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FOREWORD



In April 2006 the Advisory Council of the Technology Platform of Future Electricity Networks presented their vision for SmartGrids. The well-spring for that vision arises from the joint challenges of lower carbon energy sources and the renewal of Europe's electricity grids that are fast approaching the end of their design lives. This presents landmark opportunities for the generation and use of electricity and the transport systems by which it is conveyed. Electricity market liberalisation provides a new context for these major developments and has been a key consideration in setting out a path for effective and efficient changes for the benefit of customers and all wider stakeholders.

Following the publication of the SmartGrids vision the Advisory Council, supported and advised by 200 professionals from research institutes, universities, industry, regulators and utilities, have developed this Strategic Research Agenda (SRA) to be a resource for European and National programmes. It is a strategic document, intended to inform and inspire, facilitating the alignment of Research Programmes within the EU and its Member States. We also seek to stimulate knowledge-intensive business so providing a firm foundation for global competitiveness and sustainable employment.

The SRA has been commented upon by a mirror group of Member State representatives and we have been most appreciative of their contributions. As the energy context is fast changing, the Advisory Council will be active in making the SRA a living document. In 2007 the Advisory Council will invite comments and closer engagement from the various Associations and groups involved with the development and use of SmartGrids.

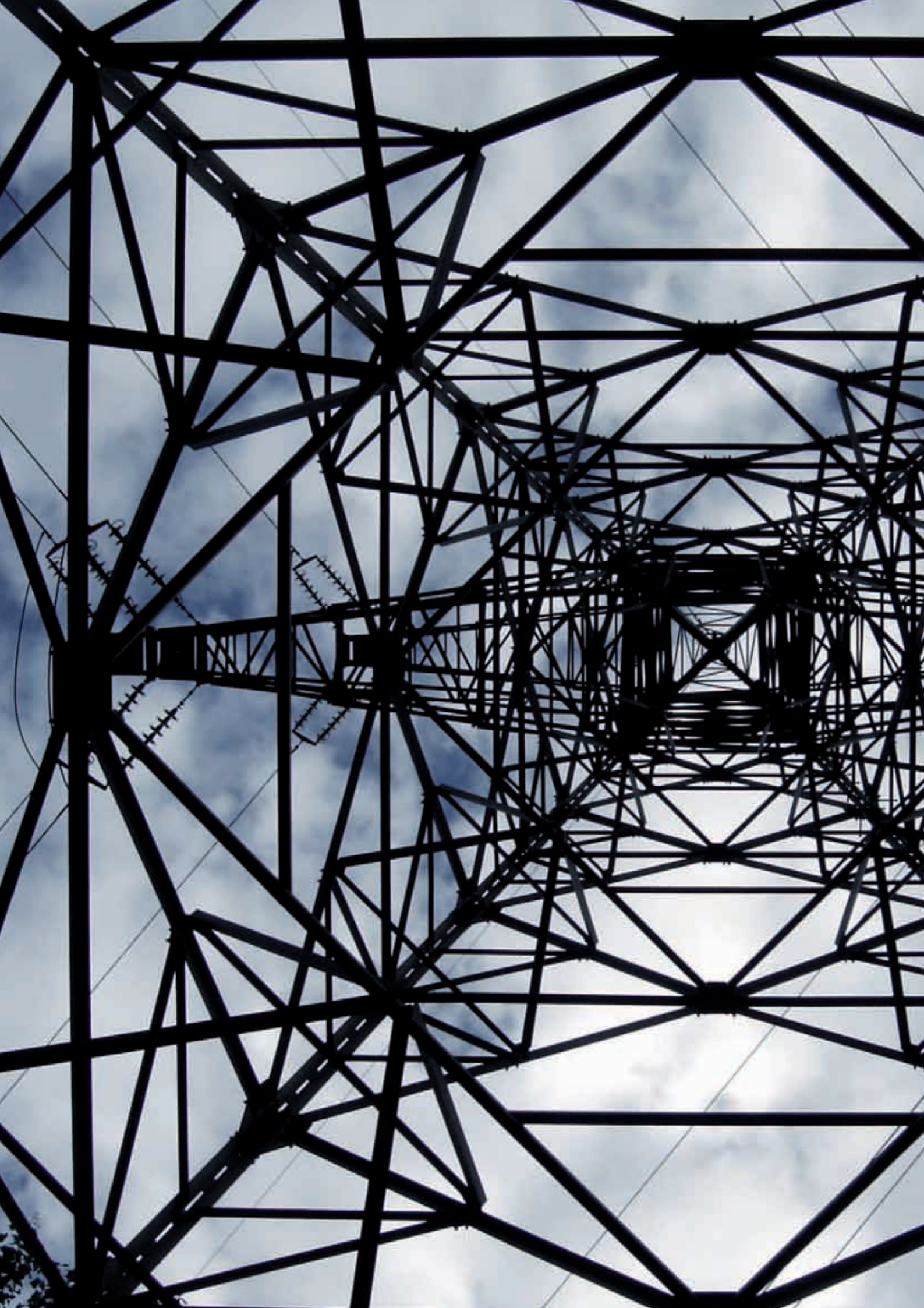
Finally I would like to thank everyone who contributed to the developments of the SRA, especially Ronnie Belmans and John Scott who took the responsibility for the editing of this document and the representatives of the Commission for their advice and facilitation.

On behalf of the European Technology Platform SmartGrids, I hope you enjoy reading this Strategic Research Agenda and I urge you to share and take forward its strategic thinking.

A handwritten signature in black ink, appearing to read 'P. Nabuurs', with a long horizontal stroke extending to the right.

Pier Nabuurs

Chairman of the ETP-SmartGrids
Chief Executive Officer of N.V. KEMA





EXECUTIVE SUMMARY



The first milestone towards the establishment of a common strategy for the development of Europe's electricity networks was set in April 2006 when the paper *'Vision and Strategy for Europe's Electricity Networks of the Future'*¹ was published. In this Vision, future electricity markets and networks must provide all consumers with a highly **reliable, flexible, accessible** and **cost-effective** power supply, fully exploiting the use of both large centralized generators and smaller distributed power sources across Europe. End users will become significantly more interactive with both markets and grids; electricity will be generated by centralised and dispersed sources; and grid systems will become more inter-operable at a European level to enhance security and cost-effectiveness. This new concept of electricity networks is described as the 'SmartGrids' vision. It will enable a highly effective response to the rising challenges and opportunities, bringing benefits to all network users and wider stakeholders.

The European Technology Platform SmartGrids has focused its efforts on the development of this **Strategic Research Agenda** (SRA). It has contributions from four working groups that represent a wide range of European industrial and academic expertise. Member State governments have also provided valuable advice and comment through the Mirror group. The SRA is a reference document that consolidates the views of stakeholders on research priorities that address the key elements of the Vision document.

The purpose of the SRA is to provide a resource for European and National programmes. It seeks to be non-prescriptive and strategic in nature; it is designed to encourage competitive activity; it is intended to be an inspiration for new thinking in important policy areas. The SRA proposes a framework for a future research programme which can be summarized by the following goals.

- To ensure that Europe's electricity networks develop in such a way that enhances Europe's competitive position while supporting environmental objectives and the commitment to sustainability.
- To capture the benefits of collaboration and co-operation in addressing challenges that are common across all Member States.
- To provide a clear framework, goals and objectives on which the research community can focus, encouraging innovative solutions where this will add value
- To generate the momentum and support necessary to convert good ideas to adopted products and solutions.

A key principle in the development of this SRA is that grid users should be at the focus of developments. To achieve this, the work has taken an integrated approach to technical, commercial and regulatory aspects, seeking delivery of added-value solutions and services to all stakeholders and end customers. It recognizes the complex factors inherent in achieving successful technology transfer from research to deployment, and also the new dimensions created by a liberalized market and its regulatory frameworks.

The scale of the challenge for Europe

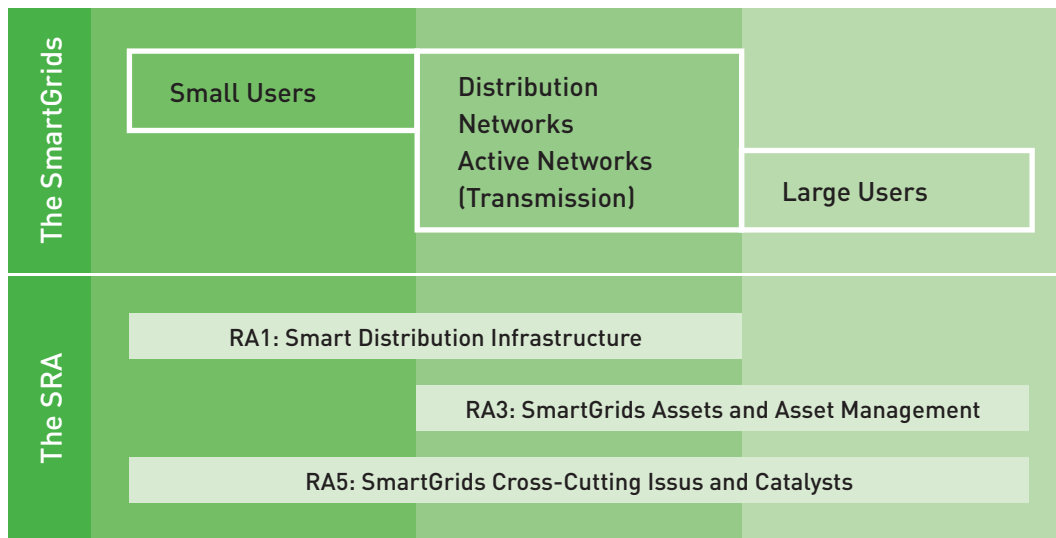
The IEA World Energy Investment Outlook 2003 states that the electricity sector in the EU has an annual turnover of about €112 billion and contributes about 1.5% to EU GDP. Investment in the sector is about €22 billion per year in the EU.

Looking ahead, EU Member States will need to invest in excess of 750 billion euros in power infrastructure over the next three decades, divided equally between generation and networks (some €90 billion will be invested in transmission and €300 billion in distribution networks).

¹ <http://www.smartgrids.eu/documents/vision.pdf>

Structure of the SRA

This SRA is presented with a two-tier structure. This structure has **five primary Research Areas (RA)** which are subdivided into a total of 19 Research Tasks (RT).



Each Research Task is explained using a common format that includes potential projects with expected deliverables; and associated Lighthouse and Catalyst projects.

Catalyst projects are specially targeted at removing commercial or regulatory barriers to ensure rapid take up of innovative solutions. **Lighthouse projects** seek operational demonstration to bridge the gap between innovation and adoption.

Strategic research priorities

The primary objective of a Technology Platform is to boost European industrial competitiveness, and it achieves this by defining research and development priorities. This document is intended as a reference agenda for the lifetime of the EC 7th Framework Programme. It is recognised that steps carried out in the near future will have an impact on the performance of the networks for decades to come. As a consequence, research priorities have been identified by considering the long term strategic value of the expected outputs.

For these reasons, the Advisory Council proposes to work closely with the EC and those states involved in the platform to maintain visibility of research activities at European level, thereby achieving prioritisation and coherence for mutual benefit.

Implementing the SRA

Research identified in this agenda will be facilitated and encouraged by the involved stakeholders. Financial support will come from regular funding schemes for collaborative research within the Framework Programme, using open tendering. However, this is only one potential source of funding. The SRA aims to mobilise a large range of public and private financing sources, including industry, international, national and regional programmes and the financial markets such as the European Investment Bank (EIB). Structural Funds have also been identified as a potential source to support the implementation of SRAs, in particular within new Member States.



Joint Technological Initiatives (JTI) could also be considered as a funding instrument for this SRA where the mobilisation and management of very substantial public and private investment and human resources is needed for a wider European level response.

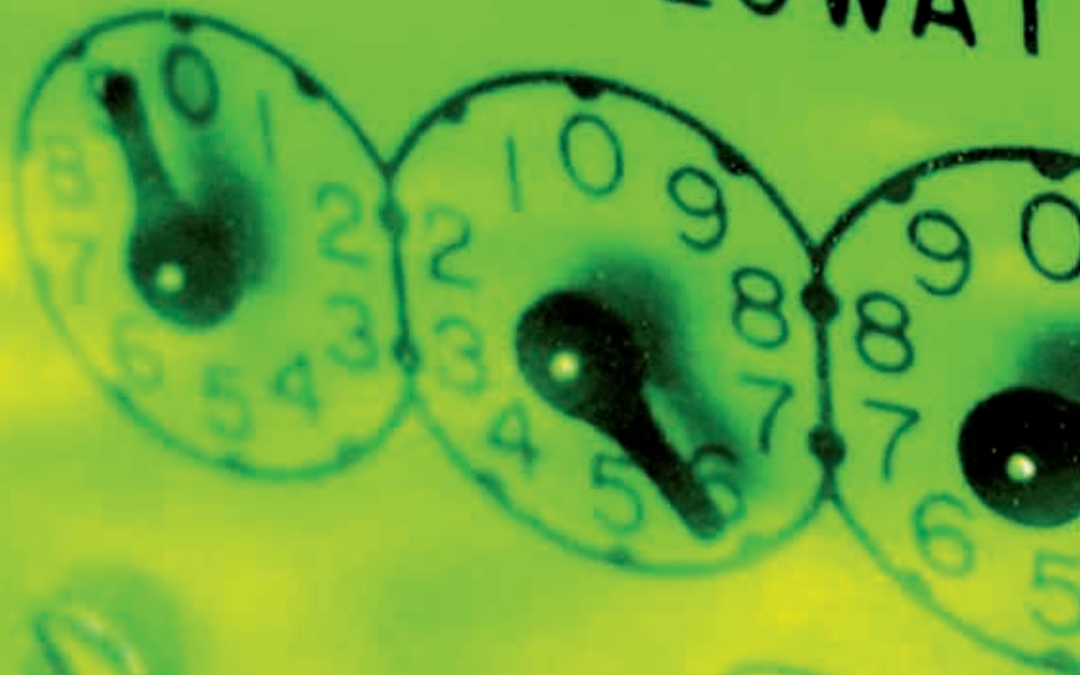
Innovation opportunities

A few examples of fields for innovation opportunities identified in this SRA:

EXAMPLES OF INNOVATION OPPORTUNITIES	
Small Users	Demand Side Participation Enhanced quality and security of supplies
Large Users	Reduced congestion for generation export Access to Europe-wide electricity markets
Distribution Networks	Integration of DER to enhance supply security and quality Achieving asset renewal cost-effectively and securely
Transmission Networks	Reduced congestion for pan European grid energy flows Open access to essential ancillary services across Europe

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BACKGROUND



THE SMARTGRIDS TECHNOLOGY PLATFORM

In recent years there has been a growing awareness, within the electricity supply industry, of the need to reinvent Europe's electricity networks in order to meet the demands of 21st century customers. Many Member States are already addressing this challenge and cooperating with others in specific areas. However, the need for a more coherent approach across Europe has been identified and in 2005 the European SmartGrids Technology Platform was established to meet the challenges seen by network owners, operators and particularly users, across the EC.

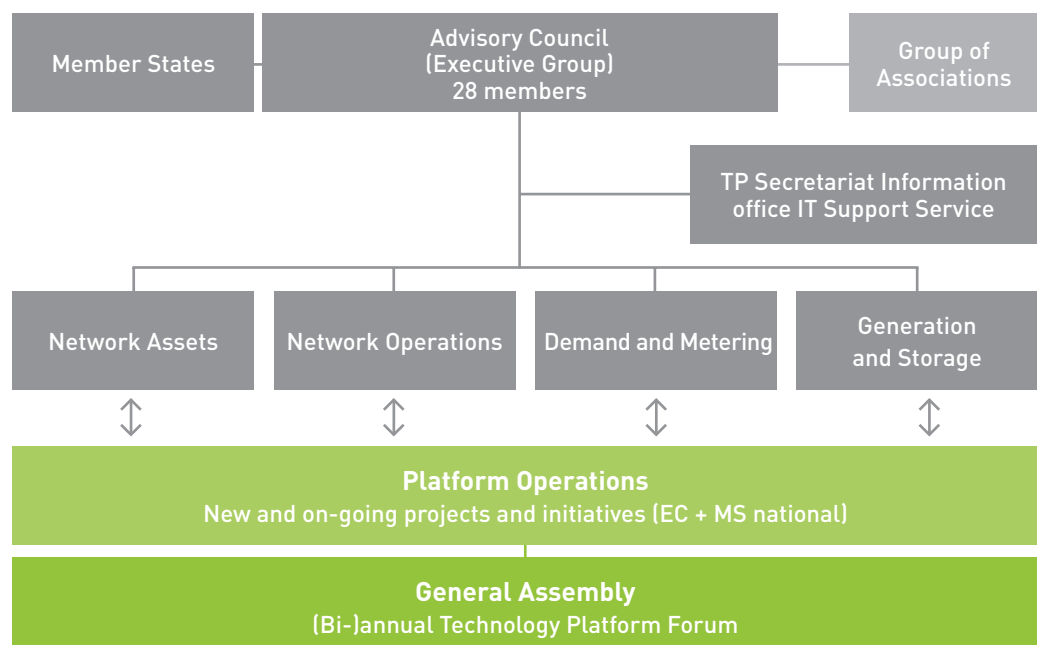
Objectives

The European Technology Platform SmartGrids has brought together all the key stakeholders from the electricity networks sector; the network companies themselves, manufacturers, users, academics and regulators. Their objectives are:

- To develop a shared vision for Europe's electricity networks of the future that is fully aligned with European wider policy objectives.
- To identify research needs and build support for an increased public and private research effort for electricity networks.
- To align ongoing RTD projects and new European, national and regional programmes on electricity transmission and distribution systems.
- To draw conclusions and recommendations for follow-up actions and the implementation of a strategic research agenda that encourages the engagement of multiple, independent parties, at both national and European levels, to ensure effective innovation take-up by Member State companies and the commercial exploitation of new knowledge beyond Europe. The SRA as developed here is a first step in that direction.

The Structure of the Technology Platform

The diagram below shows the structure of the Technology Platform. At its heart is the Advisory Council which provides direction and management of the Technology Platform. The Advisory Council is actively supported by the four Working Groups. It also seeks advice and guidance from its Mirror Group, representing Member State governments, in order to link the European and national research agendas.



The functions of the key groups are:

- **Advisory Council:** provides guidance, stimulates initiatives and monitors progress.
- **Mirror Group:** enables the involvement of Member States, candidate countries and associate states.
- **Working Groups:** take responsibility for progressing the work at a detailed level.
- **Group of Associations:** this will in the near future enable more direct participation of associations of stakeholders.

The SmartGrids Vision

The SmartGrids Technology Platform jointly produced the "Vision and Strategy for Europe's Electricity Networks of the Future"² which was published in April 2006. This document is the first milestone towards the establishment of a common strategy for the development of Europe's electricity networks.

The SmartGrids vision is about a bold programme of research, development and demonstration that charts a course towards an electricity supply network that effectively and efficiently meets Europe's future needs.

Europe's electricity networks must be:

- **Flexible:** fulfilling customers' needs whilst responding to the changes and challenges ahead.
- **Accessible:** granting connection access to all network users, particularly for renewable power sources and high efficiency local generation with zero or low carbon emissions.
- **Reliable:** assuring and improving security and quality of supply, consistent with the demands of the digital age with resilience to hazards and uncertainties.
- **Economic:** providing best value through innovation, efficient energy management and 'level playing field' competition and regulation.

Key elements of the vision include:

- Creating a **toolbox of proven technical solutions** that can be deployed rapidly and cost-effectively, enabling existing grids to accept power injections from all energy resources.
- **Harmonising regulatory and commercial frameworks** in Europe to facilitate cross-border trading of both power and grid services, ensuring that they will accommodate a wide range of operating situations.
- Establishing **shared technical standards and protocols** that will ensure open access, enabling the deployment of equipment from any chosen manufacturer.
- Developing **information, computing and telecommunication systems** that enable businesses to utilise innovative service arrangements to improve their efficiency and enhance their services to customers.
- Ensuring the successful **interfacing of new and old designs** of grid equipment to ensure interoperability of automation and control arrangements.

The SmartGrids flexible framework

A flexible approach to the RD&D challenges will be adopted. The key principles of this 'flexible framework' are as follows:

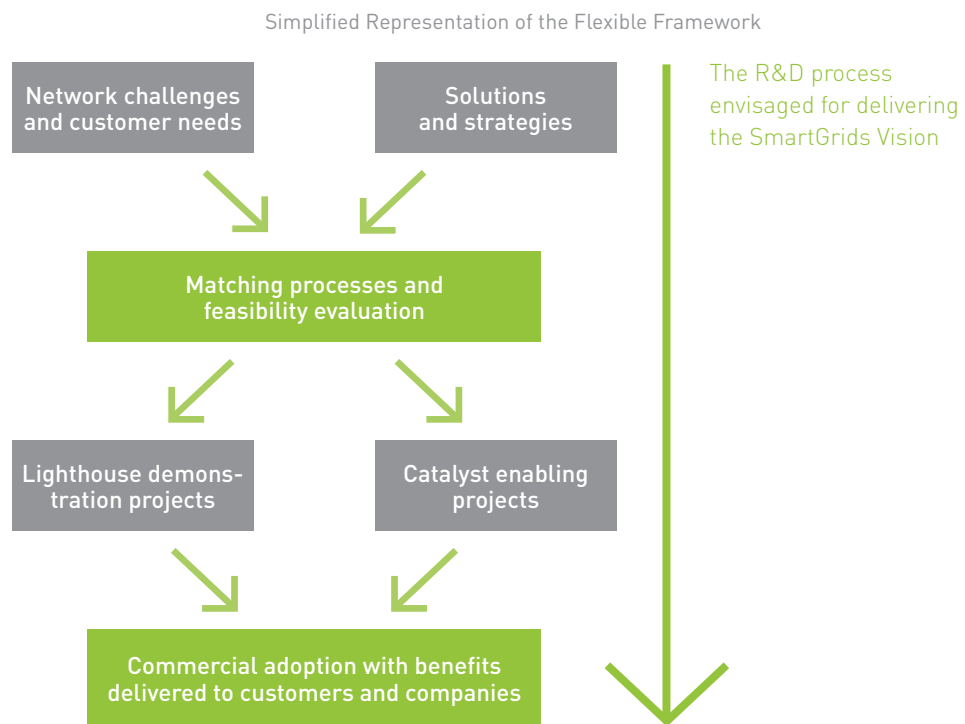
- Future network challenges and customer needs will be identified and matched.
- Solutions and strategies – to deliver an appropriate technical, commercial, environmental and regulatory balance.
- Challenges and solutions will be tested for feasibility and commercial viability.

² <http://www.smartgrids.eu/documents/vision.pdf>



- Solutions that withstand this process will be taken forward as demonstration lighthouse projects with the aim of facilitating a faster and more widespread adoption of innovation benefits; the perceived risk of adopting new technology will be mitigated and commercial adoption will follow when companies know it works.
- Catalyst projects will be undertaken in parallel with lighthouse pilot projects to address barriers that had been identified to wide-scale commercial adoption, such as developments needed to regulatory, legal or technical standards frameworks.
- Techniques such as showcasing and early adopter forums will enhance the perceived value of deploying successfully piloted innovative solutions.
- Based on early adopter deployment, real user experience and knowledge will be disseminated to the wider market place to generate awareness of and confidence in new technologies; skills transfers from research organisations to commercial users will be undertaken in a systematic way.

The diagram below shows the RD&D process as envisaged under the flexible framework.



The SmartGrids Strategic Research Agenda

Following publication of the Vision document, the Technology Platform has developed more concrete proposals by producing this Strategic Research Agenda. The purpose of the Strategic Research Agenda is to propose a framework for a programme of future research, focused on well defined goals, that addresses the key elements of the Vision. It is designed to work with the Framework Programme 7 Energy theme and in particular the Smart Networks sub-theme. This is described as follows:

Research, develop and demonstrate how to increase the efficiency, safety, reliability and quality of the European electricity and gas systems and networks notably within the context of a more integrated European energy market e.g. by transforming the current electricity grids into an interactive (customers/operators) service network, developing energy storage options and removing obstacles to the large-scale deployment and effective integration of distributed and renewable energy sources.

THE TECHNOLOGY PLATFORM – OUR MISSION

Our mission is to encourage and facilitate the efficient transformation of Europe's electricity networks so that they meet the challenges and opportunities of the 21st century. In order to fulfill or exceed the expectations of society and the particular needs of customers, we will need to strengthen the European business context for the electricity sector and for the economy dependent on it. This will ensure that Europe's electricity grids remain at the forefront, providing essential services, new economic opportunities and playing their part in achieving a low carbon future.

To do this we must:

- Identify and achieve an industry consensus on the key RD&D challenges.
- Establish a level of co-operation and collaboration between academia, manufacturers, network companies and their customers across Europe to meet the challenges in the most effective ways.
- Achieve a consensus view on the development path for Europe's networks and create an RD&D research agenda as a roadmap for the overall project.
- Set challenging but achievable targets to deliver real solutions for widespread implementation. These will utilize existing technology in new applications and also develop new plant and equipment to fill identified gaps and create new opportunities for Europe and beyond.

THE SMARTGRIDS STRATEGIC RESEARCH AGENDA – ITS PURPOSE

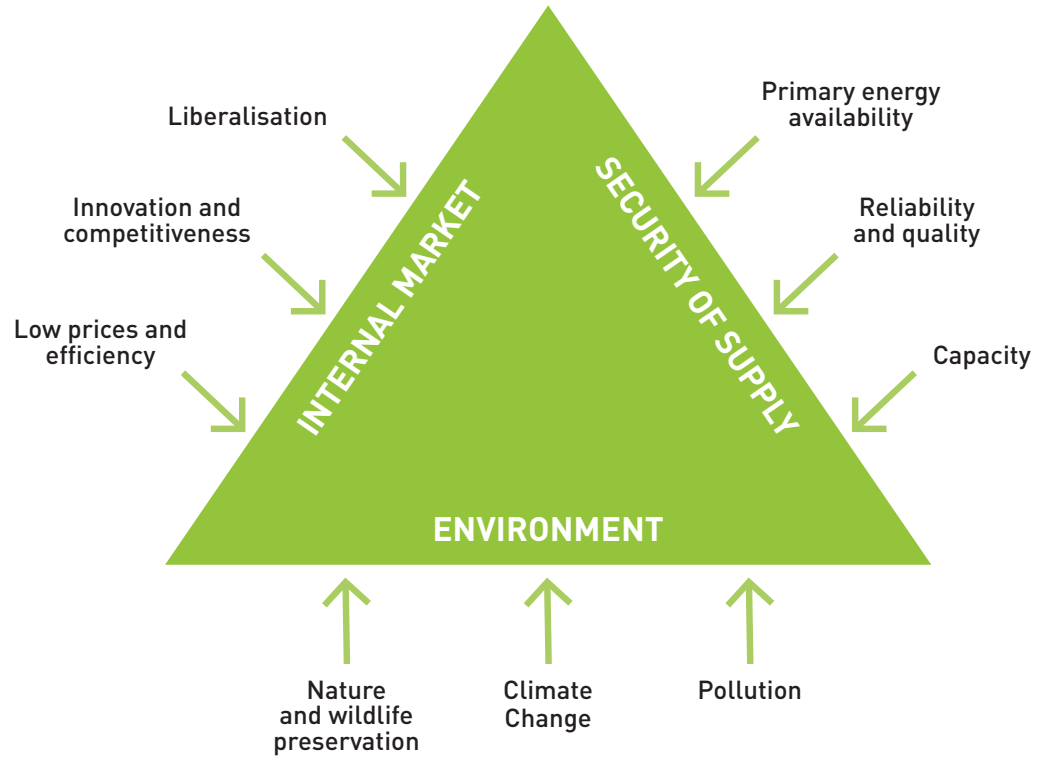
The purpose of the SmartGrids SRA can be summarized by the following discrete goals.

- Ensuring that Europe's electricity networks develop in a way that enhances Europe's competitive position without compromising environmental objectives or the commitment to sustainability.
- Capturing the benefits of collaboration and co-operation to address challenges that are common across Member States.
- Encouragement of imaginative solutions that may require community-wide adoption to be successful, including new approaches to energy efficiency and demand side participation.
- Building on previous RD&D thereby ensuring maximum benefit and elimination of duplication.
- Fully utilising current infrastructure to ensure that the most efficient use is made of existing assets that are not age expired, thereby delivering innovative and competitive solutions for European customers.
- Providing a clear framework, goals and objectives for the research community and all stakeholders to focus on.
- Generating the momentum and support necessary from all stakeholders to convert good ideas to adopted products and solutions through catalyst projects, demonstration projects, and knowledge transfer.

Development of the SmartGrids Strategic Research Agenda

Following the publication of the Vision document the Technology Platform turned its attention to the development of this SRA. The four working groups took the lead by generating potential research tasks without any constraints.

A prioritization process was then carried out involving all members of the working groups and the Advisory Council. This process allowed all involved parties to express their views on research priorities using common assessment criteria and scoring techniques. The assessment criteria were developed from the factors driving SmartGrids identified in the VISION document and illustrated below.



This process delivered the research themes and tasks that are set out in this SRA.





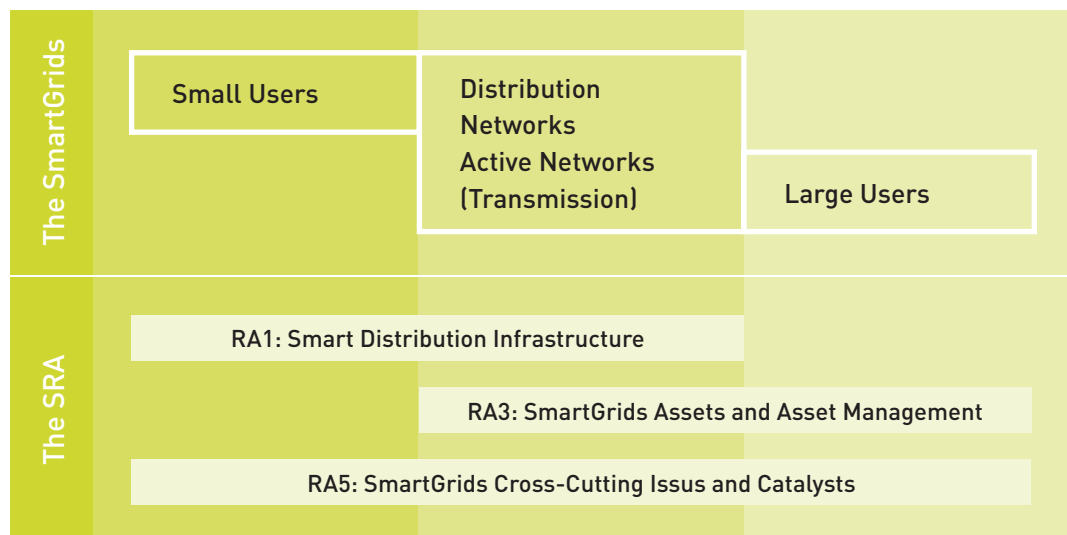
INTRODUCTION



THE STRUCTURE OF THE STRATEGIC RESEARCH AGENDA

The aim of the SRA is to define and promote Research and Technology Development (RTD) themes and projects that are in line with the objectives and conclusions of the VISION paper. The research areas and specific tasks have been selected in a logical way drawing on the views and experience of a wide cross-section of industry experts.

A key principle that has been applied in developing this SRA is that the grid user should be at the centre of the developments. Only with an accurate assessment of the requirements of the user can the electricity market develop effectively, whether the user is large (industrial) or small (residential or SME). Active user participation should not limit itself to being part of the retail or commodity market, but to really participate in the demand for new services: real time pricing, active demand side participation schemes, distributed generation. Putting the user in the centre will also stimulate the decision makers in administration and regulation to assess the social need for the research developments. The diagram below shows how the selected research areas connect with the key stakeholders.



For the purposes of this SRA, the research agenda is presented using a two-tier structure. This structure has five primary Research Areas which are sub-divided into a total of 19 research tasks. This grouping has been designed to provide a logical and self-consistent structure but, in order to link research areas that have close inter-dependencies; the classification structure has been applied with a degree of flexibility. This structure is shown in the diagram and expanded in the table below.

SmartGrids: Research Areas and Research Tasks Headline Summary	
Research Area	Research Task
RA 1 – Smart Distribution Infrastructure (Small Customers and Network Design)	RT 1.1: The distribution networks of the future – new architectures for system design and customer participation RT 1.2: The distribution networks of the future – new concepts to study DG integration in system planning
RA 2 – Smart Operation, Energy Flows and Customer Adaptation (Small Customers and Networks)	RT 2.1: The networks of the future – a system engineering approach to study the operational integration of distributed generation and active customers RT 2.2: Innovative energy management strategies for large distributed generation penetration, storage and demand response RT 2.3: The distribution networks of the future – customer driven markets
RA 3 – SmartGrid Assets and Asset Management (Transmission and Distribution)	RT 3.1: Network asset management – Transmission and Distribution RT 3.2: Transmission networks of the future – new architectures and new tools RT 3.3: Transmission networks of the future – long distance energy supply
RA 4 – European Interoperability of SmartGrids (Transmission and Distribution)	RT 4.1: Ancillary services, sustainable operations and low level dispatching RT 4.2: Advanced forecasting techniques for sustainable operations and power supply RT 4.3: Architectures and tools for operations, restorations and defence plans RT 4.4: Advanced operation of the high voltage system – seamless smart grids RT 4.5: Pre-standardisation research
RA 5 – Smart Grids Cross-Cutting Issues and Catalysts	RT 5.1: Customer Interface Technologies and Standards RT 5.2: The networks of the future –Information and Communication RT 5.3: Multiple Energy Carrier Systems RT 5.4: Storage and its strategic impact on grids RT 5.5: Regulatory incentives and barriers RT 5.6: Underpinning Technologies for Innovation

Section 4 of this SRA addresses each of the five Research Areas and their related Research Tasks. For each Research Area an Introduction is provided to give context to the Research Tasks. Each Research Task is then explained using a common format having four sections as follows:

- Objective and Purpose
- Technical Content and Scope
- Potential Projects and Expected Deliverables
- Lighthouse pilot and Catalyst projects

Section 5 then explains how this SRA will be developed in the context of FP7.

STRATEGIC RESEARCH PRIORITIES AND METHODOLOGIES

The SmartGrids SRA covers a very significant range of potential research tasks. It is intended as an agenda for the life of Framework Programme 7, a period of seven years. It is vital therefore that appropriate prioritization and programming is achieved in developing the SRA under FP7.

It is recognised that, due to the extended lifetimes of power system assets, investment decisions being taken now and in the near future will impact the performance of the networks for decades to come. It is therefore proposed that research priorities should be driven by the strategic value of the expected outputs rather than their shorter term tactical benefits.

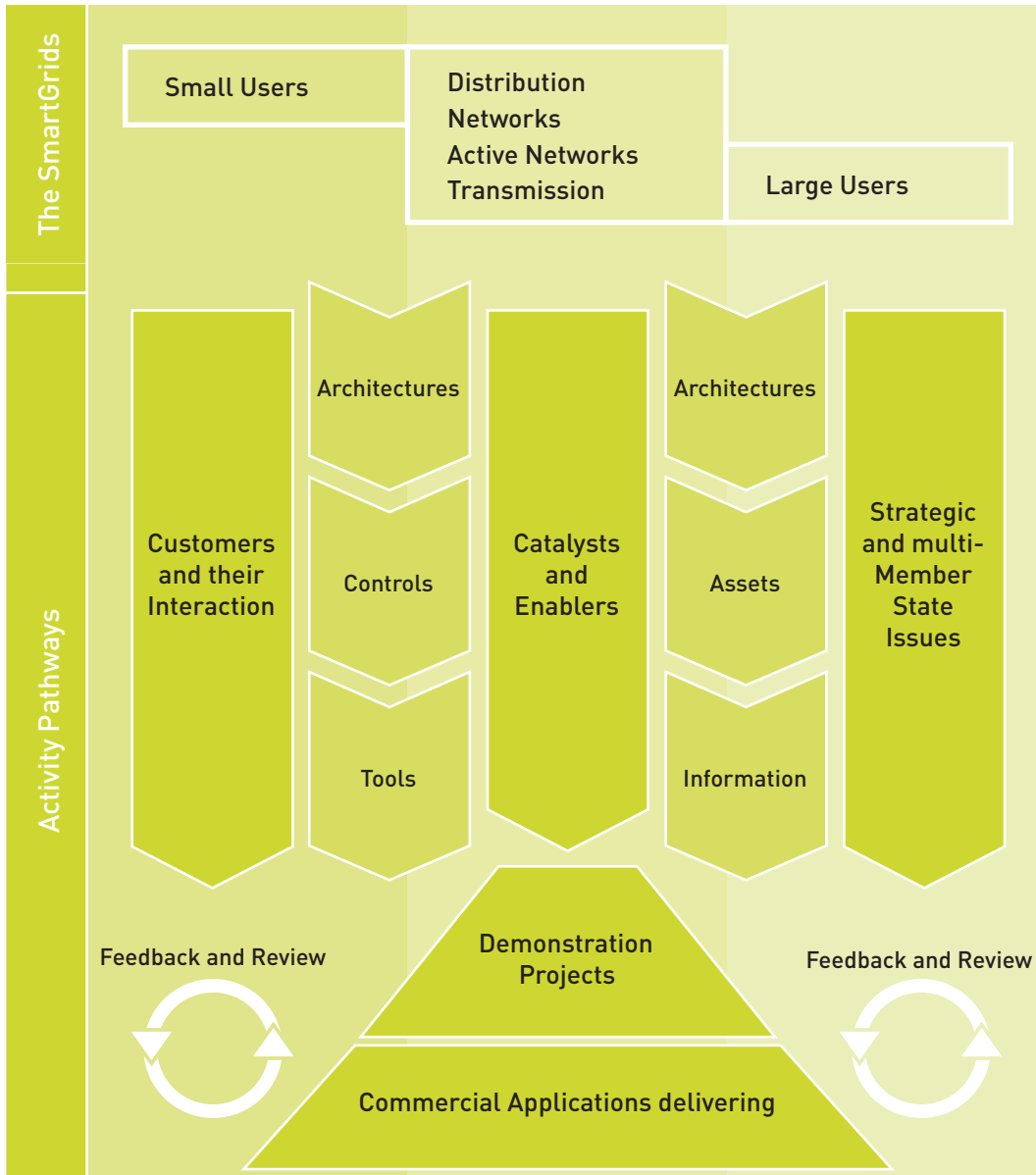


It is intended that the Technology Platform's Advisory Council will work closely with the relevant Directorates-General of the commission (Research and Transport and Energy, and where needed Competition and Environment) so that each call for proposals is focused on the highest priority issues. This will ensure a continuous dialogue between the industrially-led Technology Platform and FP7 and beyond, resulting in a coherent and prioritized research programme. The Advisory Council will also monitor parallel European, national and international research activities to ensure that effective linkages are established for mutual benefit. The final aim is to optimize grid research and technology transfer, not only harmonizing activities across Member States, but responding to priorities that have a pan-European dimension.

The table below describes the principles that will be applied in further developing the programme and prioritising the research activities.

SmartGrids Research Areas Programme and Prioritisation Principles
1 Projects likely to have long lead times will be commenced at the earliest opportunity, taking account of European priorities. This includes catalyst projects addressing regulatory and commercial potential barriers, or strategic projects that involve multiple Member States, such as cross border interoperability and data exchange issues.
2 To ensure consistency with other European projects and activities of stakeholders/organizations like e.g. UCTE, IEC, etc. an intensive exchange of information with these groups will be established in order to define the best catalyst projects and most valuable and useful strategic projects to complement existing activities and deliver the widest possible benefit.
3 Early attention will be directed towards projects assessing new network architectures; this will provide important information to projects addressing control, operation and ICT requirements.
4 Training and knowledge transfer aspects will be a formal part of the project programmes from the start.
5 Project review processes will be periodic and systematic to ensure that research activities are fully informed of other research findings and new technology developments and opportunities.
6 Where development or demonstration activity requires interaction with customers, this will be undertaken in conjunction with suppliers and consumer representative organizations.
7 An important role of the Technology Platform will be to ensure that visibility and close links are maintained with all stakeholders, particularly the network companies, regulators and Mirror Group, ie Member State, representatives.

The diagram that follows shows the high level activity pathways for SmartGrids. These indicate the principal activities and their sequencing that is proposed for delivery of the research tasks.





CO-OPERATION AND CO-ORDINATION

It is a clear aim of the SRA that FP7 projects should deliver products, solutions and intellectual property that make a tangible, visible difference to the way that networks are designed and operated for the benefit of their users.

This can only be achieved by allowing market pull to be a primary driver of our research activities. The benefits of technology push must be appreciated but they must be matched to market needs and aligned for implementation rather than pursued for their own sake.

This approach mirrors a key FP7 objective which is to focus on developing research that meets the needs of European industry, through the work of Technology Platforms and the new Joint Technology Initiatives. The FP7 assessment process will take particular account of this.

Reaching out to involve new stakeholders that are key to achieving the VISION should be an essential element of the SRA, particularly those with know-how who have not yet been involved in the RTD community. New ideas and approaches are critical to success as only a real multidisciplinary approach can result in new developments (for instance, the interdependence of ICT and electricity networks). A close collaboration with other platforms that deal with relevant subjects has to be undertaken. It is critical that the work fosters international collaboration in line with our VISION paper, clearly defining the stakeholders involved.

The industry should remain one of the key actors as they have to be convinced of the added value of innovation and its practicability. This does not only include the manufacturing industry, but also the grid operators and the regulators who will be the adopters and enablers for new developments. An effective interaction with European organizations of stakeholders such as ETSO, UCTE, Nordel, Eurelectric and CIGRE is key.

In combination with private sector activity, it is vital that public investment at least matches current R&D funding levels of major global competitors. The next step to bridging the gap between R&D and commercialisation is the development of large-scale demonstrations – ‘Lighthouse Projects’.

DELIVERY FOCUS: CATALYST PROJECTS AND LIGHTHOUSE PROJECTS

The Technology Platform is committed to delivering practical systems and solutions having a clear and economic benefit, while recognizing the challenges of technology diffusion, converting high quality research outputs into commercial applications.

In recognition of this, each of the Research Areas described in this SRA identifies potential **Catalyst Projects** that will, in parallel with the main research activities, address anticipated barriers to widespread adoption of particular research projects. Such catalyst projects might, for example, address regulatory frameworks, technical standards, open systems or hurdles in areas of health, safety or environmental care.

Furthermore, demonstration projects are an important feature of power networks innovation because it is only by this means that innovative solutions are validated in an appropriate environment and become proven for widespread adoption. Testing and confidence-building can be progressed in a laboratory environment, but full proving can only be completed in an operational situation with full exposure to ambient conditions so the non-linearities and risks of practical operational conditions are verified. It is intended that **Lighthouse Projects** will be identified where appropriate to enable this proving stage to be completed efficiently. Lighthouse Projects will be a key stage in a number of areas to bridge the gap between innovation and adoption.





RESEARCH AREAS AND TASKS



RESEARCH AREA 1 – SMART DISTRIBUTION INFRASTRUCTURE (SMALL CUSTOMERS AND NETWORK DESIGN)

Introduction

The Distribution Network is defined as the system covering all wires and equipment that play a role in supplying all medium to low voltage³ consumers and also giving network connection to DG technologies. Distributed Generation, becoming an integral part of European energy system, should provide consumers and energy providers with safe, affordable, clean, reliable, flexible and readily accessible energy services. DG has the fundamental benefit of producing electricity at or close to the point of consumption. This reduces the losses resulting from delivery to customers and allows waste heat from generators to be used beneficially. Promoting and deploying distributed generation and, indeed, technologies that facilitate demand participation, therefore have the potential to benefit energy consumers, the European energy system and the environment through the optimization of the value chain from energy suppliers to active end customers utilising SmartGrid infrastructures.

Electricity market liberalization is increasing the interest of different stakeholders to the energy field. Over the coming years, energy supply will become more and more tailored to customer needs. Beside high focus on quality of service and cost reduction, total connectivity, energy “on demand”, a service oriented portfolio and flexible contract management will play a leading role to fulfil customer expectations.

One of the enablers for this development is research for a set of “plug and play” interfacing modules for network connection of demand and DG using standardization and modularization, leading to lower costs throughout the power delivery chain and faster and simpler connections for generation and demand users. These plug and play interfacing modules will be environmentally friendly and can, to a high degree, be customized to individual needs. Through standardization, modularization and programmable functionality an economy of scale will be possible, leading to lower costs and more expandable systems. This goal has wider applicability across other Research Areas.

Enhancing this work with multidirectional communication and control systems for horizontal and vertical integration, will facilitate participation of customers and DG in system operation resulting in effective distribution control for the benefit of power quality and reliability enhancement at the connection point. This is discussed further in research Task 5.1. In this context, metering services and statistical metering tools represent the gateway for the access to the “active network”, to the transaction platform, to the decentralized facilities and are requisite to support fully the electricity demand evolution. For that reason, electronic meters and Automated Meter Management systems represent the enabling advanced hardware and software technologies to facilitate and inform customer preferences and opportunities in the energy field and to optimize demand forecasting.

This can offer the customer choice and quality of supply at relatively low cost provided that minimal technical requirements are met and measurable, enabling network operators to maximize efficiency, flexibility and reliability through the use of smart advanced technologies.

One of the major problems limiting the wider penetration of Distributed Energy Resources (DER) in today’s power systems is the lack of harmonization of grid connection requirements and the lack of compatibility of fault protection systems and metering. Differentiated definitions of grid connection requirements for the various types of generators are needed because of their different nature. Further obstacles arise from the operational engineering requirements of the networks where DER is connected. At distribution level, power flow constraints may lead to local reinforcement, in particular related to bi-directionality and possible conflicting requirements with natural gas and heat distribution networks (Combined Heat and Power). Where such obstacles are found in practice, appropriate research should be initiated to alleviate the constraints.

³ The definition of distribution system voltages varies between Member States but networks operating above 150kV are universally considered to be transmission.

The objective assessment of DER effects on the network performance emphasizes the need for new system structures. Examples include: inadequacy of existing dynamic simulation tools to handle large numbers of power electronic converters in the power system and of analytical tools to study planning and development of networks taking into account the stochastic nature of DER, both in steady state and under dynamic conditions. Deterministic approaches based on maximum-minimum conditions are generally far too conservative, unnecessarily limiting a larger penetration of DER or underestimating its potential benefits. A stochastic approach is needed.

Research Task 1.1

The distribution networks of the future – new architectures for system design and customer participation

Objective and Purpose

Distribution networks across Europe exhibit considerable differences in detailed design. However, the majority of these networks have been developed against a background of the migration of generation plant to the transmission system. As a result, the fundamental architecture of these networks has much in common. As a general rule, distribution networks have a relatively small amount of active elements, such as generators, but are instead dominated by passive elements, principally uncontrolled loads.

There is significant structural inertia in the design of distribution networks. However, if the reintroduction of more active elements is going to require networks to be 'smarter' the changes required in their fundamental architecture need to be identified at the earliest opportunity. If this can be achieved it will allow current renewal and extension plans to take account of the longer term needs of customers.

Technical Content and Scope

This research task has a number of discrete but closely inter-related elements. They include the following:

- **Future SmartGrid scenarios** – the development of future demand and generation scenarios with an integrated assessment of network architectures needed to support them. A probabilistic approach is key.
- **Transition strategies:** how to go from where we are today to the SmartGrids of tomorrow.
- **Technological acceptance of distributed generation:** define ways and business models to stimulate the competition. Socio-economic aspects of the new power world.
- **Internet-like SmartGrids:** transition of existing distribution grids to an internet-like architecture.



Potential Projects and Expected Deliverables

The tables below provide concise outlines of potential research projects related to the content and scope described above.

The distribution networks of the future – new architectures for system design and customer participation	
Project	Deliverables
Future SmartGrid scenarios	<p>A range of generation and demand scenarios will be developed (using a reference power system) based on stated assumptions for economic activity, environmental constraints/targets and technological developments related to generation and demand.</p> <p>New system configurations will be developed to respond to the future scenarios. This work will take into account the results of other relevant European projects and include where appropriate the primary power system architecture to ensure effective distribution/transmission integration. The work will also identify new equipment requirements and interfacing issues between old and new technologies and also verification and integrity assessment methods.</p>
Transition strategies	<p>This research will develop practical transition strategies from the solutions used to-day to the new network structures of SmartGrids.</p>
Technological acceptance of distributed generation	<p>This research will define methods and business models to stimulate the adoption of the new SmartGrids opportunities. This will include socio-economic aspects.</p>
Internet-like SmartGrid	<p>Developing solutions for network architectures that take the form of an internet like network where business and commodities can be freely accessed and traded.</p>

Catalyst and Lighthouse Pilot Projects

The structural inertia inherent in today's networks militates against any accelerated adoption of new architectures. However, there is potential for smaller scale adoption of new ideas and catalyst projects may be possible where significant new network extensions are being designed and built. Structural inertia problems may be slow to resolve because of multi party involvement and, on occasion, the need for change to statutes and standards.

- **Catalyst – Barriers to new technology deployment** – this project will identify potential regulatory, statutory or technical standards barriers that are likely to prevent the rapid take-up of new solutions for Smart Distribution Infrastructure. It will bring forward solutions and work with relevant sector and EU parties to dismantle unnecessary barriers. It will also identify the necessary verification, testing and certification methods for innovative plant and equipment.

Research Task 1.2

The distribution networks of the future – new concepts to study DG integration in system planning

Objective and Purpose

Network owners and operators need new methods and appropriate computing tools (e.g. load flow analysis, Geographic Information Systems – GIS) to model DG network integration aspects, to anticipate technical problems and barriers, to identify solutions, and to underpin decisions on new investments. The innovative aspects of the challenges ahead require the development of new mathematical approaches. Research must cover a range of tasks relevant to simulation and analysis needs for development of future networks. They will be confirmed through a close interaction with key stakeholders. The role of each actor and the relations required between them needs to be developed. Questions such as: what is the role of the manufacturer and what type of data/information needs to be exchanged between manufacturer and distribution network operator are extremely relevant.

Technical Content and Scope

This research task has a number of discrete but closely interrelated elements. They include the following:

- **New tools for active distribution system design** – equip the planning engineers of the future with accurate, fast and easy to use planning capabilities, utilising more real-time information to increase accuracy and reduce cycle time.
- New tools for analysis of the power system with widespread DG and active distribution networks.
- **Probabilistic techniques for DG** – assessing the risks and uncertainties of distributed generation and demand in active networks, addressing the disaggregated impacts of demand response and demand side management actions.
- **Investment planning methodologies** – how to respond to the multiple drivers and uncertainties that will affect investment choices in the future.
- **Active Management requirements** – This project will address the needs and benefits of active management. It will identify options to permit distribution systems to adapt their role to respond more like Transmission systems, particularly recognising the impact of dispersed generation.



Potential Projects and Expected Deliverables

The tables below provide concise outlines of potential research projects related to the content and scope described above.

The distribution networks of the future – new concepts to study DG integration in system planning	
Project	Deliverables
New tools for active distribution system design	Existing tools for network planning through all time frame (steady state analysis, dynamic behaviour, transient) should be enhanced for the new needs. The tasks will provide: <ul style="list-style-type: none"> • A benchmark of existing tools, • Definition of supplementary simulation models required for active distribution, • Develop or enhance algorithms needed for the new simulation models, • Approval of new models after their integration into existing tools • Development of reliability criteria Guidance how to approach the planning of networks with volatile load flows and uncertain generation (worst and best case scenarios).
Probabilistic techniques for DG	The enhancement of existing tools for network planning, new methods have to be developed, based on physical statistical analysis and probabilistic approaches, for distributed load modelling, taking into account its disaggregated nature and the effect of demand response and demand side management actions. Furthermore, the concept of risk as a direct consequence of uncertainties needs also to be integrated.
Investment planning methodologies	Provide solutions, including decision support methods and techniques, for addressing the multiple (and often concurrent) drivers that affect future investments in distribution networks, using multi-objective programming if necessary. Different targets will be weighed: costs, impact on the introduction of DG and DSM, link with reliability.
Active management requirements	This project addresses requirements for achieving active management. It will identify network options and protection principles to permit distribution systems to adapt their role to respond more like transmission systems, particularly recognising the impact of dispersed generation.

Catalyst and Lighthouse Pilot Projects

- **Catalyst – Manufacturer/network company interfaces** – this catalyst project will identify the interface aspects between network companies and material manufacturers to ensure harmonization of expectations and requirements. For example data/information exchanges. Design the specifications of DG to meet the dynamic requirements in order to follow a prescribed schedule.

RESEARCH AREA 2 – SMART OPERATION, ENERGY FLOWS AND CUSTOMER ADAPTATION (SMALL CUSTOMERS AND NETWORKS)

Introduction

The active networks of the future will efficiently link small and medium scale power sources with demand, enabling efficient decisions on how best to operate in real time. The level of control required to achieve this is significantly higher than found in the present transmission and distribution systems. Power flow assessment, voltage control and protection require cost-competitive technologies and new communication systems with far more sensors and actuators than presently used certainly in distribution systems. To manage active networks, the vision of grid computing will be adopted which assures universal access to resources. An intelligent grid infrastructure gives more flexibility concerning demand and supply providing at the same time new tools for optimal and cost-effective grid operation. Intelligent infrastructure will enable sharing of grid and IT resources including ancillary services, balancing, and microgrids behaving as virtual power plants (VPP). It creates a framework for all grid users including grid operators⁴.

In order to exploit the advantages of DG (including RES) it will be necessary to follow a “system approach”: DG will not feed the network in a stand alone mode, but will be fully integrated into the network. As is already the case for the high voltage networks, the medium and low voltage networks will in turn become “active”. The energy generated by the DG may be dispatched centrally or exported at the choice of the customer. DG will have the capability to provide ancillary services to the network and become a market participant.

The intermittency and variability of renewable generation whether wind, photo-voltaic or other technologies, can create considerable effects on power system operation. This can impact quality of supply and security margins and consequently operational costs. This clearly requires comprehensive understanding and, in some situations integrated control, of both central and distributed generation and potentially of demand resources, at all voltage levels. Given the necessary technological advancements and financial incentives, present operating practices based on centralized control need to move towards a de-centralized approach. Technological developments in the ICT area (telecommunications, distributed control, advanced forecasting techniques, on-line security assessment, etc.) can contribute significantly to these developments. The grid interfaces to be developed will have to include these elements consistent with the ambition of greater customer integration and effective Demand Side Management. Possible synergies between systems for distribution management systems and the impact of storage in power network/studies (peak load, power quality, penetration of renewables) will be analysed- as will the effect of different commercial and regulatory models on the viability and likelihood of their commercial adoption.

Research Task 2.1

The networks of the future – a system engineering approach to study the operational integration of distributed generation and active customers

Objective and Purpose

Simulation tools and methods for the analysis of power systems were historically developed and used in an off-line environment to study aspects of operation. Such tools have been upgraded and customized for use in an on-line environment for the purpose of generation dispatching, system state estimation and security analysis. The simulation and analysis software is currently orientated to conventional generation by centralised plants. The impact of decentralised generation needs to be incorporated into future operational tools and methods. SCADA enhancements will be needed to enhance data integration and display capabilities to incorporate customer real time responses.

⁴ Grid computing is the ability, using a set of open standards and protocols, to gain access to applications and data, processing power, storage capacity and vast array of other computing resources over the Internet. A Grid is a type of parallel and distributed system that enables the sharing, selection and aggregation of resources distributed across multiple administrative domains base on the resources availability, capacity, performance, cost and users' quality-of-service requirements (IBM definition).



A large number of micro-generators, uncertainties in distributed generation output (due to intermittent availability of some renewable energy sources or dependence of distributed generation operation on other services such as heat demand driven CHP), changes in power flows, especially in distribution networks, are issues that cannot effectively be dealt with by deterministic methods. Moreover, distributed generators may be connected to networks through power electronics interfaces. New, advanced controllers based on power electronics and various types of storage devices can be expected to be developed for distributed frequency and voltage control, aimed to support the operation of active distribution grids. There are limitations in the simulation of power electronic converters and of advanced digital controls and hence simulation tools need to be developed. Finally, data exchange aspects and communications requirements of network operation are largely ignored by the current models. Questions such as what data needs to be transmitted on-line for power network control and how, need to be addressed including contractual aspects related to this new type of operation.

A major aspect of demand prediction is linked with social behaviour. The demand forecast system has to be coupled intelligently with the “consumer environment”.

Technical Content and Scope

This research task has a number of discrete but closely interrelated elements. They include the following:

- **Generation dispatching and unit commitment analysis** – new tools to integrate widespread renewable and dispersed generation into operational assessments
- **Steady state analysis** – new tools for probabilistic load-flow and short circuit analysis.
- **Simulation of transient behaviours** – new tools for stability analysis, frequency domain and time domain applications.
- **Forecasting techniques and tools** – to define models based on stochastic variables such as wind, sun, precipitation, temperature, load and pricing on distributed generation outputs approaching real time and providing improved integration and prediction accuracy.
- **Benchmarking capability for software** – to enable comparisons between different techniques and algorithms and manufacturers’ products.

Potential Projects and Expected Deliverables

The tables below provide concise outlines of potential research projects related to the content and scope described above.

The networks of the future - a system engineering approach to study the operational integration of distributed generation and active customers	
Project	Deliverables
Generation dispatching and unit commitment analysis	This research will deliver new methods to predict the load and generation (in particular, RES) schedules off-line in advance (day ahead) and to control the schedules on-line with compensation for unplanned fluctuations using own reserves or demand side management/demand response (virtual power plant).
Steady state analysis	New tools will be developed to model the behaviour of intermittent distributed generation active and reactive power, in combination with different types of feeding modes for power electronic converters. It will address models of distribution feeders with single phase loads. Impact on decision making within a liberalised market (dispatchability).
Forecasting Techniques	Linking real-time integrated grid tools, with prices and weather forecasting information for improving renewable generation prediction and demand. Well defined and integrated real-time forecasting technologies capable of integration in practical, operational situations. Socio-economic evaluation of inputs and benefits of such forecasting technologies.
Simulation of transient behaviours	Models will be developed for power electronic converters, distributed generators and storage technologies, including models of digital control systems and of new control algorithms, and models for distributed controllable and responsive demand.
Benchmarking capability for software	Benchmarks will be developed for comparing the software environments of different manufacturers to suit the needs of distribution network operators. This work will assess real time targets, quality of service and cost-effectiveness.

Catalyst and Lighthouse Pilot Projects

- **Catalyst – Multi-source data harmonisation** – wide area and multi system models will require data from different data bases sources and information systems. This catalyst project will identify potential barriers and determine options for their solutions.



Research Task 2.2

Innovative energy management strategies for large distributed generation penetration, storage and demand response

Objective and Purpose

To take advantage of the full benefits of the distributed energy resources it is important to provide control structures and strategies that will:

- Enable coordinated control of various energy resources in the system, both central and distributed generation, at all voltage levels, including responsive demand.
- Coordinate the behaviour and impact of pools of large numbers of distributed generators, so that they provide the full capabilities of traditional power plants to the transmission grids, (the concept of “virtual power plants”, VPP).
- A decentralized decision making process, in order to balance demand and supply coming both from the local sources and the medium voltage distribution feeder.
- Promote the effective utilization of low carbon options and other sustainable development objectives.

There are several levels of decentralization that can be applied ranging from fully decentralized to hierarchal. By using this distributed control strategy, the lower level of control can be independently operated and disconnected from the higher control hierarchy in order to form an islanded operation as far as they have the ability to balance supply and demand locally with an acceptable power quality determined by local system requirements. Such control-independency enables parts of the network to be operated in two operation modes, autonomous (islanding) or grid-connected. This possibility increases the reliability of supply within the DG penetrated parts of the network, since their internal electricity resources can be used to supply their own demand during the disruption in the public grid. Improving reliability of supply is an important added value dimension of DG implementation. On the other hand, under the normal conditions when the grid-connected mode is applied, the system resources including the micro sources can be used and shared to supply the system demand in order to achieve the maximum system economic efficiency.

A number of structural questions need to be answered and topics studied in order to employ this level of decentralized system control. For example:

- Who is responsible or accountable?
- How can dependability be guaranteed?
- It is necessary to provide a cost/benefit allocation for all stakeholders.
- What incentives and regulatory frameworks are required in order to provide motivation to the independent power producers (IPP) and to customers to actively participate in energy management and so permit sustainable gains in efficiency, flexibility safety and economic operation of such architectures?
- Interdependencies of networks (including natural gas, communication, and heat distribution)
- How can congestion be addressed through decentralized control?
- What are the needs for extensive communication infrastructure, especially if more centralized approaches are adopted?
- What fundamental design principles would best meet the requirements of power system protection systems for networks having high DG penetration?
- How can large data volumes be handled and what are the contractual dependencies?

The enabling of active distribution network technologies will allow radically new system concepts to be implemented.

Microgrids are generally defined as low and medium voltage networks with distributed resources, together with local storage devices and controllable loads. They have a total installed capacity in the range of a few kilowatts to one or two megawatts. The unique feature of Microgrids is that, although they operate mostly connected to the distribution network, they can be automatically disconnected to operate in islanding mode, in case of faults in the upstream network and can be resynchronised after restoration of the upstream network voltage. Within the main grid, a Microgrid can be regarded as a controlled entity operated as a single aggregated load or generator and, given attractive remuneration, as a source of power or of ancillary services supporting the main network.

There are significant technical and commercial challenges that have to be addressed in order to achieve active distribution network operation and its coordinated control with the upstream conventional networks.

Technical Content and Scope

This research task has a number of discrete but closely interrelated elements. They include the following:

- **New control concepts and tools** – assessing control behaviours including Microgrids, DC Microgrids and islanding contexts.
- **New technology solutions** – to address the opportunities for innovation noting developments in other fields and sectors as well as bringing forward new thinking for energy efficiency and demand participation.
- **Options for self-healing grids** – achieving new levels of resilience for SmartGrids
- **The role of storage** – assessing the benefits and requirements of storage on the efficient operation of Microgrids and active networks. The design of the storage systems depends on the dynamics of the distributed generation.
- **Network remote control** – new approaches to decentralised operator control. Impact on efficiency and reliability.
- **Advanced demand response and demand side management techniques** – including significant demand/consumer participation, incentives and regulatory frameworks in support of large scale implementation.
- **Quality of supply in general and voltage quality and reliability in particular** – meeting the needs of tomorrow's consumers, including appropriate regulatory frameworks.



Potential Projects and Expected Deliverables

The tables below provide concise outlines of potential research projects related to the content and scope described above.

Innovative Energy Management strategies for large distributed generation penetration, storage and demand response	
Project	Deliverables
New control concepts	This research will address new control concepts and de-centralized management tools, including ICT requirements and advanced power electronics. It will examine the operating boundaries of active networks regarding frequency and voltage, and investigate variable frequency and DC network options. It will assess the possible operational benefits of DC Microgrids. The impact of different generation technologies (different prime mover characteristics) will be considered.
New technology solutions	The opportunities and need for new technologies, intelligent switches, advanced solid state protection, including new protection principles, will be assessed.
Options for self-healing networks	This research will identify and evaluate high level decentralised preventive control methodologies; it will address options for the management of unplanned outages by relying on automated network restoration. High penetration of distributed generation will be given special attention. Network restoration strategies will be developed that include the impact of renewable power sources and demand side participation.
The role of storage	The role and added value of storage as a SmartGrids component at a decentralized level will be determined and quantified.
Network remote control	Develop improved distribution system management through remote control systems. Research to address decentralised energy management, including remote management tools for stand-alone Microgrids.
Quality of supply in general and voltage quality and reliability in particular	This research will focus on achieving improved reliability and voltage quality in the context of increased distributed generation and the framework of the electricity market. The anticipated needs of future customers will be assessed and appropriate regulatory frameworks proposed.
Advanced demand side management techniques	A study based on probabilistic tools will determine the role and added value of Demand Response as a SmartGrids component.

Catalyst and Lighthouse Pilot Projects

- **Catalyst - Technical and commercial interactions** – to explore the possible conflicts between the market goals of different stakeholders and the requirements of effective engineering and operational practices; put in place the changes necessary to address these before they create a barrier to commercial adoption of Microgrids.
- **Catalyst – Structural barriers to high DG penetration** – To resolve key structural issues including: is it necessary to provide a cost/benefit allocation for all stakeholders; what interdependencies may arise between other networks (e.g. natural gas, communication, heat distribution); how should congestion be addressed (through decentralized control?); what are the needs for communication infrastructures, especially if more centralized approaches are adopted; and how to handle efficiently the large data volumes that will be involved?
- **Lighthouse project** – Pilot application of demand side response/demand side management in the environment of a microgrid to demonstrate the efficiency and the customer readiness for participation – here the existing experiences from countries like Norway and Great Britain with DSR in traditional distribution grids and pools of retail customers who can participate, will be taken into account.
- **Lighthouse project** – Demonstrate the effectiveness of demand response in a fully competitive market
- **Lighthouse Project** – Control structure and strategy for the operation of physical island systems with high penetration of DER including storage solutions. Islands can be considered as real life “laboratories” for future smart grids.

Research Task 2.3

The distribution networks of the future – customer driven markets

Objective and Purpose

The objective of this research is to engage the customer in an active role. Electricity markets (being virtual-electronic, contractual or physical) adopt the structure of an internet-like model for its information and trading capability, rather than any rigid hardware format. Power is purchased and delivered to agreed points or nodes. Its source, whether a conventional generator, a renewable energy source or an energy storage unit, is determined by the energy supplier. The system, which is enabled by modern information technology, advanced power electronic components and efficient storage, brings new flexibility and opportunities to all stakeholders.

This research topic will:

- Study and develop, business models.
- Develop ICT solutions for effective customer response programs (working in conjunction with RT 5.2).
- Perform research in customer facilities to identify the energy efficiency and demand response capability to price signals.
- Explore the single and aggregated technical customer potential to participate in energy, balancing and other grid related services.
- Develop, in large field tests customer response programs and tailored tariffs for different customer groups.



- Design and conduct customer awareness and capacity building programs.
- Develop value added services.
- Develop evaluation methodology of customer response programs.
- develop planning tools for customer response programs
- formulate recommendations for the regulatory framework, based on the behavioural aspects of the end-user, leading to base-line analysis so that any pilot installation can be assessed. Attention will be paid to special tariffs for:
 - Treatment of system losses
 - Treatment of reactive power
 - Establishing quality of service parameters and responsibilities of DSO's and DG suppliers

Commercial and Regulatory issues include:

- Coordinated, decentralised energy trading and management.
- Market mechanisms to ensure efficient, fair and secure supply and demand balancing.
- Development of islanded and interconnected price-based energy and ancillary services arrangements for congestion management.
- Secure and open access to the network and efficient allocation of network costs.
- Alternative ownership structures, energy service providers, new roles and responsibilities of supply companies, distribution companies, and consumer/customer.

Technical Content and Scope

This research task has a number of discrete but closely interrelated elements. They include the following:

- **ICT and business solutions for customer driven markets** – addressing customer facing technology and system requirements.
- **Business models for customer driven markets** – identifying the best models for adding customer value.
- **Improving supply reliability and quality** – meeting the needs of tomorrow's consumers.
- **The customer focus in customer driven markets** – delivering solutions that will enable customers to participate and gain the greatest benefit from the new SmartGrids opportunities.
- **Consumer single and aggregated demand response potential** – to identify Demand Response capability to prices and customer potential (market driven models) to participate in energy, balancing and other grid services.

Potential Projects and Expected Deliverables

The tables below provide concise outlines of potential research projects related to the content and scope described above.

The distribution networks of the future – customer driven markets	
Project	Deliverables
ICT solutions for customer driven markets	This research will develop ICT solutions for effective customer response programs (cost effective smart metering systems, integration of smart appliances, smart homes, building automation, smart CHP, fluctuating energy sources and multi-metering; it will identify effective transaction platforms for virtual market places, energy data management, billing and customer care programs, monitoring technology for customer interfaces e.g. displays, web based services, and demand prognosis. Compatibility between different generation equipment should be envisaged. This work is closely linked with co-ordination with RT 5.2.
Business models for customer driven markets	This research will study and develop business models for different market players in different market contexts. It will determine the potential and the options for value added services. Solutions should incorporate self sufficient communities and very small domestic generators.
Improving supply reliability and quality	Research for improved reliability, particularly voltage quality, to address the needs of specific high requirement users such as information, communication, medical systems (Quality on demand).
Consumer single and aggregated demand response potential	This research into customer facilities will identify the demand response capabilities to prices according to the benefits in consuming electricity at a market driven instant in time. It will identify customer potential to participate in energy, balancing and other grid services.

Catalyst and Lighthouse Pilot Projects

- **Catalyst – Regulatory aspects of customer driven markets** – this catalyst project will identify and address the regulatory aspects and potential barriers that could impede the wide spread utilisation of new value added customer developments. It will also consider what customer protection measures might be appropriate and make recommendations to the relevant national consumer bodies in this regard.
- **Lighthouse Project – Active houses** – Install and operate a cluster of houses with aggregated demand response. Provide data capture for performance analysis.



RESEARCH AREA 3 – SMARTGRID ASSETS AND ASSET MANAGEMENT (TRANSMISSION AND DISTRIBUTION)

Introduction

Much of the equipment of the present electricity networks was installed with a nominal design life of about 40 years. Increasingly this equipment is reaching the onset of significant unreliability in its life cycle. Meanwhile, the amount of load has grown beyond what has been predicted when the grid system was planned and designed. Demand has doubled since the 1960s; peak demand and its timing have also changed and will continue to do so in ever less predictable ways. In recent years, environmental policies are encouraging lower carbon generation including renewable energy sources, generally using smaller unit sizes with a far less predictable output. These developments call for the re-engineering of Europe's electricity grids incorporating an innovative response to ensure cost-effective investment.

As very significant investments will be required to renew this infrastructure, it is likely that the most efficient way forward will be to incorporate new technologies and solutions when planning and executing asset renewal. This approach 'designs-in' greater network capability, flexibility and functionality will also enable Europe's networks to respond to the challenges and uncertainties as yet unforeseen.

Asset management is hindered by the traditional paradigms of reliability and long pay back periods (>30 years) associated with capital-intensive plant. The underlying uncertainty associated with recovery of such long-term investments calls for an improved knowledge of the condition and natural life cycles of networks and their components. Any consideration of future electricity networks should take into account also the life-expectancies of future new and refurbished assets – and the functional performance expectations (e.g. reliability, security, availability, accessibility, flexibility, adaptability, safety, environmental impact, aesthetic impact, operational impact, efficiency, and whole-life cost) of all stakeholders with respect to those assets from installation to disposal.

The goal is to realise a robust and inter-operable European grid architecture to support the internal electricity markets and wider EU policy objectives. The European grid can be envisaged as a platform to facilitate the coexistence of intelligent local, self-controlling (smart) grids and active consumer participation, with high amounts of distributed generation on the one hand and large-scale centralised power plants and renewable bulk power injections on the other. The European grid will also have to fulfil control functions that are a significant challenge to decentralise e.g. supply/demand balancing (frequency control).

The interconnection of the system could be increased e.g. by selective reinforcements or by co-ordinated action to create an ultra high voltage ac or dc transmission system architecture. Such development of the network has to take place in the context of a liberalised market with many independent players. It will require both engineering innovation and effective dialogue between the European transmission system operators in order to establish a highly inter-operable European network architecture that is coherent, viable as a business proposition, and consistent with national regulatory and commercial frameworks.

The future European grid will differ from the present in several aspects such as greater large scale cross-border energy trading, the presence of variable large-scale (e.g. off shore) wind power sources, cross-border grid ancillary services (e.g. trading of reserve power) and the interaction of more dispersed generation and demand side management. There will almost certainly be new power flow patterns within Member State grids. Better utilisation of grids and more fluctuating power in-feeds from renewable sources call for improved power flow controls at the transmission level (e.g. HVDC, FACTS), to enable renewable bulk power generation facilities to provide ancillary services and for

methods to safeguard the stability of these more complex and inter-dependent transmission and distribution systems. Regional interconnection and local distribution (e.g. including mini and micro grids) will have to be developed and integrated into the architecture.

Research Task 3.1 Network asset management – Transmission and distribution

Objective and Purpose

The objectives of this research task are two-fold:

- To examine and assess the generic age and load-related asset renewal profiles and the potential scope for synergetic refurbishment and replacement with new and innovative grid equipment so as to bring out the most socio-economic and environmental benefit in the short, medium and long term. This work will assess the opportunities to strengthen the integration of sustainability principles into asset management.
- To identify both synergies and incremental costs of new assets and designs. This allows for a more reliable measure of costs and benefits of introducing new systems compared with traditional like-to-like renewal, and therefore will address the business cases for future asset investment and lifetime management. This is key to the deployment of innovative solutions in a liberalised market context.

Technical Content and Scope

This research task has a number of discrete but closely interrelated elements.

They include the following:

- Advanced methods, models and tools for asset condition monitoring including preventive maintenance.
- New tools and features/scenarios for risk and socio-economic based asset management taking into account the liberalized market and unbundling.
- Assess and quantify the generic business case for innovative assets.
- Demonstration projects using existing network infrastructure.
- New tools for risk and socio-economic aspects of asset management.
- Standardisation of subsystems and equipment.



Potential Projects and Expected Deliverables

The tables below provide concise outlines of potential research projects related to the content and scope described above.

Network asset management – Transmission and Distribution	
Project	Deliverables
Advanced methods, models and tools for asset condition monitoring	Advanced methods/models/tools for asset condition monitoring and diagnostics will be developed to examine and assess equipment residual life including the natural renewal profiles, timescales due to asset condition, preventative maintenance enhancements, utilisation and quality of supply improvement drivers.
New tools for risk and socio-economic based asset management	New tools for risk and socio-economic based asset management will be developed to address present day possibilities of decentralised generation for grid-support, reliability and power quality enhancement, including the development of scenarios for a liberalised power sector.
Assess and quantify the generic business case for innovative assets	Applications will be developed to demonstrate ability of improved methods and tools to deliver better 'knowledge' and management of network assets. This work will include a generic business case for introducing new systems as opposed to like-to-like renewal, and the likely migration path and take-up of innovative technologies. Opportunities to achieve greater sustainability in asset management will be determined.
Demonstration projects using existing network infrastructure	Demonstration projects using existing network infrastructure combined with existing and new asset management tools and technologies. These will be delivered onto appropriate platforms to demonstrate technical, commercial and regulatory feasibility and the business cases for each of the identified stakeholders arising from widespread adoption in a liberalised market. The business case will provide information for all stakeholders, including regulators and confirm that the innovative approaches add value from an overall society perspective.
New tools for risk and socio-economic aspects of asset management	New tools will be developed to account for the present day possibilities of demand resources for grid-support, reliability and power quality enhancement at the point of common coupling.
Standardisation of subsystems and equipment	Develop a standardization approach to subsystems and equipment to enable cost reduction and the wider efficiencies of common standards.

Catalyst and Lighthouse Pilot Projects

- **Catalyst – Business case potential barriers** – this catalyst project will identify and address barriers to the business case for innovative assets and systems that arise inadvertently from current regulatory and commercial frameworks. A major barrier to be overcome is the large amount of technical data but shortage of business case information derived from it.

Research Task 3.2

Transmission networks of the future – new architectures and new tools

Objective and Purpose

To enable the transition towards a pan European transmission network, it is necessary to address planning, economics and security issues for future network architectures. This includes power flow control, the integration of Microgrids operating as virtual power plant, and accommodating the differences between renewable bulk power injections, such as offshore wind, and conventional power plants

Transmission grid congestion, combined with the impact of new organisations and responsibilities for harmonized transmission planning in the liberalised market, is one of the key problems to be addressed by this research task. In this regard, uniform data exchange formats are essential for efficient communication between European system operators, for both normal and contingency situations. The options for establishing a pan European control layer will be developed and assessed for achieving improved power system coordination.

Technical Content and Scope

This research task has a number of discrete but closely interrelated elements. They include the following:

- **Blueprint for pan European interoperability** – options to enable effective cross-border power trading and mutual support for security and quality of supply.
- **Development of intelligent transmission devices and applications** – innovation is required to bring forward plant, equipment and systems and to better use current technology to best effect to achieve the levels of interoperability required. This will include analysis of the grid tasks that need to be addressed.
- **New scientific models and methods** – an inter-operable European grid require new tools for its analysis and effective development.



Potential Projects and Expected Deliverables

The tables below provide concise outlines of potential research projects related to the content and scope described above.

Transmission networks of the future – new architectures and new tools	
Project	Deliverables
Blueprint for pan European interoperability	This research will deliver a Blueprint setting out options for a future pan European power system architecture that will enable much greater interoperability between Member States. It will include time frames, responsible parties, and economic vs. ecological aspects.
Development of intelligent transmission devices and applications	Development of more intelligent devices to control power flows and avoid network congestion that can economically compete with today’s solutions (e.g. PST, HVDC, FACTS, superconducting or other types of current limiters and superconducting cables). Develop innovative and new applications to make efficient use of existing and near market technology as well as new devices.
New scientific models and methods	New scientific models and methods suitable for addressing the inter-operability of the European grid, including simulation tools, forecasting tools for load and RES power manufacturing, testing etc. Wide area monitoring and modern visualisation techniques will be required. The options for establishing a pan European control layer will be developed and assessed for achieving improved power system coordination.

Catalyst and Lighthouse Pilot Projects

- **Catalyst – Harmonisation of transmission market rules, grid codes and planning criteria** (where they impact on European grid inter-operability) – this is an essential enabler for pan European transmission grid interoperability, both for bulk power flows and cross-border ancillary services such as reserve holding.

Research Task 3.3

Transmission networks of the future – Long distance energy supply

Objective and Purpose

Hydrogen has been identified as potentially the best solution to transport available energy from remote sources to continental Europe. Typical examples are geothermal energy in Iceland, hydro power in Russia and Africa, solar power in Africa, and deep off shore wind energy.

Such a development will be studied and compared to the possibilities of long distance transmission of electric power realized either by an AC supergrid (750 kV and higher) or by DC lines (either submarine or overhead, depending on geographic conditions). Whatever the merits, both the “hydrogen option” and the “electric option” require significant technological breakthroughs, or in case of a supergrid development more of an evolutionary kind. For DC lines, more exhaustive and intensive technology developments are required.

Apart from the external challenges, caused by such new connections and bulk energy transfers, internal European grids will need to be modified fundamentally. Large amounts of bulk power will enter mainland Europe at specific points, often where there are no, or very limited, electric power grids available. Similar problems for planning and operations of the electricity networks of the future will arise when nuclear fusion might become available, leading to power plants with a unit size of several GW.

Due to on the one hand very ambitious objectives for renewable and distributed energy resources, and on the other hand possibilities for extremely large power plants, grid development will enter a high degree of uncertainty. Transmission of these extremely high power values (perhaps in the order of tens of GW) to the demand centres presents what is at present an undefined but very real technical challenge. Software development for modelling grid frequency and voltage support with large amount of power generation outside the actual synchronous area will be needed.

The next section, Research Area 4, makes note of recent interest concerning bulk power generation from desert areas. It is reported that these areas could generate very significant quantities of electricity to sell to Europe. This is an example of the potential future requirements that may need to be met by Europe's electricity networks.

Technical Content and Scope

This research task has a number of discrete but closely interrelated elements. They include the following:

- **Tools and Techniques for long distance bulk power supply** – new approaches to address the challenges and uncertainties
- **Technology to facilitate long distance bulk power supply** – power flow control and security
- **Alternative energy carrier** – hydrogen versus electric transmission of bulk power
- **Bulk Power Transfer opportunities** – assessment of feasible options



Potential Projects and Expected Deliverables

The tables below provide concise outlines of potential research projects related to the content and scope described above.

Transmission networks of the future – Long distance energy supply	
Project	Deliverables
Tools and techniques for long distance bulk energy supply	Identify and resolve the issues of large interconnected grid operation with few, extremely large supply in-feed points. Assessment will be made of balancing extremely large unit size generators. Priority assessment will be made of feasible and useful projects, addressing technical, social and economic factors.
Technology to facilitate long distance bulk power supply	Identification and development of technologies will be undertaken to allow the transportation of extremely high power values (10's of GW) over long distances.
Alternative energy carriers	Assessment will be undertaken of energy efficiency of hydrogen versus electric energy for transporting extremely large quantities of power to customers in Europe.
Bulk power transfer opportunities	Assessment will be undertaken of the interconnection opportunities for remote and economic energy sources with Europe (e.g. North Africa, Russia). Conceptualization and feasibility assessment will be made of the various options for the benefit of European customers.

Catalyst and Lighthouse Pilot Projects

- **Catalyst – Technical standards and protocols for bulk power transfer** – new bulk power technology and grid configuration will be beyond traditional experience. It is essential to address the standardisation of equipment and protocols so that implementation is not hampered and to facilitate open systems and competitive products.

RESEARCH AREA 4 – EUROPEAN INTEROPERABILITY OF SMARTGRIDS (TRANSMISSION AND DISTRIBUTION)

Introduction

The issues of system control, long-distance power supply, operation in a market environment and advanced forecasting techniques must be addressed appropriately.

The key goal is to create a flexible and scalable framework for optimally managing and sharing of all network resources involved in the electricity supply chain.

As an example of the importance of examining interoperability, a new area of interest has been identified recently concerning bulk power generation from desert areas. It is reported that deserts

in the Middle East and North Africa could generate very significant quantities of electricity to sell to Europe. According to two German research reports, studies have found that concentrated solar power plants, occupying less than 0.3 per cent of the desert area in the region, could provide 15 per cent of Europe's electricity needs by 2050. This topic is also relevant to Research Task 3.3.

Research Task 4.1

Ancillary services, sustainable operations and low level dispatching

Objective and Purpose

Ancillary services represent an important part of the operational costs of networks and are critical to efficient and secure grid operation. Typical examples are active power balancing (frequency control and stability), voltage control and stability, transmission system security and black start capability. Ancillary services are commonly defined by how they are provided rather than by the service rendered. Most services must be paid for but no generally accepted ancillary service definitions exist. A common question is how markets can be organised for their provision, as often the incumbent is the sole supplier within the control area of a Transmission System Operator (TSO). A further question that needs to be addressed is whether it might become technically possible and economically more viable for TSOs to substitute some ancillary services where appropriate by grid investments leading to the equivalent technical and operational performance. Increased contribution of the Distribution System Operators and Demand Side Response solutions to the ancillary services market, on equal conditions with traditional supplies and its coordination with the TSOs should also be assessed in detail.

Active power balancing has traditionally been the responsibility of the TSOs operating a single, well defined control area. In the liberalized markets with unbundled systems, the trend is towards decoupling the operational part and the market settlement part of balancing. As the capability to balance generation and demand within a control area in the physical sense depends highly on the capacity of the network to accommodate the additional flows due to balancing operations (increase/decrease of power injections / demand curtailment) in real-time, balancing is also closely related to short-term congestion management (intra-day) arising from unplanned deviations from submitted generation and demand patterns. For example when the system frequency drops in the UCTE synchronous area due to a loss of generation in the south of Europe, this can be balanced – within the appropriate time frame – by increased generation or demand reduction (as a paid service) in the north of Europe. With a modification to the present rules such balancing could be supplied by operating reserves in the Nordic balancing power market provided there is available capacity on the (HVDC) links between the two synchronous areas and the necessary commercial framework. The technical feasibility of a common European market for balancing that might result in a better sharing of reserve capacities has considerable potential economic merit and should be studied. The initial works and practices of UCTE (mutual reserves) and Nordel (initial steps towards a common bidding model) already point in that direction.

Issues to be addressed include matters such as:

- General guidelines and rules for renewables and DG planning, integration, scheduling and operation.
- Implementation of ancillary services markets and development of balancing markets.
- SCADA systems dedicated to active networks operation and demand management.
- Wide Area Monitoring to enable improved pan European real-time management, and its deployment.
- New fault management schemes and devices.



- Economic and secure operation of future European power transmission system with a high penetration of renewable and intermittent power generation and active networks
- Development of control systems to be integrated in existing networks, to perform remote management of clusters of DG connected in Microgrids.
- Operational experience of managing an active distribution network and evaluation of potential benefits in real time (e.g. utilisation, delay of reinforcement, reduced losses, customer interruptions, customer minutes lost).
- Meeting customer needs through clear and acceptable prices.

Technical Content and Scope

This research task requires has a number of discrete but closely interrelated elements. They include the following:

- **Ancillary services and balancing** – new thinking for providing these essential services that underpin security and quality of supplies.
- **New technologies for voltage control** – this is an important aspect of the accommodation of bulk power transfers over very long distances.
- **Sustainable operations and low level dispatching** – SmartGrids with high levels of distributed generation and demand side participation, hold significant potential for providing new forms of ancillary services.

Potential Projects and Expected Deliverables

The tables below provide concise outlines of potential research projects related to the content and scope described above.

Sustainable operations, ancillary services and low level dispatching	
Project	Deliverables
Ancillary services and balancing	<p>Definition will be undertaken of internationally acceptable ancillary services according to the benefits they provide to the market, including a study of the value of ancillary services and ways to organise markets for them. Study will be undertaken of technical alternatives to provide them.</p> <p>Study of the feasibility of acquiring ancillary services from beyond an individual control area will be undertaken. Assessment will be made of trans national investment schemes for grid support.</p> <p>Balancing in wide areas through long distance power transmission. Options for power balancing using new technologies such as HVDC, WAMs etc.</p> <p>Assessing will be undertaken of the contribution of lower voltage level grids to provide the ancillary services needed at a system wide level.</p>
New technologies for voltage control	<p>Development of technologies to control reactive power flows will be undertaken. Study will be made of the introduction of power electronic devices for providing reactive power and voltage support (including voltage controlled HVDC systems).</p>
Sustainable operations and low level dispatching	<p>Strategies will be developed for the active control of generation, demand and supply down to the lowest voltage levels.</p> <p>Research will be undertaken into the way modelling, control and resource management methodologies (developed or in development for the telecommunication networks) may be effectively adapted, enhanced and employed in the new electrical systems architectures (Power on Demand, Supply Demand Control, Demand side Management) considering not only the different engineering architectures but also the regulatory environment.</p> <p>Real time market signals to control supply and demand in a user transparent way will be assessed.</p> <p>Study of the introduction of large scale flow control devices (e.g. FACTS-based), down to the lowest voltage level, enabling islanding and resynchronisation in a reliable way.</p>

Catalyst and Lighthouse pilot Projects

- **Catalyst – Address potential commercial and regulatory barriers** – ensure that cross-jurisdiction situations do not result in a barrier to more efficient ancillary services due to inconsistencies in codes or contracts.
- **Lighthouse pilot** – a project to demonstrate how ancillary services could be scheduled on a ‘whole system’ basis involving active devices connected at both transmission and distribution levels.



Research Task 4.2

Advanced forecasting techniques for sustainable operations and power supply

Objective and Purpose

Active network operation requires knowledge of demand requirements and of intermittent generation output instant by instant. On the generation side, total reserve requirements must be understood, arranged in order of response time, including primary reserve (automatic generation control – AGC) and operating reserve (spinning and supplemental). Wind power plants have no significant impact on the demand for AGC but require operating reserve and, when penetration is high, additional secondary reserve. Demand forecasting errors and imperfect day-ahead predictions influence prices on markets for balance energy and ancillary services. The need for supplemental and balancing services depends mainly on the accuracy of prediction and is therefore extremely relevant for wind power situations.

Weather forecasting is extremely important to both demand and generation, (notably photovoltaic and wind energy for the generation side, and requirements for heat, cooling and lighting on the demand side). The algorithms that may assist in demand forecasting from available data are likely to be based on artificial intelligence, neural networks, support vector machines, and others methods that become available for assessing large quantities of data. The link with metering for feedback and self-learning will be essential.

A major aspect of demand prediction is linked with social behaviour. The demand forecast system has to be coupled intelligently with consumer behaviour patterns. For instance the requirement for electric energy in homes may depend on television programmes and public transport energy demand is very much dependent on holidays, seasons and working hours.

Beside the development and improvement of tools to provide load and generation forecasts for local areas, pan-system forecast tools for reliable grid management need to be developed. These tools will make use of temporal-spatial relations of the weather, RES generation outputs, and the behaviour of customers. They will provide network operators with a means to detect power flow bottlenecks and unintended loop flows at an early stage. These tools must be equipped with interfaces that will make them adaptable for grid management (including communication aspects) and calculation tools. Furthermore and as the final aim, an overlay forecast tool should provide an assessment of all RES generation on a European level to support the operation of interconnected control zones.

Technical Content and Scope

This research task has a number of discrete but closely interrelated elements. They include the following:

- **Benchmarking of currently applied tools** – Benchmarking of the existing forecasting methodologies and tools is a key approach for addressing the challenges, combined with determining new approaches to improve efficiency and accuracy.
- **Forecasting techniques: generation production** – the new paradigm for electricity grids introduces increased uncertainty and forecasting will be an important facility
- **Forecasting techniques: weather and demand** – changing demand make up and changing climate conditions require that fresh thinking is developed in this area
- **Forecasting techniques: company and customer aspects** – this work will address the integration of techniques both technically and socially, for generation and demand
- **Advanced modelling tools** – For determining the relationships between environmental variables and electrical energy demand patterns.

Potential Projects and Expected Deliverables

The tables below provide concise outlines of potential research projects related to the content and scope described above.

Advanced forecasting techniques for sustainable operations and power supply	
Project	Deliverables
Benchmark of currently applied tools	Analysis of the practical experience with existing forecasting technologies. Benchmarking of functions and accuracy of existing tools. Development of supplementary requirements and definition of related approaches
Forecasting techniques: generation production	Linking grid tools with weather forecasting for improving renewable generation prediction. Anticipating and assessing the impact of climate change trends relevant to conventional generation, noting particularly the impact on pollution control limits, for example cooling water temperature rise.
Forecasting techniques: weather and demand	Linking weather forecast and demand for electric energy. Setting up advanced analysis tools for finding correlations between relevant variables and electric energy demand forecasting. Anticipating and assessing the impact of trends in climatic change relevant to asset performance. Stochastic optimisation methodologies will be developed, focusing on operational applications. Emerging rainfall forecasting requirements for hydro generation will also be addressed.
Forecasting techniques: company and customer aspects	Well defined and integrated real-time forecasting technologies adaptable to practical, operational situation of the TSOs and DNOs in Europe. Linking the social environment with the electric energy demand based on advanced data mining techniques. Well defined and integrated real-time forecasting technologies capable of integration in each practical, operational situation of the TSOs and DNOs in Europe. Socio-economic evaluation of inputs and benefits of such forecasting technologies. This work will be integrated with Demand Side participation research projects.
Advanced modelling tools	Determination of the relationships between environmental variables and electrical energy demand patterns.

Catalyst and Lighthouse Pilot Projects

- **Lighthouse pilot** – deployment of new techniques/software/hardware at selected comparator sites with common performance assessment techniques and criteria.
- **Lighthouse pilot** – development and deployment of new techniques/software/hardware at multiple TSO locations in Europe to evaluate interoperable forecast tools to support grid management approaching real time.



Research Task 4.3

Architectures and tools for operations, restorations and defence plans

Objective and Purpose

Traditional design of network control systems with centralised structures is not aligned with the paradigm of unbundled electricity systems and decentralized control. In the unbundled and competitive environment systems often work closer to their limits and hence all system resources and services need to be precisely managed to ensure a high level of reliability. The main goal from the viewpoint of defence and restoration is a “*self-healing*” network with a high level of decentralised preventive control and outage management combined with automated network restoration.

It is evident that advanced control elements have to be included, both in the primary power system (e.g. power electronics) and in the secondary control systems (for example wide area monitoring WAM, advanced frequency control, and fault tolerant systems). Overall a decentralised control is required, having the capability to exchange data between the different layers, and able to split and reconnect in a dynamic way. Part of this may be achieved by means of what is now generally referred to as SCADA, but information and control will need to take place in multiple directions.

Technical Content and Scope

This research task has a number of discrete but closely interrelated elements. They include the following:

- **Options for self-healing grids** – achieving new levels of resilience for SmartGrids.
- **Control methodologies for SmartGrid resiliency** – enhancement of existing control arrangements and development of novel approaches for defence plans and definition of common rules for data exchange between control zones.
- **Simulators and training facilities for operators of SmartGrids** – ensuring that the operators can be equipped and trained to respond to the challenges of the new grid paradigm.

Potential Projects and Expected Deliverables

The tables below provide concise outlines of potential research projects related to the content and scope described above.

Architectures and tools for operations, restorations and defence plans	
Project	Deliverables
Options for self-healing grids	Identification and evaluation of high level decentralised preventive control methodologies; options for outage management with automated network restoration. Development of network restoration strategies that include the impact of high penetration of distributed generation and demand side participation. Unexpected network congestion must be dynamically resolved.
Control methodologies for SmartGrid resiliency	Determine how the control of distribution and transmission systems can be integrated into a seamless system capable of improving security and resilience. This will include linking SCADA with advanced IT and metering systems (including the potential for Wide Area Networks, WAN).
Simulators and training facilities for operators of SmartGrids	Development of advanced training equipment (including simulators) to equip operators with the capability for fast and reliable grid operation and restoration.

Catalyst and Lighthouse Pilot Projects

- **Catalyst – Technical and market interactions under contingency conditions** – this catalyst project will identify and address the potential barriers to the deployment of self-healing grid techniques, including closer TNO/DNO operational integration, created by regulatory and commercial arrangements.

Research Task 4.4
 Advanced operation of the high voltage system – seamless SmartGrids

Objective and Purpose

The vision for networks of the future has a blurring of the distinctions between distribution and transmission. No longer will there be a clear boundary based on operational behaviours. Operation of grids in the future will be ‘seamless’ in the sense of having efficient and integrated operation across the different levels of the networks.

Ensuring the operational integrity of electric power grids, particularly as loading approaches system limits, is a high priority challenge. Taking in to account the impact of more advanced, often non-linear elements used in future grids (HVDC, phase shifters, FACTS devices) the real time status of the network becomes ever more problematic to determine, yet is key to secure operation. This problem is exacerbated by the more dynamic, non predictable nature of both generators and demand foreseen in future scenarios. Operators will need to be able to evaluate in real time how close the system



is to its stability limits and whether stability could be lost causing widespread disruption through mechanisms such as voltage collapse or loss of synchronisation.

Throughout the development of active distribution grids and pan European interoperability, communication at every level is essential. The role of ICT (Information and Communication Technology) in adapting electricity networks to real time actions and managing distributed control in the network will be a critical contribution.

Adequate network infrastructure and operations are mandatory prerequisites for the development of the European Internal Electricity Market and for the integration of all resources needed. Integration and centralization of cross-border operations and decentralization of control functions must be enabled by increased TSO/DNO co-operation.

Finally, since the electricity market environment has introduced a range of different and new actors, overall grid system control has become even more complex than in the past. All stakeholders in the electricity power supply chain and all components of power system management including ancillary services, balancing, cross-border flows, should be at least compatible, but in the longer term fully harmonized into one seamless system.

Technical Content and Scope

This research task has a number of discrete but closely interrelated elements. They include the following:

- **Transmission grids real time security assessment** – innovative solutions to the demands of real time security analysis of heavily loaded grids and to the use, in real-time decisions, of dynamic calculations.
- **Transmission grids state estimation** – new techniques for ensuring the quality and accuracy of real time grid information (e.g. greater use of WAM technology).
- **Transmission grids security enhancement** – new techniques for increasing the security of grids and ensuring that operational stability limits are not exceeded.
- **Visualisation:** User interface representation of complex and critical system conditions.

Potential Projects and Expected Deliverables

The tables below provide concise outlines of potential research projects related to the content and scope described above.

Advanced operation of the high voltage system – Seamless Smart grids	
Project	Deliverables
Transmission grids real time security assessment	Develop contingency analysis tools for real time, not only based on static dc load flows, but on real, complex dynamic power flows. Develop software tools for stability analysis including HVDC, FACTS and other power flow control devices. Develop SCADA tools that can handle real time stability, linked to WAM systems. Develop tools for studying grid stability with highly non-linear elements.
Transmission grids state estimation	Enhance the capabilities of real time state estimators.
Transmission grids security enhancement	Assess the possibilities of automatic de- and re-coupling of large grids, coupled either asynchronously or synchronously. Real time coordinated control of flow control devices. Assessment tools for inter TSO flows and coordinated wide-area re-dispatch. Techniques for real time coordinated control of flow control devices. Assess the requirements and solutions for adequately robust ICT systems to support innovative security enhancements.
Visualization	New techniques at the user interface for representation of complex and critical system conditions to enable improved assimilation of information and rapid and accurate decision making for system control.

Catalyst and Lighthouse Pilot Projects

- Catalyst – Inter-company data exchange barriers** – this catalyst project will identify and address the potential barriers to real time data exchanges needed for advanced state estimation; this will require attention to Grid Codes where they intersect with grid boundaries, other regulatory frameworks, and data confidentiality aspects.

Research Task 4.5
Pre-standardisation research

Objective and Purpose

This Research task addresses Pre-Standardisation research for the efficient operation of generators in smart distribution and transmission networks.

Pre-normative research activities and development of a foundation for technical specifications for new European standards which enables the smooth implementation of distributed generation into electricity networks including testing methods, quality and performance requirements, communication



media and protocols, electrical integration and assessment of DER technologies. Also included is preparation work for a basis document for a comprehensive European interconnection standard focussing on interconnection issues to address the diversity of requirements from utilities. The role and influence of new technologies, recent developments in communication as well the new energy providers and services should be taken into account.

Technical Content and Scope

This research task requires the following discrete but closely interrelated elements:

- **Harmonised testing procedures** – develop testing approaches according to the most recent developments in DER technologies
- **Harmonised national standards** – This is an essential step leading to the inter-operability of European grids
- **European interconnection standard** – accelerating the rate of deployment of DER technologies.

Potential Projects and Expected Deliverables

The table below provides concise outlines of potential research projects related to the content and scope described above.

Pre-standardization research	
Project	Deliverables
Harmonised testing procedures	This project will determine the necessary testing procedures and the necessary laboratory infrastructure.
Harmonised national standards	This project will determine the necessary standards needed for inter-operability of the European grid system.
Develop harmonized European DER interconnection standard	This project will examine the user/supplier/network interfaces and make proposals for greater consistency of policy and harmonisation of rules.

Catalyst and Lighthouse Pilot Projects

- **Lighthouse Pilot Project** – Establish European Laboratory facilities for DER testing and Certification.

RESEARCH AREA 5 – SMART GRIDS CROSS-CUTTING ISSUES AND CATALYSTS

Introduction

A number of technological and regulatory developments are envisaged in order to enable the fundamental grid changes described under the previous Research Areas. These developments however, are not limited to one of the previous four Research Areas as such, but are cross-cutting issues.

Therefore, these have been grouped as a separate Research Area.

The first, second and fourth are internal to the SmartGrids of the future: “Customer Interface Technologies and Standards”, “Information and Communication” and “Storage and its Strategic Impact on the Grid”.

The third is a more diverse issue, i.e. “Multi-Energy Carrier Systems”, where future, possibly very intensive and close links with other energy carriers will be studied. The fifth addresses “Regulatory Incentives and Barriers” being a key issue in the deployment of SmartGrids that will support the customer centric, market driven route to the future. The sixth task addresses the underpinning technologies that are necessary for the significant level of innovation that will be needed.

Research Task 5.1 Customer interface technologies and standards

Objective and Purpose

Electronic meters and Automated Meter Management systems (AMM), characterised by providing two way communications, represent the enabling advanced technologies to enable customer choice in the energy field of the future. Metering services are a potential enabler for the gateway for customer access to the “active network”, to the transaction platform for business and to decentralized facilities.

Multidirectional communication and control systems for horizontal and vertical integration will be needed to facilitate customer participation and DG to system operation. Communications will also be an enabler for new control functionality and ancillary services.

A comprehensive survey of metering systems and communication technologies is a necessary first step in this evolution. It will be followed by the formal definition of protocols, data formats and all the necessary modules of integrated open-access Integrated Automatic Meter Management Systems. Among the functions covered will be automatic meter reading, remote (re)connection, flexible tariff management, demand side management and demand response to market and network signals, and integration of Distributed Generation. Prototypes will be developed and tested so inter-operability between different options can be validated. Following this, lighthouse projects will be deployed in the field to test functionality and customer response to the systems. No particular communication medium (PLC, GSM, radio, etc.) is precluded. While it is the functionality (rather than the type) that is important, Power Line Carrier (PLC) is an option that warrants development as a potential competitor to other channels such as GSM. PLC has particular application where commercial alternatives are not available, such as in geographically remote areas. PLC dimensions for further development include application on underground networks and the impact of network voltage level changes.

The objective is to define, develop and test a standard-based and interoperable customer-side energy management system capable of managing local power demand and re-dispatching local loads, so that the customer can take full advantage of real-time energy prices, network status information, and other market based opportunities, with particular focus towards Distributed Generation and demand side participation. The system will be based on a new, non-proprietary open architecture



that will support bi-directional communications between all parties involved and the meter, and through the meter with manageable home appliances and distributed generation devices.

The impact is potentially very significant as it will lift the barrier to wide deployments of Automatic Meter Management Systems. This will be facilitated by defining and validating an open access architecture, thus free from proprietary ties, that will lead to low-cost metering systems that are interoperable and therefore could be deployed in large scale roll-outs.

Technical Content and Scope

This research task has a number of discrete but closely interrelated elements. They include the following:

- **Defining the customer gateway** – Electronic meters and Automated Meter Management systems (including real time pricing, interface with home and process automation, data collection, and billing).
- **Communication layer definitions** – defining and documenting the communications system.
- **Communications system solutions** – a key component to active grids and dispersed generation management ensuring device inter-operability for open systems between vendors.
- **Architecture proving study** – laboratory proving of the component elements.
- **Field test and validation** – field proving of the concepts and consumer interactions.

Potential Projects and Expected Deliverables

The tables below provide concise outlines of potential research projects related to the content and scope described above.

Customer interface technologies and standards	
Project	Deliverables
Defining the customer gateway	Defining the SmartGrids requirements for Electronic meters and Automated Meter Management systems; evaluating existing technologies and proposing refinements and new devices (such as integrating this functionality into the active network management node).
Communication layer definitions	The deliverable for this project is a full documented specification of all communication layers, protocols, messages, routing algorithms, modulation techniques, and all required components.
Communications system solutions	This project will address device inter-operability for open systems between vendors
Architecture proving study	The deliverable for the next phase is the successful demonstration of the architectures on a laboratory test-bed.
Field test and validation	The deliverable for the final phase is a field test that will validate not only the architecture but also the efficiency of the functionality provided.

Catalyst and Lighthouse Pilot Projects

- **Lighthouse pilot** – a joint project across Member States with common assessment techniques and criteria

Research Task 5.2

The networks of the future—information and communications

Objective and Purpose

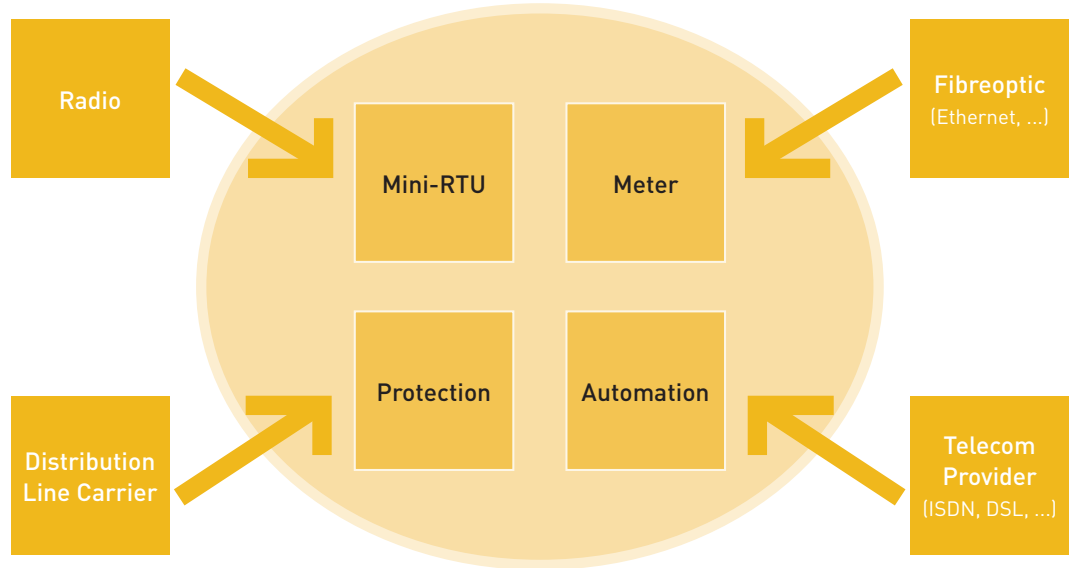
In order to realise the concepts dealing with customer integration, effective Demand Side Management and active networks there is a fundamental need to study, develop and implement economic, efficient and reliable data information exchange. Present communication architectures have evolved to serve centralised monitoring, control and command. In future it is likely that distributed architectures will require greater flexibility for information flows. Speed of delivery will depend on the actual need (high priority data for real-time control versus lower priority data required for market signals, and low priority for asset management and planning activities), with high and low bandwidth data links being optionally depending on the function. Currently installed infrastructures will need to evolve into more flexible communication solutions due to the potentially high cost of replacement. The proposed communication solutions must be scaleable (suitable for the needs of small utilities from control centre to household meter, to large utilities and industrial users) as well as reliable, providing redundancy and self-healing properties. A large scale penetration of communication facilities at the distribution level offers the following advantages.

- Improved distribution system management through remote control opportunities – e.g. shortening supply interruptions after fault clearing from ~1 h (on average) to only a few minutes by remote reading of short circuit indicators and control of disconnectors.
- Decentralized energy management – e.g. provision of system services through clustering of dispersed and renewable generation, storage and demand side management with off-line planning and on-line dispatch of power exchange with the neighbouring systems.
- Metering services – e.g. automated billing “from meter to cash”, energy cost optimization, home automation. The communication developed should be based on standardized data models and services – independent of the data sources whether substation, power station, distributed generation unit, industrial or household customer.

Technical Content and Scope

This research task has a number of discrete but closely interrelated elements. They include the following:

- **Communications system solutions** – a key component to active grids and dispersed generation management
- **Device inter-operability** – more open systems between vendors



Potential Projects and Expected Deliverables

The tables below provide concise outlines of potential research projects related to the content and scope described above.

The networks of the future –information and communications	
Project	Deliverables
Communications system solutions	Research the solutions for reliable communication networks dedicated to system security and operation. Prototype a modern control centre with advanced electronic metering systems (EMS) control functions, with tools for planning and operation support. Research the use of existing communications infrastructures to be enhanced to deliver the performance required by the new concepts.
Device inter-operability	Develop concepts for interoperability of devices and systems across vendors. Research the opportunities for increased use of “off-the-shelf” components, reducing overall cost and making resilience more possible.

Catalyst and Lighthouse Pilot Projects

- **Catalyst – Open systems and communication protocols** – it is important that communications and information transfer developments maintain open access and standardisation principles. This catalyst project will identify and address potential barriers and ensure that developments harmonise with international practices and development trends.

Research Task 5.3 Multiple energy carrier systems

Objective and Purpose

While the main focus of this research agenda is on the development of the electricity networks for the future, the existence of the other energy distribution mechanisms cannot be neglected. These are the networks for natural gas, district heating, biomass or other fossil or renewable fuels. Also attention has to be paid to the possible development of a hydrogen infrastructure. There is no common understanding of which network, or which combination of networks, offers the best technical, the best environmental and the overall most economic solution. It is still an open question, whether all networks are competing with each other or whether a specific combination would offer synergetic potential. Chances for merging different technologies for the supply of primary energy (natural gas, synthetic fuels), electricity and heat are obviously there, but there is no instrument to assess the individual competitiveness in a given situation (rural, densely populated, Northern Europe, Southern Europe).

The goal of the research is to identify an optimisation of several infrastructures, together or combined, respecting their internal dependencies while seeking efficiencies through the elimination of unnecessary duplications. Furthermore all renewable sources generate electricity and, since electricity cannot be stored in large quantities directly, it can be envisaged that a coupling with the gas infrastructure with its inherent storage capabilities may be advantageous.

Technical Content and Scope

This research task has a number of discrete but closely interrelated elements. They include the following:

- **Multi energy system modelling** – new models for assessing the interconnection of differing energy systems.
- **Options for optimization** – identifying the most effective strategies planning and operating strategies (energy efficiency, economical and environment).
- **Regulatory issues:** coordinated regulatory steps towards multi energy carrier systems.



Potential Projects and Expected Deliverables

The tables below provide concise outlines of potential research projects related to the content and scope described above.

Multiple energy carrier systems	
Project	Deliverables
Multi energy system modelling	Development of integrated energy system models and technical methods to “couple” or “interconnect” the different infrastructures while respecting their internal dependencies. The modelling will address the new situation and the dynamics of interchanges.
Options for optimisation	The models will be used to identify which strategy is technically, economically and/or environmentally advantageous. This will reveal the degree and influence of control needed when the regional or national infrastructures are different under various circumstances.
Regulatory issues	A harmonised approach to multiple energy carrier systems needs to be determined and progressed towards implementation.

Catalyst and Lighthouse Pilot Projects

- **Catalyst – Potential regulatory barriers to storage** – identify and address the regulatory aspects of storage including licensing and standards.
- **Lighthouse Pilot** – Study of the coupling of energy carrier systems in selected cities and buildings (gas/electricity, district heating/electricity, cooling/heating/electricity of, say, a large office building).

Research Task 5.4 Storage and its strategic impact on grids

Objective and Purpose

This research task will examine the strategic role and added value of storage on electricity grids. Storage could in principle be installed and shared at different levels from central installations (several hundred MW) to dispersed installations across the networks or at the customer (from 10 MW down to the kW range, for instance plug-in hybrid cars).

Transport systems of the future may include electric vehicles that require rapid recharging, placing new and considerable demands on grid infrastructure, supply quality and network control. This transportation aspect of storage will be considered to assess its strategic impact.

Research in the following issues has to be performed:

- Economic aspects of storage (e.g. comparison with peak hours energy prices).
- Definition of interfaces and data flow between storage unit and DER, efficient battery management according to an energy management strategy.

- Large field testing of alternative configurations of storage integrated with central and distributed generation, electricity networks and customers, and including economic and technical assessments.
- Study of ancillary services provision using storage.
- Study of electric vehicle impacts on grids, e.g. recharging demand.

Technical Content and Scope

This research task has a number of discrete but closely interrelated elements. They include the following:

- **Assessment of storage options** – strategic application and economic aspects and interfacing requirements
- **Field testing in operational conditions** – to confirm technical and economic characteristics

Potential Projects and Expected Deliverables

The tables below provide concise outlines of potential research projects related to the content and scope described above.

Storage and its strategic impact on grids	
Project	Deliverables
Assessment of storage options	This research will determine the key application and economic aspects of storage (e.g. impact on electricity grids and comparison with peak hours energy prices). It will identify the requirements at interfaces for data flow between storage units and DER, for efficient storage device management, and for energy management strategies. The opportunities for using storage to provide ancillary services to the grids will also be assessed. The impact of electric vehicle recharging will be assessed at a strategic level. Identification of commercial and regulatory barriers preventing storage solutions from being adopted.
Field testing in operational conditions	Under this phase of the work, field testing of different configurations of storage will be undertaken including economic, regulatory and technical evaluations.

Catalyst and Lighthouse Pilot Projects

- **Lighthouse pilot** – manufacturer sponsored storage plant installations in high value applications with detailed monitoring of technical and commercial performance.



Research Task 5.5 Regulatory incentives and barriers

Objective and Purpose

A number of regulatory issues are identified elsewhere in this Strategic Research Agenda as catalyst projects associated with specific Research Tasks. The overall target is the optimization of the overall value chain of supplying electricity to the final consumers. In addition the following regulatory issues will be addressed as they are important enabling issues for the wide deployment of innovation.

- Integration of balancing and intra-day markets across Europe (needed for inter-operability and for balancing large amounts of wind power).
- Harmonization of regulatory frameworks – particularly addressing renewables support in relation also to the renewables certificate market.
- User/Supplier/Network interfaces – e.g. the energy and capacity issues that arise if domestic users sometimes produce and sometimes consume electricity e.g. where domestic CHP or PV distributed generation is installed.

Technical Content and Scope

This research task requires has a number of discrete but closely interrelated elements. They include the following:

- **Balancing and intra-day market integration** – a harmonised position across Europe needs to be assessed.
- **Incentive frameworks** – assessing the various arrangements that are in place, and the barriers that may exist under the liberalised market and the opportunities for greater harmonization. To that end, the possibility of common EU-wide renewables support through a renewables certificate markets should be investigated and solutions proposed. Also it is necessary to investigate and address the perversities that can arise where multiple incentives and penalties exist for the deployment of new and innovative solutions.
- **Energy/capacity issues at consumer network interfaces** – assessing and addressing the differences across Europe and the scope for greater consistency and harmonization.

Potential Projects and Expected Deliverables

The tables below provide concise outlines of potential research projects related to the content and scope described above.

Regulatory incentives, barriers and incentive frameworks	
Project	Deliverables
Balancing and intra-day market integration	This project will examine the opportunities for closer integration of balancing markets across Europe. This will address the need to facilitate greater inter-operability noting particularly the requirements for balancing large amounts of wind power.
Incentive frameworks	This work will address the opportunities for greater harmonization of regulatory frameworks – particularly addressing renewables support and identifying barriers to adoption with proposals to overcome those barriers. Within that context possible solutions shall be determined for EU wide renewables support by means of a certificates system/ market shall be investigated.
Energy/capacity issues at consumer network interfaces	This project will examine the user/supplier/network interfaces and make proposals for greater consistency of policy and harmonisation of rules. In particular it will bring forward proposals to address the energy and capacity issues that arise where domestic users sometimes produce and sometimes consume energy e.g. the impact of micro-generation and demand side participation.

Catalyst and Lighthouse Pilot Projects

- Note - This Research Topic is a cross-cutting Catalyst Project in its own right.

Research Task 5.6
Underpinning technologies for innovation

Objective and Purpose

The scale of the SmartGrids challenge facing Europe’s electrical energy networks is such that radical innovation will be required. Incremental development based on existing practice will not be sufficient. In the short term, the very considerable base of innovative techniques and technologies that have been developed in universities and research organisations over the last 20-30 years can and should be exploited. However it is necessary to continually refresh and replace this knowledge base and also to make use of developments in other rapidly advancing technology areas (e.g. in Information and Communication Technology). Thus, this Task will address those underpinning technologies that are likely to make a material contribution to innovative electricity networks. It will operate through a combination of technology assessment and detailed research on specific technologies.

The transfer of data outside companies, for example network parameters and operational parameters, can be problematic particularly in a liberalised market environment. This may apply to transfer



between companies for planning or real time operations, or between companies and researchers for R&D activities such as developing and verifying models, tools and control systems. New approaches are needed in this domain if future developments such as greater pan-European interoperability are not to be compromised.

Technical Content and Scope

This research task requires has a number of discrete but closely interrelated elements. A key initial task is to review the various international Technology Assessments (Road Maps etc) that exist to identify the most promising technology developments and to understand the views of others.

They include the following:

- **Technology assessment** – Initially a comprehensive assessment of those technologies capable of fundamental change of energy networks will be undertaken.
- **Advanced materials** – Based on the Technology Assessment, research will be undertaken in advanced materials to meet the SmartGrids challenges for networks.
- **Advanced communications** – The rapid advances in communication technologies will be kept under constant review to assess their application for electricity networks.
- **Advanced data management and processing** – The opportunities for improved data accessibility, data management and processing, particularly on Distribution Networks will be investigated.

Potential Projects and Expected Deliverables

The tables below provide concise outlines of potential research projects related to the content and scope described above.

Customer interface technologies and standards	
Project	Deliverables
Assessment of underpinning technologies for electricity networks.	Review will be undertaken of the various international technology assessment and road maps. The areas of fundamental research will be prioritized for their likely benefit to networks
Advanced materials for overhead transmission	High temperature conductors suitable for use on both transmission and distribution circuits to increase their thermal ratings will be determined; also improved insulations systems.
Advanced materials for underground/submarine transmission	High temperature conductors and insulation systems for cable transmission will be assessed. Also high temperature superconducting cables and Gas Insulated Lines
Advanced ICT	Development will be taken beyond current Wide Areas Measurement and Phasor Measurement systems to determine integrated ICT solutions for both transmission and distribution networks. New solutions will be developed for data access, transfer and management between all parties in the liberalised sector, including researchers.

Catalyst and Lighthouse pilot Projects

- **Catalyst – Network data accessibility** – Assessment and solution proposals to address the difficulties of achieving transfer of network data, for example between companies, and between companies and researchers.
- **Lighthouse pilot** – Evaluation of standards and practices for high temperature overhead conductors (Transmission and Distribution).
- **Lighthouse pilot** – Increased rating of submarine ac transmission circuits.
- **Lighthouse pilot** – Evaluation and best practice guide for Phasor measurement units (particularly on distribution networks).





THE STRATEGIC
RESEARCH AGENDA –
MAKING IT HAPPEN



INTRODUCTION

The aim of the SRA is to stimulate the research needed to enable SmartGrids to become a reality, bringing benefits to customers and wider stakeholders at all levels, private and public, national, European and international. It is evident that the investment in research needed will be substantial and cannot be realised efficiently by individual companies or even by individual countries.

In this respect, SmartGrids can be viewed as a realisation of the Lisbon agenda, where a firm collaboration between public and private research funds is envisaged in order to make Europe the most efficient economy by 2010. There are very real economic, societal and technical issues at stake in securing a reliable and sustainable electric energy supply to meet future challenges. This task cannot be overestimated and is a key issue for agendas internationally; here Europe can make a material contribution in a global context.

As a first step in making this a reality, actions should commence in 2007 around three basic pillars: create engagement and commitment of stakeholders participating in SmartGrids; establish funding mechanisms to mobilise private and public investments; and align EU, national and regional research programs.

The Framework Programme (FP) is the European Union's main instrument for funding research and development. The FP is proposed by the European Commission and adopted by Council and the European Parliament following a co-decision procedure. FPs have been implemented since 1984 and cover a period of five years with the last year of one FP and the first year of the following FP overlapping. The current FP is FP6, which will be running up to the end of 2006.

It has been proposed for FP7, however, that it should run for seven years. It will be fully operational as of 1 January 2007 and will expire in 2013. It is designed to build on the achievements of its predecessor towards the creation of the European Research Area, and carry it further towards the development of the knowledge economy and society in Europe.

FRAMEWORK PROGRAMME 7 – OBJECTIVES

The Community has the objective of strengthening the scientific and technological bases of the Community's industry and assuring a highly competitive capability. To this end, the Community shall promote all the research activities deemed necessary, in particular by encouraging undertakings, including small and medium size enterprises, research centres and universities in their research and technological development activities.

Taking into account the research needs of all Community policies and building upon wide-spread support from European industry, the objectives of FP in the period 2007 to 2013 should build upon the achievements of the sixth Framework Programme in creating the European Research Area and carry them further towards the development of a knowledge-based economy and society in Europe. Among these objectives, the following actions are particularly important:

- Trans-national co-operation at every scale across the EU should be supported.
- The dynamism, creativity and excellence of European research at the frontier of knowledge should be enhanced.
- The human potential in research and technology in Europe should be strengthened qualitatively and quantitatively.
- The research and innovation capacities throughout Europe should be enhanced and their optimal use ensured.

In order to realise these objectives, the following Specific Programmes have been proposed: trans-national co-operation on policy-defined themes ("Co-operation"), investigator-driven research based on the initiatives of the research community ("Ideas"), support of individual researchers ("People"), and support of research capacities ("Capacities").

The Specific Programme "Co-operation" supports all types of research activities carried out by different research bodies in trans-national co-operation. Eligible actions range from collaborative research projects, the creation of networks of excellence and the coordination of research programmes. International co-operation with non-EU countries is also included. Accounting for over half FP7's total budget, the "Co-operation" Programme aims to gain or consolidate leadership in key scientific and technology areas.

FRAMEWORK PROGRAMME 7 – THEMES

The Specific Programme "Co-operation" is sub-divided into nine thematic areas (the themes) corresponding to major fields of the progress of knowledge and technology, where research must be supported and strengthened to address European social, economic, environmental and industrial challenges. The overarching aim is to contribute to sustainable development. Each one will be operationally autonomous while at the same time ensuring coherence within the programme and allowing for joint activities cutting across different themes through, for example, joint calls.

Energy is one of these nine themes, which includes nine Research Activities, among these Smart Energy Networks aims to increase the efficiency, safety and reliability of the European electricity and gas systems and networks e.g. by transforming the current electricity grids into an interactive service network and to remove obstacles to the large-scale deployment and effective integration of distributed and renewable energy sources.

A key difference between FP7 and its predecessors is the focus on developing research that meets the needs of European industry, through the work of Technology Platforms and a selected number of potential Joint Technology Initiatives. The FP7 assessment process will take particular account of this. The concept of the SmartGrids platform has been developed in such a way that this industrial involvement has been embedded from the start.

Although the first call for the 7th Framework Programme is now well on its way to being published by the end of 2006, the discussions with the platform have had a major impact on its content.

SMARTGRIDS STRATEGIC RESEARCH AGENDA AND RELATED RESEARCH INITIATIVES

To make the research agenda a reality, it is important that it is taken into consideration by all stakeholders, international, European and at the Member State level. It is clear that the financial impact is such that it cannot be addressed by the European initiatives alone, certainly not within the EU 7th Framework Programme.

Clearly, the SmartGrids platform has to study carefully the output coming from a number of key research programmes supported within the fifth and sixth framework programmes.

Within the European Commission, several Directorates-General address subjects that are in one way or another linked with the work content of the SmartGrids platform. Clearly, DG-RTD and TREN play a key role, for instance with the RDD&D and TEN-E projects, and DG-Competition monitors the



development of the energy market. DG-Environment supports research having links with electric energy generation and its use. Links can also be found with research in the ICT society.

The IEA (International Energy Agency) has launched ENARD (Electricity Networks Analysis, Research and Development) dealing with related problems. The grid operators also undertake analysis in a coordinated, international manner (ETSO, UCTE, Nordel). Other organisations such as Eurelectric should be noted here too. The European regulators via CEER and ERGEG have indirect impact on the abilities of regulated network companies to be involved in research activities.

Within the international framework, closer links will be established between SmartGrids and key players like CIGRE, CIRED, IEEE, standardisation institutes, and EPRI. The links with research centres of the major material and service providers is another key element in undertaking the necessary RDD&D activities.

Last but not least, the SRA has to be considered carefully in conjunction with national research initiators. Endorsement of the SRA by them will be a key factor for the success of the programme of work. The constructive support that the platform has received from the Mirror Group continues to be of great value in this regard.

At the high level, the Technology Platform proposes to monitor the progress of projects supported by FP7 and encourage stakeholder participation and co-funding, as well as track relevant activities outside Europe. Particular attention will be given to the progress of the SRA 'Catalyst projects' as these will be critical to ensuring that successful research is translated into commercial application. It will report on the success of FP7 projects in meeting the Platform's goals and provide mechanisms for professional networking and interchange in the SmartGrids arena. The Technology Platform has taken careful steps to ensure that Technical issues have been addressed in conjunction with Regulatory and Commercial aspects; this approach is key to successful deployment in a liberalised energy sector and will be perpetuated as part of the Platform's high level role going forward.





THE SRA AND NATIONAL AND REGIONAL PROGRAMMES



The Member and Associated States are represented in the SmartGrids' Mirror Group as set out in Appendix 4. A modern, smart electrical grid infrastructure is one of the priorities in Europe's energy policy. It is necessary to make a reliable, sustainable, secure and affordable electricity supply possible. The Strategic Research Agenda (SRA) is seen as a living document and can serve as the primary RTD guide towards a modern electricity infrastructure.

The SRA can give Europe an impulse towards securing the supply of electricity and bringing the European industry into a leading global position. To achieve this, it is recommended to use the SRA as a strategic input to the EC framework Programmes. The Member States should use the SRA as an input to determine national and regional funding for programs and/or projects in this field.

In the EU, a significant part of public RTD funding comes from national and national and regional governments. Reaching a point where this spending becomes more in line with the scope of SRA requires not only the willingness of the States, but also a great effort. To support this process an ERA-Net Project involving a number of members should be established.

The Mirror Group members are asked to promote the SRA in their countries. The R&D activities should be aligned with the SRA wherever possible. This can improve the effectiveness of the work and the benefits will be achieved faster.

The Mirror group has developed a table that gives an overview of the SRA topics and the links with projects in progress national and regional levels. This will be made available on the SmartGrids website.





ANNEXES



SUMMARY OF CATALYST AND LIGHTHOUSE PILOT PROJECTS

Research Task	Catalyst Projects Addressing potential barriers to adoption of Research Task outputs
<p>RT 1.1 – The distribution networks of the future – new architectures for system design and customer participation</p>	<p>Barriers to new technology deployment – this project will identify potential regulatory, statutory or technical standards barriers that are likely to prevent the rapid take-up of new solutions for Smart Distribution Infrastructure. It will bring forward solutions and work with relevant sector and EU parties to dismantle unnecessary barriers. It will also identify the necessary verification, testing and certification methods for innovative plant and equipment.</p>
<p>RT 1.2 – The distribution networks of the future – new tools to study DG integration in system planning</p>	<p>Manufacturer/network company interfaces – this catalyst project will identify the interface aspects between network companies and material manufacturers to ensure harmonization of expectations and requirements. For example data/information exchanges. Design the specifications of DG to meet the dynamic requirements in order to follow a prescribed schedule.</p>
<p>RT 2.1 – The networks of the future – new tools to study the operational integration of distributed generation and active customers</p>	<p>Multi-source data harmonisation – wide area and multi system models will require data from different data bases sources and information systems. This catalyst project will identify potential barriers and determine options for their solutions.</p>
<p>RT 2.2 – Innovative energy management strategies for large distributed generation penetration, storage and demand response</p>	<ul style="list-style-type: none"> • Technical and commercial interactions – to explore the possible conflicts between the market goals of different stakeholders and the requirements of effective engineering and operational practices; put in place the changes necessary to address these before they create a barrier to commercial adoption of Microgrids. • Structural barriers to high DG penetration – to resolve key structural issues including: is it necessary to provide a cost/benefit allocation for all stakeholders; what interdependencies may arise between other networks (eg natural gas, communication, heat distribution); how should congestion be addressed (through decentralized control?); what are the needs for communication infrastructures, especially if more centralized approaches are adopted; and how to handle efficiently the large data volumes that will be involved.
<p>RT 2.3 – The distribution networks of the future – customer driven markets</p>	<p>Regulatory aspects of customer driven markets – this catalyst project will identify and address the regulatory aspects and potential barriers that could impede the wide spread utilisation of new value added customer developments. It will also consider what customer protection measures might be appropriate and make recommendations to the relevant national consumer bodies in this regard.</p>
<p>RT 3.1 – Network asset management – Transmission and distribution</p>	<p>Business case potential barriers – this catalyst project will identify and address barriers to the business case for innovative assets and systems that arise inadvertently from current regulatory and commercial frameworks. A major barrier to be overcome is the large amount of technical data but shortage of business case information derived from it.</p>

Research Task	Catalyst Projects Addressing potential barriers to adoption of Research Task outputs
RT 3.2 – Transmission networks of the future – new architectures and new tools	Harmonisation of transmission market rules, grid codes and planning criteria (where they impact on European grid inter-operability) - this is an essential enabler for pan European transmission grid interoperability, both for bulk power flows and cross-border ancillary services such as reserve holding.
RT 3.3 – Transmission networks of the future – long distance power supply	Technical standards and protocols for bulk power transfer – new bulk power technology and grid configuration will be beyond traditional experience. It is essential to address the standardisation of equipment and protocols so that implementation is not hampered and to facilitate open systems and competitive products.
RT 4.1 – Ancillary services, sustainable operations and low level dispatching	Address potential commercial and regulatory barriers – ensure that cross-jurisdiction situations do not result in a barrier to more efficient ancillary services due to inconsistencies in codes or contracts.
RT 4.3 – Architectures and tools for operations, restorations and defence plans	Technical and market interactions under contingency Conditions – this catalyst project will identify and address the potential barriers to the deployment of self-healing grid techniques, including closer TNO/ DNO operational integration, created by regulatory and commercial arrangements.
RT 4.4 – Advanced operation of the high voltage system – seamless smart grids	Inter-company data exchange barriers – this catalyst project will identify and address the potential barriers to real time data exchanges needed for advanced state estimation; this will require attention to Grid Codes where they intersect with grid boundaries, other regulatory frameworks, and data confidentiality aspects.
RT 5.2 – The networks of the future –information and communications	Open systems and communication protocols – it is important that communications and information transfer developments maintain open access and standardisation principles. This catalyst project will identify and address potential barriers and ensure that developments harmonise with international practices and development trends.
RT 5.4 – Storage and its strategic impact on grids	Potential regulatory barriers to storage – identify and address the regulatory aspects of storage including licensing and standards.
RT 5.5: Regulatory incentives and barriers	Note – this Research Task is a cross-cutting catalyst project in its own right.
RT 5.6 – Underpinning technologies for innovation	Assessment and solution proposals to address the difficulties of achieving transfer of network data, for example between companies, and between companies and researchers.



Research Task	Lighthouse Pilot Projects Establishing demonstration and proving of innovative developments in operational situations
RT 2.2 – Innovative energy management strategies for large distributed generation penetration, storage and demand response	<ul style="list-style-type: none"> • Pilot application of demand side response / demand side management in the environment of a microgrid to demonstrate the efficiency and the customer readiness for participation – here the existing experiences from countries like Norway and Great Britain with DSR in traditional distribution grids and pools of retail customers, who can participate, will be taken into account. • Demonstrate the effectiveness of demand response in a fully competitive market. • Control structure and strategy for the operation of physical island systems with high penetration of DER including storage solutions. Islands can be considered as real life “laboratories” for future smart grids.
RT 2.3 –	Active houses – install and operate a cluster of houses with aggregated demand response. Provide data capture for performance analysis.
	A project to demonstrate how ancillary services could be scheduled on a ‘whole system’ basis involving active devices connected at both transmission and distribution levels.
	<ul style="list-style-type: none"> • Deployment of new techniques/software/hardware at selected comparator sites with common performance assessment techniques and criteria. • Development and deployment of new techniques/software/hardware at multiple TSO locations in Europe to evaluate interoperable forecast tools to support grid management approaching real time.
	Establish European laboratory facilities for DER testing and certification.
	Joint project across Member States with common assessment techniques and criteria.
	Study of the coupling of energy carrier systems in selected cities and buildings (gas/electricity, district heating/electricity, cooling/heating/electricity of, say, a large office building)
	Manufacturer sponsored storage plant installations in high value applications with detailed monitoring of technical and commercial performance.
	<ul style="list-style-type: none"> • Evaluation of standards and practices for high temperature overhead conductors (Transmission and Distribution) • Increased rating of submarine ac transmission circuits. • Evaluation and best practice guide for phasor measurement units (particularly on distribution networks)

LIST OF ACRONYMS

AC	Alternating Current
AGC	Automatic Generation Control
AMM	Automated Meter Management
CEER	Council of European Energy Regulators
CHP	Combined Heat and Power
CIGRE	International Council on Large Electric Systems
CIRED	Congrès International des Réseaux Electriques de Distribution, in English International Conference on Electricity Distribution.
CO₂	Carbon Dioxide
DC	Direct Current
DER	Distributed Energy Resources
DG	Distributed Generation
DNO	Distribution Network Operator
DSM	Demand Side Management
DSR	Demand Side Response
ENARD	Electricity Networks Analysis, Research and Development project
EPRI	Electric Power Research Institute
ERGEG	European Regulators' Group for electricity and gas
ETP	European Technology Platform
ETSO	European Transmission System Operators group
EU	European Union
FACTS	Flexible AC Transmission Systems
FP	Framework Programme
GDP	Gross Domestic Product
GIL	Gas Insulated Line
GIS	Geographic Information Systems
GSM	Groupe Spécial Mobile – the European group set up to establish European mobile telephony protocols and which was later anglicised to Global System for Mobiles to preserve the acronym.
HVDC	High Voltage Direct Current



ICT	Information and Communication Technology
IT	Information Technologies
IEA	International Energy Agency
IEEE	The Institute of Electrical and Electronics Engineers
NO_x	Nitrogen Oxides
NORDEL	Organisation for Nordisk Elsamarbeid. Nordel is a body for co-operation between the transmission system operators (TSOs) in the Nordic countries (Denmark, Finland, Iceland, Norway and Sweden)
PLC	Power Line Carrier
PST	Phase Shifting Transformer
R&D	Research and Development
RES	Renewable Energy Source
RDD&D	Research, Development, Demonstration and Deployment
RTD	Research and Technological Development
SO₂	Sulphur Dioxide
SCADA	Supervisory Control and Data Acquisition
TSO	Transmission System Operator
UCTE	Union for the Co-ordination of Transmission of Electricity
VPP	Virtual Power Plants
WAN	Wide Area Networks
WAM	Wide Area Measurement

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In April 2006 the Advisory Council of the Technology Platform of Future Electricity Networks presented their vision for SmartGrids. The well-spring for that vision arises from the joint challenges of lower carbon energy sources and the renewal of Europe's electricity grids that are fast approaching the end of their design lives. This presents landmark opportunities for the generation and use of electricity and the transport systems by which it is conveyed. Electricity market liberalisation provides a new context for these major developments and has been a key consideration in setting out a path for effective and efficient changes for the benefit of customers and all wider stakeholders.

Following the publication of the SmartGrids vision the Advisory Council, supported and advised by 200 professionals from research institutes, universities, industry, regulators and utilities, have developed this Strategic Research Agenda (SRA) to be a resource for European and National programmes. It is a strategic document, intended to inform and inspire, facilitating the alignment of Research Programmes within the EU and its Member States.

