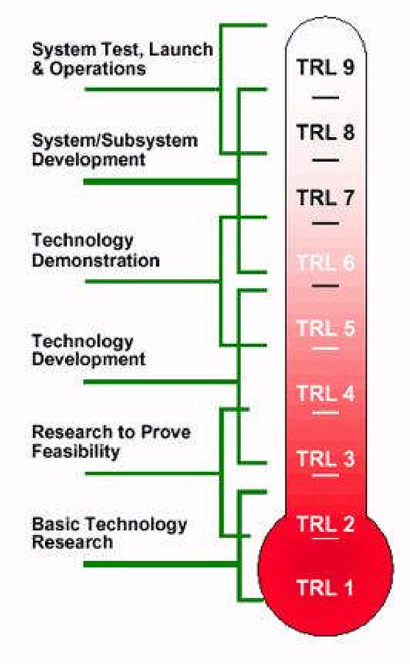
- **innovation benefits will need to be demonstrated**; it is likely that in due course there will be a request for evidence from a network company, from the regulator or internally, to demonstrate that innovation benefits are being delivered and that the roll-out of innovation is being optimally deployed. It may be helpful to design the necessary data capture and reporting into the innovative projects from the outset.

5 ACKNOWLEDGEMENTS

KEMA is pleased to acknowledge the willing co-operation of many parties in drawing together the references and observations contained in this report. KEMA has sought to be impartial in its filtering and short-listing of projects and has stated the commercial parties involved for the benefit of report readers – it is not KEMA's intention to indicate any form of product endorsement.

APPENDIX A: NASA'S TECHNOLOGY READINESS LEVELS

Technology Readiness Level (TRL) is a measure used by many of the world's major companies and agencies to assess the maturity of evolving technologies (materials, components, devices, etc.) prior to incorporating that technology into a system or subsystem. Generally speaking, when a new technology is first invented or conceptualized, it is not suitable for immediate application. Instead, new technologies are usually subjected to experimentation, refinement, and increasingly realistic testing. Once the technology is sufficiently proven, it can be incorporated into a system/subsystem.



KEMA has used its best judgement to assign TRL scores using the framework indicated above. Where the status of a project is uncertain we have used a mid score of 5.0 Where a project is judged to cross TRL levels, say 6/7, this is noted in the dashboard as 6.5

APPENDIX B: CASE STUDIES – TECHNICAL DETAILS

Case study 1: Kythnos Micro-grid, Greece

Title: Micro-grid in Gaidouromantra, Kythnos	
Company: Centre for Renewable Energy Sources and Saving (CRES), National Technical University of Athens (NTUA)	**Parties involved:** Dr. Stathis Tselepis Prof. Nikos Hatziargyriou
Stage of development: Completed, new control and energy management approaches development on-going	**Regulatory regime:** Operating as a pilot system

Project description:

The electric system in Gaidouromantra, Kythnos is currently a 3-phase low voltage system formed by battery inverters. Over the years, for various experimental purposes, it has been modified from 3-phase to 1-phase and recently, in June 2007, it was reconfigured as a 3-phase system for the needs of the EC project "More-Micro-grids". The micro-grid system is composed of the overhead power lines and a communication cable running in parallel to serve the monitoring and control needs. It is electrifying 12 vacation houses in a small valley in Kythnos, an island in the cluster of Cyclades situated in the middle of the Aegean Sea. The grid and safety specifications for the house connections respect the technical solutions of the Public Power Corporation (PPC), which is the local electricity utility. The reason for such a decision was taken on grounds that potentially the micro-grid may be connected with the rest of the island grid. Each house has an electricity counter meter of the type provided by PPC and is supplied with one-phase current, limited by a 6A fuse. This means that each home can have lighting, a refrigerator, water pump and small electrical appliances. The residents were asked from the beginning to use high-efficiency appliances, such as fluorescent lamps and refrigerators with good insulation.

The settlement is situated about 4 kilometres away from the closest pole of the medium voltage line of the island. A system house of about 30 m2 surface area was built in the middle of the settlement in order to house the battery inverters, the battery banks, the diesel genset and its tank, the computer equipment for monitoring and the communication hardware, called "System Hut". The grid electrifying the users is powered by 3 Sunny-island battery inverters, which when they are forming a 1-phase system, they are connected in parallel to form one strong single-phase in a master slave configuration, allowing the use of more than one battery inverter only when more power is demanded by the consumers. Each battery inverter (SI4500) has a maximum power output of 3.6kW. The battery inverters in the Kythnos system have the capability to operate in both isochronous or droop mode. The operation in frequency droop mode gives the possibility to pass information on to switching load controllers in case the battery state of charge is low and also to limit the power output of the PV inverters when the battery bank is full.

Until June 2007, the main system was composed of 10kWp of Photovoltaics divided in smaller PV sub-arrays and a battery bank of nominal capacity 53kWh and a 3-phase diesel genset with a nominal output of 5kVA, when used in 1-phase configuration and 9 kVA when operating in 3-phase configuration. A second system with a 2 kWp PV array is mounted on the roof of the system hut, connected to a Sunny-island inverter and a 32kWh battery bank. This second system provides the power for the monitoring and communication needs of the whole micro-grid system. The PV modules are integrated as shade canopies to various houses of the settlements. The grid and the rest of the systems were installed in 2001, in the framework of two European projects (PV-MODE, JOR3-CT98-0244 and MORE, JOR3CT98-0215). The complete system costs were supported by the General Directorate XII of the European Commission (E.C.), which funded 50% of the projects costs, while the rest is funded by national subsidies or by own contributions according to the status of each partner in the projects.

The main partners and in the two projects were CRES, SMA and ISET e.V. They invested in the systems and they are responsible for the maintenance of and repairs to the systems for 10 years. After that period, it is planned to hand over the system's operation to a local organisation. A local electrician in the island of Kythnos was trained during the project and he is still employed according to the needs to service and maintain the systems. In order to ensure good management and maintenance of the systems, contracts have been drawn up between CRES, the Municipality of Kythnos and the house owners concerning the responsibilities and rights of all parties. CRES is responsible for the book-keeping and management of the systems (incomes and expenses for maintenance and reparations).

In the first two projects, apart from the demonstration of the new battery inverter technology, the main challenge was to control a micro-grid with distributed PV generators. Control solutions, based on grid frequency variation (droop control) as communication signal, have been adopted. The battery inverter was able to vary the grid frequency in order to provide simple control information to the distributed PV inverters and to the load controllers installed in each house. The load controllers were developed by E-Connect (UK) and are able to disconnect the whole house load. The Sunny island battery inverter, when the battery state of charge is low, mimics the effect of an overloaded generator which is slowing down thus effectively decreasing the micro-grid frequency. The load controllers are operated in the frequency mode, that is, they sense the grid frequency and they disconnect the house when the frequency drops below a set frequency (49.14 Hz), provided that the battery state of charge is low or it is overloaded by the users. The houses are re-connected randomly when the grid frequency is increased as the battery state of charge is increased. This allows the houses to come back onto the grid progressively, than suddenly coming all together, overloading the system again. Based also on the grid frequency value (when above 50Hz), the PV inverters are able to continuously de-rate their power output, in order to avoid overcharging the battery bank. Finally, a back-up diesel generator was integrated smoothly in the system to charge the batteries.

In the framework of the European project More-Micro-grids, contract no.: 019864, which started in January 2006 and will last for 4 years, CRES, ISET and SMA are responsible to upgrade the micro-grid systems and then using the LV grid of Gaidouromantra in Kythnos they will demonstrate centralized and decentralized control strategies in islanding mode. In addition, ISET, CRES and SMA will monitor the performance of the system for one year and analyze its operation.

Moreover, intelligent load controllers were developed by NTUA and ANCO that fit into the house AC plugs facilitating control of individual loads using agents. A Micro-grid Central Controller has been installed at the System Hut responsible for optimization of operations, or alternatively, to simply coordinate local controllers, which then assume primary responsibility for optimization. In the centralized approach, all necessary decisions are made by a central controller, while in the decentralized approach, agents negotiate though the communication link to arrive at solutions.
Expected impact and benefit: The benefits were mainly technical, scientific and commercial for the involved institutions in the project. The local residents are satisfied from the electricity service provided. The inverter manufacturer gained experience for the developed products and thanks to the publicity and good operation of the system opened new markets. Several hundreds of new installations of such systems in the immediate 5 years after the project initial operation (in 2001) were implemented. The research institutions due to the experience and competence gained were able to participate in new R&D projects broadening their knowledge. Partners of these projects have significantly contributed to EU and international activities providing significant input to the Micro-grids and Smart Grids concepts.
Business drivers for implementation: 1,6 billion people worldwide without electric power. The "smart grid" of the near future in the developed world.
Operational experience and challenges: A viable scheme of maintenance and operation is essential for the sustainability of such systems. The consumers are not involved in the management of the micro-grid and they have a tendency to overuse the system which leads to shut downs in the period when all the settlers are present (July-August) and use energy. The consumers' energy demand increases by the year.
IP, Patents and knowledge sharing:
Conditions that have facilitated and encouraged development: There was financial support from European programs, JOULE and FP6 and there is social and environmental need for the electrification of small settlements in remote areas with free local renewable resources, where the conventional power supply systems are too expensive to install, operate and maintain.

Case study 2: PowerMatcher, the Netherlands

Title

PowerMatcher

Lead Company / Sponsor	**Parties involved**
Energy Research Centre of The Netherlands	Part of FENIX project
Stage of development	**Regulatory regime**
Testing	

Project description

ECN has developed the PowerMatcher control concept for coordination of supply and demand in electricity networks with a high share of distributed generation that implements the market-based control theory. It is concerned with optimally using the possibilities of electricity producing and consuming devices to alter their operation in order to increase the over-all match between electricity production and consumption.

Each device is represented by a software agent that tries to operate the process associated with the device in an economically optimal way, so no central optimisation algorithm is needed and the communication overhead in contact with an auctioneer is very limited. The only information that is exchanged between the agents and the agent platform (the electronic market) are bids. These bids express to what degree an agent is willing to pay for or receive a certain amount of electricity. As a response the market clearing price is returned, so the agent knows how to act; start producing (resp. consuming), or wait for the next bidding round.

The electronic market is implemented in a distributed manner via a network structure in which so called PowerMatchers, as depicted in the figure below, coordinate demand and supply of a cluster of devices directly below it. The PowerMatcher in the root of the tree performs the price-forming process; those at intermediate levels aggregate the demand functions of the devices below them.

Expected impact and benefit

PowerMatcher agent concept works very well for virtual power plant control. Without any infringement of user comfort, the market-based control leads to substantial peak load reduction of 30% in summer and 50% in winter. A Fit-and-Forget policy did not provide benefits to the DNO in comparison to the baseline case. The load-duration curve was lowered on average by adding the μ-CHPs. However, the peak load remained virtually unchanged.

The PowerMatcher can also exploit the use of the CHP's booster mode in an optimal way, producing on average more electricity than in a fit-and-forget policy, without consuming significant more amounts of gas.

μ-CHP is just one example of a device that has potential for market-based coordination. Other distributed generation may be included such as solar and PV, and storage systems. Also consuming devices may become part of a VPP. Heat pumps and air conditioners can provide ample flexibility in operation to participate in market-

based coordination. Thus the PowerMatcher concept may also become a valuable tool as an improved alternative for demand response programs.
Business drivers for implementation The main business driver is to provide a platform for integration of DG with the grid.
Operational experience and challenges Field test for 10 nodes successfully conducted. Filed test for 100-300 nodes currently on. Scheduled test for 3000+ nodes planned later.
IP, Patents and knowledge sharing All IP rights currently rests with ECN. ECN plans to partner with other commercial and academic institutes to broaden the development efforts.
Conditions that have facilitated and encouraged development

Case study 3: Orkney Active Distribution Network Management, GB

Title Orkney Active Distribution Network Management	
Lead Company / Sponsor Scottish & Southern Energy	**Parties involved** Strathclyde University, Glasgow Smarter Grid Solutions
Stage of development The status at August 2009 is that the active network management system (main and backup PLCs) is installed and operational.	**Regulatory regime**
Project description The amount of Distribution Generation allowed to connect to the Orkney distribution network is currently limited by network constraints. An increase in renewable energy generation is commonly accepted to be an important part of the plan to meet GB and international emissions reductions targets. Renewable resources are often	

located in remote areas where the connection to the national grid will be via weak distribution networks requiring substantial network infrastructure reinforcement.

The Orkney Isles are an area of abundant renewable resource with several wind farms and the European Marine Energy Centre. Orkney is connected to the mainland network by two 33kV submarines cables and analysis shows that the active network management scheme may be capable of releasing capacity for DG connections by up to three times the firm capacity of the existing distribution network

To enable active management of the power flows on Orkney, the network has been segregated into control zones. Control logic has been designed to regulate the output (trim) or trip the New Non Firm Generation (NNFG) as required. The inputs to the control logic are status indications from generators and network components, and analogue representations of power flows at zone intersections or 'pinch points'. Each zone will have its own control logic. Measurement of power flows at zone intersections and other critical points will inform the decision making process performed by the control logic.

The NNFG are approached for curtailment on a last-in first-off (LIFO) basis. Measurement of the export power flow to the Scottish mainland breaching a pre-determined threshold will result in all of the NNFG on Orkney being approached for curtailment according to LIFO. If an overload is measured between a zone and the Orkney 'Core' then the NNFG in the zone will be regulated according to LIFO.

The principles of operation for the ANM scheme hold for other situations where the thermal capacity of radial distribution networks is under utilised or acts as a barrier to the connection of new DG units. The scheme is therefore expected to be applied to other parts of the GB network in the event of a successful trial and full roll-out.

Expected impact and benefit

The full operational use of the programme will follow in 2010, so it is too early to quantify the benefits. There have been a number of non-financial benefits, one of which has been avoiding a 'connections queue' that is awaiting primary reinforcement. SSE have only addressed generation projects on Orkney that have gained planning consent.

The status at August 2009 is that the active network management system (main and backup PLCs) is installed and operational; the first 2 generators are now under construction (having been delayed by consent approvals) and are expected to be linked into the scheme later in 2009. A further 7 generators have accepted the proposition and are expected to follow soon after. This will bring some 17MW of highly dispersed wind generation into the active management scheme. SSE have installed a new high speed communications system to provide the measurement points for the generation. SSE are considering the merits of integrating dynamic line ratings and energy storage as further development stages.

Business drivers for implementation

SSE engaged with Strathclyde University in Glasgow to develop the philosophy for this project; they were a natural partner arising from prior relationships. A government grant (DTI Technology Programme) in 2004 provided a helpful stimulus for the early work with Strathclyde.

Also, SSE utilised the GB Regulator's innovation incentive mechanisms IFI (Innovation Funding Incentive) and RPZ (Registered Power Zone) which fitted well with the proposed developments.

Operational experience and challenges

SSE have commented that there were commercial challenges to be resolved alongside the technical ones

(constraining the operation of wind farms for example); their reflection is that the special status of being an Ofgem RPZ helpfully ring-fenced the development so that new commercial arrangements, suitably simplified, could be put forward to get the project moving.
IP, Patents and knowledge sharing
Conditions that have facilitated and encouraged development

Case study 4: Energy Smart Miami, USA

Title Energy Smart Miami	
Lead Company / Sponsor City of Miami, Florida	**Parties involved** Florida Power & Light Group General Electric (GE) Cisco, Silver Springs Networks
Stage of development Energy Smart Miami could begin later this year and be completed by the end of 2011	**Regulatory regime** Florida Energy Commission promotes competition and encourages adoption of Renewable.
Project description Energy Smart Miami represents an alliance of local government and private enterprises. Miami is partnering with FPL, GE, Cisco Systems and Silver Spring Networks to launch Energy Smart Miami, a model electricity system for American cities and cornerstone of a broader $700 million state wide investment. The backbone of Energy Smart Miami will be the deployment of more than 1 million advanced wireless “Smart Meters” to every home and most businesses in Miami-Dade County. These meters will give Florida Power & Light Company (FPL) customers more information and control over their electricity usage while also providing FPL with information that will enhance system efficiency and reliability. Implementation of the Smart Meters will be based on open network architecture, allowing other providers to develop and deploy new applications that could, for example, help consumers better manage the electricity usage of their air conditioning and appliances.	
Expected impact and benefit • Smart-Grid Automation and Communications. More like the Internet than an electric network, the new smart grid system will connect smart meters, high-efficiency transformers, digitised substations, power generation and other equipment through a centralised information and control system. • Smart Meters. Through the Energy Smart Miami initiative, smart meters will be installed in more than 1	

million homes and most businesses in Miami-Dade County, helping FPL customers lower their electric bills by giving them substantially more information to make decisions about their electricity consumption.

- Renewable Energy Integration. Several local universities and schools will receive solar power installations to help meet energy needs with renewable, non-polluting technologies. Battery installations will enable some solar locations to store power for use during times of peak demand.
- Plug-in Hybrid Electric Vehicles (PHEVs). 300 plug-in hybrid electric vehicles will be added to the FPL fleet serving Miami-Dade County. The PHEVs will be powered through approximately 50 new charging stations. Additional PHEVs will be rolled out in trials at Miami Dade College, Florida International University, the University of Miami and the City of Miami.
- Consumer Technology Trials. Using the capabilities of installed smart meters, the initiative will conduct approximately 1,000 trials of additional consumer communications and empowerment systems to determine which delivers the greatest energy savings and consumer satisfaction.

Business drivers for implementation

Operational experience and challenges

IP, Patents and knowledge sharing

Conditions that have facilitated and encouraged development

Public Private Joint venture which aims to meets President Obama's criteria as a "shovel-ready" project to qualify for matching funds from the American Recovery and Reinvestment Act of 2009, commonly known as the federal stimulus package.

Case study 5: InovGrid, Portugal

Title: INOVGRID	
Company: Energias de Portugal (EDP)	**Parties involved:** EDP, Efacec, Logica, Contar/Janz
Stage of development: Demonstration phase on 50.000 households	**Regulatory regime:** n.a.

Project description

In the current world macroeconomic context, the need for new types of power generation serving as alternatives to the use of fossil resources, combined with the objectives of reliability and of supplies while inducing competitiveness in markets, is also initiating a genuine change in paradigm in power grids and in the way they interact with consumers, where both (grids and consumers) will play a significantly more active role than they currently do.

The new paradigm of the electricity sector rests on a more efficient use of energy, thereby resulting in benefits for consumers themselves (through the emergence of new market products directed at energy efficiency and at micro-production) as well as for the electricity distribution grid operator. The new paradigm for supporting the electrical system hinges on strong emphasis on managing demand, renewable energy sources and micro-production (distributed production) while developing the concept of consumer/producer. This new paradigm is explored in the development of this project, while proposing the implementation of a set of functionalities which, by exploiting the communication infrastructures to be installed, will make a set of vital tools available for the technical and commercial operation of power distribution grids in the future. In this regard, the InovGrid project presents itself as an R&D catalyst, as it provides business opportunities while promoting an increase in distributed generation and bringing about the supply of innovative services to users.

The **InovGrid** project, launched by EDP Distribuição, as the Electric Power Distribution Grid Operator (DGO), is ultimately aimed at developing a set of functionalities and new devices to be installed in the field which will enable the equipping of the current electric power distribution grid with a level of intelligence to respond to the challenges put forth by new paradigms regarding the operation of the electrical system. In this regard, this project will make it possible to equip the DGO with a set of new functionalities associated with managing electric power distribution. On the other hand, the idea is to generate a market of opportunities surrounding this new paradigm of Smart Grids.

The main objectives of this project include:

- **Enabling attention to be focused on consumers,** by creating conditions for making available new value-added services, innovative price plans, two-way interaction between consumers and the grid, pressure on prices, …
- **Bringing about the liberalization of electricity markets** – by inducing competition and flexibility in rates, new products and services, transnational competition, …
- **Inducing demand modulation**, by smoothing peaks of consumption, thus contributing toward greater alignment between the supply and demand for energy, …

Ensuring greater supply safety, by diversifying renewable sources and increasing the ability to integrate distributed generation in the system, with special emphasis on micro-production, …

Promoting the renovation of grids and their operation, using investments that will make grids more reliable and efficient, namely by increasing the level of automation and remote control, …

These objectives will be based on the development of infrastructures on the distribution grid, which will enable expanded monitoring and control capabilities, while making it easier to integrate distributed generation.

Expected impact and benefit:

This solution will enable various stakeholders in the electricity sector to obtain significant benefits, namely:

The consumer/producer may see an increase in the ability to produce energy through micro-production, via the existence of an efficient distribution grid control and management structure; they can play an active role in managing their energy consumption, by contributing toward aligning supply with demand while reducing their energy costs; they may have access to new services, new types of pricing and innovative price plans which, under pressure from the competition, will tend to markedly lower their energy bill. It also enables the reduction of costs in various operations such as doing away with manual metering costs, making fraud detection easier, lowering interrelationship costs between marketer (or grid operator) and consumers (change of contracted power scale, cut-off and reconnecting, sending messages) and debit problems, thereby passing on to customers the benefits afforded by the remote operation of services. It also makes sure customers are always billed according to their actual power consumption, regardless of how often they are billed;

Marketers can diversify their supply of services and offer new types of pricing to their customers, by looking at new instruments in order to participate in the market and compete among themselves. Reduction of metering costs, as well as costs with rate changes, and cut-off and reconnecting. Dissuasion against fraud. Reduction of errors in predicting consumption via better quality consumption estimates;

The Regulator will see the creation of better conditions for market development, with positive implications on the reduction of electricity rates. Likewise, he shall have access to a set of value-added information for controlling how the market operates along with operating conditions;

The Distribution Grid Operator will increase operating efficiency, while being able to increase the reliability of their grids and can also increase the quality of service in the electricity supply, by optimizing investments while reducing their operational costs and their energy losses. It will also allow for the introduction of improvements in grid operation and in future planning, based on more detailed information regarding operating conditions. A more precise estimate of technical and non-technical losses. Greater swiftness in detecting faults, easier location of where they occur, so as to restore service more quickly. More complete and reliable grid monitoring;

The National Economy will benefit, at least, from the greater energy efficiency, resulting from better use of available energy sources.

Business drivers for implementation:

The main business drivers for the project implementation are the constant requirements of CAPEX optimization and reduction, the need of workforce adjustments in the sector and a steady OPEX are leading to the need of a new vision for the sustained development of the grid, capable of facing the new sector challenges. This is made by developing Distributed Energy Resources (DER) and enhancing its penetration and the development of a Pan-European energy market.

In fact, the distributed generation diffusion can offer value to the grid system operators by providing a deferral of investments to transmission and distribution systems and reduction of losses in the distribution system. At the same time, a better knowledge of both the energy flow and the grid assets' condition, as well as the possibility to control loads through Demand Response, enables a new approach to network operation, supported by risk management, pre-fault detection, and dynamic reconfiguration & self-healing capabilities, with significant impact on quality of service. Better supported investment decisions and a reduction of the overall maintenance costs are also expected.

Operational experience and challenges:

The project is being developed in 2 phases:

- Pilot where 500 EB's are installed in selected consumers and
- A Demonstration Phase where we will install 50.000 EB's in a group of selected consumers.

The choice of having a pilot phase of 500 consumers has allowed us to test on the field all the technology that has been developed in-house. This pilot allowed us to carefully select the networks and customers and to reinforce the internal knowledge on the technology capabilities.

Additionally it has been key to build on experience and adapt the internal commercial and operational processes to rollout to 50.000 consumers. In this phase we will have a very good approach to what a standardize installation process will be if we decide to rollout to the remaining market of 6 million consumers in Portugal.

Bringing a new technology to life is always challenging both from a technical point-of view and a commercial point-of-view. The key is to allow processes to evolve and to have the flexibility to introduce changes in the way. By maintaining the flexibility when the pilot is manageable (500 consumers) we are able to detect and act on issues that appear along the way.

IP, Patents and knowledge sharing:

The development of the InovGrid project led to the definition of a new solution to the grid management. The overall solution consists of several components developed from scratch which, articulated among themselves, allow us to address the objectives for the system. The main components of this solution are:

- Energy Box: devices to be installed at consumers/producers (including modules for measuring, actuation, processing, interface, communication, etc.);
- Distribution Transformer Controller (DTC): local control equipment to be installed at switching stations (including modules for measuring, actuation, processing, interface, communication, etc.);
- Grids/Communications: equipment and technologies for information transmission;
- Information Systems: systems and applications for management and central data processing.

The project guarantees that the intellectual property developed by **InovGrid** is available to all partners and is

protected by a specific contract. It is true that the level of interaction among partners in the project has been key to enhance the R&D side of the project and for that knowledge sharing tools have been extensively applied within the project in order to allow information to flow among partners. Note that the DTC won an innovation prize in 2009 awarded by COTEC Portugal. In our opinion this is critical to the success of the project due to its innovative character and the lack of field expertise of all partners in this area. Additionally, the development of a trust system where all can work with the same objective allows partners to share issues and possible solutions that guarantee the project's success.
Conditions that have facilitated and encouraged development: Apart from what was mentioned previously, we believe that the adoption of a single goal by all partners has facilitated the development of the project. Also the encouragement of the regulator to sponsor the project was key to its success. In a world dependent on energy, evolution is a necessary constant. The needs and the potential of modern technologies require continuous evolution of electricity grids. EDP is in the cutting edge of world operators prepared to meet this challenge. We see it as an opportunity to evolve and create a future that is more sustainable in energy terms. • More environmentally sustainable, by using new forms of energy generation and raising energy efficiency, and with more proactive input from consumers. • Greater supply reliability and quality, through more effective management of the grid and greater control over energy generation sources. • More competitiveness, by reducing operating costs and providing innovative services that are better adapted to the customers' needs.

Case study 6: Distributed Generation Connection Planner, GB

Title DG Connection Planner	
Lead Company / Sponsor Department for Trade and Industry (now DECC)	**Parties involved** EDF Energy Networks CE Electric GB IMASS Limited Senergy Econnect
Stage of development Demonstration	**Regulatory regime** IFI
Project description This project built on the work reported in "Internet Services for Planning Distributed Generation connections" funded by the DTI to provide DG developers access to suitable connection locations and estimated connection	

costs. The system uses an OS map background to allow users to position a proposed generator connection, DNO LTDS data to derive suitable connection scenarios and costing information for the provision of budget estimates.
Expected impact and benefit Areas where the network is likely to be sufficiently robust to support generation connections can be identified by developers prior to making formal contact with the DNO. The DG developer may be prepared to accept a lower accuracy on costs and be more interested in assessing the engineering feasibility. This is likely to be particularly true if the applicant has a number of sites under consideration and wants to eliminate those that are in locations that are going to be difficult to connect. This could reduce the need for significant reinforcement in support of generation connections by providing visibility of the more suitable locations. The research has already had a positive impact. The cost mapping technology developed by this project was specifically referenced as a desirable development for all DNOs in Ofgem's policy review document for DPCR5. The most promising route to implementation may be to offer a service free of charge to developers on behalf of all DNOs. There has also been interest from other DNOs in extending the use of cost and capacity mapping down to smaller schemes, which would connect to the 11kV distribution network.
Business drivers for implementation
Operational experience and challenges
IP, Patents and knowledge sharing
Conditions that have facilitated and encouraged development

Case Study 7: AURA – NMS (Active Network Management System), GB

Title AURA – NMS (Automated Regional Active Network Management System)	
Lead Company / Sponsor	**Parties involved**
Scottish Power/EDF/ABB	ABB, EDF, Imperial (leading 6 other universities) - partly funded by EPSRC (GB university funding body)

Stage of development	Regulatory regime

Project description

This project aims to produce a control structure and set of control algorithms that realise the notion of an active distribution network and enhance the service a network operator provides to load and generation customers, improving network performance (asset use, etc.).

In general the scoping and development will consider the following major areas.

- Distributed Generation and demand side management to facilitate the connection of DG to the network;
- Develop a controller that will monitor electricity networks, isolate faults quickly and allow distributed generation to remain connected and operating.

The SP portion of this work is to focus on constraint management techniques for use on new / existing generation connections, focussing on the 33kV and 132kV networks. Although relevant to both SP-D and SP-M networks, the principle focus in case studies will be to overcome existing limitations in SP-M, with a focus on:

- Overcoming complexity of existing hard-wired intertripping schemes
- Determining a solution for managing multiple generation connections in a given locality
- Developing and implementing a system that can work in harmony with existing SCADA infrastructure
- Overcoming communications / equipment limitations of existing systems

Expected impact and benefit

Benefits are expected to include:

- Development of a constraint management solution with relevant experts
- Implement solution and prove concept
- Potential to create Registered Power Zone for additional revenue on the DG incentive
- Maximisation of the contribution of DG to the electricity network;
- Reduction in carbon emissions and help towards the GB governments climate change targets;
- Reduction in network losses by having the source of generation close to the load;
- Improvement in quality and security of supply;
- Improvement in network resilience; and
- Reducing the current market failures to increase network capacity for DG.

Business drivers for implementation

Operational experience and challenges

IP, Patents and knowledge sharing

Conditions that have facilitated and encouraged development

Case study 8: Intelligent Network Switching, NZ

Title Intelligent Network Switch Scheme	
Lead Company / Sponsor Vector Group, New Zealand	**Parties involved** None
Stage of development Implemented	**Regulatory regime** The initiative was not driven by any regulatory pressure or incentive.

Project description

Vector has developed a scheme to enable load to be rapidly transferred from one part of its distribution network to a neighbouring part of the network to defer investment in augmentation. The salient features of this load transfer scheme are:

- fully automated – when a fault is detected in a part of the network covered by the scheme, an automatic switching sequence will be initiated which will isolate the fault and rearrange the network to restore supply.
- fast response – the switching sequence is pre-programmed, and hence offering a fast supply restoration to customers.
- high capacity – the fast operation of the scheme allows rapid off loading of zone substation transformers (which are usually operated in parallel) under post contingency conditions.

This in turn allows the transformers to operate to a short term (5 minute) rating, thus deferring reinforcement investments. This automatic switching is performed independent of the main SCADA system.

Expected impact and benefit

The main objective of maintaining customer service at least cost was achieved. The project assessment was based on the deferral of a NZ$7m (£3.5 m) zone substation and sub-transmission cable upgrade for 7 years, by making use of the short-term overload rating of equipment, and the peak load diversity between adjacent zone substations.

There have been additional benefits. Through this project, we have better understood the capability of our network, understood more about alternative operational communication channels (in this case the radio link), the risk aspects of introducing new technologies, and importance of maintaining continuity of knowledge (and the risk of failure to do so).

Business drivers for implementation

Operational experience and challenges

IP, Patents and knowledge sharing

Conditions that have facilitated and encouraged development

Case study 9: Fenix, Europe

<table>
<tr><td colspan="2">Title
FENIX: Flexible Electricity Networks to Integrate the expected 'energy evolution'</td></tr>
<tr><td>Lead Company / Sponsor
Iberdrola SA</td><td>Parties involved
Electricité de France, EDF Energy Networks
Red Eléctrica de España SA, National Grid Transco
SIEMENS Aktien-gesellschaft Österreich PSE
Korona Inzeniring DD, Areva T&D Energy Management Europe
ZIV PmasC SL, ScalAgent Distributed Technologies, ECRO SRL
Pöyry Energy Consulting, Fundación LABEIN, Energy Research Centre of the Netherlands, Groupment pour inventer la distribution électrique de l'avenir, Institut für solare energieversorgungstechnik verein an der universität Kassel E.V. (ISET)
The University of Manchester, Vrije Universiteit Amsterdam
Imperial College London and Gamesa Innovation and Technology</td></tr>
<tr><td>Stage of development
Proof of concept</td><td>Regulatory regime
IFI for the GB contribution and overall, support from EU Framework funding FP7</td></tr>
<tr><td colspan="2">Project description
The objective of FENIX is to boost Distributed Energy Resources (DER) by maximizing their contribution to the electric power system, through aggregation into Large Scale Virtual Power Plants (LSVPP) and decentralised management.
The project is organised in three phases:
Analysis of the DER contribution to the electrical system, assessed in two future scenarios (Northern and Southern) with realistic DER penetration Areva T&D, ZIV, EDF Energy Networks, National Grid and Imperial College were involved in the Northern Scenario demonstration hosted by Woking Council. The Southern Scenario is being demonstrated in Bilbao, Spain by Iberdrola using Siemens DEMS;
Development of a layered communication and control solution validated for a comprehensive set of network use cases, including normal and abnormal operation, as well as recommendations to adapt international power standards; and
Validation through 2 large field deployments, one focused on domestic CHP aggregation, and the second aggregating large DER in LSVPPs (wind farms, industrial cogeneration), integrated with global network management and markets.</td></tr>
<tr><td colspan="2">Expected impact and benefit
To conceptualise, design and demonstrate a technical architecture and commercial framework that would enable DER based systems to become the solution for the future cost efficient, secure and sustainable EU electricity supply system.

FENIX seeks to evaluate the potential for a new market player known as Commercial Aggregators to revolutionise the operation of the future electricity market. Commercial Aggregators will in future contract with a wide portfolio of dispatchable distributed energy resources to create 'virtual power plants'. The Commercial Aggregators will not only trade the production of their VPP's on the wholesale market, they will also use the inherent flexibility of their combined portfolios to offer a range of balancing / reserve services, interacting with DNOs acting as Technical Aggregators to manage the impact of flexible generation on their networks, optimising</td></tr>
</table>

power flows and future investments.
Business drivers for implementation Preparing for an increase in DER penetration so that DER can be an integral part of the network as opposed to being viewed as the problem. FENIX will demonstrate the proof of concept tools to manage Commercial Virtual Power Plants as well as Technical VPP to manage network access and constraints (should they become necessary).
Operational experience and challenges Finding clusters of small scale DER connected to a distribution networks are not very common, yet. Monitoring of existing DG has not been easy. Communications and the use of fixed IP addresses have presented problems.
IP, Patents and knowledge sharing IP belongs to the individual partners of project who developed the IP. E.g. PowerMatcher belongs to ECN, E-terraTrade is a system developed by Areva T&D.
Conditions that have facilitated and encouraged development Funding from the EC was essential to facilitate this integrated project. Strong project management from Iberdrola supported by Labein ensured the project partners worked together. Regular face to face meeting provided opportunities to resolve issues and misunderstanding (especially when English is not the first language of many partners).

Case study 10: D-VAR system, USA

Title D-VAR system	
Lead Company / Sponsor American Superconductor Inc.	**Parties involved** None
Stage of development Commercially ready and in use	**Regulatory regime**
Project description The American Superconductor (AMSC) dynamic VAR (Volt Ampere Reactive) system is a powerful, cost-effective solution that dynamically stabilises and regulates voltage on power transmission grids and industrial operations. Utilizing AMSC's proprietary PowerModule power electronic converters, D-VAR systems detect and instantaneously compensate for voltage disturbances by injecting leading or lagging reactive power at key points on transmission and distribution grids. Each D-VAR solution is customised to meet specific customer needs and	

includes inherent flexibility to accommodate changing grid conditions.
Expected impact and benefit Transfer capacity of a power grid is often limited due to voltage instability. D-VAR systems provide a proven solution to address voltage stability issues and relieve associated constraints. D-VAR systems can be a valuable tool in increasing the power transfer capacity of the grid. D-VAR systems allow wind farms to meet utility interconnection requirements including low voltage ride through (LVRT), voltage regulation and power factor correction. D-VAR systems can also mitigate transient voltage events and "soft switch" capacitors which extends the life of wind turbine gearboxes, switches and other components.
Business drivers for implementation The purposes of reactive power compensation are to regulate line voltage; to regulate the power factor (the phase relationship of current and voltage) of either generating plant or heavy industrial plant such as mine winders; and to help generating plant to ride through brief low voltage events on their grid connection. This is of particular value and importance to wind farms and other generating plant which may be located in remote places where the local grid is weak in these respects. Wind farms are required to comply with the grid code of the country they are in, and the GB code is a relatively onerous one, requiring a significant range of reactive power capability even at real power generation levels down to zero (turbines not rotating). D-VAR system enables wind farm operators to comply with these requirements.
Operational experience and challenges The D-VAR system has been on the open market for several years. Customers are mostly wind farm developers, electric utilities, and turbine manufacturers. American Superconductors have a large installed base of over 100 sites, not all of which are wind farms. In the GB, there are 10+ wind farm sites and one (in Orkney) which is used to regulate the voltage on the subsea cable from the mainland.
IP, Patents and knowledge sharing American Superconductors is a fully commercial, listed corporation. There is no subsidy or other non-commercial element.
Conditions that have facilitated and encouraged development

Case study 11: Bankside Heat Transfer, GB

Title Bankside Substation Heat Transfer	
Lead Company / Sponsor EDF Energy Networks	**Parties involved** Wilson Transformers, Arup
Stage of development Demonstration	**Regulatory regime** IFI
Project description Substation transformers produce waste heat which is usually lost to the environment. The re-planted substation at Bankside, adjacent the Tate Modern art gallery, will use transformers with water cooled heat exchangers. It is proposed that the waste heat from the transformers will be used by the Tate Modern to assist with their building heating process. This will benefit EDF Energy Networks, as less energy will need to be expended within cooler fans at the substation, lower maintenance and replacement of cooler fans will be incurred.	
Expected impact and benefits • Waste heat will be used by a third party • Fewer maintenance interventions for cooling • Less auxiliary electricity consumption • Lower noise level from coolers	
Business drivers for implementation Finding an alternative to venting waste heat into the environment.	
Operational experience and challenges The control system and the third party heat exchanger have been installed with energy monitoring. The Tate Modern is likely to be able to utilise the heat within the following year. Transformer coolers are quiet in operation when they are required to provide additional cooling.	
IP, Patents and knowledge sharing IP belongs to Wilson transformers.	
Conditions that have facilitated and encouraged development The replacement of the transformers at Bankside provided the opportunity to consider the heat exchange alternative.	

Case study 12: GenAVC Voltage Control on DG Networks, GB

Title GenAVC voltage control system	
Lead Company / Sponsor EDF Energy	**Parties involved** Senergy Econnect
Stage of development Demonstration / Deployment	**Regulatory regime** IFI / RPZ
Project description GenAVC has been developed by Econnect to manage voltage rise issues associated with the connection of Distributed Generation (DG) into 11kV networks. This system had achieved satisfactory operation in a trial at Martham Primary substation. The trial demonstrated the principles of voltage control can be applied to reduce the target busbar voltage and minimise network constraints. At Horton Quarry, a landfill gas generator experiences nuisance trips during times of low demand. This project produced a generic tool to assess the benefits of the GenAVC solution. A comparison of the output of this assessment tool with traditional methods of solving voltage rise issues was carried out.	
Expected impact and benefit The tool showed that GenAVC was a solution and a commercial grade GenAVC was installed at Steyning primary to demonstrate that GenAVC provided the least-cost connection for DG when additional generation capacity is sought.	
Business drivers for implementation The GenAVC tool allows DG connection planners the opportunity to offer alternatives to the traditional network reinforcement solutions.	
Operational experience and challenges The demonstration showed that voltage rise issues can be managed and the occasional disconnections of the generator can be avoided. Communications has been the biggest challenge. There is a requirement for a continuously operating communication link between the landfill site and the primary substation. This is currently provided by a BT EPS-9 leased line which is terminated at each end by SHDSL modems. There have been problems with the reliability of this link. ADSL communications equipment is thought to be able to solve this problem.	
IP, Patents and knowledge sharing IP belongs to Senergy Econnect.	
Conditions that have facilitated and encouraged development Excess gas at a landfill gas site had to be flared off, adding to atmospheric pollution and prompting plans for an additional 1MW of generation. An initial survey indicated that this was not possible without substantial and expensive network reinforcement which would have made the project unviable. However GenAVC was shown to facilitate a connection for increased export.	

In spite of the communication difficulties experienced at the test location, this technology is being offered to DG developers where a voltage rise issue is identified and the assessment tool indicates that GenAVC is an appropriate solution.

Case study 13: Distributed Battery energy storage, USA

Title Distributed Energy Storage	
Lead Company / Sponsor American Electric Power	**Parties involved** NGK Insulators Ltd. (NGK) S&C Electric Company.
Stage of development Implemented	**Regulatory regime** The initiative was not driven by any regulatory pressure or incentive.

Project description

AEP installed a 1-MW, 7.2-MWh NaS battery in an existing substation in Charleston, West Virginia, in 2006. The battery is roughly 80% efficient at the point of connection to the grid. However, if the reduced transmission and distribution losses due to load levelling are taken into account, the battery is effectively 90% efficient, The purpose of the battery is to reduce the peak load on overloaded equipment in the station until AEP builds a new substation in the neighbourhood. By reducing the peak load, AEP planned to defer the cost of building a new substation for several years—until the load has grown—to better utilize the new substation capacity. Partially funded by the U.S Department of Energy (DOE), the Charleston storage project was the first megawatt-scale application of NaS battery storage in the United States.

The details of this electricity storage installation and its benefits, such as arbitrage value, reduction in transformer oil temperature, and improvement of the load factor, are all documented in a DOE/Sandia report (SAND2007-3580).

In 2008, AEP installed three 2-MW, 14.4-MWh NaS energy storage systems at three different locations on its system. the functionality of the new storage systems has been greatly enhanced. The key features of the three new systems are triggered peak shaving and dynamic islanding.

Expected impact and benefit

The primary benefits are:

Triggered peak shaving: Triggered peak shaving does not allow the battery to be discharged unnecessarily during daily peak hours; rather, it discharges the battery when the load of a nearby “bottleneck” on the grid exceeds a certain “trigger” level. The ultimate effect is that it helps in saving cost by differing capital investment and providing an option to go for it when economically it's more feasible to do so.

Dynamic islanding: Dynamic islanding allows a utility to continue serving a group of customers when the rest of the grid loses power: An island is the part of a grid or distribution feeder that remains energized by using the

electricity storage during an outage. “Dynamic” islanding refers to the variable size of the served island based on the energy in the battery and load information (the battery power is limited, and the load, depending on the time of day, would be very variable). Frequency regulation: Financial feasibility studies indicates that frequency regulation will be much cheaper using storage device rather than using conventional spare capacity (which is normally about 1% of total connected load). The carbon reduction is an additional advantage using this approach.
Business drivers for implementation The business drivers for this projects are all commercial. If utilities could monetize and add up all the available benefits of energy storage, it would pay for itself, many times over. With the relatively high cost of current electricity storage technologies, the challenge for utilities today is to learn how to realize multiple values in the storage value stream. These benefits, however, are site and application specific, making them difficult to generalize across the industry. Service- related benefits, such as improved reliability and load levelling, may have the support of state energy commissions and may help with cost recovery. Market-related benefits, such as financial gains from energy arbitrage and frequency regulation, appeal to investors. A utility may choose to justify the storage system based on a combination of both service- and market-related benefits.
Operational experience and challenges The operational experience so far has been encouraging and the project is in it's third stage of implementation.
IP, Patents and knowledge sharing All the IP rights rest with project developers and there is no involvement of any regulatory body. U.S Department of Energy (DOE), has far partially funded the project but there is no evidence of sharing any IP rights. Further information required to fully substantiate the claim.
Conditions that have facilitated and encouraged development Apart from the load by Department of Energy, the project was supported and developed by AEP internally only.

Case study 14: Flywheel Energy Storage, USA

Title Flywheel Energy Storage	
Lead Company / Sponsor Beacon Power, Pentadyne Power Corporation	**Parties involved** Multiple
Stage of development Implementation	**Regulatory regime**

Project description

Flywheel energy storage system is designed to respond to a regional transmission operator signal to quickly add or subtract power from the grid in a frequency regulation support mode. Using this concept, the flywheel recycles energy (store energy when generation exceeds loads; discharge energy when load exceeds generation) instead of trying to constantly adjust generator output.

Monitoring and data acquisition has been specified such that system availability and power/energy parameters will be accessible via the website. Any time the system is operated, the kilowatts supplied or absorbed by the storage unit and the total system efficiency will be viewable via graphical display by day, week, month, etc.

Expected impact and benefit

- Increased Available energy: Because present day generators need to be operated below their maximum capability to provide regulation, they are not available to provide their maximum power. Typically generators need to be below their maximum capacity by 2 times the amount of regulation in order to provide headroom for safe operation. If all regulation were accomplished by Flywheel Energy Storage system, then there would be an additional 2-4 % generation capacity without adding new generators.
- Support Distributed Generation with Local Voltage Support: Several Projects have already shown the benefits of using flywheels for local voltage support. This includes a project on the NY City transit system, where ten 1.6 KWh flywheels provide support between train stations. As flywheel storage increases, as will be demonstrated by this project, the feasibility of larger scale application of Flywheel Energy Storage system for local voltage support will be more practical.

Business drivers for implementation

To ensure a functional and reliable grid, the Independent System Operators (ISOs) that operate the various regional grids must maintain their electric frequency very close to the operating frequency. When the supply of electricity exactly matches the demand, grid frequency is held at a stable level. Grid operators, therefore, seek to continuously balance electricity supply with load to maintain the proper frequency. They do this by directing about one percent of total generation capacity to increase or decrease its power output in response to frequency deviations. Changing power output causes greater wear and tear on equipment, and fossil generators that perform frequency regulation incur higher operating costs due to increased fuel consumption and maintenance costs. They also suffer a significant loss in "heat rate" efficiency and produce greater quantities of CO_2 and other unwanted emissions when throttling up and down to perform frequency regulation services.

Operational experience and challenges

Beacon Power has completed the connection of a second megawatt of flywheel energy storage to the New England power grid. Beacon's first 1 MW Smart Energy Matrix flywheel system has been absorbing and injecting (i.e., recycling) electricity to provide frequency regulation services on the ISO New England grid since November 2008.

IP, Patents and knowledge sharing

Conditions that have facilitated and encouraged development

Beacon Power is a listed company in America. U.S. Department of Energy has Offered $43 Million Loan Guarantee to Beacon Power for Flywheel Energy Storage Project. The DOE's Loan Guarantee Program was established pursuant to Title XVII of the Energy Policy Act of 2005. The Act authorized DOE to make loan guarantees 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."

Case study 15: Carbon capture and transport, GB

Title Carbon Capture and Storage	
Lead Company / Sponsor National Grid, GB	**Parties involved** National Grid Gas (NGG), National Grid Carbon (NGC), Scottish Power
Stage of development Proposal to Ofgem, currently under consultation with industry	**Regulatory regime** Currently the asset is regulated under NGG licence
Project description National Grid is investigating the possible future reuse of some of its high pressure natural gas transmission pipelines to transport carbon dioxide from power stations and heavy industry to storage offshore. Scotland and the Humber region in England have been identified as offering some of the best opportunities for Carbon Capture and Storage (CCS) in Europe, with power stations and other heavy industry close to the North Sea oil and gas fields which, when depleted, could provide storage for their carbon dioxide emissions. CCS networks in Scotland and Humberside could together result in a reduction of up to 78 million tonnes of carbon dioxide (60 for Humberside and 18 for Scotland) going into the atmosphere every year. That's equivalent to taking nearly all of Britain's cars off the road. Instead of being released into the atmosphere, carbon dioxide is captured at power stations and heavy industry and is compressed. The compressed carbon dioxide is pumped through a network of pipelines, some new and some formerly used for natural gas, to a suitable well previously used for gas extraction. The carbon dioxide is pumped through the well into porous rock which previously held gas deep beneath the sea bed. The carbon dioxide filters into the porous sandstone reservoir, filling the tiny spaces which once held natural gas. It is trapped from escaping by the layers of solid rock above, just as the gas was trapped for millions of years. There are four main Scottish feeders between Avonbridge and St Fergus for natural gas bringing GB Continental Shelf (GBCS) and Norwegian Continental Shelf (NCS) gas down to England, through Scotland. With GBCS production going into severe decline, gas forecasts indicate that three feeders should be sufficient to transport future gas supplies to St Fergus, allowing one to be re-used for CO2 transportation. The feeder requires Ofgem consent to release it from natural gas duty as it is currently part of the regulated National Transmission System owned and operated by NGG. NGG therefore submitted a formal proposal to	

Ofgem to dispose of the feeder so that it can be re-used for CO_2 transportation. The resultant initial consultation with industry has just concluded. The proposal is conditional upon progression within DECC's CCS demonstration competition.

New connecting infrastructure will be required at either end of the re-used feeder to enable CO_2 to flow from Longannet to St Fergus. Pipe re-engineering, refurbishment and pipework/ valvework at Above Ground Installations (AGIs) will also be required to ensure the new pipe is separated from the NTS and safe to transport CO_2.

If the feeder is removed from natural gas service it will be transferred to National Gas Carbon – a subsidiary of NG separate from NGG. Ofgem will need to be satisfied that the disposal is in the consumer interest (e.g. by sharing in the proceeds of the disposal).

The DECC CCS demonstration project is being funded through a levy on electricity consumers. Because reuse of the gas pipeline will be a lower cost option then building a new CO_2 pipeline it should therefore have wider benefits through delivering the CCS demonstration at a lower cost

Expected impact and benefit

Alongside this substantial reduction in greenhouse gas emissions, CCS would also bring benefits to security of electricity supply by allowing coal to remain part of a future diverse low carbon energy mix.

National Grid is exploring opportunities to apply its expertise in gas pipelines to CCS. It is looking at developing networks where clusters of power stations or other heavy industry adopting CCS use the same pipeline infrastructure. This would be much more practical and economic than the wasteful duplication of each building its own separate pipeline.

We are unable to release cost benefits at this stage as the DECC competition rules prevent any disclosure of price information. In addition the value of the assets proposed for re-use are still under discussion. In our view, it seems logical that a re-use proposal would provide a cheaper solution, and be more environmentally friendly than a new-build demonstration solution. Given the competition may be funded through a consumer levy, any reduction in demonstration costs is a saving to the taxpayer – if this is DECC's preferred option in the competition

Business drivers for implementation

National Grid is keen to 'do the right thing' and has a group strategy of promoting national and company measures to tackle climate change. This proposal strongly aligns corporate strategy with Government policy, maximising efficiency and asset utilisation. CCS could be a key tool in securing future low carbon, flexible energy supplies and the next step is demonstration at scale – we believe we have the innovation, skills and experience that are needed.

Operational experience and challenges

CO_2 transportation on this scale would be new to the GB though there is some international experience. The pressure rating on the existing feeder limits CO_2 transportation to vapour phase which, at this scale, we believe is a world first. National Grid is working with several universities and external advisors on technical areas to ensure operational success and safety.

IP, Patents and knowledge sharing

The demonstration competition requires the learning to be disseminated and National Grid supports this approach as it is consistent with tackling climate change on a global scale.

Conditions that have facilitated and encouraged development

The DECC competition and NGG transportation licence have combined to make the formulation and development of this proposal quite complex, but there is a clear internal desire at senior level, to try and facilitate CCS given the potential considerable benefits. The Innovation Funding Initiative (IFI) money has helped to advance the proposal by funding work to explore the feasibility and safety of CO2 transportation in a reused gas feeder.

NG's licence obligations encourage innovation and also an efficient and economic approach. This has combined with a regulatory remit for sustainability and as such Ofgem are exploring our proposal through industry consultation and due process. There is unfortunately a protracted timeline associated with consulting and in this particular instance, this may result in a missed opportunity - to have a pre-agreed framework for innovation may help in the future.

Case study 16: Biogas gate-keeper – Biogas injection in natural gas public network, The Netherlands

Title: Gate-keeper – biogas infeed to the public natural gas network	
Company / lead sponsor: Biogast	**Parties involved:** STEDIN.NET (former Eneco Networks) ASN Bank National Lottery (government subsidy) Cirmac Hoogheemraadschap Hollands Noorderkwartier
Stage of development: Fully operational	**Regulatory regime:** Feed-in tariff
Project description: In September 2007, the first installation in The Netherlands which retrieves biogas from the sewage treatment process for domestic and transport use officially entered service in the city of Beverwijk, after a year of trials. The Hoogheemraadschap Hollands Noorderkwartier treats the sewage of around 1 million Dutch citizens in 20 plants. At its plant in Beverwijk some 1,5 million cubic meters of biogas gets released which, up till now, was used in two gas engines. The excess was flared. The old system needed replacement, and after a feasibility study it became apparent that an anaerobic fermentation system had several advantages: it is more efficient, requires less maintenance and reduces CO2 emissions. The new system from BioGast Sustainable Energy upgrades biogas resulting from the fermentation of sewage sludge to biomethane which is then fed into the gas grid of ENECO Energie. The system samples	

every 3 minutes the quality of the upgraded gas to access whether is suits the strict gas regulations. When the quality drops, the injection is suspended (hence the nickname 'Gate Keeper'). Furthermore, as part of the project, bio-filters have been installed in various places of the network to study possible contaminations and biohazards, such as the spores of the mad cow disease. The BioGast system is targeting yearly production of 650,000 m3 of gas—sufficient for more than 400 households. A filling installation has been added to the BioGast which allows cars to fill up their tanks with the green gas. Hollands Noorderkwartier Water Board will purchase natural gas fuelled cars which will run on the CO2 neutral biogas. Interestingly, the installation is contained in a single container, allowing rapid replication of the system as a 'plug-in' that can be integrated with other sewage treatment facilities.
Expected impact and benefit: Technology is now better understood, improved and beginning to standardise, reducing the cost. Ready for deployment roll-out. A good understanding is vital as the financial implications of gas related accidents can be enormous.
Business drivers for implementation: Project is consider a very important lighthouse project for Eneco, putting them on the map as thought leaders.
Operational experience and challenges: The original system was built from bespoke elements
IP, Patents and knowledge sharing: First the project was not consider core business, but the 'new energy' department of Eneco (not the network company) developed this project. The project can be rolled out further. Concept is part of the non-regulated business, so profit is allowed.
Conditions that have facilitated and encouraged development: The main trigger was financial; the developer receives a subsidy for injecting gas into the network. The payment for injecting is higher than for burning the gas locally in a CHP, especially if the heat cannot be used. Without the subsidy, the project would not be viable. It is expensive to procure and to run.

Case study 17: Hydrogen injection in natural gas field trial, The Netherlands

Title: H2 injection in gas network	
Company / lead sponsor: STEDIN.NET (former Eneco Networks)	**Parties involved:** Council of Ameland Gasterra NAM (Dutch Oil Association)
Stage of development: Demonstration	**Regulatory regime:** n/a
Project description: By many, hydrogen is consider the energy carrier of the future. When hydrogen is ignited, the combustion produces heat but no greenhouse gases. In theory, hydrogen could replace natural gas (partly) as a source, which is a big step towards a sustainable future. However the practicalities of hydrogen combustion may not prove as ideal as the theory. To test this concept live, STEDIN, Sustainable Ameland (a Dutch island) and Gasterra have started a demonstration project in a small community at Ameland in the Netherlands. The main could of the demonstration is to understand the impact the hydrogen/natural gas plant on equipment and burners and to understand the human experience. The trail started late 2008 and will last for three years. 14 Houses are supplied with a blend of 5 to 20 % hydrogen to the natural gas. The blending is performed onsite. For this project, a new special gas distribution system has been installed. The hydrogen is generated during the day by electrolysis powered by photovoltaic and stored locally.	
Expected impact and benefit: Technical: gained knowledge on H2, impact on equipment, mixing Social: understanding customer's expectations, increased customer engagement	
Business drivers for implementation: Working towards a sustainable energy supply	
Operational experience and challenges: Odourising of the gas mixture was a problem, the normal process is difficult to downscale. Next step: combine with biogas project to obtain larger synergy.	
IP, Patents and knowledge sharing: n/a	
Conditions that have facilitated and encouraged development: The project was trialled in cooperation with the Council of Ameland and their partnership with several	

companies called 'Sustainable Ameland', dedicated to preserve the natural beauty of the island by developing a sustainable energy supply.

Case Study 18: Effect of Electric Vehicles on Distribution Networks

Title: Effect of Electric Vehicles on Distribution Networks	
Company: Central Networks	**Parties involved:** In Phase 1: ARUP, Warwick University & E.ON Engineering.
Stage of development: Phase 1 is complete Phase 2 in planning stage	Regulatory regime: IFI
Project description: Investigate the impact of charging electric vehicles on conventionally designed distribution networks. Phase 1) Network Modelling Phase 2) Demonstration and measurement; as part of the Coventry and Birmingham Low Emissions Demonstration (CABLED) project.	
Expected impact and benefit: Phase 1a) Provide knowledge to overcome the barriers in the use of network connected vehicles by the development of models to represent operating conditions. Phase 1b) Identify real world demand requirements on distribution networks from charging / storage / discharging cycling as determined by actual vehicle operation and the capabilities of the distribution network load. Phase2a) Determine the network impact of the simultaneous charging of multiple electric vehicles by construction and monitoring of strategically placed groups of charging facilities to produce reference data. This will allow the creation of typical demand profiles and provide a greater understanding of typical diversity factors. In addition it will provide data on potential cumulative power quality issues, including harmonics and power factor. Phase 2b) Determine the adaptation techniques which will need to be introduced in to distribution networks to mitigate the impact of simultaneous charging of multiple electric vehicles in different uptake scenarios. This includes modelling various adaptation techniques to calculate the effectiveness and efficiency of the network, through fault contingencies to losses and comparing with conventional reinforcement options. Where feasible include optimum adaptation techniques in demonstration network and monitor. Phase 2c) Review smart grid technology in respect to the simultaneous charging of multiple electric vehicles. Determine both the critical and optimum data requirements from the distribution network and charging control. Evaluate potential system architectures and communication options necessary to	

maximize multiple electric vehicle charging with respect to their monitoring and data handling efficiency, failure resilience considerations, installation and maintenance requirements, etc. Design system with view for inclusion in demonstration network and monitoring.
Business drivers for implementation: The potential fuel vector shift in the transport sector from fossil fuels to electricity, required to achieve compliance with Government Policies on Renewable Energy and Carbon reduction, means that the simultaneous charging of multiple electric vehicles is a foreseeable scenario.
Operational experience and challenges:
IP, Patents and knowledge sharing: IP and knowledge gained from Phase 1 has been shared with project partners and various Government departments. No Patents developed at this point in time
Conditions that have facilitated and encouraged development: Availability of funding under IFI

Case Study 19: Dynamic Line Rating, GB

<table>
<tr><td colspan="2">Title: Dynamic Line Rating</td></tr>
<tr><td>Company: Central Networks</td><td>Parties involved:
AREVA and USi</td></tr>
<tr><td>Stage of development:

Four Power Donut sensors, for measuring temperature and current on the 132kV overhead line, have been installed at strategic locations together with ambient temperature sensors.</td><td>Regulatory regime:

IFI</td></tr>
<tr><td colspan="2">Project description:

Central Networks has developed the first RPZ in the UK. This involves the application of an active rating to a 132kV overhead line based on real time measurements of ambient temperature and wind speed.

Active ratings calculations based on CIGRE 207 equations are carried out at Central Networks’ centre as part of the RPZ load management scheme that will curtail generation in the event of the line rating becoming exceeded. In addition, there are two innovative areas, which required further research and are being funded via the IFI mechanisms:

• Risk assessments identified the requirements for a local autonomous overload protection scheme, which calculates the line rating from local parameters in the event of a loss of communications. This would enable a higher current rating to be maintained while preventing the line thermal rating becoming exceeded.

• As verification of the assumptions made in the derived ratings, sensors will be attached temporarily to the conductors at various critical positions on the overhead line.</td></tr>
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Expected impact and benefit:

The project will:

- Develop and demonstrate an overload protection system which is compatible with a central controlled active rating load management scheme.
- Verify the derived rating of the overhead line by comparing with measured real time conductor data.

Technical benefits - potentially great in the better utilisation of assets.

Social benefits – potential for more renewable generation connected, and in shorter timescales. Also reduced costs and physical environmental impact.

Financial benefits – actually only expenditure so far. Potentially very significant through the avoidance of capex, and the extension of the principle to other situations. (Though the UK regulatory approach inadvertently tends to encourage network investment through the provision of a return on the regulated asset base).

Difficult to sensibly quantify the benefits as can be a) this project b) similar projects c) the opportunity to rewrite the rule book on circuit capacity and design for the UK.

Business drivers for implementation:

The idea emerged and was cultivated by the network management team who have been developed or encouraged to be innovative in outlook and actions.

Operational experience and challenges:

Few learning points – make sure the project is fully resourced / expect it to take longer than you plan / involve others early, so they become part of the idea / ensure all costs included and CBA before and after / communicate with 'the outside world' and in the appropriate language / have data sheets and story line on stock / embed the idea in the business policy / plan an exit strategy if the project doesn't deliver, to avoid leaving stranded pet projects.

IP, Patents and knowledge sharing:

Conditions that have facilitated and encouraged development:

Case Study 20: New gas works concepts - examples of minimal trenching , France/Germany

Project Title: New gas works concepts: examples of minimal trenching	
Company: Gaz de France, S&P – Stuttgart, DVGW - Bonn	**Parties involved:** ETDE
Stage of development: R& D projects	**Regulatory regime:**
Project description: Three R&D projects are in progress, co-ordinated by Gaz de France, DVGW – Bonn and S&P - Stuttgart. Two of them focus on the development of minimal intrusion into roadways while ensuring optimum quality and reduction of costs, when building a gas network: • Placement in narrow trench with recycling of material (DVGW / Gaz de France project) for suburban or rural areas. • Laying at Shallow depth (Gaz de France / ETDE project) for urban environment. The essential aspects of these projects are the comparison of guidelines and required performances in France and Germany, the treatment of excavated soils for re-employment as backfill material and a long term study of the behaviour of recycled materials.. A technique in service is already tested internationally, in Switzerland and the UK. The third project deals with the optimisation of GPR in order to find every distribution network under the streets. The objectives are to characterise the performances of existing radar systems and develop new systems capable of satisfying user needs.	
Expected impact and benefit: The objective of these R&D projects is to optimise the trench geometry in the gas networks in order to: i) improve the safety of gas networks, ii) limit the impact of works for neighbours, iii) reduce the environmental impact and iv) improve economic efficiency. These projects are expected to culminate in a 'professional guideline with a view to harmonisation of French-German standards' and the main benefits obtained lie in the opportunities to use, in Europe, new technologies with evolutions of laying rules for the distribution gas pipes.	
Business drivers for implementation: Cost efficiency; safety, environmental impact, highway disruption.	
Operational experience and challenges:	
IP, Patents and knowledge sharing:	
Conditions that have facilitated and encouraged development: Gas mains replacement and laying of new mains is an increasing challenge for network companies, especially in congested urban areas.	

APPENDIX C: PROCESS OF CASE STUDY SELECTION

Using this consistent set of information, selection criteria were applied to the individual projects based on the high level categories described by Ofgem. Each project was assigned a score based on its value contribution to Security of Supply, Carbon Reduction and Efficiency as shown in Figure 22.

Those projects that had the highest total score across the three classifications were taken forward to the next stage of the evaluation process.

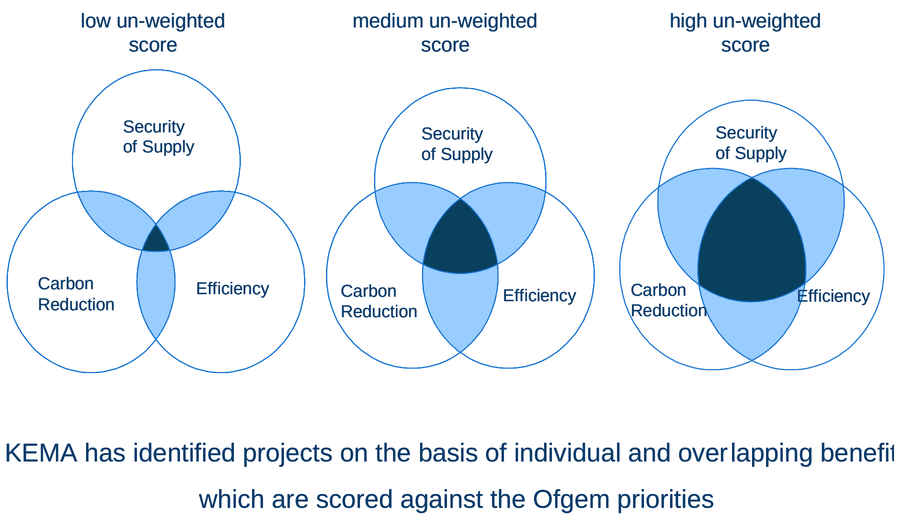

Figure 22: High level project selection criteria

Where an individual project returned a high score (5 out of potential 5) in just one category but exhibited a high level of innovation, or was otherwise worthy of comment, it was included in the filtered list of potential case studies. Figure 23 demonstrates the process used to select the required number of case studies for detailed analysis.

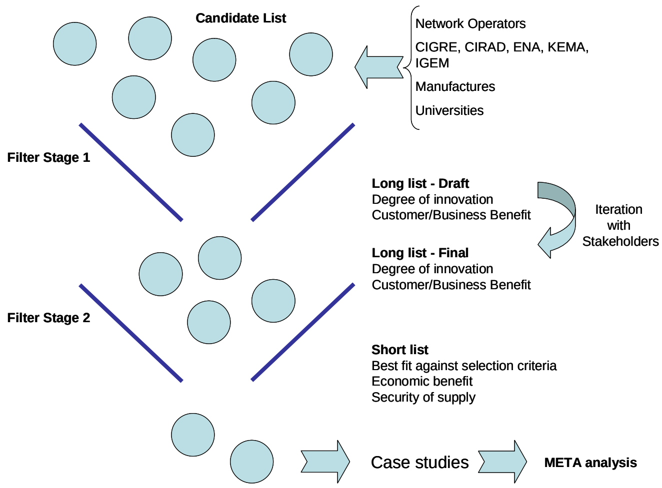

Figure 23: Process for case study selection

These projects were further analysed, Figure 24 against more detailed selection criteria to provide some differentiation between the projects ensuring that those that were most representative of innovation (and associated benefits) were chosen for the detailed case studies.

Innovation Benefit Ranking for a sample project

S.No	Assessment Topic	Rank	Weightage
1	Cost efficiency	9	100%
2	Quality of Supply benefit	3	60%
3	Low carbon solutions	9	100%
4	Wider environmental/sustainability objectives	5	60%
5	Energy efficiency	6	80%
6	Security of supply and resilience	10	100%
7	Government social energy objectives	9	80%
8	Asset utilisation	9	60%
9	Asset replacement and new architectures	7	40%
10	Safety	5	80%
11	Alternative use of networks	8	100%
12	Alternative energy sources	9	80%
	Overall Innovation benefit Ranking	**7.68**	

Figure 24: Sample weighting for innovation projects

The process took the long list of potential case studies from 201 to 68 in the first stage and then from 68 to 22 in the second stage. This provided a manageable number of candidates for the final case studies that provide the basis for this report. Some redundancy in the case study numbers was allowed for in case it was not possible to provide all the information necessary to develop a meaningful case study, as shown in Figure 23.

APPENDIX D: SHORT LIST OF INNOVATION PROJECTS

This section includes details of the 69 projects that were short-listed from the global scan and filtering process. These innovation projects are classified, based on the supply chain, in the following categories:

1. Electricity Customer, EC
2. Electricity General, EG
3. Electricity Networks, EN
4. Electricity Primary Sources, EP
5. Electricity Storage, ES
6. Gas Customer, GC
7. Gas General, GG
8. Gas Networks, GN
9. Gas Primary Source, GP
10. Gas Storage, GS

Each selected project was further categorised based on the technology type and the target area that it addresses. 11 technology types and 17 target areas were identified, covering almost every aspect of network technologies. The projects that were most representative of innovation (and associated benefits) were chosen for the detailed case studies.

Technology Type	Clarification
Measurement & Analysis	Real time management of plant
Automation & Intelligence	Event driven, network reconfiguration
Decentralisation & Aggregation	Distributed and micro applications, service provision, VPP
Operational Control & Optimisation	Real time management
Modelling & Forecasting	
Electricity Storage – chemical	e.g. battery. Flow cell
Electricity Storage – non chemical	e.g. CAES, flywheel
Local Grid Balancing Techniques	
Network Architectures	Radial, interconnected, AC, DC, Dynamic islanding
Alternative Fuels	E.g. biogas, hydrogen; CO2 categorised here also
Heat Management	

Target Area	Clarification
Supply Quality	Interruptions, duration
Waveform Quality	
Security of Supply	Local level
System Performance Enhancement	System Stability, security, resilience
Interconnections between systems	Inter-system performance
Asset Performance Enhancement	e.g. rating of lines, cables, transformers
Asset Life Extension	
Fault Level Management	
Voltage Management	
Customer Interaction	
Electric Vehicle Integration	
New Generation – connections	
New Generation – operation	
Energy Efficiency	
Gas Safety	
Gas Types & Sources	CCS categorised here also
Gas Asset Applications	

Based on KEMA's assessment of the individual projects, the following graphs illustrate the degree of contribution of each project to the three main key assessment criteria:

- Quality of Supply
- Cost Efficiency
- Carbon Reduction

The contribution is plotted as LOW, MED or HIGH. The y-axes of the following three graphs illustrate the project maturity based on the TRL level of each project. The index of the project references (P1, P2, etc.) in the graphs is stated after the plots.

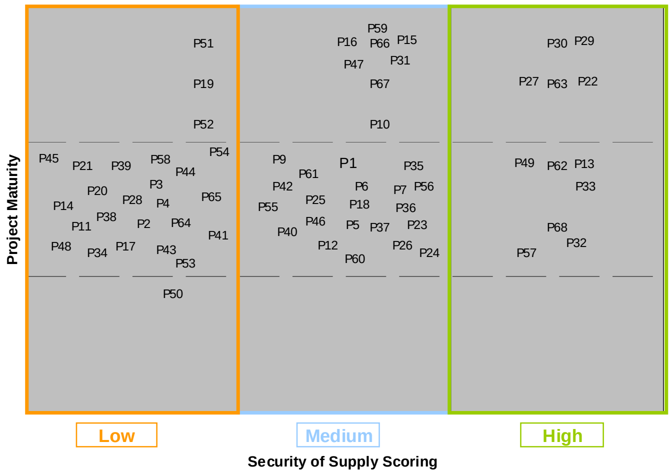

Figure 25 Contribution to Security of Supply vs. project maturity

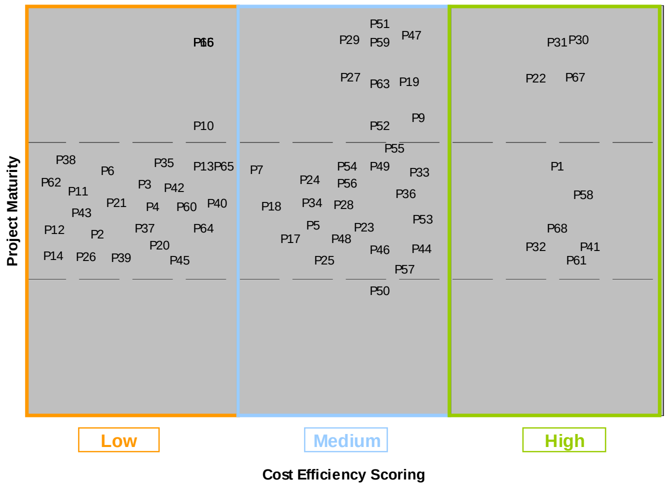

Figure 26 Contribution to Cost Efficiency vs. project maturity

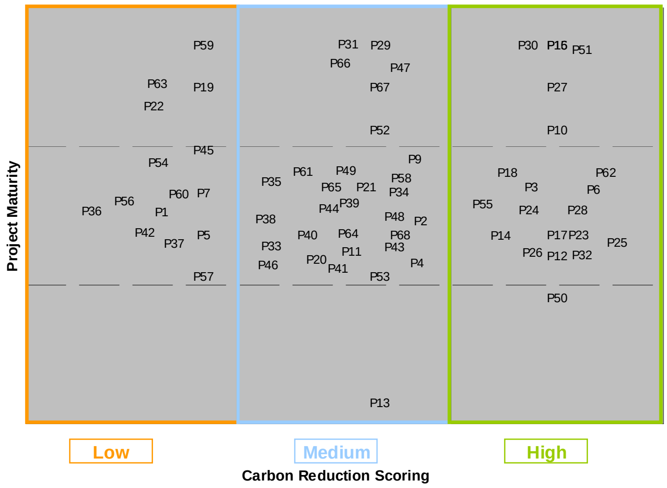

Figure 27 Contribution to Carbon Reduction vs. project maturity

Index	
P1.	MUltiNet and SP AusNet gas distribution pressure controller
P2.	Smart Metering
P3.	Naturalhy Project
P4.	Power quality and Management System (PoMS)
P5.	Networked Control Systems Tolerant to faults (NECST)
P6.	Virtual Fuel Cell Power Plant
P7.	SCADA on Web
P8.	Mannheim smartgrid project
P9.	Power electronics for future utility applications
P10.	Kythnos Micro Grid
P11.	Biopropane pipeline
P12.	Biogas injection in natural gas network
P13.	PowerMatcher
P14.	Carbon Capture and Storage Simulation
P15.	Bio gate keeper - Biogas injection in natural gas public network
P16.	Hydrogen Injection in Natural Gas field trial
P17.	Preparation of EV demonstration project
P18.	GROW-ders
P19.	Dynamic current rating optimisation for underground cables
P20.	Use of heat from compressor stations
P21.	Compressed air energy storage
P22.	Automatic Switching scheme
P23.	InovGrid
P24.	AURA-NMS (Automated Regional Active Network Management System)

P25. Energy Storage for Distribution Systems
P26. Understanding Networks with High Penetrations of Distributed Generation
P27. Impact of Climate Change on the UK Energy Industry
P28. DG Planning Software
P29. GenAVC Assessment Tool
P30. Deucheran Hill Wind Farm Generation Management Scheme
P31. Dynamic Ratings
P32. Effect of Electric Vehicles on Distribution Networks
P33. Control System Automation Algorithm
P34. DG Connection Planner
P35. Network Risk Management
P36. City Centre Substation Cooling
P37. Primary SCADA Communications using IP
P38. Bankside Heat Transfer
P39. 33kV Voltage Control strategies
P40. Development of Redox flow battery for energy storage
P41. FENIX Flexible Electricity Networks to Integrate the expected 'energy evolution'
P42. IHost developments
P43. Optimising System Design for Improved Performance and reduced Losses
P44. Distribution Transformer with on-load tap changer
P45. Vulnerable Customers UPS
P46. Control for doubly fed induction generators (DFIG) for wind farm operation
P47. Hybrid Static Compensation Package for Onshore Wind
P48. Thermal Modelling and Active Network Management
P49. Distributed energy storage
P50. Carbon capture and transport
P51. Orkney Active Distribution Network Management
P52. Superconducting Fault Level Limiter
P53. Supergen FutureNet & FlexNet
P54. LVSure concept for automation of LV distribution networks
P55. Boulder Smart Grid City
P56. Grid Friendly Appliance Controller
P57. Multi-Function Solid-State Switchgear for Distribution System of the Future
P58. Advanced Metering Infrastructure Development and Integration (part of Intelligrid Consortium)
P59. D-SMES
P60. Wide-Area Voltage Instability Load Shedding
P61. Energy Smart Miami
P62. Flywheel Energy Storage
P63. D-VAR
P64. Use of storage to mitigate wind volatility and ramping
P65. Prospects of multilevel VSC technologies for power transmission
P66. Virtual Power Plant (multi-site remote despatching software)
P67. Bio gate keeper - Biogas injection in natural gas public network
P68. Hydrogen Injection in Natural Gas field trial

1. Electricity Customer

1.1 Smart Metering
Energy Australia, Australia

Energy Australia (major electricity distribution network company) is trialling their smart grid strategy in the Newington estate. They are going to deploy between 1000-2000 smart electricity meters in addition to their kiosk monitoring solution. Each house in the Newington estate will have electricity, gas, clean water and grey water individual monitored. While Newington is a new estate they are also including Silverwater with a high percentage of old housing in order to capture off-peak hot water services. Around 100 homes are going to be FULLY monitored with an in home display and 8 major appliances individually metered. This is where the real innovation comes in as amongst other items they intend to test and develop algorithms to indentify individual appliances from the total energy consumption (Note that Energy Australia recently announced a $10 million grant to the Universities of Newcastle and Sydney to assist in the trial analysis). It appears to be a well designed trial with a control group and several different categories of customer.

Selected as case study: no

Technology Type(s):	Target Area(s):
1. Measurement & analysis 2. Automation & Intelligence	1. Energy Efficiency 2. System Performance Enhancement

Quality of Supply	Cost Efficiency	Carbon Reduction	Project Status (TRL)	Degree of innovation challenge	GB regulatory fit	Roll out potential
√	√	√√	4.0	√√	√√	√√

1.2 Advanced Metering Infrastructure Development and Integration (part of Intelligrid Consortium)
Electric Power Research Institute (EPRI), USA

The Advanced Metering Infrastructure Development and Integration Project will develop an industry-wide reference design for AMI. The design will describe how various metering components are expected to operate together as a system, providing services including demand response, net metering, real-time pricing and appliance management.

Selected as case study: no

Technology Type(s):	Target Area(s):
1. Measurement & analysis 2. Operational Control & optimisation	1. Energy Efficiency 2. System Performance Enhancement

Quality of Supply	Cost Efficiency	Carbon Reduction	Project Status (TRL)	Degree of innovation challenge	GB regulatory fit	Roll out potential
√	√√√	√√	5.0	√	√√√	√√

1.3 Grid Friendly Appliance Controller
Pacific Northwest National Laboratory (PNNL), USA

Device based on the gate array chip, commonly found in cell phones, which monitors line frequency, detects dips, and sheds load to compensate. Potential applications for the device are refrigerators, air conditioners, water heaters and various other appliances. The device turns appliances off for a few seconds to a few minutes in response to overloading of the network. Potential to provide feeder voltage support and spinning reserve.

Selected as case study: no

Technology Type(s):	Target Area(s):
Automation & Intelligence [Event Driven]	1. Security of Supply 2. Voltage Management 3. System Performance Enhancement

Quality of Supply	Cost Efficiency	Carbon Reduction	Project Status (TRL)	Degree of innovation challenge	GB regulatory fit	Roll out potential
√√	√√	√	5.0	√√	√√√	√√

2. *Electricity General*

2.1 Boulder Smart Grid City
Accenture, Grid Point; OSI Soft; CURRENT; Ventyx USA, Usa

SmartGridCity is the USA's first fully integrated smart grid community and will incorporate the largest and densest concentration of these emerging technologies to date. Boulder, Colorado has been selected as the site of SmartGridCity. Boulder is a suitably sized city for a project such as this, and offers a mix of residential and commercial customers. It's home to academic and research institutions (including Colorado University, National Centre for Atmospheric Research, and the National Institute for Standards and Technology) already working with this emerging technology and studying long-term benefits.

Selected as case study: no

Technology Type(s):	Target Area(s):
1. Measurement & Analysis 2. Local Grid Balancing 3. Automation & Intelligence 4. Decentralisation & Aggregation 5. Operational Control & Optimisation	1. Supply Quality 2. Security of Supply 3. System Performance Enhancement 4. Energy Efficiency 5. New Generations - Connections 6. New Generation - Operations

Quality of Supply	Cost Efficiency	Carbon Reduction	Project Status (TRL)	Degree of innovation challenge	GB regulatory fit	Roll out potential
√√	√√	√√√	6.0	√√√	√	√√

2.2 Kythnos Micro Grid

EU FP5, 6 and 7. A consortium led by National Technical University of Athens (NTUA); 14 partners from 7 EU countries, including utilities, equipment manufacturers, and research, Greece

An interesting example of a micro-grid scheme that has been successfully developed and deployed on the Greek Island of Kythnos. The micro-grid connects demand centres in a small community and provides a variety of renewable and storage energy sources to provide the functionality for grid balancing and continuity of supply. Several pilot µgrid installations have been completed. Some twelve houses in a small valley on Kythnos Island Greece are supplied by a µgrid composed of 10 kW of PV, a 53 kWh battery bank, and a 5 kW diesel genset. The µgrid includes 3 SMA3.6 kW inverters connected in parallel to form one strong single-phase circuit in a master slave configuration. An innovative aspect of this system is that the battery inverters operate in frequency droop mode without fast electrical controls.

Selected as case study: yes

Technology Type(s):	Target Area(s):
1. Network Architecture 2. Local Grid balancing techniques	1. Security of Supply 2. Supply Quality

Quality of Supply	Cost Efficiency	Carbon Reduction	Project Status (TRL)	Degree of innovation challenge	GB regulatory fit	Roll out potential
√√	√	√√√	6.5	√√√	√	√√

2.3 PowerMatcher

Energy Research Centre of The Netherlands, Netherlands

The PowerMatcher is an intelligent software approach for distributed control of power producers, power consumers and storage systems. The PowerMatcher enables control of a cluster of devices, such that the cluster behaves as one single system. This is achieved by tuning of demand and supply within the cluster in an optimal way. The PowerMatcher makes use of advanced ICT technology such as multi-agent systems and electronic markets.

PowerMatcher has been developed (and is in development) in several national and international projects. An important one is the EU CRISP project.

Selected as case study: yes

Technology Type(s):	Target Area(s):
Decentralisation & Aggregation	1. New Generation - Connection 2. New Generation - Operation

Quality of Supply	Cost Efficiency	Carbon Reduction	Project Status (TRL)	Degree of innovation challenge	GB regulatory fit	Roll out potential
√√√	√	√√	5/6	√√√	√√	√√√

2.4. Virtual Power Plant (multi-site remote despatching software)
Encorp, USA, Colorado

The Virtual Power Plant allows companies to aggregate and control multiple energy systems remotely and is "technology-neutral" by design, which means its software can communicate with any and all types and brands of power generation technology (i.e. diesel or gas engine/generator sets, gas turbines, micro-turbines, fuel cells, wind, hydro, and energy storage) in any combination or mode of operation. The Virtual Power Plant is an open-protocol end-to-end design, with the capability to interface with commercial building automation systems, industrial energy management systems and utility grid control systems.

Selected as case study: no

Technology Type(s):	Target Area(s):
Decentralisation & Aggregation	1. New Generation - Operations 2. New Generation - Connections

Quality of Supply	Cost Efficiency	Carbon Reduction	Project Status (TRL)	Degree of innovation challenge	GB regulatory fit	Roll out potential
√√	√	√√	8.5	√	√√√	√√

2.4 D-SMES

American Superconductor, GE, USA

D-SMES - Superconducting Magnetic Energy Storage (SMES -)is a shunt connected Flexible AC Transmission (FACTS) device designed to increase grid stability, improve power transfer, and increase reliability. Unlike other FACTS devices, D-SMES injects real power as well as dynamic reactive power to more quickly compensate for disturbances on the utility grid. Fast response time prevents motor stalling, the principal cause of voltage collapse. Each trailer contains four quadrant, IGBT inverters rated at 250 kW and stacked to handle the output demands of the system. The inverters provide up to 2.3 times nominal instantaneous over-current capability and can also be configured for continuous VAR support. Each 250 kW building block operates independently, improving reliability. D-SMES is an option for utilities with voltage instability or transfer limitations. Trans. Grid volts: 69-500 kV, Frequency: 50 or 60 Hz.

Selected as case study: no

Technology Type(s):	Target Area(s):
Local Grid Balancing	1. Security of Supply 2. Voltage Management 3. System Performance Enhancement

Quality of Supply	Cost Efficiency	Carbon Reduction	Project Status (TRL)	Degree of innovation challenge	GB regulatory fit	Roll out potential
√√	√√	√	8.5	√√	√√√	√√

2.6. Impact of Climate Change on the GB Energy Industry

GB DNOs, GB

In 2006 the Met Office carried out a scoping study on the impacts of climate change on the GB energy industry. The report was the result of collaboration between E.ON GB, EDF Energy, National Grid and the Met Office Hadley Centre to scope the impacts of climate change on the GB energy industry. This Phase 2 project was industry funded; it involved 11 GB energy companies and was undertaken by the Met Office. It focussed on the priorities identified by the earlier scoping study. During the project new tools and methods required to understand the impact of climate change on the energy industry were developed and new data resources designed to address gaps in underpinning information were produced

Selected as case study: no

Technology Type(s):	Target Area(s):
Measurement & analysis	1. Security of Supply 2. Customer Interaction

Quality of Supply	Cost Efficiency	Carbon Reduction	Project Status (TRL)	Degree of innovation challenge	GB regulatory fit	Roll out potential
√√√	√√	√√	7.5	√√	√√√	√√√

2.7 Orkney Active Distribution Network Management
SSE, GB

New generators accepted under the RPZ scheme will be instructed to limit their output to match the available export capacity to the mainland grid. Available capacity will be derived from real time network measurements and will depend upon the level of Orkney demand and output of existing generation.

Selected as case study: yes

Technology Type(s):	Target Area(s):
Operational Control & Optimisation	1. Security of Supply 2. Voltage Management

Quality of Supply	Cost Efficiency	Carbon Reduction	Project Status (TRL)	Degree of innovation challenge	GB regulatory fit	Roll out potential
√	√√	√√√	8.5	√√	√√√	√√

2.8 Mannheim smartgrid project

MVV Energie AG Germany's largest publicly listed municipality network., Germany

see also the SmartHouse/SmartGrid which is a EU-funded project (EU FP7) whose goal is to demonstrate how ICT-enabled collaborative aggregations of Smart Houses can achieve maximum energy efficiency

Selected as case study: no

Technology Type(s):	Target Area(s):
Decentralisation & Aggregation	

Quality of Supply	Cost Efficiency	Carbon Reduction	Project Status (TRL)	Degree of innovation challenge	GB regulatory fit	Roll out potential
√	√√	√√	7.5	√√	√	√√

2.9 Energy Smart Miami

GE, FPL, Cisco, City of Miami, Silver Spring Networks, USA

The backbone of Energy Smart Miami will be the deployment of more than 1 million advanced wireless "Smart Meters" to every home and most businesses in Miami-Dade County. These meters will give Florida Power & Light Company (FPL) customers more information and control over their electricity usage while also providing FPL with information that will enhance system efficiency and reliability. Implementation of the Smart Meters will be based on open network architecture, allowing other providers to develop and deploy new applications that could, for example, help consumers better manage the electricity usage of their air conditioning and appliances.

Selected as case study: yes

Technology Type(s):	Target Area(s):
Measurement & analysis	Smart metering

Quality of Supply	Cost Efficiency	Carbon Reduction	Project Status (TRL)	Degree of innovation challenge	GB regulatory fit	Roll out potential
√√	√√√	√√	3.5	√√	√√	√√√

3. *Electricity Networks*

3.1 SCADA on Web

Forschungsgemeinschaft für Elektrische Anlagen und Stromwirtschaft e.V. (FGH), Germany

It is intended to establish the ScadaOnWeb technology as a standard platform to process monitoring and control applications that are distributed over the web. The technology will support the use of off-the shelf applications for data visualisation; the identification of hazard situations using rule bases and process optimisation. It will define a standard for meta-data that gives semantics to structured numeric dataset. This meta-data will reference standards for units of measure, and ontologies for properties in different engineering domains. The demonstrators will play a key role in the project by validating the ScadaOnWeb technology and ensuring rapid industry acceptance and standardisation.

Selected as case study: no

Technology Type(s):	Target Area(s):
1. Measurement & analysis	1. Security of Supply 2. Energy Efficiency

Quality of Supply	Cost Efficiency	Carbon Reduction	Project Status (TRL)	Degree of innovation challenge	GB regulatory fit	Roll out potential
√√	√√	√	5.0	√√	√√√	√

3.2 Superconducting Fault Level Limiter
New and Renewable Energy Centre (NaREC), GB

This project aims to design, develop and trial three 12kV Superconducting Fault Current Limiting (SFCL) devices on three different GB distribution networks. Three devices (one per DNO) will be constructed and installed covering a range of applications: transformer tails; bus section; interconnected network connection.

Selected as case study: no

Technology Type(s):	Target Area(s):
Operational Control & Optimisation	System Performance Enhancement

Quality of Supply	Cost Efficiency	Carbon Reduction	Project Status (TRL)	Degree of innovation challenge	GB regulatory fit	Roll out potential
√	√√	√√	6.5	√√√	√√√	√√√

3.3 Supergen FutureNet & FlexNet
GB universities, Industrial partners, GB, 8 universities and some 20 industrial partners, part funded by EPSRC GB government grant

The four year Smart Grids FutureNet investigation by a consortium of eight GB universities and many industrial sponsors concluded in summer 2007. It is now being progressed to a research program for a follow-on four year study - the £7m FlexNet consortium. FutureNet addressed electrical power networks to support and encourages renewable energy sources while providing the standards of service that customers expect. FlexNet will lay out the major steps, technical, economic, market design, public acceptance and others, that will lead to flexible networks, including starting to showcase these so that they can be taken up by the commercial sector, Government and Regulators for practical implementation

Selected as case study: no

Technology Type(s):	Target Area(s):
1. Measurement & analysis 2. Modelling & Forecasting	1. Supply Quality 2. Security of Supply 3. System Performance Enhancement 4. Energy Efficiency 5. New Generations - Connections 6. New Generation - Operations

Quality of Supply	Cost Efficiency	Carbon Reduction	Project Status (TRL)	Degree of innovation challenge	GB regulatory fit	Roll out potential
√	√√	√√	3.0	√	√√√	√√

3.4 Dynamic current rating optimisation for underground cables
KEMA, The Netherlands

Systems that monitor cable core temperature using optical fibres or thermocouples in order to provide a dynamic current rating have been developed. Thermocouples are fitted to existing cables where optical fibres are not available. Mathematical modelling is undertaken to determine the cable performance under dynamic loading conditions and to provide information on insulation ageing. Real time temperature data and overload capabilities can be accessed to allow greater operational flexibility.

Selected as case study: no

Technology Type(s):	Target Area(s):
1. Measurement & analysis 2. Operational Control & optimisation	1. Security of Supply 2. Supply Quality

Quality of Supply	Cost Efficiency	Carbon Reduction	Project Status (TRL)	Degree of innovation challenge	GB regulatory fit	Roll out potential
√	√√	√	7.5	√	√√√	√√

3.5 InovGrid

EDP Distribution (Portuguese DNO and sponsor of the project), Inesc Porto (research institute related to the Faculty of Engineering of Porto), EFACEC (Portuguese manufacturer of equipment for electric networks), Logica, and Janz (Portuguese smart meter manufacturer), Portugal

The project relates to smart grids. The objective is to set the way for a more active role of clients in the management of the distribution system. The project embraces the following main areas: 1. Smart metering and energy management looking to advance for example to controllable loads in order to increase energy efficiency 2. To create technical conditions for the smooth (safe and reliable) integration of distributed generation, particularly micro-generation 3. Move to smart grids creating conditions for smart management, control and increase of flexibility of the distribution grid There is not necessarily a sequence to the tasks. They are being carried out simultaneously to a large extent with different degrees of completeness.

Selected as case study: no

Technology Type(s):	Target Area(s):
1. Measurement & Analysis 2. Automation & Intelligence 3. Operational Control & Optimisation	1. Energy Efficiency 2. System Performance Enhancement 3. New generation - Connection 4. New Generation - Operation 5. Customer Interaction

Quality of Supply	Cost Efficiency	Carbon Reduction	Project Status (TRL)	Degree of innovation challenge	GB regulatory fit	Roll out potential
√√	√√	√√√	4.0	√√	√√	√√

3.6 33kV Voltage Control strategies

EDF Energy, GB

This project proposes a study to evaluate active voltage control and reactive power flow management of interconnected 33kV systems (via SCADA), to minimise losses whilst accommodating embedded generation. With the provision of real and reactive power measurements, generator outputs and tap changer positions, the project will develop voltage control strategies taking into the account DG contributions and co-ordination with various EDF Energy Networks and National Grid strategies

Selected as case study: no

Technology Type(s):	Target Area(s):
1. Measurement & analysis 2. Operational Control & Optimisation	1. Voltage Management 2. Supply Quality 3. Energy Efficiency

Quality of Supply	Cost Efficiency	Carbon Reduction	Project Status (TRL)	Degree of innovation challenge	GB regulatory fit	Roll out potential
√	√	√√	4.0	√√	√√√	√√

3.7 LVSure concept for automation of LV distribution networks

EATL, GB DNOs, GB, consortium of DNOs, EA Technology

A desktop modelling of a novel automation concept to traditional LV distribution networks based on the EA Technology "SignalSure" system, which is currently in operation on rail signalling circuits in the GB. EA Technology has carried out projects on behalf of a number of GB Distribution Network Operators through the Innovation Funding Initiative (IFI) to assess deployment options, technical constraints, benefits and safety implications.

Selected as case study: no

Technology Type(s):	Target Area(s):
1. Modelling & Forecasting 2. Automation & Intelligence	1. Supply Quality 2. Security of Supply 3. System Performance Enhancement

Quality of Supply	Cost Efficiency	Carbon Reduction	Project Status (TRL)	Degree of innovation challenge	GB regulatory fit	Roll out potential
√	√√	√	6.0	√	√√√	√

3.8 DG Planning Software
EDF Energy, GB

The purpose of this project was to investigate how to model distributed generation, by using automated interfaces to pass data between the existing EDF Energy Networks' Smallworld/Netmap GIS system and a next generation network modelling/analysis tool called DigSilent PowerFactory. The project identified two candidate interface technologies – one produced by Mettenmeier, and the other produced by ITS. These enabled data transfer between Netmap and PowerFactory. A proof of concept application was developed using both candidate interfaces.

Selected as case study: yes

Technology Type(s):	Target Area(s):
1. Modelling & Forecasting 2. Automation & Intelligence	1. Security of Supply 2. Asset Performance Enhancement 3. System Performance Enhancement

Quality of Supply	Cost Efficiency	Carbon Reduction	Project Status (TRL)	Degree of innovation challenge	GB regulatory fit	Roll out potential
√	√√	√√√	4.5	√	√√√	√√

3.9 Network Risk Management
EDF Energy, GB

The aim of this project is to develop algorithms for calculating the risk, which the continued use of the components of a distribution system pose, to ongoing satisfactory system operation. It will take into account the significant levels of uncertainty that characterise both the condition of the individual assets and the overall operation of the network.

Selected as case study: no

Technology Type(s):	Target Area(s):
1. Modelling & Forecasting 2. Measurement & Analysis	1. Asset Performance Enhancement 2. Security of Supply 3. System Performance Enhancement

Quality of Supply	Cost Efficiency	Carbon Reduction	Project Status (TRL)	Degree of innovation challenge	GB regulatory fit	Roll out potential
√√	√	√√	5.0	√	√√√	√√

3.10 DG Connection Planner
EDF Energy, GB

This project is to build on the work reported in “Internet Services for Planning Distributed Generation Connections” funded by BERR, to provide DG developers with access to suitable connection locations and estimated connection costs. The system uses an OS map background to allow users to position a proposed generator connection, DNO Long Term Development Statement (LTDS) data to derive suitable connection scenarios and costing information for the provision of budget estimates

Selected as case study: no

Technology Type(s):	Target Area(s):
1. Modelling & Forecasting 2. Measurement & Analysis	New Generation - Connections

Quality of Supply	Cost Efficiency	Carbon Reduction	Project Status (TRL)	Degree of innovation challenge	GB regulatory fit	Roll out potential
√	√√	√√	4.5	√	√√√	√√

3.11 Networked Control Systems Tolerant to faults (NECST)
Industrial and academic consortium, EU

The aim of the NeCST is to explore research opportunities in the direction of distributed control system in order to enhance the performances of diagnostics and fault tolerant control systems. This will lead to improving the intensive use of NeCST technologies for the reactivity, autonomy and monitoring of large scale systems. The systems under consideration in the framework of this project can be considered as a distributed network of nodes operating under highly decentralised control, but unified in accomplishing complex system-wide goals.

Selected as case study: no

Technology Type(s):	Target Area(s):
1. Operational Control & optimisation 2. Measurement & Analysis	1. System Performance Enhancement 2. Supply Quality

Quality of Supply	Cost Efficiency	Carbon Reduction	Project Status (TRL)	Degree of innovation challenge	GB regulatory fit	Roll out potential
√√	√√	√	4.0	√√	√√√	√

3.12 AURA-NMS (Automated Regional Active Network Management System)
Scottish Power, GB

This project aims to produce a control structure and set of control algorithms that realise the notion of an active distribution network and enhance the service a network operator provides to load and generation customers, improving network performance (asset use, etc.).

Selected as case study: yes

Technology Type(s):	Target Area(s):
1. Operational Control & Optimisation [Real time management]	1. Asset Performance Enhancement 2. New Generation Connections

Quality of Supply	Cost Efficiency	Carbon Reduction	Project Status (TRL)	Degree of innovation challenge	GB regulatory fit	Roll out potential
√√	√√	√√√	4.5	√√√	√√	√√√

3.13 Automatic Switching scheme
Vector Group, New Zealand

Vector has developed a scheme to enable load to be rapidly transferred from one part of its network to a neighbouring part of the network to defer investment in augmentation. The salient features of this load transfer scheme are: (1) fully automated – when a fault is detected in a part of the network covered by the scheme, an automatic switching sequence will be initiated which will isolate the fault and rearrange the network to restore supply. (2) fast response – the switching sequence is pre-programmed, and hence offering a fast supply restoration to customers. (3) high capacity –the fast operation of the scheme allows rapid off loading of zone substation transformers (which are usually operated in parallel) under post contingency conditions. This in turn allows the transformers to operate to a short term (5 minute) rating, thus deferring reinforcement investments. In a specific application Vector managed to defer reinforcement to Onehunga substation (about $5 million) by seven years.

Selected as case study: yes

Technology Type(s):	Target Area(s):
Automation & Intelligence	1. Security of Supply 2. System Performance Enhancement

Quality of Supply	Cost Efficiency	Carbon Reduction	Project Status (TRL)	Degree of innovation challenge	GB regulatory fit	Roll out potential
√√√	√√√	√	7.5	√√	√√√	√√√

3.14 Wide-Area Voltage Instability Load Shedding
Electric Power Research Institute (EPRI), USA

This project will provide grid operators a safety net to guard against voltage instability. By shedding the right amount of load in a coordinated manner across a wide area during a voltage collapse, the system will halt a cascading blackout. The type of control needed to modernize the interconnected power system, it can replace ineffective under-voltage load shedding, which may be triggered unnecessarily. The system will also enable the grid to be operated to its fullest capacity. This new project combines two technologies to arrest a potentially cascading blackout at the last second: the smart relay called the voltage instability predictor and the wide-area measurement system. In the new scheme, a number of VIPs deployed across a wide area continuously monitor the system at various locations on the grid and predict when a given part of the system is going into a voltage collapse. These assessments are broadcast through the WAMS to a central controller, which decides where and how much load to shed at various locations. This triggers a load-shedding system coordinated to stop the voltage collapse.

Selected as case study: no

Technology Type(s):	Target Area(s):
Automation & Intelligence	1. Security of Supply 2. Voltage Management 3. System Performance Enhancement 4. Interconnections between systems

Quality of Supply	Cost Efficiency	Carbon Reduction	Project Status (TRL)	Degree of innovation challenge	GB regulatory fit	Roll out potential
√√	√	√	5.0	√√√	√√√	√

3.15 IHost developments
Electricity North West (ENW), GB

This project is supporting a number of other projects and is aiming to provide an interface between the Line Tracker, Re-Zaps, TP-22 devices and the Control Room Management System. It is recognised that to extend the 'Active' part of our network greater visibility is needed at the lower voltage levels, IHost provides a means to achieve this

Selected as case study: no

Technology Type(s):	Target Area(s):
Automation & Intelligence	1. Supply Quality 2. System Performance Enhancement

Quality of Supply	Cost Efficiency	Carbon Reduction	Project Status (TRL)	Degree of innovation challenge	GB regulatory fit	Roll out potential
√√	√	√	5.0	√	√√√	√

3.16 Primary SCADA Communications using IP
EDF Energy, GB

This project demonstrated that IP protocols can be used securely to provide the necessary primary substation SCADA communications used in distribution networks.

Selected as case study: no

Technology Type(s):	Target Area(s):
Automation & Intelligence	System Performance Enhancement

Quality of Supply	Cost Efficiency	Carbon Reduction	Project Status (TRL)	Degree of innovation challenge	GB regulatory fit	Roll out potential
√√	√	√	4.0	√	√√√	√√

3.17 Control System Automation Algorithm
Central Networks, GB

Development and demonstration of Self Healing Networks by using an automated switching algorithm which can carry out real-time circuit tracing to identify source and alternative supplies.

Selected as case study: no

Technology Type(s):	Target Area(s):
Automation & Intelligence [Event Driven]	Electric Vehicle Integration

Quality of Supply	Cost Efficiency	Carbon Reduction	Project Status (TRL)	Degree of innovation challenge	GB regulatory fit	Roll out potential
√√√	√√	√√	5.0	√√	√√	√√√

3.18 FENIX
Flexible Electricity Networks to Integrate the expected 'energy evolution'
EU FP6, Imberdrola, Arriva T&D, Ziv, EDF Energy Networks, National Grid, Imperial (Woking Council), GB

The objective of FENIX is to boost Distributed Energy Resources (DER) by maximizing their contribution to the electric power system, through aggregation into Large Scale Virtual Power Plants (LSVPP) and decentralized management.

Selected as case study: yes

Technology Type(s):	Target Area(s):
Decentralisation & Aggregation	1. System Performance Enhancement 2. New generation - Connections 3. New Generation - Operations

Quality of Supply	Cost Efficiency	Carbon Reduction	Project Status (TRL)	Degree of innovation challenge	GB regulatory fit	Roll out potential
√	√√√	√√	3.5	√√√	√√	√√

3.19 D-VAR

American Superconductor, USA

With the wide spread connection of DG, distribution networks are becoming more dynamic in their operating behaviour with an increased need for active network management. It is required to have transmission-type solutions but at a much lower voltage level. This manufacturer has designed and has implemented such devices, utilising power electronic converters, for use on distribution networks.

Selected as case study: yes

Technology Type(s):	Target Area(s):
Local Grid Balancing	1. Security of Supply 2. Voltage Management 3. System Performance Enhancement

Quality of Supply	Cost Efficiency	Carbon Reduction	Project Status (TRL)	Degree of innovation challenge	GB regulatory fit	Roll out potential
√√√	√√	√	7.5	√√	√√√	√√

3.20 City Centre Substation Cooling
EDF Energy, Central Networks, GB

This project will develop passive cooling techniques to apply to existing secondary substations. The cooling solutions will address the issues of reinforcement and the growth of air conditioning and cooling in city centre sites. Specifically deployment will: • Lower secondary transformer skin temperatures by 10 C on all sites enabling load ratings to be re-benchmarked, • In conjunction with the battery management ensure that power is available for automatic regeneration when required.

Selected as case study: no

Technology Type(s):	Target Area(s):
Measurement & analysis	1. Asset Performance Enhancement 2. Energy Efficiency

Quality of Supply	Cost Efficiency	Carbon Reduction	Project Status (TRL)	Degree of innovation challenge	GB regulatory fit	Roll out potential
√√	√√	√	5.0	√	√√√	√√

3.21 Bankside Heat Transfer
EDF Energy, GB

Substation transformers produce waste heat which is usually lost to the environment. The re-planted substation at Bankside, adjacent to the Tate Modern art gallery, will use transformers with water cooled heat exchangers. It is proposed that the waste heat from the transformers will be used by the Tate Modern to assist with its building heating process. This will benefit EDF Energy Networks, as less energy will need to be expended within cooler fans at the substation, and lower maintenance and replacement of cooler fans will be incurred.

Selected as case study: yes

Technology Type(s):	Target Area(s):
Measurement & Analysis	1. Asset Performance Enhancement 2. Energy Efficiency

Quality of Supply	Cost Efficiency	Carbon Reduction	Project Status (TRL)	Degree of innovation challenge	GB regulatory fit	Roll out potential
√	√	√√	5.5	√	√√√	√√

3.22 Dynamic Ratings
Central Networks E.ON, GB

Central Networks has developed the first Registered Power Zone (RPZ) in the GB. This involves the application of an active rating to a 132kV overhead line based on real time measurements of ambient temperature and wind speed.

Selected as case study: yes

Technology Type(s):	Target Area(s):
Measurement & analysis	1. Security of Supply 2. Asset Performance Enhancement

Quality of Supply	Cost Efficiency	Carbon Reduction	Project Status (TRL)	Degree of innovation challenge	GB regulatory fit	Roll out potential
√√	√√√	√√	8.5	√√	√√√	√√√

3.23 Distribution Transformer with on-load tap changer
Unities Utilities, GB

Increased penetration of DG on the LV network, particularly domestic combined heat and power (DCHP) units, is expected to have a significant adverse affect on the voltage regulation. This is a concern especially when a large number of DCHP units are installed

Selected as case study: no

Technology Type(s):	Target Area(s):
Measurement & Analysis	1. Voltage Management 2. New Generation - Operation

Quality of Supply	Cost Efficiency	Carbon Reduction	Project Status (TRL)	Degree of innovation challenge	GB regulatory fit	Roll out potential
√	√√	√√	5.5	√√	√√√	√√

3.24 Understanding Networks with High Penetrations of Distributed Generation
Central Networks, GB

Development of a distribution network model onto which different types and penetrations of Distributed Generation can be incorporated to understand the effects which could be encountered on real networks. An enabling project for DG.

Selected as case study: no

Technology Type(s):	Target Area(s):
Modelling & Forecasting	1. System Performance Enhancement 2. New generation - Connections

Quality of Supply	Cost Efficiency	Carbon Reduction	Project Status (TRL)	Degree of innovation challenge	GB regulatory fit	Roll out potential
√√	√	√√√	3.5	√	√√√	√√√

3.25 Effect of Electric Vehicles on Distribution Networks
Central Networks, GB

Investigate the impact of charging electric vehicles on conventionally designed distribution networks.

Selected as case study: yes

Technology Type(s):	Target Area(s):
Modelling & Forecasting	Electric Vehicle Integration

Quality of Supply	Cost Efficiency	Carbon Reduction	Project Status (TRL)	Degree of innovation challenge	GB regulatory fit	Roll out potential
√√	√√√	√√√	3.5	√	√	√√√

3.26 Optimising System Design for Improved Performance and reduced Losses Central Networks, GB

The project aims to provide Central Networks with an optimising tool, which will consider both performance and system losses of alternative networks, under different degrees of distributed generation penetration.

Selected as case study: no

Technology Type(s):	Target Area(s):
Operational Control & Optimisation	1. Energy Efficiency 2. System Performance Enhancement

Quality of Supply	Cost Efficiency	Carbon Reduction	Project Status (TRL)	Degree of innovation challenge	GB regulatory fit	Roll out potential
√	√	√√	4.0	√√	√√	√√

3.27 Power electronics for future utility applications
paper, Germany RWTH Aachen University

This investigation addressed medium-voltage converters, originally developed for industrial drives (e.g. in steel and paper mills), have now entered utility applications. Power electronics are the key enabling technology to meet smart grid challenges. There is also the possibility of using DC instead of AC transmission and distribution systems. New opportunities now arise for the use of modern VSC-HVDC, such as DC distribution systems. Cycloconverters, a rather conventional technology, have been applied recently in innovative ways to increase the efficiencies of very high-power pumped- hydro storage systems. The development of new converter systems is always strongly related to the available device technology, including future high-power devices.

Selected as case study: no

Technology Type(s):	Target Area(s):
Operational Control & optimisation	1. New Generation - connections 2. Security of Supply 3. System Performance Enhancement

Quality of Supply	Cost Efficiency	Carbon Reduction	Project Status (TRL)	Degree of innovation challenge	GB regulatory fit	Roll out potential
√√	√√	√√	6.0	√√	√√√	√√

3.28 Thermal Modelling and Active Network Management
Scottish Power, GB

This project explores the potential benefits arising from: (a) the improved utilisation of power system assets through the use of real time knowledge of the thermal status of the power system and (b) the development of an active controller to facilitate this exploitation and to balance those issues requiring action by operational staff and those that can be dealt with by machine intelligence.

Selected as case study: no

Technology Type(s):	Target Area(s):
Operational Control & optimisation	1. Security of Supply 2. Voltage Management 3. System Performance Enhancement

Quality of Supply	Cost Efficiency	Carbon Reduction	Project Status (TRL)	Degree of innovation challenge	GB regulatory fit	Roll out potential
√	√√	√√	4.0	√√	√√√	√√√

3.29 Power quality and Management System (PoMS)
DISPOWER EU, EU

PoMS is a novel ICT application developed by Fraunhofer ISE as part of the EU DISPOWER project, which implements active management of distributed generation, controllable consumption, storage and power quality devices in low voltage grids, and covers economic optimisation as well as interventions in case of irregularities - project completed.

Selected as case study: no

Technology Type(s):	Target Area(s):
Operational Control & optimisation	1. Supply Quality 2. System Performance Enhancement

Quality of Supply	Cost Efficiency	Carbon Reduction	Project Status (TRL)	Degree of innovation challenge	GB regulatory fit	Roll out potential
√	√	√√	5.0	√√	√√	√

3.30 GenAVC Assessment Tool
EDF Energy, GB
GenAVC has been developed by Econnect to manage voltage rise issues associated with the connection of Distributed Generation (DG) into 11kV networks. This system has achieved satisfactory operation in a trial at Martham Primary substation., at Horton Quarr

Selected as case study: yes

Technology Type(s):	Target Area(s):
Operational Control & Optimisation	1. Voltage Management 2. New Generation [Connections]

Quality of Supply	Cost Efficiency	Carbon Reduction	Project Status (TRL)	Degree of innovation challenge	GB regulatory fit	Roll out potential
√√√	√√	√√	8.5	√√	√√√	√√√

3.31 Preparation of EV demonstration project
Senter Novem, The Netherlands

The introduction of plug-in hybrid and electric vehicles can lead to extra electricity demand during peak hours. The electricity demand of these vehicles can be managed, giving the grid owners a controlled demand. One possibility is to charge the batteries at night when prices are low and enough wind energy is available. This type of network management is needed to facilitate the maximum contribution of renewable energy sources. These topics are studied in the Dutch ITM project by KEMA, ECN, Essent Netwerk, Continuon and IWO, sponsored by SenterNovem.

Selected as case study: no

Technology Type(s):	Target Area(s):
Operational Control & Optimisation	Electric Vehicle Integration

Quality of Supply	Cost Efficiency	Carbon Reduction	Project Status (TRL)	Degree of innovation challenge	GB regulatory fit	Roll out potential
√	√√	√√√	4.0	√√	√	√√√

3.32 Prospects of multilevel VSC technologies for power transmission
Siemens Energy, USA and Germany

Innovative solutions with HVDC (High Voltage Direct Current) and FACTS (Flexible AC Transmission Systems) have the potential to cope with the new smart grid challenges. New power electronic technologies with self-commutated converters provide advanced technical features, such as independent control of active and reactive power, the capability to supply weak or passive networks and less space requirements. In many applications, the VSC (Voltage-Sourced Converter) has become a standard for self-commutated converters and will be increasingly used in transmission and distribution systems in the future. This kind of converter uses power semiconductors with turn-off capability.

Selected as case study: no

Technology Type(s):	Target Area(s):
Operational Control & optimisation	1. Security of Supply 2. System Performance Enhancement

Quality of Supply	Cost Efficiency	Carbon Reduction	Project Status (TRL)	Degree of innovation challenge	GB regulatory fit	Roll out potential
√	√	√√	5.0	√√	√√√	√√

3.33 Deucheran Hill Wind Farm Generation Management Scheme
SSE, GB

Scheme manages access to the transmission system of a wind farm. Measurements of load and circuit breaker positions allow decisions to be made through logic control to constrain / trip wind generation.

Selected as case study: no

Technology Type(s):	Target Area(s):
Operational Control & Optimisation	1. Security of Supply 2. Voltage Management

Quality of Supply	Cost Efficiency	Carbon Reduction	Project Status (TRL)	Degree of innovation challenge	GB regulatory fit	Roll out potential
√√√	√√√	√√√	8.5	√	√√√	√√

3.34 Multi-Function Solid-State Switchgear for Distribution System of the Future (Part of the EPRI Advanced Distribution Automation (ADA) Programme)
Electric Power Research Institute (EPRI), USA

The objective of the EPRI ADA programme is to create the distribution system of the future, a multifunctional system that may be more accurately described as a 'power exchange system'. This project supports participants to make the advances required in electrical infrastructure to capture the advantages of ADA. In development is a family of low-cost solid-state switchgear for a range of distribution applications that will lower capital costs for switchgear and improve system reliability. The low-cost solid-state switchgear will be developed to provide the switches needed for increased sectionalizing, capacitor and static VAR compensator switching, distributed generation switching, load management, and other switching functions that will be part of ADA and the Distribution System of the Future.

Selected as case study: no

Technology Type(s):	Target Area(s):
Operational Control & optimisation [Real time management]	1. Supply Quality [Interruptions] 2. Security of Supply

Quality of	Cost	Carbon	Project	Degree of	GB	Roll out

Supply	Efficiency	Reduction	Status (TRL)	innovation challenge	regulatory fit	potential
√√√	√√	√	3.0	√√√	√√√	√√

4. Electricity Primary Source

4.1 Virtual Fuel Cell Power Plant
Initiative Brennstoffzelle (IBZ), Germany

The Virtual Fuel Cell Power Plant is a series of decentralised residential micro-CHPs using fuel cell technology, installed in multi-family- houses, small enterprises, public facilities etc., for individual heating, cooling and electricity production. Centrally controlled and grid-connected, these elements of the virtual power plant contribute to meet peaking energy demand in the public electricity grid and act as a virtual power plant. Simultaneously this application is a fast door-opener for a broad market entrance of fuel cells with its ecological and economical benefits. Severe testing in different environments including requirements from techniques, users, norms and utilities is necessary.

Selected as case study: no

Technology Type(s):	Target Area(s):
Decentralisation & Aggregation	1. Security of Supply 2. New Generation - Connection 3. New Generation - Operation

Quality of Supply	Cost Efficiency	Carbon Reduction	Project Status (TRL)	Degree of innovation challenge	GB regulatory fit	Roll out potential
√√	√	√√√	5.0	√√	√	√√

4.2 Control for doubly fed induction generators (DFIG) for wind farm operation
Centre for Distributed Generation and Sustainable Electricity Systems, GB universities, GB

This project investigates the impact that large penetrations of wind energy have on system operation and network dynamic and transient stability. Models of DFIG machines and their controllers are being developed to facilitate wind farm connections that comply with the GB grid code, and the issues associated with the intermittency and storage requirements for this source of energy.

Selected as case study: no

Technology Type(s):	Target Area(s):
Modelling & Forecasting	1. Security of Supply 2. Supply Quality

Quality of Supply	Cost Efficiency	Carbon Reduction	Project Status (TRL)	Degree of innovation challenge	GB regulatory fit	Roll out potential
√√	√√	√√	3.5	√	√√√	√√

5. *Electricity Storage*

5.1 Distributed energy storage
American Electric Power, GB

AEP installed a 1-MW, 7.2-MWh NaS battery in an existing substation in Charleston, West Virginia, in 2006.

Selected as case study: yes

Technology Type(s):	Target Area(s):
1. Storage 2. Local Grid balancing techniques	1. Security of Supply 2. Supply Quality

Quality of Supply	Cost Efficiency	Carbon Reduction	Project Status	Degree of innovation	GB regulatory fit	Roll out potential

			(TRL)	challenge		
√√√	√√	√√	5.5	√√	√	√√√

5.2 GROW-ders. Large European demonstration project to prove the value of small-scale (mobile) energy storage systems in local grids
European Commission, KEMA, The Netherlands

GROW-DERS offers a solution by using transportable and flexible storage systems made possible with new developments in power electronics. This innovative demonstration project offers operational experience and exhibits the technical and economical feasibility of storage systems. The Project realizes three transportable flexible storage systems, an assessment tool for optimal distribution network management, and completes a description of concept directions for EU regulatory framework. The result of the GROW-DERS project is a savings of over $700 million per year for the countries participating in EU-FP 6, and the annual integration of 275 billion kWh of sustainable energy generation.

Selected as case study: no

Technology Type(s):	Target Area(s):
Electrical Storage - Chemical	1. Security of Supply 2. Supply Quality

Quality of Supply	Cost Efficiency	Carbon Reduction	Project Status (TRL)	Degree of innovation challenge	GB regulatory fit	Roll out potential
√√	√√	√√√	4.5	√√	√	√√

5.3 Vulnerable Customers UPS
EDF Energy, GB

This project aims to develop solutions that provide continuity of electrical power to vulnerable customers - those who are classified as needing a combination of lights, appliances, electronics and medical equipment to remain operational in the event of a power failure.

Ceres Power has developed the capabilities and specialist expertise to deliver a fuel cell solution.

Selected as case study: no

Technology Type(s):	Target Area(s):
Electrical Storage - Chemical	1. Security of Supply 2. Supply Quality

Quality of Supply	Cost Efficiency	Carbon Reduction	Project Status (TRL)	Degree of innovation challenge	GB regulatory fit	Roll out potential
√√	√	√	6.0	√√	√	√√

5.4 Energy Storage for Distribution Systems
Central Networks, GB

Energy Storage is a key enabling technology for the development of innovative solutions to manage and control the electrical networks of the future. A staged research and development programme will lead to the manufacture of a prototype 1MW redox flow battery with a capacity of several MWh, which will be connected to the distribution system and operated for a period of up to 24 months.

Selected as case study: no

Technology Type(s):	Target Area(s):
Electrical Storage - Chemical	System Performance Enhancement

Quality of Supply	Cost Efficiency	Carbon Reduction	Project Status (TRL)	Degree of innovation challenge	GB regulatory fit	Roll out potential
√√	√√	√√√	3.5	√√	√	√√√

5.5 Development of Redox flow battery for energy storage
Scottish Power, GB

A part funded project through the DTI Technology Programme TP/3/ERG/6/1/16587 (D05/726039) that aims to develop (design, build, test and install) an 11kV 250kW Redox flow battery unit for energy storage.

Selected as case study: no

Technology Type(s):	Target Area(s):
Electrical Storage - Chemical	System Performance Enhancement

Quality of Supply	Cost Efficiency	Carbon Reduction	Project Status (TRL)	Degree of innovation challenge	GB regulatory fit	Roll out potential
√√	√	√√	5.0	√√	√	√√

5.6 Use of storage to mitigate wind volatility and ramping
CA ISO and CEC, KEMA USA, USA

Utilizing a dynamic model KERMIT. The project will identify how much storage of what type should be used in the presence of high wind penetration scenarios. (This is latest in a string of such projects; a similar one is currently in progress in the NL)

Selected as case study: no

Technology Type(s):	Target Area(s):
Modelling & Forecasting	1. System Performance Enhancement 2. Security of Supply

Quality of Supply	Cost Efficiency	Carbon Reduction	Project Status (TRL)	Degree of innovation challenge	GB regulatory fit	Roll out potential

√	√	√√	4.0	√	√	√

5.7 Hybrid Static Compensation Package for Onshore Wind
Synergy Econnect, GB

Hybrid Static Compensation Package for Onshore Wind Project Size: 7 x 1.7MW Turbines The provision of the Hybrid Statcom equipment to allow Grid Code Compliance. This equipment allowed a previously unviable project to go ahead as the turbines themselves were unable to operate between the voltage guidelines required in the Grid Code. The static compensation equipment allows voltage control of the wind farm and thus meet the requirements of the Grid Code. Completion Date: April 2007

Selected as case study: no

Technology Type(s):	Target Area(s):
Operational Control & optimisation	1. New Generation - Operation 2. New Generation - Connection 3. Voltage Management

Quality of Supply	Cost Efficiency	Carbon Reduction	Project Status (TRL)	Degree of innovation challenge	GB regulatory fit	Roll out potential
√√	√√	√√√	8.5	√√	√√√	√√

5.8 Compressed air energy storage
ManTurbo, The Netherlands

Compressed air in caverns. When electricity is cheap or with peak electricity from wind generators, compressors can be driven to compress air in salt caverns.

Selected as case study: no

Technology Type(s):	Target Area(s):
Storage - Non-Chemical	System Performance Enhancement

Quality of Supply	Cost Efficiency	Carbon Reduction	Project Status (TRL)	Degree of innovation challenge	GB regulatory fit	Roll out potential
√	√	√√	5.5	√	√	√√

5.9 Flywheel Energy Storage

Beacon Power, Pentadyne Power Corporation and others, USA

Flywheel energy storage system is designed to respond to a regional transmission operator signal to quickly add or subtract power from the grid in a frequency regulation support mode. Using this concept, the flywheel recycles energy (store energy when generation exceeds loads; discharge energy when load exceeds generation) instead of trying to constantly adjust generator output. Monitoring and data acquisition has been specified such that system availability and power/energy parameters will be accessible via the website. Any time the system is operated, the kilowatts supplied or absorbed by the storage unit and the total system efficiency will be viewable via graphical display by day, week, month, etc.

Selected as case study: yes

Technology Type(s):	Target Area(s):
Storage - Non-Chemical	System Performance Enhancement

Quality of Supply	Cost Efficiency	Carbon Reduction	Project Status (TRL)	Degree of innovation challenge	GB regulatory fit	Roll out potential
√√√	√	√√√	6	√√	√√	√√√

6. Gas General

6.1 Carbon Capture and Storage Simulation
institutions and universities, The Netherlands

With increased focus on carbon capture and sequestration gas network operators are looking to employ their gas networks for carbon capture and transport. There are significant differences in behaviour within gas networks using alternative gases and this project provides a simulation tool to assess impacts on various network components prior to implementation.

Selected as case study: no

Technology Type(s):	Target Area(s):
Alternative Fuels	Gas Types & Sources

Quality of Supply	Cost Efficiency	Carbon Reduction	Project Status (TRL)	Degree of innovation challenge	GB regulatory fit	Roll out potential
	√	√√√	3.5	√	√√√	√√

6.2 Carbon capture and transport
National Grid, GB

National Grid is investigating the possible future reuse of some of its high pressure natural gas transmission pipelines to transport carbon dioxide from power stations and heavy industry to storage offshore. Scotland and the Humber region in England have been identified as offering some of the best opportunities for Carbon Capture and Storage (CCS) in Europe, with power stations and other heavy industry close to the North Sea oil and gas fields which, when depleted, could provide storage for their carbon dioxide emissions.

Selected as case study: yes

Technology Type(s):	Target Area(s):
Alternative Fuels	Gas Types & Sources

Quality of Supply	Cost Efficiency	Carbon Reduction	Project Status (TRL)	Degree of innovation challenge	GB regulatory fit	Roll out potential
√	√√	√√√	2.5	√√	√√	√√

6.3 CO2 storage: Technology review and challenges ahead
Schlumberger Carbon Services, International

The Processes & Technologies to assess CO2 site performance factors largely exist today. The state of technology is sufficient to convince the scientific community and the legislator to start commercial projects into well characterised aquifers. This project presents an example of storage timeline costs, from the site selection and site characterisation to the storage site monitoring activities. It focuses in the remaining technical challenges that still exist and that mainly lie in modelling and in measurements / monitoring of the storage site.

Selected as case study: no

Technology Type(s):	Target Area(s):
Alternative Fuels	Gas Types & Sources

Quality of Supply	Cost Efficiency	Carbon Reduction	Project Status (TRL)	Degree of innovation challenge	GB regulatory fit	Roll out potential
√	√√	√√√	2.5	√√	√√	√√

6.4 Challenges for CO2 capture, TNO Science and Industry, The Netherlands

TNO is an independent research organisation that participates in a multifunctional pilot plant at E.ON with CO2 capture technology. 250 kg/hr CO2 is captured from flue gas from a pulverised coal power plant. The main CO2 capture challenges identified by TNO are the cost reduction, the energy penalty, the scale up and a number of external challenges (interfaces with transport and storage, public perception).

Selected as case study: no

Technology Type(s):	Target Area(s):
Alternative Fuels	Gas Types & Sources

Quality of Supply	Cost Efficiency	Carbon Reduction	Project Status (TRL)	Degree of innovation challenge	GB regulatory fit	Roll out potential
√	√√	√√√	2.5	√√	√√	√√

6.5 LNG Business and Innovation, GDF SUEZ, France

GDF Suez is developing a number of R&D projects that can help the LNG industry to take up its next challenges, such as:

- Considering new types of gas has become a necessity (stranded gas , offshore gas fields: LNG FPSO, arctic, unconventional gas: tight gas, shales, CBM)
- Improving shipping efficiency
- Improving regasification terminal efficiency
- Offshore/floating regasification terminals

Selected as case study: no

Technology Type(s):	Target Area(s):
Alternative Fuels	Gas Types & Sources

Quality of Supply	Cost Efficiency	Carbon Reduction	Project Status (TRL)	Degree of innovation challenge	GB regulatory fit	Roll out potential
√	√√	√√√	2.5	√√	√√	√√

6.6 The CO_2 pilot at Lacq, Total, France

Total is developing a CO2 pilot at Lacq in order to demonstrate the technical feasibility and reliability of an integrated CO2 capture, transportation, injection and storage onshore scheme for steam production at a reduced scale (1/10th of future facilities). The project involves the design and operation of a 30 MWth oxucombustion boiler for CO2 capture and the development and application of geological storage qualification methodologies, monitoring and verification techniques on a real operational case in order to prepare future larger scale long term storage projects.

Selected as case study: no

Technology Type(s):	Target Area(s):
Alternative Fuels	Gas Types & Sources

Quality of Supply	Cost Efficiency	Carbon Reduction	Project Status (TRL)	Degree of innovation challenge	GB regulatory fit	Roll out potential
√	√√	√√√	3	√√	√√	√√

6.7 A new generation of liquefaction processes for LNG FPSO applications, USA

Mustang Engineering is developing LNG Smart Liquefaction Technologies in order to minimise the risks (technical and commercial), minimise flammable refrigerants, provide reliable and flexible operation, use industry-proven components at optimum sizes, utilise compact modular design, minimise equipment count and operate efficiently. FPSO refers to Floating Production Storage and Offloading The main benefits obtained from these projects can be summarised in the following:

- Less equipment results in less cost, easier operation
- High efficiency
- Handles variable feed rates and compositions
- Turndown to zero; circulating refrigerant gas keeps system cold
- Quick start-up (warm). Rapid cool-down / refrigeration sequence

After smaller, simpler LNG FPSOs become proven. Future designs are likely to incorporate more complex and more efficient processes.

Selected as case study: no

Technology Type(s):	Target Area(s):
Alternative Fuels	Gas Types & Sources

Quality of Supply	Cost Efficiency	Carbon Reduction	Project Status (TRL)	Degree of innovation challenge	GB regulatory fit	Roll out potential
√	√√	√√√	3	√√	√√	√√

7. Gas Networks

7.1 MUltiNet and SP AusNet gas distribution pressure controller
SP AusNet, Australia

Water and gas networks can be operated more efficiently if pressure can be controlled more effectively at the fringes of the network. Higher than normal pressure results in more leakage and the danger of pipe failure and low pressure does not meet regulatory safety and service standards. Controlling pressure from local controllers proves very ineffective and it has been proven that there is greater efficiency in providing a systemic control approach. The MultiNet and SP AusNet gas distribution networks in Victoria use a common software application to manage a group of controllable field regulators to obtain a desired pressure outcome at one or more fringe sites. The application interacts with real-time SCADA data, a database of pressure profiles and an interactive GUI. The level of operator supervision is minimal and alarms are targeted specifically to indicate weak parts of the network, non-responsive controllers and any other operational issues.

Selected as case study: no

Technology Type(s):	Target Area(s):
1. Measurement & analysis 2. Automation & Intelligence	1. System Performance Enhancement 2. Gas Safety

Quality of Supply	Cost Efficiency	Carbon Reduction	Project Status (TRL)	Degree of innovation challenge	GB regulatory fit	Roll out potential

√√	√√√	√	5.5	√√	√√√	√√

7.2 Biopropane pipeline
Eon, The Netherlands

Biopropane pipeline for power station Maasvlakte, near Rotterdam, The Netherlands

Selected as case study: no

Technology Type(s):	Target Area(s):
Alternative Fuels	Gas Type & Sources

Quality of Supply	Cost Efficiency	Carbon Reduction	Project Status (TRL)	Degree of innovation challenge	GB regulatory fit	Roll out potential
√	√	√√	4.0	√	√	√√

7.3 Biogas injection in natural gas network
Gasunie, The Netherlands

Biogas in the regional transport grid of The Netherlands

Selected as case study: yes

Technology Type(s):	Target Area(s):
Alternative Fuels	Gas Type & Sources

Quality of Supply	Cost Efficiency	Carbon Reduction	Project Status (TRL)	Degree of innovation challenge	GB regulatory fit	Roll out potential
√√	√	√√√	3.5	√	√	√√

7.4 Bio gate-keeper - Biogas injection in natural gas public network
Eneco Energy, BioGast, STEDIN, The Netherlands

Biogas in the regional transport grid of The Netherlands; gas from a biogas digester (public waste water company). A 'biogas gatekeeper' concept for establishing a safe and effective interface between the biogas provide and the natural gas public network. Fully operational since 2007. Significant innovation challenges arising from public safety issues (gas quality and flame behaviour, also bio hazard issues; significant recovery issue if off-spec gas gets into public network). A second project started up in 2009 in NL with refinements and new features; see Mijdrecht roject)

Selected as case study: yes

Technology Type(s):	Target Area(s):
Alternative Fuels	Gas Type & Sources

Quality of Supply	Cost Efficiency	Carbon Reduction	Project Status (TRL)	Degree of innovation challenge	GB regulatory fit	Roll out potential
√√	√	√√√	8.5	√√√	√	√√

7.5 Hydrogen Injection in Natural Gas field trial
Eneco, GasTerra, NAM, and Ameland urban authority, The Netherlands

14 houses Almeland are supplied with a mixture of natural gas and hydrogen (up to 20%). Hydrogen produced by PV electrolysis. Main objective is to ascertain effect of hydrogen on network equipment and customer reactions.

Selected as case study: yes

Technology Type(s):	Target Area(s):
Alternative Fuels	Gas Types & Sources

Quality of Supply	Cost Efficiency	Carbon Reduction	Project Status (TRL)	Degree of innovation challenge	GB regulatory fit	Roll out potential
		√√	6.5	√√	√	√

7.6 Use of heat from compressor stations
Tebodin and Fugro, The Netherlands

Use of heat from gas compressor stations (note heat from compressor stations natural gas that has to be cooled down after compression from e.g. 80 degr. Celc. to 50 or 30 degr. Celc. by means of aftercoolers – In general for compressor stations the load and thus heat generation, is very variable). Tebodin and Fugro just started a co-operation about heat storage an extraction in the sub-soil.

Selected as case study: no

Technology Type(s):	Target Area(s):
Heat Management	Energy Efficiency

Quality of Supply	Cost Efficiency	Carbon Reduction	Project Status (TRL)	Degree of innovation challenge	GB regulatory fit	Roll out potential
√	√	√√	5.0	√	√√	√

7.6 New gas works concepts: examples of minimal trenching

Three R&D projects are in progress, co-ordinated by Gaz de France, DVGW – Bonn and S&P - Stuttgart. Two of them focus on the development of minimal intrusion into roadways while ensuring optimum quality and reduction of costs, when building a gas network. The third project deals with the optimisation of GPR in order to find every distribution network under the streets. The objectives are to characterise the performances of existing radar systems and develop new systems capable of satisfying user needs.

Selected as case study: no

Technology Type(s):	Target Area(s):
1. Network Architecture 2. Local Grid balancing techniques	Gas asset applications

Quality of Supply	Cost Efficiency	Carbon Reduction	Project Status (TRL)	Degree of innovation challenge	GB regulatory fit	Roll out potential
√	√	√	5.0	√√√	√√	√√

8. Gas Primary Source

8.1 NATURALHY Project
Loughborough University – 39 partners EU, EU

Adding hydrogen to the natural gas system (GET now KEMA Gas Consultancy and Services, coordinates the project for Gasunie)

Selected as case study: No

Technology Type(s):	Target Area(s):
Alternative Fuels	Gas Type & Sources

Quality of Supply	Cost Efficiency	Carbon Reduction	Project Status (TRL)	Degree of innovation challenge	GB regulatory fit	Roll out potential
√	√	√√√	5.0	√√	√	√√

APPENDIX E: LONG LIST OF INNOVATION PROJECTS

This section includes details of the 196 projects that were short-listed from the global scan and filtering process. These innovation projects are classified, based on the supply chain, in the following categories:

11. Electricity Customer, EC
12. Electricity General, EG
13. Electricity Networks, EN
14. Electricity Primary Sources, EP
15. Electricity Storage, ES
16. Gas Customer, GC
17. Gas General, GG
18. Gas Networks, GN
19. Gas Primary Source, GP
20. Gas Storage, GS

Category Electricity Customer

1. Development of Pilot Demand Supply Interface (DSIF) (Verification of System Function in Anonymous Demand Area Power System (ADAPS))

Central Research Institute of the Electric Power Industry (CRIEPI), EU

(Category: EC)

Demand Supply InterFace (DSIF) that provides energy demand-supply control between customers and power quality improvement is also proposed as one of the most important components of ADAPS. DSIF, which is installed near the customer distribution panel, monitors energy use of each customer, controls and manages customer load and DG to the benefit of both customers and the distribution network operator using real time information such as electricity tariff and network power flow. Basic design for ADAPS management logic with Low Voltage Network Management System (LVNMS) and DSIF has been conducted. Demonstration test with pilot DSIF is required to verify system functions.

<u>2. Smart metering</u>

BMWi Bundesministerium für Wirtschaft und Technologie, Federal Ministry of Economics and Technology, Germany, Germany

(Category: EC)

Study on potential of smart metering in terms of energy efficiency, done by KEMA

<u>3. ITM (Intelligent Transport Management). Studying the consequences of EV on the electricity infrastructure</u>

SenterNovem (subsidy), Netherlands

(Category: EC)

The ITM project looks at impact and management of electric vehicles on the grid (www.itm-project.nl). Bi-directional chargers in electric vehicles will be a part of this study.

<u>4. Smart meters</u>

Vector Group, New Zealand, New Zealand

(Category: EC)

Vector is implementing an advanced metering rollout programme encompassing 550,000 domestic and small business customers through New Zealand. Vector owns the metering and communications assets while its joint venture partner Siemens co-owns and operates the AMI infrastructure platform. Starting in 2008 the rollout programme had completed over 50,000 installations across seven distribution network areas and has seen installation rates averaging 3,800 per month. Key benefits of the programme include: • providing a project of sufficient scale to make AMI cost effective • targeting quality of energy delivery in constrained networks through voltage management, early harmonics detection before faults occur and frequency keeping • cost effective access to reactive power data not previously available • network planning improvements through detailed understanding of load profiles and growth • outage management improvements and post outage analysis capability to enhance network operation • cost effective import/export metering to facilitate small scale embedded generation projects • reduce unaccounted for energy and wholesale energy reconciliation • improve revenue assurance • enhance ability to support flexible tariff options to facilitate beneficial changes in consumer demand behaviour

<u>5. The Sub</u>

Vector Group, New Zealand, New Zealand

(Category: EC)

Situated inside the Auckland CBD Quay Street substation, The Sub is a demonstrated example by Vector of how demand side energy and communications technologies can be incorporated into energy efficient and high speed broadband connected homes and businesses. Rapid advances in on-site power generation and management may soon offer the possibility for customers to make and manage their own energy. The kitchen demonstrates smart and efficient appliances that are now becoming available to customers. Technologies featured here include: • Evacuated tube hot water heating • Micro wind turbine • Photovoltaic solar panels • Combined heat and power generation unit • Instantaneous boiler • Smart meter • Energy management system High speed fibre. Many of these energy generation, management and telecommunications technologies are likely to be part of Vector's future. Some are clearly more advanced and closer to coming to market than others. But what The Sub clearly demonstrates is that there is currently rapid innovation underway in both demand side energy technologies and telecommunications. Costs are rapidly falling and capabilities are quickly growing. Significant commercial opportunities could soon emerge for organisations that can respond quickly enough.

6. A Scoping Study: Demand Side Measures on the UK Electrical System

KEMA, UK

(Category: EC)

This project considers the possibilities for demand side management (DSM) in the GB for small business and residential customers. The report considers DSM as the ability to modify and control patterns of usage; temporarily reducing and shifting customer demand without necessarily reducing overall energy consumption. The report suggests potential GB DSM programmes based on a review of international activities. Included within the recommendations are opportunities for Intermittent generation combined with DSM.

7. Domestic Metering Innovation

Ofgem, UK

(Category: EC)

This document sets out the potential costs and benefits of smart metering and what might need to be done to deliver smarter meters. A review of the technology is included as is a review of international activities in this area. This document acts as a reference point for smart metering and is part of an ongoing consultation process that will produce further reports and results in the future.

8. Advanced Metering \field Trial Update

The Carbon Trust, UK

(Category: EC)

The overall aim of the Carbon Trust's field trial is to understand, quantify and demonstrate the potential of Advanced Metering to deliver both significant cost and carbon emission reductions in less energy intensive organisations. Carbon Trust experience indicates that Advanced Metering, if properly used as a demand management tool, reduces energy consumption (and costs) by between 10% and 15%.

9. Grid Friendly Appliance Controller

Pacific Northwest National Laboratory (PNNL), USA

(Category: EC)

Device based on the gate array chip, commonly found in cell phones, which monitors line frequency, detects dips, and sheds load to compensate. Potential applications for the device are refrigerators, air conditioners, water heaters and various other appliances. The device turns appliances off for a few seconds to a few minutes in response to overloading of the network. Potential to provide feeder voltage support and spinning reserve.

10. Smart Grid strategy

Energy Australia, Australia

(Category: EG)

Energy Australia (major electricity distribution network company) is trialling their smart grid strategy in the Newington estate. They are going to deploy between 1000-2000 smart electricity meters in addition to their kiosk monitoring solution (you can comment on the intelligent RTU's they already deploy throughout their network). Each house in the Newington estate will have electricity, gas, clean water and grey water individual monitored. While Newington is a new estate they are also including Silverwater with a high percentage of old housing in order to capture off-peak hot water services. Around 100 homes are going to be FULLY monitored with an in home display and 8 major appliances individually metered. This is where the real innovation comes in as amongst other items they intend to test and develop algorithms to identify individual appliances from the total energy consumption (Note that Energy Australia recently announced a $10 million grant to the Universities of Newcastle and Sydney to assist in the trial analysis). It appears to be a very well designed trial with a control group and several different categories of customer.

Category Electricity General

11. Distribution network design, management and regulation

Tractebel Eng., Belgium, Belgium

(Category: EG)

In the present context of the Electric Supply Industry characterized by a market that is open down to the small customers connected to the low voltage network, the implementation of Distributed Energy Resources requires innovative solutions that could lead to efficient regulation schemes as well as new implementations of demand response and even defence plans for ensuring the robustness of the system facing serious disturbances. This supposes that some of the propositions from the "Smart Grids" concept must be deployed. This is in fact one of the conclusions of the EU-DEEP EU integrated project about the integration of DER in the network and in the market

12. Cell Controller Project

Energinet.dk, Denmark

(Category: EG)

Development of an advanced power management system that operates portions of the distribution system as fully controllable micro-grids (cells), utilizing generation and load assets. Cell controller can provide active/reactive power control, monitoring/control of AVRs, and the fast islanding of the cell in the case of a severe grid fault. Cell controller currently undergoing laboratory-scale testing. An area of network has been identified for future pilot trials.

13. Power quality and Management System (PoMS)

DISPOWER, EU

(Category: EG)

PoMS is a novel ICT application developed by Fraunhofer ISE as part of the DISPOWER project (Work Project 10), which implements active management of distributed generation, controllable consumption, storage and power quality devices in low voltage grids, and covers economic optimisation as well as interventions in case of irregularities

14. MICROGRIDS

Industrial and academic consortium, EU

(Category: EG)

The project will investigate, develop and demonstrate the operation, control, protection, safety and telecommunication infrastructure of Micro-grids and will determine and quantify their economic benefits. Operation and Control concepts in both stand-alone and interconnected mode on Laboratory Micro-grids will be demonstrated. The effect of Micro-grids formation on the increase of renewable energy sources and other micro sources share (target 15%), on the reduction of annual losses (target 10%), on the increase of reliability levels (target 30%) and on the reduction of energy cost for the end-user (target 10%) will be investigated by simulation on actual distribution systems provided by the participating Utilities.

<u>15. Towards Smart Power Networks, Lessons learned from European Research FP5 Projects</u>
European Commission, EU
(Category: EG)
This report summarises the main outcomes of the FP5 projects relating to the integration of distributed energy resources with European distribution networks. In addition, it suggests some preliminary indications of emerging areas for focus within upcoming FP7.

<u>16. MORE MICROGRIDS</u>
Industrial and academic consortium, EU
(Category: EG)
This project aims to increase the penetration of micro-generation in electrical networks through the exploitation and extension of the micro-grids concept, involving the investigation of alternative micro-generation control strategies and alternative network designs. Work Programme A will develop microcontrollers for micro-sources and loads capable to provide more efficient voltage and frequency control in case of islanded operation.

<u>17. SMARTGRIDS</u>
Industrial and academic consortium, EU
(Category: EG)
The SMARTGRIDS technology platform aims to increase the efficiency, safety and reliability of European electricity networks and to remove obstacles to the large-scale integration of distributed and renewable energy sources. Research areas include: smart distribution infrastructure; smart operation and management of energy flow.

<u>18. Advanced Power Converters for Universal and Flexible Power Management in Future Electricity Networks (UNIFLEX)</u>
Industrial and academic consortium, EU
(Category: EG)
The objective of this project is to develop advanced power conversion techniques to meet new application needs in the Future European Electricity Network, and to validate these techniques in hardware. The power converters must be able to provide intelligent power management as well as ancillary services. The final objective of the project is the hardware

validation of the modular architecture and its control at a representative power level (500kVA).

19. Development of Reliable Communication Architecture Suited to Power System Control in the Liberalized Electric Power Industry

Central Research Institute of the Electric Power Industry (CRIEPI), EU

(Category: EG)

Control and communication systems for power system operation and maintenance have long been constructed individually and exclusively for each application. With the liberalization of electricity markets, increasing interconnectivity between different control systems and devices but also cost cutting of system construction and operation are required. While widely applied, off-the-shelf and standardised techniques are preferable with respect to interconnectivity and cost cutting; they struggle to ensure the real-time features, reliability and security required for power system control. The objective of this project is to develop and demonstrate the techniques for ensuring real-time features, reliability and security of power system communications when off-the-shelf and standardised methods are applied.

20. open public extended network (OPEN) metering project

RWE, Iberdrola, ERNA, manufacturers and others, EU

(Category: EG)

Spanish utility group Iberdrola has announced that the European Commission has approved the open public extended network (OPEN) metering project to develop an open standard technology for remote meter management. The project will be coordinated by Iberdrola within the 7th Framework Program for the promotion of research, development and innovation (RDI) in the energy field. The project consortium comprises nineteen partners including electricity companies, meter manufacturers, communications companies, research centres and universities from seven European countries (Spain, Belgium, France, Germany, Holland, Italy and Switzerland). The main objective of the OPEN Meter project is to specify a comprehensive set of open and public standards for AMI, supporting electricity, gas, water and heat metering, based on the agreement of the relevant stakeholders in this area. Partners will carry out activities resulting in identifying and filling the knowledge gaps necessary to enable the relevant industries to agree, implement and embrace the new set of international standards specified. With a budget of more than €4 million, 60 percent of which will be subsidized, the 30-month project envisages the large-scale implementation of remote electricity and gas meters. To date, such large-scale implementation has been hampered by the lack of a set of widely accepted open standards capable of guaranteeing the interoperability of systems and devices produced by different manufacturers. The project will take advantage of the existing international and European standards, technologies and solutions, adapting them to the specific needs of AMI where possible, and carrying out research and technological development activities where necessary. Members of the OPEN Meter consortium include utilities EDF, Endesa, ENEL, Iberdrola, Netbeher Nederland and RWE, meter manufacturers Actaris, Elster, Landis+Gyr and ZIV Medida, technology partners Advanced Digital Design, Current, ST Microelectronics and Usyscom, research centres/universities CESI Ricerca, KEMA and Karlsruhe University, as well as the European standardization body CENELEC and the DLMS User Association.

21. Power electronics for future utility applications

RWTH Aachen Univ., Aachen, Germany, Germany

(Category: EG)

Medium-voltage converters, originally developed for industrial drives (e.g. in steel and paper mills), have nowadays entered utility applications. For several years, the growing need for power quality in distribution systems in conjunction with the large scale integration of renewable energy sources has boosted the demand for new technologies. Together with communication systems, power electronics are the key enabling technology to meet these challenges. This paper addresses several utility applications for power electronics, some of which are in use already today though market penetration is still low. In the field of high power inverters, conventional 3-level hard-switching converters as presently used e.g. in wind turbines are presented alongside with soft-switching converters and their possible applications such as STATCOMs or mini-turbines. The possibility of using DC instead of AC transmission and distribution systems will be discussed. DC systems have already been used for several decades to transmit bulk power. New opportunities for the use of modern VSC-HVDC will be shown, such as DC distribution systems. For this novel application, new technologies are needed, such as multi-megawatt DC-DC converters and DC circuit breakers; possible concepts for these technologies will be addressed. Cyclo converters, a rather conventional technology, have been applied recently in innovative ways to increase the efficiencies of very high-power pumped- hydro storage systems. Due to the fact that the development of new converter systems is always strongly related to the available device technology, future high-power devices will finally be discussed

22. PowerMatcher

Energy Research Centre of the Netherlands, Netherlands

(Category: EG)

The PowerMatcher is an intelligent software concept for distributed control of power producers, power consumers and storage systems. The PowerMatcher enables control of a cluster of devices, such that the cluster behaves as one single system. This is achieved by tuning of demand and supply within the cluster in an optimal way. The PowerMatcher makes use of advanced ICT technology such as multi-agent systems and electronic markets. PowerMatcher has been developed (and is in development) in several national and international projects. An important one is the CRISP project (see project 043).

23. InovGrid

EDP Distribution (portuguese DNO and sponsor of the project), Inesc Porto (research institute related to the Faculty of Engineering of Porto), EFACEC (portuguese manufacturer of equipment for electric networks ranging from control and protection to power, Portugal

(Category: EG)

The project relates to smart grids. The objective is to set the way for a more active role of clients in the management of the distribution system. The project embraces the following main areas: 1. Smart metering and energy management looking to advance for example to controllable loads in order to increase energy efficiency 2. To create technical conditions for the smooth (safe and reliable) integration of distributed generation, particularly micro-generation 3. Move to smart grids creating conditions for smart management, control and increase of flexibility of the distribution grid There is not necessarily a sequence to the tasks. They are being carried out simultaneously to a large extent with different degrees of completeness.

24. Smart Networks trial

Western Power Distribution, UK

(Category: EG)

This has developed techniques and systems to provide network measurements via communication paths established from all HV /LV ground and pole mounted substations fed from a 132/11 and 66/11kV primary substation in Wales, and feed these into the network company corporate Enmac SCADA system. This capability forms a cornerstone of active network deployment, whilst already providing greater network loading and profile data than has previously been obtainable. Such data provides for improved utilisation, reduced connection costs, site specific cost benefit studies on loss reduction and can meet requests from community groups for local energy consumption data to aid their own energy reduction initiatives.

25. Modelling the Interaction Between an In-line Voltage Regulator and a Doubly-fed Induction Generator

EATL, UK

(Category: EG)

The connection of small wind farms to the 11kV rural network is limited to sites which are electrically close to the primary 33/11kV substation. Focusing on the planned connection of two DFIG wind turbines onto the distribution network in Northern Wales, this project models the use of in-line voltage regulators at sections of the 11kV network, allowing the remote connection of DFIG turbines to the network, achieving enhanced levels of distributed generation in the area.

26. Synchronous compensators for mini-grids and islanding

Econnect, UK

(Category: EG)

The main purpose of the project was to develop equipment suitable for use in remote locations which would permit islanded operation of wind turbine systems equipped with induction generators. The project aimed to demonstrate methods by which induction wind turbine generators can operate in islanded mode, receiving voltage control from synchronous compensators and frequency control from distributed intelligent load controllers. This was to be achieved by developing a design methodology and applying it to the construction of two test systems, incorporating a 20kW stall-regulated wind turbine and a 300kW pitch-regulated wind turbine respectively. Each wind turbine was to be islanded from the electricity grid, fitted with the synchronous compensator and distributed load control technology, and tested.

27. Impact of Climate Change on the UK Energy Industry

UK DNOs, UK

(Category: EG)

In 2006 the UK Meteorological Office carried out a scoping study on the impacts of climate change on the GB energy industry. The report was the result of collaboration between E.ON GB, EDF Energy, National Grid and the Met Office Hadley Centre to scope the impacts of climate change on the GB energy industry. This Phase 2 project was industry funded; it involved 11 GB energy companies and was undertaken by the Met Office. It focussed on the priorities identified by the earlier scoping study. During the project new tools and methods required to understand the impact of climate change on the energy industry were developed and new data resources designed to address gaps in underpinning information were produced.

28. City Centre Substation Cooling

EDF Energy, Central Networks, UK

(Category: EG)

This project will develop passive cooling techniques to apply to existing secondary substations. The cooling solutions will address the issues of reinforcement and the growth of air conditioning and cooling in city centre sites. Specifically deployment will: • Lower secondary transformer skin temperatures by 10°C on all sites enabling load ratings to be re-benchmarked, • In conjunction with the battery management ensure that power is available for automatic regeneration when required.

29. Bankside Heat Transfer

EDF Energy, UK

(Category: EG)

Substation transformers produce waste heat which is usually lost to the environment. The re-planted substation at Bankside, adjacent to the Tate Modern, will use transformers with water cooled heat exchangers. It is proposed that the waste heat from the transformers will be used by the Tate Modern to assist with its building heating process. This will benefit EDF Energy Networks, as less energy will need to be expended within cooler fans at the substation, and lower maintenance and replacement of cooler fans will be incurred.

30. SmartGrids- vision or reality?

, UK

(Category: EG)

This assessment addresses whether Europe's electricity grids which meets the challenges, take advantage of future market opportunities and fulfil society's expectations requiring vigorous research efforts and a robust technical solution. The SmartGrids European technology platform has been introduced to enhance the level of coherence between the European, national and regional programmes and address the challenges of future networks. This assessment explains why it is critical that the industry strives towards a shared vision and the benefits that SmartGrids technology platform will bring to the industry. It also highlights a number of pilot studies which are currently taking place as a result of the research and development.

31. Distribution Design to Integrate Distributed Generation in the Distribution System of the Future (Part of the EPRI Advanced Distribution Automation (ADA) Programme)

Electric Power Research Institute (EPRI), USA

(Category: EG)

The objective of the EPRI ADA programme is to create the distribution system of the future, a multifunctional system that may be more accurately described as a 'power exchange system'. The aim of this project is to provide sponsors with tools and information needed to effectively redevelop distribution systems to take advantage of new system topologies and system-level concepts that add functionality and operating benefits. The project will provide advanced distribution concepts that will increase the strategic value of the new distribution system component technologies. The new system features will allow more strategic operation of the distribution system to capture the benefits of using DG as a tool in ADA, resulting in increased system reliability. Interim report due 12/07.

32. Gridwise

U.S. Department of Energy Office of Electricity Delivery & Energy Reliability. Pacific Northwest National Laboratory (PNNL), USA

(Category: EG)

GridWise is a vision for transforming the USA's electric power grid using advanced communications, automated controls and other forms of information technology. The GridWise vision integrates the energy infrastructure, processes, devices, information and markets into a collaborative arrangement that allows energy to be generated, distributed and consumed more efficiently. Similar to the nervous system in a living organism, GridWise will enable devices at all levels within the grid – from utility to consumer – to independently sense, anticipate and respond to real-time conditions by accessing, sharing and acting on real-time information. Note also Gridwise Alliance and GridWise Architecture Council.

33. Gridworks

U.S. Department of Energy Office of Electricity Delivery & Energy Reliability, USA

(Category: EG)

GridWorks is a program activity in the U.S. Department of Energy's Office of Electricity Delivery and Energy Reliability (OE). Its aim is to improve the reliability of the electric system through the modernization of key grid components: cables and conductors, substations and protective systems, and power electronics. The GridWorks multi-year plan is the result of extensive consultation with representatives of the electric utility industry, power system equipment manufacturers, other Federal and State agencies, universities, and national laboratories. Over 160 electricity experts and practitioners participated in the GridWorks R&D planning workshop and webcast to identify technical barriers to grid modernization, determine the most important needs for GridWorks to address, and set goals and priorities for these needs.

34. Advanced Metering Infrastructure Development and Integration (part of Intelligrid Consortium)

Electric Power Research Institute (EPRI), USA
(Category: EG)
The Advanced Metering Infrastructure Development and Integration Project will develop an industry-wide reference design for AMI. The design will describe how various metering components are expected to operate together as a system, providing services including demand response, net metering, real-time pricing and appliance management.

Category Electricity Networks

35. PD-Online. Partial discharge monitoring of medium voltage cables (continuously)
Various, Australia
(Category: EN)
The traditional method was to bury sensors at fixed lengths along the line but this effectively left monitoring gaps and was expensive to install and difficult to access in the event of failed sensors. A further extension to this project has been the development of fibre Optic Current and Voltage transducers that use light to measure power flows on high voltage networks in cooperation with University of Sydney and ABB Australia.

36. HV Cable temperature Monitoring System
Transgrid, Australia, Australia
(Category: EN)
A number of large 330kV cables transverse the city of Sydney carrying a significant load. During the implementation of a 27km 330kV underground a separate project was established to monitor the temperature along the length of the line by applying a signal to a fibre optic cable which is parallel to the physical load bearing cable. The technique developed made it possible to build up a temperature profile across the line. This is used by operators to determine load bearing limits based on climatic conditions and other factors. The traditional method was to bury sensors at fixed lengths along the line but this effectively left monitoring gaps and was expensive to install and difficult to access in the event of failed sensors. A further extension to this project has been the development of fibre Optic Current and Voltage transducers that use light to measure power flows on high voltage networks in cooperation with University of Sydney and ABB Australia.

37. SF6 Containment Scheme
TransGrid, Australia
(Category: EN)

With the advent of large transmission substations in densely populated areas in fairly confined spaces there has been a move away from oil-cooled switchgear and transformers to SF6 cooling. Generally the SF6 is stored in the equipment at 6x atmospheric pressure so for large transmission substations with 3 SF6-cooled transformers and up to 27 switchable bays a significant amount of compressed gas is present. SF6 is not a poisonous gas but in large quantities can provide suffocation due to lack of oxygen and is recognised as a green house gas. The design of the 330kV Haymarket Substation building in Sydney included special cavities and dampers which could be controlled by SCADA to collect and store any escaped SF6. This protects not only people within the building but anybody nearby from the potential high volume of gas that could potentially escape.

38. Zero-sequence harmonics current minimization using zero-blocking reactor and zig-zag transformer

Key Lab. of Power Syst. Protection, North China Electr. Power Univ., Beijing, China, China

(Category: EN)

In the distribution power system, the third harmonics of zero-sequence caused by nonlinear loads usually result in high-voltage distortion levels throughout the facility, neutral conductor overloading, motor heating, transformer heating, increased losses, and excessive harmonic injection onto the utility supply system. This paper presents a novel method for minimizing the zero-sequence harmonics by using zero-sequence blocking reactor (ZSBR) and Zig-Zag transformer. Zig-Zag transformer is a special connection of three-phase transformer's windings. The ZSBR is also a special connected transformer, whose three windings are wounded in the same core. The ZSBR has zero reactance for positive and negative-sequence components but giving three times of self-reactance for zero- sequence reactance. The ZSBR placed in series with the source provides high zero-sequence impedance while the Zig-Zag transformer placed parallel with the load provides low zero- sequence impedance. Thus, the zero-sequence harmonics currents tend to flow through the Zig-Zag transformer instead of the source, and the purposes of eliminating harmonic is gained. In this paper, an analysis is carried out; simulations and laboratory tests are used to evaluate the performance of the Zig- Zag transformer and ZSBR under ideal and non-ideal power conditions. The simulation and laboratory test results indicate that the combination of ZSBR and Zig-Zag transformer as filter is a better and effective way to attenuate the neutral current, which also provides an innovative way to improve power quality.

39. ADDRESS. Large European demonstration project to proof the value of active demand tools and methods

European Commission, EU

(Category: EN)

ADDRESS researches, develops and deploys technologies and processes to increase usage of distributed generation and renewable energy resources. The project aims to develop new innovative architecture for Active Distribution Networks (ADN) that is able to balance power generation and demand in real time. This allows network operators, consumers, retailers and stakeholders to benefit from the increased flexibility of the entire system. Innovative use of communications, automation and household technologies combine with new trading mechanisms and algorithms, providing ADN with low cost and reliable solutions. The secure and reliable operation of the distribution networks must also take into account distributed generation, energy storage systems and large customers connected at the MV level. The main objectives of this project are twofold: to develop technical solutions at the end user location to make demand active, and at the power system level to allow the participation of demand in power system markets and in service provision; to identify the possible barriers against active demand development on the power systems and develop solutions and recommendations to remove these barriers. The project seeks to exploit the benefits of active demand in an optimal and market-based way while fulfilling the customer's expectations. It will do this by identifying the benefits for the different power system participants, and developing appropriate markets and contractual mechanisms to stimulate the development of active demand.

40. Improvement of the quality of supply in Distributed Generation networks through the integrated application of power electronic techniques (DGFACTS)

Industrial and academic consortium, EU

(Category: EN)

DGFACTS introduces the use of the FACTS devices in distribution systems by designing a set of modular systems, so-called DGFACTS Systems, to optimally improve the stability and quality of supply of each electric power distribution network according to its characteristics and requirements. This will allow a high degree of renewable energy sources and distributed generation penetration in the current and evolving distribution systems.

41. DG-GRID

Industrial and academic consortium, EU

(Category: EN)

After identifying relevant new innovative concepts required for grids in the longer term - when large electricity volumes are supplied by renewable energy sources and CHP and a large share of power generating capacity is connected to the distribution levels - consequences for short term regulation and operations of distribution network operators are analysed and assessed in Work Package 4 (WP4).

<u>42. Networked Control Systems Tolerant to faults (NECST)</u>
Industrial and academic consortium, EU
(Category: EN)
The aim of the NeCST is to explore research opportunities in the direction of distributed control system in order to enhance the performances of diagnostics and fault tolerant control systems. This will lead to improving the intensive use of NeCST technologies for the reactivity, autonomy and monitoring of large scale systems. The systems under consideration in the framework of this project can be considered as a distributed network of nodes operating under highly decentralised control, but unified in accomplishing complex system-wide goals. Final Review due end of 2007.

<u>43. Autonomous Demand Area Power System</u>
Central Research Institute of the Electric Power Industry (CRIEPI), EU
(Category: EN)
The demand area power system enables the connection and operation of large numbers of DG units. This has been conceived as an alternative to traditional radial or loop distribution systems. According to CRIEPI, the demand area power system offers improved performance with large amounts of DG in areas such as system protection, islanding, system stability and voltage control. It is, however, more expensive than other alternatives as it includes supply/demand interfaces at each consumer and new 'loop controllers' to control line voltages and power flows.

<u>44. Development of Operation Control Technique for Autonomous Demand Area Power System (ADAPS)</u>
Central Research Institute of the Electric Power Industry (CRIEPI), EU
(Category: EN)
Part of the ADAPS programme, the purpose of which is to establish the smooth introduction and effective use of Distributed Generation, while preventing the grid interconnection problems such as influence on power quality and safety. The aim of this project is to demonstrate uninterrupted power supply method by isolated operation in the high voltage non-fault section of the network using Loop Power Control, and to develop and demonstrate the isolated operation method in low voltage distribution using DG, storage battery and the technique of cutting off selected load of customer. Demonstration tests have been performed, confirming that isolated operation of the whole low voltage distribution line can be

continued during faults using the design method, resulting in more domestic customers avoiding outage during faults.

45. PoDIS (Power Delivery Information System)

Fortum, Finland

(Category: EN)

A web based system acquiring information from the Swedish smart meters (AMM). This application reads the status of each site to inform the operator if the power is on (or off). This could be seen as a step towards a low-voltage SCADA. The product is internally developed by Fortum.

46. Potential of power electronics in electricity distribution systems

Lappeenranta Univ. of Technol., Lappeenranta, Finland; Fortum Distrib. , Finland, Finland

(Category: EN)

Electricity distribution technology is taking remarkable step by implementing the low-voltage DC-technology to the distribution networks. The first installations of this economical, transmission capacity and power quality increasing innovation in public electricity distribution will be done in coming years. Recent research results shows that there are remarkable potential for low-voltage DC technology in distribution networks, especially in rural areas

47. Technical solutions for the compensation of harmonics in earth fault current

E.ON edis AG, Fürstenwalde, Germany, Germany

(Category: EN)

During the operation of medium voltage grids with resonant earthed system the earth fault current reaches critical values which are higher than the standard limits in DIN EN 0228 and 0101. This includes a long-term risk situation (effective touch voltage, double earth fault), because of the fact that these grids are stay in operation with the earth fault for up to two hours. The reasons for the increased earth fault current are voltage distortions in the MV and HV grids. They cause higher harmonic current components in the earth fault current. To re-establish uncritical grid situations it will be necessary to reduce these component values, especially of the 5th and 7th harmonic. KEMA-IEV, as member of a triple cooperation team with E.ON edis AG and H. Kleinknecht GmbH & Co. KG, took part in all stages of development of different passive and active filter models. Principle phases were: ·software development for earth fault current and harmonic calculations ·work out technical possibilities to reduce or to limit earth fault currents ·tests and operation of different 20 kV prototype models and selection of the optimal solution ·development of and pre-series model for industry suitable use. The solutions were developed, analysed and brought in operation to test their capability of reduction harmonic earth fault current components. The final prototype and the pre-series model consist of a five phase active filter (FAF) installed on the transformer star point and the three-phase a. c. busbar. Measurements in normal operation and in earth fault situations showed that the prototype is in working order and the reduction of the harmonic components functions as expected.

48. Monitoring Overhead Lines

Envia Verteilnetz GmbH, Halle, Germany, DSO; E.ON edis AG, Fürstenwalde, Germany, DSO; Wemag Netz, Schwerin, Germany, DSO, Germany

(Category: EN)

The monitoring of overhead lines (OHL) holds significant theoretic potential to extend the capacity/load of HV OHL temporarily. The surrounding temperature and the wind speed have the largest impact and therefore the largest potential with regard to rising the current carrying capacity. The impact of solar radiation can be neglected. For practical implementation during grid operation, the direct measurement of conductor rope temperature as well as the usage of an appropriate calculation model to represent the relations in (n-1)case within the control system is required. Three existing static calculation models were analysed regarding their accuracy. KEMA also developed a robust temperature sensor for conductor rope temperature measurement and verification of the model under operation. The CIGRE model represents the conductor rope temperature most accurate. As expected, the static models do not represent the reality when the surrounding values change extremely. For these cases, a higher calculation error exists and needs compensation. Besides calculation errors, additional environmental conditions of the OHL need consideration.

49. SCADA on Web

Forschungsgemeinschaft für Elektrische Anlagen und Stromwirtschaft e.V. (FGH), Germany

(Category: EN)

It is intended to establish the ScadaOnWeb technology as a standard platform to process monitoring and control applications that are distributed over the web. The technology will support the use of off-the shelf applications for data visualisation; the identification of hazard situations using rule bases and process optimisation. It will define a standard for meta-data that gives semantics to structured numeric dataset. This meta-data will reference standards for units of measure, and technologies for properties in different engineering domains. The demonstrators will play a key role in the project by validating the ScadaOnWeb technology and ensuring rapid industry acceptance and standardisation.

50. High temperature superconducting fault current limiter

Nexans, Germany

(Category: EN)

Implementation of the first fault current limiter (10kV, 10 MVA) into the energy grid for RWE Energy took place in 2004 in Netphen near Siegen (Germany). The next stage of development is for a 110kV unit. These devices exhibit rapid resistance or reactance changes above defined current limits. Excessive currents cause a change of state from superconducting to resistive which results in a lower fault current.

51. Network Driven DSM

International Energy Agency, International

(Category: EN)

This report outlines a multi-national research project to be undertaken under the auspices of the international Energy Agency Demand Side Management Programme. The research project will investigate network-driven DSM measures which may provide viable alternatives to augmentation of electricity networks. The workplan incorporates six subtasks: Worldwide survey of network-driven DSM projects; Assessment and development of network-driven DSM measures; Incorporation of DSM measures into network planning; Evaluation and acquisition of network-driven DSM resources; Communication of information about network-driven DSM and Role of Load Control and Smart Metering In Achieving Network-Related Objectives. The initial four subtasks have been completed, subtasks 5 & 6 are still continuing. Reports from tasks 1&2 are available from 10/07, reports from tasks 3&4 available from 04/08.

52. Demonstrative Project on New Power Systems

New Energy and Industrial Technology Development Organization (NEDO), Japan

(Category: EN)

This project is developing technologies such as SVR's, SVC's and supply-demand balance controllers to maintain the power quality of the system even when decentralized power sources, including new forms of energy, are connected to the grid en masse. Alongside this work, NEDO is also conducting verification studies with a model power distribution system composed of decentralized power sources that also include new energy, a load simulator, and grid line control devices.

53. Dynamic current rating optimisation

KEMA, Netherlands

(Category: EN)

Systems that monitor cable core temperature using optical fibres or thermocouples in order to provide a dynamic current rating are available. Thermocouples are fitted to existing cables where optical fibres are not available. Mathematical modelling is undertaken to determine the cable performance under dynamic loading conditions and to provide information on insulation ageing. Real time temperature data and overload capabilities can be accessed to allow greater operational flexibility.

54. Distributed Intelligence in Critical Infrastructures for Sustainable Power (CRISP)

Consortium led by Energy Research Centre of the Netherlands (ECN), Netherlands

(Category: EN)

The CRISP project aims to investigate, develop and test how latest advanced intelligence by ICT technologies can be exploited in a novel way for cost-effective, fine-grained and reliable monitoring, management and control of power networks that have a high degree of Distributed Generation and penetration of renewable energy sources.

55. Planning criteria

Vector Group, New Zealand, New Zealand

(Category: EN)

Vector made a decision to move away from using the n-1 deterministic criteria for the development of its electricity sub-transmission and distribution network. The modified criteria adopt a reliability based approach. The modified methodology takes advantage of the fact that most substation and feeder peaks occur over a very short period (typically a couple of hours in a day for residential areas and a couple of hundred hours in a year). By accepting a small risk that supply to customers may be lost if a fault occurs during the substation or feeder peak demand times in the planning process, a significant number of reinforcement projects have deferred over the past ten years. To insure the risks of supply loss to customers is limited to an acceptable level, the revised planning criteria require that adequate back stop capacity from neighbouring substations or other means (such as backup generators) are available to restore supply within three hours. By adopting this planning strategy, Vector has managed to defer about $200 million of reinforcement expenditure over the past ten years. Service outcomes seen by customers (as measured by SAIDI and SAIFI) have been maintained (i.e. no deterioration in the 10 years since this decision was implemented).

56. Automatic Switching scheme

Vector Group, New Zealand, New Zealand

(Category: EN)

Vector has developed a scheme to enable load to be rapidly transferred from one part of its network to a neighbouring part of the network to defer investment in augmentation. The salient features of this load transfer scheme are: • fully automated – when a fault is detected in a part of the network covered by the scheme, an automatic switching sequence will be initiated which will isolate the fault and rearrange the network to restore supply. • fast response – the switching sequence is pre-programmed, and hence offering a fast supply restoration to customers. • high capacity –the fast operation of the scheme allows rapid off loading of zone substation transformers (which are usually operated in parallel) under post contingency conditions. This in turn allows the transformers to operate to a short term (5 minute) rating, thus deferring reinforcement investments. In a specific application we managed to defer reinforcement to Onehunga substation (about $5 million) by seven years.

57. Automation and Control

Vector Group, New Zealand, New Zealand

(Category: EN)

Vector is an industry leader in the automation and control of its electricity distribution network and is continually developing technologies which enable the development of the next generation of ‘smart distribution network’. Vector was the first utility in Australasia to use IEC61850, which is the international standard for substation automation; Vector now has more than 60 substations and 500 intelligent electronic devices which are capable of operating to IEC61850 standard. All new substation equipment installed by Vector is designed to use modern communication protocols based on Ethernet and TCP/IP networking as found in IT networks. Traditional copper wiring for communication can now be forgone in favour of fibre optic and modern radio based technology such as 3G and GPRS. One of the applications of mobile communications technology is the use of hand held devices to enable field staff to send and receive asset and network information to facilitate data collection and inputting, improve emergency response, and streamline administration.

58. Application of Bayesian networks in distribution system risk management

SINTEF Energy Res., Trondheim, Norway; EdF R&D, Paris, France, Norway, France

(Category: EN)

There is an increasing trend towards using the concept of risk assessment as an important tool in distribution system asset management. In an ongoing R&D project (RISK DSAM), the main objective is to investigate how information about risk exposure can improve maintenance and reinvestment decisions in an electrical distribution company. As the popularity of Bayesian networks (BN) is increasing, the capacity of this methodology is being explored in the project. The paper presents the BN framework and the link to risk based asset management of electrical distribution systems. Examples are included to illustrate the concept as well as a case study evaluating the risk of failure of an overhead line and its dependence of risk influencing factors such as maintenance intensity and environment.

59. Studies on a LV DC network

Univ. Politehnica Bucuresti, Bucharest, Romania, Romania

(Category: EN)

In this paper, one application targeting a small-scale DC network supplying signal processing laboratory (personal computers, universal motors and other low-voltage, low-power loads) is proposed, in order to analyze the technical interconnecting possibilities of isolated power systems. As a first step, simulations using the already implemented network elements models in DIgSilent were performed in order to choose an optimal location of the generation units, considering restrictions related to available space, safety and future development. The next step was to develop mathematical models of the loads characteristics when each module is supplied with direct voltage, in order to further test direct DC supply of the laboratory. The paper is a consequence of the new approach oriented to innovative technologies for integrating dispersed and intermittent sources (DG) into distribution networks

60. Eskom extends low-voltage network

Escom, South Africa

(Category: EN)

An electronic voltage regulator provides an economic solution for some rural electrification situations in South Africa. Opportunities exist in developing countries for innovative technologies to be applied on networks that supply electricity to large rural communities. Often, these communities are in low-density rural areas of some 70 households/sq km (180/sq mile). As an alternative to extending medium-voltage (MV) overhead lines, it is now possible to install an electronic voltage regulator (EVR) on a low-voltage (LV) overhead network to maintain voltage within statutory limits.

61. Superconducting Fault Current Limiter

Scottish Power, UK

(Category: EN)

This project aims to design, develop and trial three 12kV Superconducting Fault Current Limiting (SFCL) devices on three different GB networks. A prototype FCL has been developed with the aim for a trial installation on the ScottishPower network.

62. Incipient cable fault detection and location

EDF Energy Networks, UK

(Category: EN)

The use of partial discharge measurement has been a well known method of checking the condition of electrical insulation. Over the past 10 years, EDF Energy Networks has been actively involved in the development of "on-line" partial discharge monitoring and mapping techniques. Opportunities to improve the existing technology have been identified. This project has taken the laboratory into the distribution network to monitor underground cables and switchgear. To date over 700 circuits are being monitored and several faults have been detected and avoided customer interruptions. Given the implied future costs associated with wholesale MV underground cable replacement over the longer-term, and the fact that some signs of accelerated failure are now evident, the development of this technique is regarded as essential to ensuring the minimisation of customer interruptions and the optimisation of future investment.

63. Fluid Filled Cable leak location using PFT tracers.

EDF Energy Networks, UK

(Category: EN)

This project is to evaluate the suitability of using PFT tracer technology to determine cable leak location and reduce the number of excavations required. The technology was developed by NASA. Benefits that are being realise include: Faster and more accurate oil leak locations; Operational cost savings with fewer and smaller excavations; and Positive impact on environment due to faster detection and repair, and reduced excavation. Between October 2008 and February 2009 the cost of locating 7 leaks were collected and compared against the traditional methods previously employed. Significant savings have been realised. The technique will enable leak rates to be minimised over the necessary longer-term programme to retire life-expired fluid filled cables.

64. Dynamic Thermal rating and active Network Management

, UK

(Category: EN)

This project is concerned with the use of DTR techniques to ease the limitations on a highly constrained area of the network due to the penetration of renewable generation. The area of concern is in North Wales and it is aimed to develop prototype controllers to enhance the utilisation of assets and reduce the constrains on the system. Also as a consequence of this project another project has been established to look at the embedded generation that is due to/might be connected to the distribution network and applying a system of constrains as well as enhanced ratings to optimise the management and scheduling of embedded generation. It is proposed to submit this project for an RPZ application.

65. Aura NMS – Autonomous Regional Active Network Management System

Aura NMS is a £6M a Strategic Partnership between the EPSRC, ABB, EDF Energy Networks and SP Energy Networks, UK

(Category: EN)

It will develop a distributed control system to deliver real-time automated reconfiguration initially to a regional network of up to four primary substations; economically, efficiently and effectively integrate large amounts of small scale distributed generation taking into account legacy infrastructure and renewal programmes; and network optimisation for losses and availability taking into account DG and electrical energy storage. The 11kV network supplied from Reigate, Horley and Nutfield primary substations will be the open loop demonstration network for the trial. An electrical energy storage device is being installed on the Martham network near an existing windfarm. The challenge is to demonstrate that Active Network Management solutions can be offered as an alternative to network reinforcement. £6M approx cost.

66. EP2 project.

Met Office - Climate Change Impacts on Energy, UK

(Category: EN)

This has been a highly geared project involving all the major GB Energy companies, spanning networks, generation and supply. It employed the world class research facilities of the met Office Hadley Centre to model, in our case, network impacts of climate change. It included assessment on overhead line ratings, and weather loads, underground cable ratings, transformer ratings, and "urban heat island" effects. The outputs are valuable in identifying the probabilities of impacts and identification of areas, such as wood pole overhead line design, where early intervention is probably warranted. The also greatly assist in meeting the new obligations of adaptation reporting power under the climate change act 2008.

67. FR3 filled power transformer

Coopers Power system, UK

(Category: EN)

This is a £1.2M project to design and build two transformers that will be filled with FR3 vegetable oil manufactured by Coopers Power system. This required considerable design work and evaluation of the various components used in the manufacture of the transformer. A 132/33kV transformer has been installed at Luton Grid and a 33/11kV transformer has been installed in Guildford. The demonstrations will: • Evaluate the possibility of the use of FR3 as the initial fluid to be used in a transformer with 132kV as the primary voltage; • Demonstrate the operational and environmental benefits of FR3 filled transformer; • Assess the reaction of the components used in the manufacture of a transformer with the fluid; and • In particular, assess the fluid use in the tap-changer and other components. Each transformer will be equipped with a comprehensive monitoring system to enable data to be obtained regarding the performance of the transformer and compare with another similar transformer filled with mineral oil.

68. "Embedded Controller" for Active Management of LV Distribution Networks

Econnect Ltd, UK

(Category: EN)

Modelled and simulated the effect of the connection of small-scale embedded generation to LV Distribution Networks through a range of scenarios. Simulation data used to develop design specifications for "Embedded Controller", leading to the building and testing of a prototype. Project successful in defining design specifications for effective prototype "Embedded Controller", proven through simulation and testing of a lab-based prototype.

69. Voltage Control Policy Assessment Tool

EATL, UK

(Category: EN)

Develop effective policies for applying voltage control technologies for enabling increasing connections of small generators. This project is developing a tool for DNOs to assess new approaches and find the best that allows maximum connections at the lowest cost for the developer, customer and DNO.

70. Enhancing protection and control systems to maximise benefits

EATL, UK

(Category: EN)

Defining best practice management of protection and control systems to enhance future network performance, and provide the ability to manage the risks associated with the connection of DG.

71. Single Phase LV Voltage Regulator

SP Power Systems/Electricity North West, UK

(Category: EN)

Development of device for use on the Scottish Power network in the GB. Deploy and demonstrate how distributed electronic voltage regulation could improve the effectiveness of an existing distribution infrastructure. Studies have shown that regulating the incoming line voltage reduces the average amount of electricity used by 10%.

72. BAM Solution 3.8 – Active voltage control with remote sensing

DGCG – TSG – WS3, UK

(Category: EN)

An area-based voltage control method with remote voltage sensing. Controller comprises of two main blocks: state estimation and control functionality.

73. BAM Solution 2.5 – Is Limiter

DGCG – TSG – WS3, UK

(Category: EN)

It is possible to increase the network impedance only at the time when the impedance of the network needs to be increased i.e. at the time when fault current flows. This can be achieved by the use of a device known as an Is limiter – a fault current limiting device. The key advantage of using such a device is that it retains the existing low network impedance under normal network conditions, and hence avoids any of the problems associated with increasing network security risks, losses and voltage control associated with permanently increasing network impedance. There are a number of possible locations for using Is limiters in networks, the most obvious positions being in series with a bus section circuit breaker, or in series with a dedicated generator connection.

74. BAM Solution 2.8 – Active fault level management

DGCG – TSG – WS3, UK

(Category: EN)

This project considers integrating fault level management strategies for a flexible and coherent network design approach.

75. BAM Solution 3.3 – Generator reactive power control

DGCG – TSG – WS3, UK

(Category: EN)

Reactive power control at the DG unit or at the connection point of several DG units. Solutions are dependant on the different generator technologies and are based on either generator power factor control or reactive compensation equipment.

76. In-line voltage regulators for 2.4kV to 34.5kV systems

Cooper Industries, UK

(Category: EN)

Cooper Industries manufacture in-line voltage regulators for 2.4kV to 34.5kV systems. These provide a 32 step +/-10% tap range with ratings between 33kVA and 1MVA in both directions. Provide voltage regulation of the downstream circuit section.

77. BAM solution 3.5 – Line voltage regulation e.g. a single regulator on a circuit

DGCG – TSG – WS3, UK

(Category: EN)

The use of line voltage regulators can be viewed as an extension to active voltage control on the distribution network. Line voltage regulators can be placed strategically within a feeder, such that the voltage regulator and the generator work together to control the downstream voltage, whilst the existing substation OLTC and Automatic Voltage Control scheme (AVC) controls the rest of the passive network in the conventional manner.

78. BAM Solution 3.5 – Line voltage regulation

EATL, UK

(Category: EN)

Develop a guide through improved operational design practices, to communicate effectively innovative options for line voltage regulation.

79. BAM Solution 3.6 – Cancellation CTs

DGCG – TSG – WS3, UK

(Category: EN)

The use of Cancellation Current Transformers (CTs) is a means to modify the OLTC AVC arrangements. Cancellation CTs can be used to remove the feeder with generation connected to it from the AVC control mechanism when Line Drop Compensation (LDC) is used.

80. BAM Solution 3.7 – Virtual VT

DGCG – TSG – WS3, UK

(Category: EN)

A MicroTAPP relay with a virtual VT that uses algorithms to calculate the voltage on the non-controlled side of the transformer and effective control to be carried out. When the generation is operating on power factor control the MicroTAPP can control the LV side; when the generation is operating on voltage control the MicroTAPP can control the HV side.

81. Tap changers – reverse power flow capability

EATL, UK

(Category: EN)

Research transformer reverse power flow capability to provide a reference document on equipment in networks and the most cost-effective option available.

82. Reverse Power Flow Capabilities of OLTC Transformers

Electricity North West, UK

(Category: EN)

This work concerns the analysis of the reverse power flow capability of on-load tap-changers with the aim to find the penetration level of DG that can be connected to the network. An in-detail analysis of the switching sequence during tap changing is presented, the physical constraints that limit the switching process are identified and the reverse power flow capability is calculated as an optimisation problem.

83. Solid State/Two-Position Tap Changing Transformer

Electricity North West commissioning AREVA, UK

(Category: EN)

Solid-state tap changers are under development. The main advantage could be the improved reliability and lower maintenance requirements over existing mechanical devices. It is expected that full reverse power flow capability will be possible. This transformer is being developed for smaller distribution transformers.

84. Dynamic transformer rating equipment

Dynamic Ratings, UK

(Category: EN)

Optical fibre temperature measurement is employed to determine the winding temperature and provide an input to the dynamic rating and insulation ageing software. The system provides transformer load monitoring and control, although the method of controlling the load is not stated. A full system replaces all existing transformer control equipment, including the AVC control and the pump and fan controls. It can be fitted to new transformers or retrofitted to existing transformers. Development work is being undertaken on more advanced equipment.

85. Network management systems for active distribution networks – a feasibility study
SP Power Systems LTD, UK
(Category: EN)
Discusses the technical feasibility of modifying an existing distribution network operator supervisory control and data acquisition system to one where some form of active management would be possible. Provides recommendations that could facilitate active management through SCADA.

86. Supergen Highly Distributed Power Systems Consortium (University / Industry consortium)
Universities: Bath, Imperial College London, Loughborough Oxford, Manchester and Strathclyde., UK
(Category: EN)
The Supergen HDPS consortium is researching networks of small energy generators and storage devices. Small-scale distributed energy resources will need to be effectively co-ordinated in the power system. The consortium is researching protection, control and communications interfacing for distributed energy resources. Network-friendly power interfaces for the modular connection of different types of distributed energy resources will make is possible to connect many devices.

87. Supergen Future Network Technologies (Futurenet) Consortium
Industrial and academic consortium, UK
(Category: EN)
Futurenet has the task of researching the changes which will help evolve the energy network for very high levels of distributed generation beyond 2010. This research includes finding solutions for the problems created by embedding renewable energy sources to the distribution network.

88. Supergen Energy Infrastructure Consortium – AMPerES (Asset Management and Performance of Energy Systems)
Industrial and academic consortium, UK
(Category: EN)

The aim of this consortium is to provide the tools to enable reliability of energy supply at minimum cost in the context of ageing plant, a drive to employ renewable and distributed generation and an environmental imperative. Of particular relevance to ANM is Work Project 3: ‘New Protection, Control and Management’. WP3: Strategies to maximise the absorption of new generation; Design and evaluation of loss of grid detection and amelioration techniques; Protection and control of synchronous islands; and Use of condition monitoring data to enhance protection.

89. Supergen Flexnet Consortium
Industrial and academic consortium, UK
(Category: EN)
Flexnet is a continuation of the work delivered by the Supergen Futurenet consortium (037). This work will examine the factors which dictate the future form of the electricity network in the GB, and the degree of flexibility required. The project will also investigate how this network flexibility can be delivered through smart, flexible controls, and power electronics devices. Of particular relevance to ANM is the work investigating the role of ANM in the planning of distribution networks and the development of new system operator interfaces and decision support provisions.

90. Novel protection methods for active distribution networks with high penetrations of distributed generation
DTI Centre for Distributed Generation and Sustainable Electricity Systems (University of Manchester and University of Strathclyde), UK
(Category: EN)
The underlying guiding force of this work is to provide a continuing support to the power industry in terms of integration of large amounts of renewable energy sources into existing distribution networks. The current project follows directly from the initial 9-month programme of work, which provided a realistic assessment of the solution gaps and major issues associated with distribution system protection in the GB. The aim of this phase of the project is to “close the gaps” in protection system architectures by proposing novel solutions in these areas.

91. The performance of networks using alternative network splitting configurations
EATL, UK
(Category: EN)
This project looks at the performance of networks using network splitting configurations, and the performance, issues, problems, and approaches which need to be addressed before an

option is considered/implemented. Modelling and analysis was carried out on 4 generic and stylised networks to help gain a view as to the effects network splitting configurations has on reasonable factors such as fault level, customer interruptions, customer minutes lost and harmonics.

92. Development of High-temperature super-conducting Fault-current Limiter

VA TECH T&D UK Ltd, UK

(Category: EN)

This project forms the first stage of a programme intended to deliver a full-scale fault current limiter for installation in an electrical distribution network for endurance testing, trial and demonstration purposes. This project was initiated to continue with work started in 1995 under a DTI – LINK Collaborative Research Programme: Enhanced Engineering Materials "Enhancing the Properties of Bulk High Temperature Superconductors and their Potential Application as Fault Current Limiters".

93. Superconducting Fault Current Limiter

ENW/SP Power Systems/CE Electric & NaRec, Applied Superconductor Ltd, UK

(Category: EN)

This project aims to design, develop and trial three 12kV Superconducting Fault Current Limiting (SFCL) devices on three different GB distribution networks. Three devices (one per DNO) will be constructed and installed covering a range of applications: transformer tails; bus section; interconnected network connection.

94. Renewables network impact study

The Carbon Trust, UK

(Category: EN)

This project assesses the ability of the electricity networks to accommodate the Government's target to have 10% of electricity generated in the GB from renewable energy sources by 2010 and 20% by 2020. Annex 3 considers the investment and reinforcements required at the distribution level. The study is largely based on real projects and generators' business plans and uses a "bottom-up" approach to map rising renewable capacity onto distribution networks. A generic distribution model is used to represent the GB distribution networks due to the lack of detailed information and impracticality of basing studies on full network information.

95. Assessment of islanded operation of distribution networks and measures for protection

Econnect, UK

(Category: EN)

The objective of this project was to develop a framework and recommendations for a detailed review of existing guidelines and practices related to islanded operation of distribution networks and loss of mains protection. Includes requirements of intertripping schemes for distributed generation.

96. Operation of Active Distribution Networks

DTI Centre for Distributed Generation and Sustainable Electricity Systems, UK

(Category: EN)

This project is concerned with the operation of active distribution networks and the specification of novel network scenarios and event schedules that will characterise potential problems in active distribution networks. From an analysis of these scenarios, the project will review the tools currently available within Distribution Management System (DMS) and Energy Management System (EMS) offerings, determine the requirements for new tools, and thereby deliver a timely assessment of the implications of active networks on operations.

97. Planning of Active Distribution Networks

DTI Centre for Distributed Generation and Sustainable Electricity Systems, UK

(Category: EN)

Assessing alternative reinforcement options in active distribution networks requires co-ordination of network investment and operation over a wide range of system conditions. This project is building on and extending the capabilities of the developed single state sequential optimal power flow and developing a practical analysis tool to assist distribution network planners with optimising combined operation and investment of active distribution networks through balancing network reinforcement costs against costs of constraints and losses, while satisfying network voltage and thermal constraints.

98. ETR124: Guidelines For Actively Managing Power Flows Associated With The Connection Of A Single Distributed Generation Plant

Energy Networks Association, UK

(Category: EN)

This report considers solutions to overcome power flow constraints associated with the connection of a single generation plant. However, when a network designer is assessing the connection requirements for Distributed Generation it will also be necessary to consider constraints associated with voltage control and fault levels. Solutions to these two issues are out of scope for this report. The report considers both pre and post-fault constraints and real-time control of generation.

99. ETR126: Guidelines for actively managing voltage levels associated with the connection of a single distributed generation plant

Energy Networks Association, UK

(Category: EN)

This report describes conceptually five basic Active Management solutions for overcoming the variations in network voltage that could result from the connection of Distributed Generation plant. Each solution is presented as a stand-alone option. The distribution network operator is expected to consider the ability of each solution to deliver the required level of voltage control necessary to ensure that the network remains within statutory limits. This report also provides guidance on situations where a particular solution is most likely to be suitable

100. Network Manager SCADA/DMS

ABB, UK

(Category: EN)

Fully integrated solutions with advanced functionality. A commercially available product designed to improve utilisation of the distribution network; increase productivity of the workforce; enhance information flows between operations, engineering, management and customers.

101. e-terra SCADA/EMS

AREVA, UK

(Category: EN)

AREVA T&D's e-terrascada™ is part of the product set which makes up AREVA T&D's e-terraplatform™.

102. CallistoIES

Remsdaq, UK

(Category: EN)

CallistoIES is an advanced architecture processing system that provides the functionality of SCADA, programmable logic controller, advanced power system signal processing, power quality monitor, digital fault recorder and substation computer control platform. Highly flexible product and application functionality, combined with scaleable I/O and communications interfaces makes CallistoIES suitable for use in large primary and secondary substations, on outside plant and at the various ground and pole mounted automation points of a power network. Wide range of communications protocols and media can be used.

103. ENMACTM System

GE Energy, UK

(Category: EN)

The ENMAC system is a fully integrated, advanced network management solution that automates real-time management, monitoring and control of electrical distribution networks.

104. Distribution Management System Controller

Econnect, UK

(Category: EN)

This project assesses the potential benefits of changing the operational philosophy of the distribution network and distributed generation from passive to active management, specifically focusing on the voltage control aspect of active management. The most beneficial are schemes with area based coordinated control of OLTCs and voltage regulators; achieving a 3 fold increase in the capacity of distributed generation that can be connected.

105. A Technical Review and Assessment of Active Network Management Infrastructures and Practises

EATL, UK

(Category: EN)

The report explores current approaches and infrastructures for monitoring and active operational control of distribution networks. The report briefly reviews the development of ANM, current network infrastructures and best practises, and various implementations of ANM to the Distribution network. Current regulatory and technical barriers which prevent the adoption of ANM are identified, and actions to overcome these barriers recommended

106. AURA-NMS (Autonomous Regional Active Network Management System)

Universities: Imperial College London, Strathclyde, Edinburgh, Durham, Loughborough, Bath, Manchester, UK

(Category: EN)

Project aims to produce a control structure and set of control algorithms that realise the notion of an active distribution network and enhance the service which Network Operators provide to load and generation customers. In general the scoping and development will consider the following major areas: Distributed Generation and demand side management to facilitate the connection of DG to the network; Develop a controller that will monitor electricity networks, isolate faults quickly, and allow distributed generation to remain connected and operating.

107. Distribution System State Estimation (DSSE)

EDF Energy, UK

(Category: EN)

The aim is to develop prototype algorithms for Distribution System State Estimation (DSSE), taking into account the greater use of active components in future distribution networks. The effectiveness of the new algorithms will be evaluated using a suitable section of EDF Energy Networks' network model, providing a useful demonstration of the algorithms' ability to facilitate new approaches for the operation and control strategies of future active distribution networks.

108. DG Demonet - Concept

Arsenal Research, UK

(Category: EN)

The main goal of the 'DG DemoNet Concept' project is to analyze the possibilities for implementing different technical solutions for enabling a very high DG penetration of the medium voltage grid. The project demonstrates how active operation of distribution networks can be realized based on innovative solutions as model for future electricity networks. Work includes development of a new voltage-control scheme. Simulation studies have been used to find and compare different solutions for voltage control. Different control techniques have been examined to improve the performance of the distribution network and allow more DG to be connected. Within the project an economical evaluation of each voltage control solution will be carried out.

109. 33kV Voltage Control

EDF Energy, UK

(Category: EN)

This project proposes a study to evaluate active voltage control and reactive power flow management of interconnected 33kV systems via SCADA to minimise losses while accommodating embedded generation. With the provision of real & reactive power measurements, generator outputs and tap-changer positions, the project would develop voltage control strategies taking into the account DG contributions and co-ordination with various internal strategies and those of National Grid.

<u>110. Thermal Modelling and Active Network Management</u>

PB Power, UK

(Category: EN)

This project seeks to explore the potential benefits arising from: (a) the improved utilisation of power system assets through the use of real time knowledge of the thermal status of the power system and (b) the development of an active controller to facilitate this exploitation and to balance those issues requiring action by operational staff and those that can be dealt with by machine intelligence.

<u>111. AURA-NMS (Automated Regional Active Network Management System)</u>

Scottish Power, UK

(Category: EN)

This project aims to produce a control structure and set of control algorithms that realise the notion of an active distribution network and enhance the service a network operator provides to load and generation customers, improving network performance (asset use, etc.).

<u>112. Understanding Networks with High Penetrations of Distributed Generation</u>

, UK

(Category: EN)

Development of a distribution network model onto which different types and penetrations of Distributed Generation can be incorporated to understand the effects which could be encountered on real networks.

<u>113. GenAVC Assessment Tool</u>

EDF Energy, UK

(Category: EN)

GenAVC has been developed by Econnect to manage voltage rise issues associated with the connection of Distributed Generation (DG) into 11kV networks. This system has achieved satisfactory operation in a trial at Martham Primary substation. At Horton Quarry.

<u>114. Dynamic Ratings</u>

Central Networks, UK

(Category: EN)

Central Networks has developed the first RPZ in the GB. This involves the application of an active rating to a 132kV overhead line based on real time measurements of ambient temperature and wind speed.

115. Effect of Electric Vehicles on Distribution Networks

, UK

(Category: EN)

Investigate the impact of charging electric vehicles on conventionally designed distribution networks. Deployment of charging points and battery exchange facilities.

116. Control System Automation Algorithm

Central Networks, UK

(Category: EN)

Development and demonstration of Self Healing Networks by using an automated switching algorithm which can carry out real-time circuit tracing to identify source and alternative supplies.

117. Network Risk Management

EDF Energy, UK

(Category: EN)

The aim of this project is to develop algorithms for calculating the risk, which the continued use of the components of a distribution system pose, to ongoing satisfactory system operation. It will take into account the significant levels of uncertainty that characterise both the condition of the individual assets and the overall operation of the network.

118. Primary SCADA Communications IP Upgrade

EDF Energy, UK

(Category: EN)

This project demonstrated that IP protocols can be used securely to provide the necessary primary substation SCADA communications used in distribution networks.

119. 33kV Voltage Control

, UK

(Category: EN)

This project proposes a study to evaluate active voltage control and reactive power flow management of interconnected 33kV systems (via SCADA), to minimise losses whilst accommodating embedded generation. With the provision of real and reactive power measurements, generator outputs and tap changer positions, the project will develop voltage control strategies taking into the account DG contributions and co-ordination with various EDF Energy Networks and National Grid strategies.

120. FENIX

Flexible Electricity Networks to Integrate the eXpected 'energy evolution'

EDF Energy, UK

(Category: EN)

The objective of FENIX is to boost Distributed Energy Resources (DER) by maximizing their contribution to the electric power system, through aggregation into Large Scale Virtual Power Plants (LSVPP) and decentralized management.

121. IHost developments

Electricity North West, UK

(Category: EN)

This project is supporting a number of other projects and is aiming to provide an interface between the Line Tracker, Re-Zaps, TP-22 devices and the Control Room Management System. It is recognised that to extend the 'Active' part of our network greater visibility is needed at the lower voltage levels, IHost provides a means to achieve this.

122. Optimising System Design for Improved Performance and reduced Losses

Central Networks, UK

(Category: EN)

The project aims to provide Central Networks with an optimising tool, which will consider both performance and system losses of alternative networks, under different degrees of distributed generation penetration, as well as to provide the necessary parameters .

123. Distribution Transformer with on-load tap changer

, UK

(Category: EN)

Increased penetration of DG on the LV network, particularly domestic combined heat and power (DCHP) units, is expected to have a significant adverse affect on the voltage regulation. This is a concern especially when a large number of DCHP units are installed.

124. LVSure concept for automation of LV distribution networks

EA Technol., UK; Scottish Power, Electricity North West, UK

(Category: EN)

This paper describes the desktop modelling of a novel automation concept to traditional LV distribution networks based on the EA Technology "SignalSure" system, which is currently in operation on rail signalling circuits in the GB. EA Technology has carried out projects on behalf of a number of GB Distribution Network Operators through the Innovation Funding Initiative (IFI) to assess deployment options, technical constraints, benefits and safety implications. The findings from the project carried out for ScottishPower are presented in this paper

125. Multi-Function Solid-State Switchgear for Distribution System of the Future (Part of the EPRI Advanced Distribution Automation (ADA) Programme)
Electric Power Research Institute (EPRI), USA
(Category: EN)
The objective of the EPRI ADA programme is to create the distribution system of the future, a multifunctional system that may be more accurately described as a 'power exchange system'. This project supports participants to make the advances required in electrical infrastructure to capture the advantages of ADA. In development is a family of low-cost solid-state switchgear for a range of distribution applications that will lower capital costs for switchgear and improve system reliability. The low-cost solid-state switchgear will be developed to provide the switches needed for increased sectionalizing, capacitor and static VAR compensator switching, distributed generation switching, load management, and other switching functions that will be part of ADA and the Distribution System of the Future.

126. Intelligent Universal Transformer (Part of the EPRI Advanced Distribution Automation (ADA) Programme
Electric Power Research Institute (EPRI), USA
(Category: EN)
The objective of the EPRI ADA programme is to create the distribution system of the future, a multifunctional system that may be more accurately described as a 'power exchange system'. This project supports participants to make the advances required in electrical infrastructure to capture the advantages of ADA. The intelligent universal transformer (IUT) is an advanced power electronic system replacement for conventional distribution transformers. The IUT will provide numerous system operating benefits and added functionality relative to conventional transformers. It will have power quality enhancement functions, such as sag correction. It will be capable of being configured to provide three-phase power from a single-phase line. It will have remote communication capability and can be used as a smart monitoring node as part of a larger networked ADA monitoring capability in the Distribution System of the Future.

127. Distribution Fault Anticipator (DFA) (Part of the EPRI Advanced Distribution Automation (ADA) Programme)

Electric Power Research Institute (EPRI), USA

(Category: EN)

The objective of the EPRI ADA programme is to create the distribution system of the future, a multifunctional system that may be more accurately described as a 'power exchange system'. This project aims to develop Distribution Fault Anticipator (DFA) equipment which detects subtle early warning signs of incipient failures, enabling proactive diagnosis and repair of distribution networks. By providing a warning that line apparatus is in an early stage of failure, the DFA will enable the utility to take action, often before a full failure develops and affects customers. This technology also enables condition-based maintenance on certain types of apparatus, allowing certain forms of time-based, preventive maintenance activities to be reduced or even eliminated.

128. First Generation ADA Monitoring System for Distribution Network of the Future (Part of the EPRI Advanced Distribution Automation (ADA) Programme)

Electric Power Research Institute (EPRI), USA

(Category: EN)

The objective of the EPRI ADA programme is to create the distribution system of the future, a multifunctional system that may be more accurately described as a 'power exchange system'. This project addresses the development and evaluation of monitoring systems for ADA and the distribution system of the future. In past work, the project has developed a definition of requirements and design basis for the real-time ADA monitoring system

129. Development of innovative distributed power interconnection and control systems

National Renewable Energy Laboratory (NREL), USA

(Category: EN)

Encorp is developing technologically enhanced devices such as an advanced controller, a power sensor module, and revenue-grade meters. It is also developing communication capabilities. These were included in a distributed power systems interconnection demonstration and will be further tested in future demonstrations.

130. Distributed Intelligent Agents for Decision Making at Local Distributed Energy Resource (DER) Levels

Infotility, USA

(Category: EN)

This project will develop intelligent, smart software components to improve the reliability, efficiency, security, and stability of the U.S. electrical transmission and distribution network.

131. Intelligrid Architecture for Distribution Companies: the building codes for the future grid (part of Intelligrid Consortium)

Electric Power Research Institute (EPRI), USA

(Category: EN)

The IntelliGrid Architecture for Distribution Companies project develops the tools and methodologies required to design, demonstrate, and deploy communications-based systems for use in distribution operations. The focus of the project is to develop an architecture that integrates across distribution-specific areas, as well as across transmission operations and consumer communications. This architecture will result in widely available advanced automation equipment that can be integrated, managed, and secured in distribution operations.

132. Distribution Fast Simulation and Modelling (part of Intelligrid Consortium)

Electric Power Research Institute (EPRI), USA

(Category: EN)

This project is developing a high-performance "look-ahead" capability for a self-healing grid—one capable of automatically anticipating and responding to power system disturbances while continually optimizing its own performance. The work develops functional requirements, followed by software design and testing. The result will be a software system that provides faster-than-real time simulation and modelling of electricity grid dynamics.

133. Integrated Monitoring for Distribution Companies (part of Intelligrid consortium)

Electric Power Research Institute (EPRI), USA

(Category: EN)

The Integrated Monitoring for Distribution Companies Project builds on the foundation established in the IntelliGrid Architecture design (087). Advanced technologies will enable better monitoring of distribution substation electrical conditions and equipment performance. The technologies will integrate with systemwide information infrastructures for convenient use in both real-time applications and applications that analyze longer-term trended information. These applications must integrate with distribution applications such as SCADA, feeder automation, electrical databases, geographic information systems, outage management systems, and asset management.

<u>134. D-VAR</u>

American Superconductors, USA

(Category: EN)

Dynamic VAR system similar to a STATCOM. Provides an instantaneous continuous source of reactive power. Can be used to resolve voltage stability issues, increase transfer capabilities, minimise voltage flicker, improve fault ride through and steady state voltage regulation.

<u>135. SuperVAR</u>

American Superconductors, USA

(Category: EN)

American Superconductor's SuperVAR machines are rotating machines, much like motors and generators, and utilize high temperature superconductor technology and serve as reactive power "shock absorbers" for the grid, dynamically generating or absorbing reactive power (VARs), depending on the voltage level of the transmission system.

<u>136. D-SMES</u>

American Superconductors, USA

(Category: EN)

D-SMES is a shunt connected Flexible AC Transmission (FACTS) device designed to increase grid stability, improve power transfer, and increase reliability. Unlike other FACTS devices, D-SMES injects real power as well as dynamic reactive power to more quickly compensate for disturbances on the utility grid. Fast response time prevents motor stalling, the principal cause of voltage collapse. The proprietary inverter design is based on the Power Electronic Building Block (PEBB) concept. Each trailer contains four quadrant, IGBT inverters rated at 250 kW and stacked to handle the output demands of the system. The inverters provide up to 2.3 times nominal instantaneous over-current capability and can also be configured for continuous VAR support. Each 250 kW building block operates independently, improving reliability.

<u>137. Wide-Area Voltage Instability Load Shedding</u>

Electric Power Research Institute (EPRI), USA

(Category: EN)

This project will provide grid operators a safety net to guard against the voltage instability that may occur during a cascading blackout. By shedding the right amount of load in a coordinated manner across a wide area during a voltage collapse, the system will halt a cascading blackout in its track. The type of control needed to modernize the interconnected power system, this system can replace ineffective under-voltage load shedding, which may be triggered unnecessarily. The system will also enable the grid to be operated to its fullest capacity and give operators confidence that cascading blackouts will be prevented. This new project combines two technologies to arrest a potentially cascading blackout at the last second: the smart relay called the voltage instability predictor and the wide-area measurement system. In the new scheme, a number of VIPs deployed across a wide area continuously monitor the system at various locations on the grid and predict when a given part of the system is going into a voltage collapse. These assessments are broadcast through the WAMS to a central controller, which decides where and how much load to shed at various locations. This triggers a load-shedding system coordinated to stop the voltage collapse.

138. Prospects of multilevel VSC technologies for power transmission

Siemens USA, Milpitas, CA, USA, USA

(Category: EN)

Deregulation and privatization are posing new challenges to high voltage transmission and distributions systems. System components are loaded up to their thermal limits, and power trading with fast varying load patterns is leading to an increasing congestion. In addition to this, the dramatic global climate developments call for changes in the way electricity is supplied. Innovative solutions with HVDC (High Voltage Direct Current) and FACTS (Flexible AC Transmission Systems) have the potential to cope with the new challenges. New power electronic technologies with self-commutated converters provide advanced technical features, such as independent control of active and reactive power, the capability to supply weak or passive networks and less space requirements. In many applications, the VSC (Voltage-Sourced Converter) has become a standard for self-commutated converters and will be increasingly more used in transmission and distribution systems in the future. This kind of converter uses power semiconductors with turn-off capability

Category Electricity Primary Source

139. Distributed Generation with High Penetration of renewable Energy Sources (DISPOWER)

Industrial and academic consortium, EU

(Category: EP)

Elaboration of strategies and concepts for grid stability and system control in distributed generation (DG) networks. Assessments of impacts to consumers by ICTs, energy trading and load management. Development of planning and design tools to insure reliable and cost effective integration of DG components in regional and local grids. Improvement and adaptation of test facilities and performance of experiments for further development of DG components, control systems as well as design and planning tools. Of particular relevance to active management is project highlight 17: A Power Quality Management Algorithm for Low Voltage Grids with Distributed Resources.

140. Integration of Renewable Energy Sources and Distributed Generation into the European Electricity Grid (IRED)
Industrial and academic consortium, EU
(Category: EP)
A continuation and integration of the cluster of relevant projects highlighted under the European Commission 5th Framework Programme. Documents available online of relevance to active management are 'Towards Smart Power Networks' (see project 051) and 'Ways to Handle the Integration of RE-power into the Grid'

141. European Distributed Energy Partnership that will help the Large scale Implementation of distributed energy resources in Europe (EU-DEEP)
Industrial and academic consortium, EU
(Category: EP)
The birth of a European Distributed Energy Partnership that will help the large-scale implementation of distributed energy resources in Europe (EU-DEEP). The EU-DEEP integrated project, consisting of a group of eight European energy utilities, aims to remove, in five and half years, most of the technical and non-technical barriers, which prevent a massive deployment of distributed energy resources (DER) in Europe. The project will implement a demand-pull approach, providing five "fast-tracks options" to speed up the large-scale implementation of DER in Europe by defining five market segments which will benefit from DER solutions, and fostering the R&D required to adapt DER technologies to the demands of these segments.

142. Flexible Electricity Networks to Integrate the eXpected 'energy evolution' (FENIX)
Industrial and academic consortium, EU
(Category: EP)
The objective of FENIX is to boost DER (Distributed Energy Resources) by maximizing their contribution to the electric power system through aggregation into Large Scale Virtual Power Plants (LSVPP) and decentralized management. The project is organized in three phases: - Analysis of the DER contribution to the electrical system, assessed in two future scenarios

(Northern and Southern) with realistic DER penetration -Development of a layered communication and control solution validated for a comprehensive set of network use cases, including normal and abnormal operation, as well as recommendations to adapt international power standards. Validation through 2 large field tests in Spain and UK.

143. Effective participation of distributed generation in liberalised electricity markets (SUSTELNET)

Industrial and academic consortium, EU

(Category: EP)

Within the SUSTELNET research project, a consortium of 10 research organisations will analyse the technical, socio-economic and institutional dynamics of the European electricity system and markets. Areas of relevance to active management lie in work package 3: Technical Aspects of Distributed Generation Integration.

144. Determination of the Required Conventional Power Plant Output in Extreme Load Flow Situations

Vattenfall Europe Transmission, Germany, Germany

(Category: EP)

Starting from the planned addition to the wind energy plants in the control area of Vattenfall Europe Transmission, a feed-in of about 9,000 MW is to be expected on short notice. It must be possible to transport this load over the network of Vattenfall Europe Transmission. In this context, it had to be determined which minimal load from conventional power plants must be provided in this extreme load flow situation. Within the framework of the study, parameters that are relevant to the derivation of the required minimal conventional power plant load were determined and researched. Within these parameters were, among others, the load balance and the possible power gradients. Various yet practicable power plant operation scenarios were developed that were assessed under the consideration of all parameters. The result showed that the former necessary minimal power feed-in from conventional power plants can be reduced by about 1,000 MW.

145. Extra/additionally payment for wind turbines with highly developed technologies

E.ON edis, Germany, Germany

(Category: EP)

The rapidly rising amount of renewable wind energy installations will have a great influence on the performance of the extra-high voltage transmission network especially during grid faults. Three fundamental principles for support to stabilize the grid are lost, when conventional power plants are replaced by wind farms. These are the contribution to the primary or frequency control, the voltage control and the possibility to ride through faults. For overcoming these problems the German Government gives an incentive for wind farm operator which is stated in the law for the precedence of renewable energies (EEG 2009). According to this, new onshore wind turbines can receive a compensation of 0.5 cent/MWh additionally to the normal payment. Also owners of older wind turbines constructed between 2002 and 2008 can profit from the bonus with 0.7 cent/MWh, if they are able to observe defined requirements. The functional requirements are determined by the degree for system services of wind turbines (SDLWindV). The proof of the technical equipment ensued by the submission of certifications of the wind turbine units and an expert opinion of the entire wind farm to the network operator. KEMA-IEV fulfils the demands made on a surveyor to make an expert opinion based on the technical standards part 4 and 8 of the FGW (Fördergesellschaft Windenergie e.V.) and the certification of the wind turbine unit. An essential position is entitled to the network operators who have to acknowledge the expert opinion. This why, it is inevitable to incorporate the suggestions of the network operator and the transmission system operator in the opinion. The first (distribution) network operator discussing the content of the expert opinion is E.ON edis. Their position to the “system service bonus” shows that the support of wind turbines to stabilize the grid plays an important role for increasing the reliability of the energy supply and avoidance of the reduction of the power feed-in through wind farms during periods within the grid operates at limit values. The emphasis of the opinion is up to the analysis of the steady state and transient behaviour of the entire wind farm with the models of the wind turbines. In addition to the modelling, the inspection of the configuration of protection equipment at the substation and at the single wind turbines on-site is substantial for an irrevocably opinion. At the moment the certification of wind turbine units represents the bottleneck of the procedure. The huge number of wind turbines (approx. 5000 old wind turbines) is challenging the manufacturer of wind turbines.

146. Virtual Fuel Cell Power Plant

Initiative Brennstoffzelle (IBZ), Germany

(Category: EP)

The Virtual Fuel Cell Power Plant is a series of decentralised residential micro-CHPs using fuel cell technology, installed in multi-family- houses, small enterprises, public facilities etc., for individual heating, cooling and electricity production. Centrally controlled and grid-connected, these elements of the virtual power plant contribute to meet peaking energy demand in the public electricity grid and act as a virtual power plant. Simultaneously this application is a fast door-opener for a broad market entrance of fuel cells with its ecological and economical benefits. Severe testing in different environments including requirements from techniques, users, norms and utilities is necessary.

147. Application of interruptible contracts to increase wind-power penetration in congested areas

Hellenic Transmission System Operator, Greece

(Category: EP)

This project utilises interruptible contracts for wind farms to control the power flow through congested corridors by issuing power reduction commands, whenever security limits are violated. The control is implemented using Programmable Logic Controllers (PLCs). Both preventative and corrective control actions can be taken to ensure power flows are within N-1 security limits.

148. FENIX – The aggregation of small scale DG

led by Iberdrola and supported by EDF Energy, UK

(Category: EP)

FENIX is a €15M 4 year (ending Sept 2009) multinational European Framework 6 funded project, led by Iberdrola and supported by EDF Energy, which seeks to evaluate the potential for a new market player known as Commercial Aggregators to revolutionise the operation of the future electricity market. Commercial Aggregators will in future contract with a wide portfolio of dispatchable distributed energy resources to create 'virtual power plants'. The Commercial Aggregators will not only trade the production of their VPP's on the wholesale market, they will also use the inherent flexibility of their combined portfolios to offer a range of balancing / reserve services, interacting with DNOs acting as Technical Aggregators to manage the impact of flexible generation on their networks, optimising power flows and future investments. Given that, by 2020, intermittent wind generation is expected to make a major contribution to the British generation portfolio, flexible and responsive VPPs could make a major contribution to supporting a low carbon economy by enabling a higher contribution from distributed energy and mitigating wholesale price volatility. Under the FENIX project, northern (GB) and southern (Spain) scenarios have been tested using real-life generation portfolios and the proposal is now to extend this to full-scale field trials over the period 2010 – 2015.

149. Facilitate Increased Generator Connections to the Orkney Distribution Network

Scottish Hydro Electric Power Distribution Ltd, UK

(Category: EP)

Initial specification of active power flow management scheme. Scheme works through the identification of control zones and available capacity for export from the Orkney distribution network. Power flows are managed using operating margins and generator output regulation and tripping.

150. GenAVC
Econnect, UK
(Category: EP)
GenAVC is a controller for electricity distribution networks that aims to increase the amount of energy that can be exported onto the distribution networks by generating plants. GenAVC is device for regulating voltage on 11kV circuits.

151. Active local distribution network management for embedded generation
Econnect, UK
(Category: EP)
The objective of this project and report are to design, build and install a GenAVC system at two trial sites in the GB, to assess the performance on different network topologies and with different types of DG plants, to investigate the adaptation of the GenAVC's control functionality to the network topology and type of DG plant, and to integrate the GenAVC system with the operational requirements and communications facilities of two distribution network operators. The next stage of testing will entail the operation of the controller in 'closed loop'

152. Martham Primary Registered Power Zone: GenAVC
EDF Energy, UK
(Category: EP)
Measured parameters from the generator and primary substation are fed into a state estimator. The output of the system biases the target voltage of the traditional substation Automatic Voltage Controller (AVC).

153. Steyning Registered Power Zone
EDF Energy, UK
(Category: EP)
This project has developed a generic tool which assesses the benefits of connecting a GenAVC solution to a section of the distribution network around Steyning. The tool is able to compare connections using traditional methods of solving voltage rise issues with those of installing GenAVC. Initial indications are that for the selected scheme, GenAVC will generate additional voltage headroom throughout the whole 11kV network connected to the primary substation at Steyning, which has led to the trial installation of GenAVC at Steyning,

Monitoring of the network before and after the installation will demonstrate whether the assessment tool can provide planning information that can be relied on.

154. Skegness / Boston Registered Power Zone

Central Networks, UK

(Category: EP)

Dynamic ratings are calculated using real-time load and local temperature information. This allows the thermal capacity of the network to be utilised more effectively for accommodating increased connections of wind energy.

155. Orkney Registered Power Zone

Scottish Hydro Electric Power Distribution Ltd, UK

(Category: EP)

New generators accepted under the RPZ

156. Assessing the feasibility of establishing Registered Power Zones on Northern/Yorkshire Electricity

Econnect, UK

(Category: EP)

Assesses the feasibility of establishing RPZs at two selected sites on Northern/Yorkshire distribution network, considering connection requirements, control techniques and cost/benefit analysis. Investigates innovative technologies suitable for RPZs

157. Deucheran Hill Wind Farm Generation Management Scheme

Scottish Hydro Electric Power Distribution Ltd, UK

(Category: EP)

Scheme manages access to the transmission system of a wind farm. Measurements of load and circuit breaker positions allow decisions to be made through logic control to constrain / trip wind generation.

158. BAM Solution 2.3 – Converter technology for wind turbines

DGCG – TSG – WS3, UK

(Category: EP)

This project concerns the cost benefit analysis of converter technology for wind turbines. The extra cost of power electronic converters for wind turbines can increase costs, but the costs may be outweighed by the benefits of reduced fault current contribution.

159. BAM Solution 2.3 – Converter Technology
EATL, UK
(Category: EP)
To obtain outline costs and high-level technical benefits for commercially available converters across a range of generator types.

160. Control for doubly fed induction generators (DFIG) for wind farm operation
DTI Centre for Distributed Generation and Sustainable Electricity Systems, UK
(Category: EP)
This project investigates the impact that large penetrations of wind energy have on system operation and network dynamic and transient stability. Models of DFIG machines and their controllers are being developed to facilitate wind farm connections that comply with the GB grid code, and the issues associated with the intermittency and storage requirements for this source of energy are explored.

161. BAM solution 3.4 – Generator real power control
DGCG – TSG – WS3, UK
(Category: EP)
Overvoltage can be prevented by generator real power control or generator constraint. Constraining more than one generator adds both flexibility and complexity. The constraint mechanism has not been identified.

162. BAM Solution 4.3.1 – Direct Intertripping
DGCG – TSG – WS3, UK
(Category: EP)
Distributed generation circuit breaker is opened in the event of an upstream circuit breaker opening. Reliant on communications links between circuit breakers.

163. BAM Solution 4.3.2 – Generator trip based on power flow measurements
DGCG – TSG – WS3, UK
(Category: EP)
Trip distributed generation unit when measured export exceeds capacity. Trip is only armed when export exceeds network firm capacity.

164. BAM Solution 4.3.3 – Generator power output control based on power flow measurements
DGCG – TSG – WS3, UK

(Category: EP)

Power flows are monitored and distributed generation output is controlled to ensure all flows are within plant ratings. This can be modified to incorporate short term ratings during normal and contingency operations. Scheme may require intertrip back-up.

165. United Kingdom Generic Distribution System

DTI Centre for Distributed Generation and Sustainable Electricity Systems, UK

(Category: EP)

The GBGDS project has produced a library of resources to support research, development and testing of new technologies and methods that will facilitate an increase in distributed generation in GB distribution networks. The primary component of the GBGDS is a set of generic network models, which are representative of GB EHV and HV networks. The GBGDS also provides profile data and tools for converting data to different proprietary software formats.

166. Active Generator Constraint for an Offshore Windfarm

EDF Energy, UK

(Category: EP)

An intelligent control system utilises additional capacity during intact network conditions, while sending “down turn” or constraint signals to the wind farm during fault conditions when there is insufficient circuit capacity.

167. Distributed Energy Neural Network Integration System (DENNIS)

Orion Engineering, UK

(Category: EP)

The purpose of this research is to demonstrate a neural network control system for managing small distributed generation. This project is developing a single unit controller and demonstrating the ability of an aggregated community of distributed generators, managed by an intelligent "neighbourhood controller" to meet individual power requirements and operate as a virtual single large generator to sell power or other services to a utility.

168. Virtual Power Plant (multi-site remote despatching software)

Encorp, UK

(Category: EP)

The Virtual Power Plant allows companies to aggregate and control multiple energy systems remotely and is "technology-neutral" by design, which means its software can communicate with any and all types and brands of power generation technology (i.e. diesel or gas engine/generator sets, gas turbines, microturbines, fuel cells, wind, hydro, and energy storage) in any combination or mode of operation. The Virtual Power Plant is an open-protocol end-to-end design, with the capability to interface with commercial building automation systems, industrial energy management systems and utility grid control systems.

169. Deucheran Hill Wind Farm Generation Management Scheme

SSE, UK

(Category: EP)

This scheme manages access to the transmission system of a wind farm. Measurements of load and circuit breaker positions allow decisions to be made through logic control to constrain / trip wind generation.

170. DG Connection Planner

EDF Energy, UK

(Category: EP)

This project is to build on the work reported in "Internet Services for Planning Distributed Generation Connections" funded by BERR, to provide DG developers with access to suitable connection locations and estimated connection costs. The system uses an OS map background to allow users to position a proposed generator connection, DNO Long Term Development Statement (LTDS) data to derive suitable connection scenarios and costing information for the provision of budget estimates.

171. Development of a generic wind farm SCADA system

Garrad Hassan, UK

(Category: EP)

This project addresses the complications of incompatible systems for wind farm operation and control by developing a generic system that will communicate with all turbine types and store performance data in a consistent way. A unit called a "remote interface unit" has been developed to communicate directly with the turbine controllers and provide a standard interface to the rest of the SCADA (Supervisory Control And Data Acquisition) system. The completed system will be available as a commercial product, incorporated within an overall SCADA solution.

172. Aggregation of Distributed Generation Assets in New York State

Electrotek Concepts, USA

(Category: EP)

This project demonstrates a system that allows DG to participate in competitive markets in much the same way as large central-station power plants. This approach involves aggregating the distributed demand-side resources into a single transaction entity consistent with the requirements of the New York Independent System Operator (NYISO). This single entity then buys or sells capacity and energy in NYISO markets.

173. Enterprise-Wide Distributed Generation Energy Management System

RealEnergy, USA

(Category: EP)

The purpose of this project is to evaluate the interconnection process and the technical, communication, and regulatory experiences of managing distributed generation. RealEnergy has developed and implemented a distributed generation energy management system that balances system integration, communications, metering, billing, monitoring, alarming, and control with equipment run-time allocations, thermal and electric storage requirements, power flows, and the real-time valuation of grid services.

174. Communications protocols for distributed energy resources (part of Intelligrid Consortium)

Electric Power Research Institute (EPRI), USA

(Category: EP)

IntelliGrid will encompass highly automated smart distribution systems including small generators and storage devices located near customer loads. An open communications architecture will allow these devices to be added to the system over time without custom redesign of the communication and control system at every incremental addition. Initial projects are developing and field testing object models (standardised formats for exchanging data between different pieces of equipment) starting with fuel cells and reciprocating engines.

Category Electricity Storage

175. GROW-ders. Large European demonstration project to proof the value of small-scale (mobile) energy storage systems in local grids

European Commission, EU

(Category: ES)

In the European Grow-Ders project two different mobile storage systems – a flywheel system and two Li-ion batteries – plus a combined rig will be evaluated on five sites using a technical-economic assessment tool to determine optimal storage applications.

176. Energy Island. Innovative concept for large-scale energy storage
Dutch utilities and TSO TenneT, Netherlands
(Category: ES)
The Energy Island designed by KEMA, Lievense and the Das Brothers incorporates a new concept in pumped hydro storage – an inverse offshore pump accumulation station (IOPAC). On the Energy Island when there is a surplus of wind energy, the excess energy is used to pump sea water out of the interior 'subsurface-lake' into the surrounding sea. When there is a shortage of wind power, sea water is allowed to flow back into the interior 'lake' through commercially available generators to produce energy. The IOPAC is unique from conventional pumped hydro storage systems in that it would be stationed on an artificial island off the Dutch coast in the North Sea and comprised of a ring of dikes surrounding a 50 meter deep reservoir. The island itself would be built from materials dredged to deepen the interior reservoir. Analysis shows that the proposed Energy Island storage system would have a maximum generation capacity of 1,500 MW, depending on the water level. It also would have an annual storage capacity of more than 20 GWh – enough energy to offset 500 to 840 kilotons of CO2 emissions. In the next phase of the feasibility study further analysis will be made of the costs and benefits of additional regulating reserve, download wind power, CO2 reduction, and environmental impact.

177. Compressed air in caverns (When electricity is cheap or with peak electricity from wind compressors can be driven to compress air in salt caverns)
ManTurbo, Netherlands
(Category: ES)
The need for pressurized vessels or for mining (into salt caverns or aquifers) can be obviated by placing the pressurized air underwater in flexible containers (e.g. plastic bags) at the bottom of deep lakes or off sea coasts with steep drop-offs. Challenges include the limited number of suitable locations and the need for very-high-pressure pipelines between shore and depth. Academia has received €1.4 million (£1.1 million) in funding from E.ON to develop a new generation of undersea storage bags that will collect energy in the form of compressed air.

178. The future value of electrical energy storage in the UK with generator intermittency

University of Manchester, UK

(Category: ES)

In order to manage the balance between demand and supply under increased uncertainty due to penetration of wind generation, the electrical system will need to hold increased amounts of reserve. This reserve will be generally supplied by a combination of synchronised reserve, provided by part-loaded generating plant and standing reserve, in the form of storage and/or flexible generation, such as OCGTs. In this context, OCGT technology is a prime competitor to storage. In this work we evaluated the benefits of using storage for providing a part of the reserve needs in the form of standing reserve, against the reserve being provided by part loaded synchronised plant only (no standing reserve) and part of the reserve being provided by standing OCGT plant. The benefits were evaluated in terms of (i) savings in fuel cost associated with system balancing, (ii) corresponding reduction in CO2 emissions and (iii) indirectly, additional amount of wind energy that can be absorbed.

179. Electricity storage, a solution in network operation?

Energy Storage Association (ESA), UK

(Category: ES)

This paper gives an overview and comparison of utility scale energy storage technologies. The paper presents energy storage as a network solution for applications such as voltage control, power quality, system reliability, incorporating renewables, increasing system utilisation and deferring investments.

180. Application of Storage and Demand Side Management

EDF Energy, UK

(Category: ES)

The aim of this project is to investigate the benefits of integration of electricity Storage and Demand Side Management (DSM) technologies in the operation and development of active distribution networks. This is achieved through a feasibility assessment of alternative applications of DSM and storage to solve network problems; the development of techniques for optimisation of the operation of active distribution networks, including real time control of storage and load control devices to manage network voltage and flow profiles in real time; and the quantification and optimisation of the multiple value streams of various storage applications and load control management.

181. Energy Storage for Distribution Systems
Central Networks, UK
(Category: ES)
Energy Storage is a key enabling technology for the development of innovative solutions to manage and control the electrical networks of the future. A staged research and development programme will lead to the manufacture of a prototype 1MW redox flow battery with a capacity of several MWh, which will be connected to the distribution system and operated for a period of up to 24 months.

182. Development of Redox flow battery for energy storage
Scottish Power, UK
(Category: ES)
A part funded project through the DTI Technology Programme TP/3/ERG/6/1/16587(D05/726039) that aims to develop (design, build, test and install) an 11kV 250kW Redox flow battery unit for energy storage.

183. Vulnerable Customers UPS
EDF Energy, UK
(Category: ES)
This project aims to develop solutions that provide continuity of electrical power to vulnerable customers - those who are classified as needing a combination of lights, appliances, electronics and medical equipment to remain operational in the event of a power failure. Ceres Power has developed the capabilities and specialist expertise to deliver a fuel cell solution.

184. Use of storage to mitigate wind volatility and ramping
CA ISO and CEC, USA
(Category: ES)
Utilizing KEMA dynamic model KERMIT. Idea is to identify how much storage of what type should be used in the presence of high wind penetration scenarios. (this is latest in a string of such projects; a similar one is going on in the NL)

Category Gas General

185. The CO2 pilot at Lacq
Total, France, France
(Category: GG)

Total is developing a CO2 pilot at Lacq in order to demonstrate the technical feasibility and reliability of an integrated CO2 capture, transportation, injection and storage onshore scheme for steam production at a reduced scale (1/10th of future facilities). The project involves the design and operation of a 30 MWth oxucombustion boiler for CO2 capture and the development and application of geological storage qualification methodologies, monitoring and verification techniques on a real operational case in order to prepare future larger scale long term storage projects.

186. LNG Business and Innovation

GDF SUEZ, France, France

(Category: GG)

GDF Suez is developing a number of R&D projects that can help the LNG industry to take up its next challenges, such as:

- Considering new types of gas has become a necessity (stranded gas , offshore gas fields: LNG FPSO, arctic, unconventional gas: tight gas, shales, CBM)
- Improving shipping efficiency
- Improving regasification terminal efficiency
- Offshore/floating regasification terminals

187. CO2 storage: Technology review and challenges ahead

Schlumberger Carbon Services, International, International

(Category: GG)

The Processes & Technologies to assess CO2 site performance factors largely exist today. The state of technology is sufficient to convince the scientific community and the legislators to start commercial projects into well characterised aquifers. This project presents an example of storage timeline costs, from the site selection and site characterisation to the storage site monitoring activities. It focuses in the remaining technical challenges that still exist and that mainly lie in modelling and in measurements / monitoring of the storage site.

188. Use of heat from compressor stations

Tebodin and Fugro just started a corporation about heat storage an extraction in the sub-soil., Netherlands

(Category: GG)

Use of heat from compressor stations. Note that heat from compressor stations for natural gas has to be cooled down after compression from e.g. 80 degr. Celc. to 50 or 30 degr. Celc. by means of after-coolers. In general for compressor stations the load and thus heat generation, is very variable.

189. Challenges for CO2 capture

TNO Science and Industry, The Netherlands, Netherlands

(Category: GG)

TNO is an independent research organisation that participates in a multifunctional pilot plant at E.ON with CO2 capture technology. 250 kg/hr CO2 is captured from flue gas from a pulverised coal power plant. The main CO2 capture challenges identified by TNO are the cost reduction, the energy penalty, the scale up and a number of external challenges (interfaces with transport and storage, public perception).

190. A new generation of liquefaction processes for LNG FPSO Applications

Mustang Engineering, Wood Group, USA, USA

(Category: GG)

Mustang Engineering is developing LNG Smart Liquefaction Technologies in order to minimise the risks (technical and commercial), minimise flammable refrigerants, provide reliable and flexible operation, use industry-proven components at optimum sizes, utilise compact modular design, minimise equipment count and operate efficiently. The main benefits obtained from these projects can be summarised in the following: Less equipment results in less cost, easier operation High efficiency Handles variable feed rates and compositions Turndown to zero; circulating refrigerant gas keeps system cold Quick start-up (warm). Rapid cool-down / refrigeration sequence. After smaller, simpler LNG FPSOs become proven. Future designs are likely to incorporate more complex and more efficient processes.

Category Gas Networks

191. MUltiNet and SP AusNet gas distribution pressure controller

SP AusNet, Australia

(Category: GN)

Water and gas networks can be operated more efficiently if pressure can be controlled at the fringes of the network. Higher than normal pressure provides more leakage and the danger of pipe failure and low pressure does not meet regulatory standards. Controlling pressure from local controllers proves very ineffective and it has been proven that there is more efficiency in providing a systemic control approach. The MultiNet and SP AusNet gas distribution networks in Victoria use a common software application to manage a group of controllable field regulators to obtain a desired pressure outcome at one or more fringe sites.

The application interacts with real-time SCADA data, a database of pressure profiles and an interactive GUI. The level of operator supervision is minimal and alarms are targeted specifically to indicate weak parts of the network, non-responsive controllers and any other operational issues.

192. Minimal trenching

DVGW (Bonn), Gaz de France (St Denis), S&P (Stuttgart), France, Germany, France, Germany

(Category: GN)

Optimisation of the trench geometry in order to: Improve the safety of gas networks, limit the impact of works for neighbours, reduce the environmental impact, improve economic efficiency. 3 R&D projects in progress: i) Placement in narrow trench with recycling of material, ii) Laying at shallow depth with new self compacting concretes and iii) Optimised GPR to find every distribution networks under the streets. Benefits obtained: opportunities to use, in Europe, new technologies with evolutions of laying rules for the distribution gas pipes.

Category Gas Primary Sources

193. Naturalhy Project - Adding hydrogen to the natural gas system

Loughborough University – 39 partners (GET now KEMA Gas Consultancy and Services, coordinates the project for Gasunie), EU

(Category: GP)

The use of hydrogen as an energy carrier is considered by some commentators an essential element for achieving global sustainable development. Progress towards the development of a full hydrogen system requires a practical strategy within the context of an existing natural gas system. The transition to a full hydrogen system will be lengthy, costly and require significant R&D. The aim of NATURALHY is to test all critical aspects of a hydrogen system by adding hydrogen to natural gas in existing networks. This transitional approach will provide further experience with the transmission of hydrogen and natural gas mixtures and, by means of innovative separation technologies, the hydrogen utilisation in end use applications. The development of the road map for the use of hydrogen in the EU of IP HYWAYS is being supported. The economic, social and environmental costs and benefits of hydrogen systems including production technologies will be evaluated and compared with existing systems. Issues of safety, durability and pipeline integrity will be investigated. A Decision Support Tool will be developed to assist the technical implementation of hydrogen. In co-operation with NoE HYSAFE, awareness of the attractions of hydrogen will be raised. A systematic and co-ordinated approach is being adopted in NATURALHY with a collection of work packages focussing on all vital components of transitional and full hydrogen systems. A European consortium of 40 partners with extensive experience and skills has been assembled. In addition to a management team, guidance will be provided by a Strategic Advisory Committee. Potential collaboration and synergies will be fostered with complementary projects. Established information networks will be used in dissemination.

194. Biogas in the regional transport grid of the Netherlands
Gasunie, Netherlands
(Category: GP)
In this project, methods are being derived for characterizing the effects of biogas addition to natural gas on the behaviour of end-use equipment. The current activities are focused on specifications for the use of fermentation gases (methane/CO2 mixtures) in domestic appliances. The methods rely on the physics and chemistry of combustion, and the physical response of appliances to changes in gas composition, to assess changes in appliance behaviour with varying composition. In this fashion, the ambiguity of empirical appliance testing is avoided. Specifically, flame lift, the major combustion effect expected from high CO2 content, which causes increased CO emissions and can lead to the escape of combustible mixture in houses, is assessed using burning velocities, allowing for changes in fuel-air ratio caused by varying the Wobbe Index. The predictions using the method have been successfully tested using lift data from laboratory experiments on well-defined geometries. A “lift index” is derived that permits decisions regarding acceptability of a given composition, for both “pure” biogases and the admixture of biogas with natural gas.

Category Gas Storage

195. Recent developments in the prediction and optimization of the mixing of different qualities of LNG in a storage tank
Gaz de France, France
(Category: GS)
The liberalization of gas markets worldwide, as well as the multiplication of LNG production sites resulting in an increase in LNG trade and the inherent increase of gas demand, has put increased pressure on gas companies to find innovative solutions in order to adapt to this changing environment. In particular, LNG import terminals are often faced today with the need to handle a variety of different qualities of LNGs in the same tanks, in order to reduce capital and operating costs. Also, this need is reinforced by the prospect of performing third

party access to the gas network. It is within this context and as a response to the above mentioned trends, that Gaz de France, in collaboration with Enagas and Osaka Gas, developed new tools, standards and procedures, which help their operators to be better prepared in dealing with the diversification of LNG supply sources. In particular, efficient mixing of various LNG qualities in a same tank was aimed for, while at the same time avoiding LNG stratification occurrence.

196. CO2 Storage and transportation

E.g. IF Technology, SenterNovem, Shell, GdF, Gasunie, Netherlands

(Category: GS)

Building CCTS (Carbon, Capturing, Transport and Storage) infrastructure requires research efforts in many areas to get the lacked knowledge needed in its different stages. The knowledge required to build up a CO2 infrastructure should include an understanding of the different processes (capturing-transportation-storage) and the influence of each one of these processes on the others. A first work has been carried out to identify the research topics in the different research areas for the different project sections. A simulation tool has been built up coupling between the economical and the energetic aspects to get an optimized CO2 transport system. Research and engineering activities, have been launched to supply this tool with reliable models.

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