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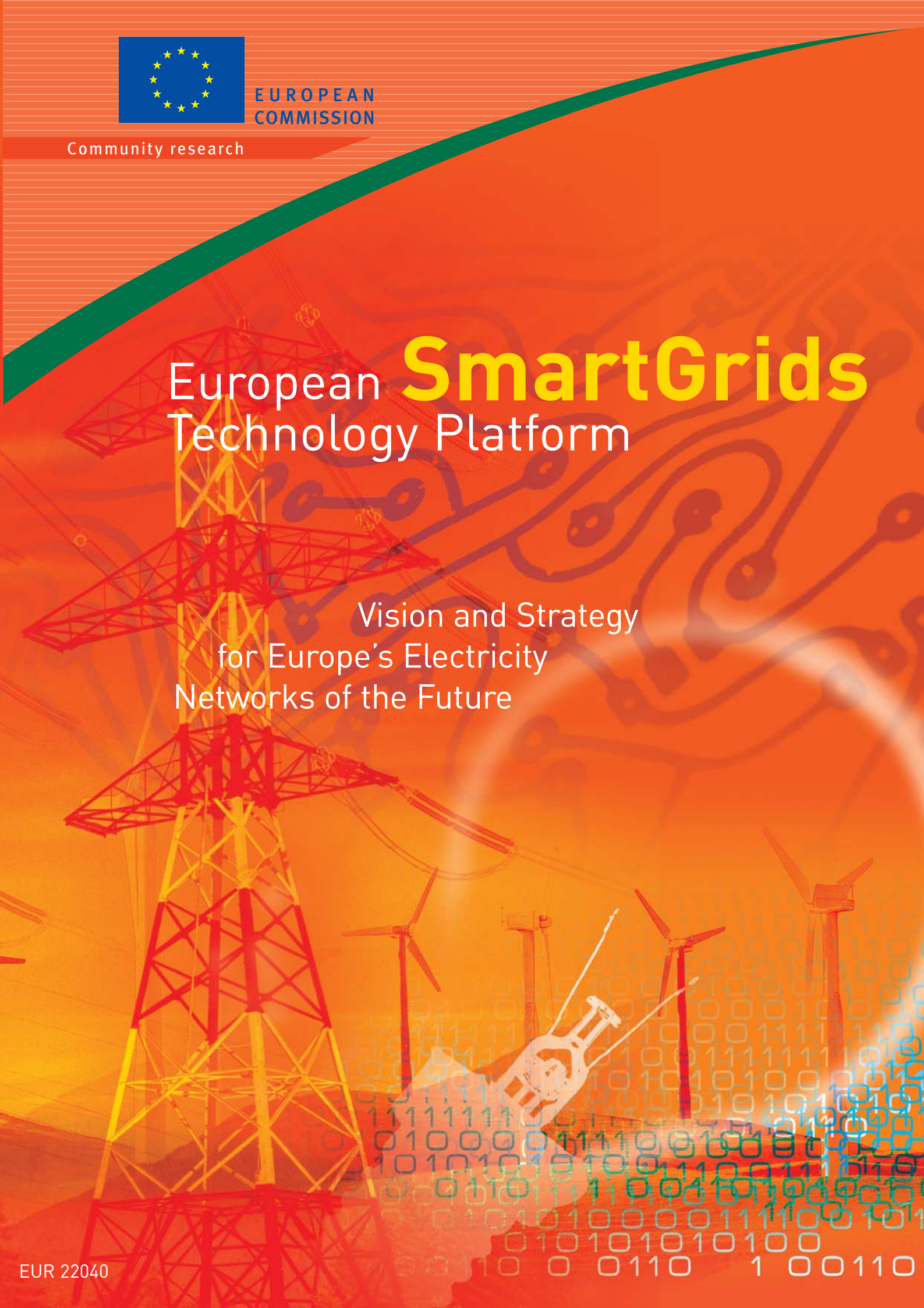
European SmartGrids Technology Platform

Vision and Strategy for Europe's Electricity Networks of the Future



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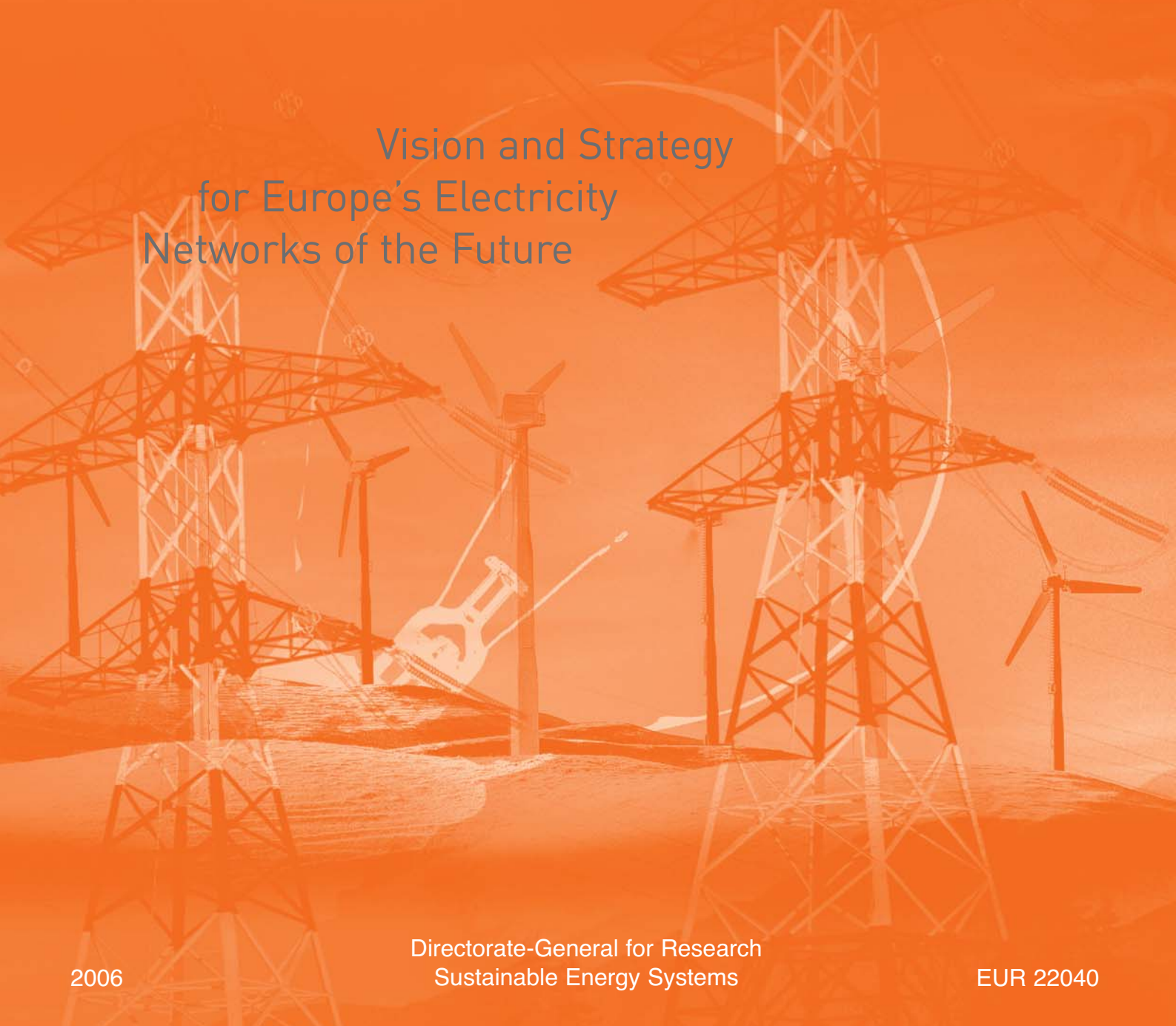
European SmartGrids Technology Platform

Vision and Strategy for Europe's Electricity Networks of the Future



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Foreword

Efficient transmission and distribution of electricity is a fundamental requirement for providing European citizens, societies and economies with essential energy resources. The need to renew Europe's electricity networks, meet growing electricity demand, enable a trans-European electricity market and integrate more sustainable generation resources (including renewable sources), presents major challenges. Research and development have an important role to play in addressing them.

The move towards a more integrated European Research Area has resulted in a better pooling of dispersed resources and expertise. Under the EU's Sixth Framework Programme (FP6), important projects and actions have benefited from improved information exchange, innovative solutions and co-ordination. Technological advances in transmission and distribution of electricity supported by FP6 are not an exception: they are stimulating the generation of new knowledge, innovation and European integration.

The vision for electricity networks of the future presented here by the Advisory Council of the technology platform "SmartGrids" proposes that Europe should move forward in different ways in these important fields. This vision would lead to new products, processes and services, improving industrial efficiency and use of cleaner energy resources while providing a competitive edge for Europe in the global market place. At the same time, it would ensure the security of the infrastructure, helping to improve the daily lives of ordinary citizens. All this makes smart grids an important element for achieving the largest knowledge-based economy in the world.

In this highly regulated sector, efficient knowledge sharing and the pooling of research and technological development resources of all disciplines are now critical. Through co-operative RTD actions, both within and outside the Union, Europe is creating a critical mass of ideas and solutions strengthening European excellence. The setting up of this Technology Platform for the "Electricity Networks of the Future" is one way of responding to these objectives. It, will hopefully bring together all parties involved in smart grids to develop a Strategic Research Agenda.

I wish this initiative every success and expect to see the activities of the platform leading to greater energy sustainability in Europe and beyond.

Janez Potočnik
Commissioner for Science and Research

1. Executive Summary

Europe's electricity networks have provided the vital links between electricity producers and consumers with great success for many decades. The fundamental architecture of these networks has been developed to meet the needs of large, predominantly carbon-based generation technologies, located remotely from demand centres. The energy challenges that Europe is now facing are changing the electricity generation landscape.

The drive for lower-carbon generation technologies, combined with greatly improved efficiency on the demand side, will enable customers to become much more inter-active with the networks. More customer-centric networks are the way ahead, but these fundamental changes will impact significantly on network design and control.

In this context, the European Technology Platform (ETP) SmartGrids was set up in 2005 to create a joint vision for the European networks of 2020 and beyond. The platform includes representatives from industry, transmission and distribution system operators, research bodies and regulators. It has identified clear objectives and proposes an ambitious strategy to make a reality of this vision for the benefits of Europe and its electricity customers.

The energy policy context

The European Commission's 2006 Green Paper "A European Strategy for Sustainable, Competitive and Secure Energy" emphasises that Europe has entered a new energy era. The overriding objectives of European energy policy have to be sustainability, competitiveness and security of supply, necessitating a coherent and consistent set of policies and measures to achieve them.

Europe's electricity markets and networks lie at the heart of our energy system and must evolve to meet the new challenges. The future trans-European grids must provide all consumers with a highly reliable, cost-effective power supply, fully exploiting the use of both large centralised generators and smaller distributed power sources throughout Europe.

A shared vision

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

The vision embraces the latest technologies to ensure success, whilst retaining the flexibility to adapt to further developments. Network technologies to increase power transfers and reduce energy losses will heighten the efficiency of supply, whilst power electronic technologies will improve supply quality. Advances in simulation tools will greatly assist the transfer of innovative technologies to practical

application for the benefit of both customers and utilities. Developments in communications, metering and business systems will open up new opportunities at every level on the system to enable market signals to drive technical and commercial efficiency.

Making it happen

Enabling Europe's electricity grids to meet the challenges and opportunities of the 21st century and fulfil the expectations of society requires intensified and sustained research efforts. It is essential that this takes place in a coherent way addressing technical, commercial and regulatory factors, to minimise risk and allow business decisions to be made by companies in an environment of stability.

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 inter-operability of automation and control arrangements.

These and other elements will be addressed through a Strategic Research Agenda that the Technology Platform will produce in 2006.

Delivering the benefits

The projects resulting from the SmartGrids vision will stimulate innovation in new network and associated information technologies. The benefits of new technologies will have a positive effect for Europe's citizens and for international business. Job opportunities will be broadened as the networks require workers with new skills and integration across new technology areas.

SmartGrids will help achieve sustainable development. Links will be strengthened across Europe and with other countries where different but complementary renewable resources are to be found. An increasingly liberalised market will encourage trading opportunities to be identified and developed. SmartGrids networks will, in addition to electricity flows, establish a two-way flow of information between supplier and user.

For a successful transition to a future sustainable energy system all the relevant stakeholders must become involved: governments, regulators, consumers, generators, traders, power exchanges, transmission companies, distribution companies, power equipment manufactures and ICT providers. Coordination at regional, national and European levels is essential and the SmartGrids Technology Platform has been designed to facilitate this process.

2. The origins of SmartGrids

*The **SmartGrids** European Technology Platform for Electricity Networks of the Future began its work in 2005. Its aim was to formulate and promote a vision for the development of Europe's electricity networks looking towards 2020 and beyond. What lies at the heart of this vision and what does it hope to achieve?*

SmartGrids is a new concept for electricity networks across Europe. The initiative responds to the rising challenges and opportunities, bringing benefits to all users, stakeholders and companies that perform efficiently and effectively.

The vision will input into European and national research, development and demonstration programmes over the coming years. This will be done via **an integrated and innovative approach** to technical, commercial and regulatory dimensions. The vision will stimulate constructive dialogue between all stakeholders involved in the electricity sector and help to ensure the European public and private investments required for the implementation of the research and development (R&D) strategies.

The time is now

The electricity grids that serve European consumers today have evolved over more than a hundred years. However, new challenges arising from market liberalisation and technical breakthroughs call for **fresh thinking**. Current grids have served well but will not be adequate in the future: grids must ensure **secure and sustainable** electricity supplies throughout Europe, take advantage of new technologies and comply with new policy imperatives and changing business frameworks.

Responding to needs

The electricity sector faces new challenges and opportunities which must be responded to in a vision of the future:

- **User-centric approach**: increased interest in electricity market opportunities, value added services, flexible demand for energy, lower prices, microgeneration opportunities;

- **Electricity networks renewal and innovation**: pursuing efficient asset management, increasing the degree of automation for better quality of service; using system wide remote control; applying efficient investments to solve infrastructure ageing;

SmartGrids' mission is to create a shared vision which:

- *enables Europe's electricity grids to meet the challenges and opportunities of the 21st century;*
- *fulfils the expectations of society;*
- *strengthens the European business context for the electricity sector and its international opportunities.*

- **Security of supply**: limited primary resources of traditional energy sources, flexible storage; need for higher reliability and quality; increase network and generation capacity;

- **Liberalised markets**: responding to the requirements and opportunities of liberalisation by developing and enabling both new products and new services; high demand flexibility and controlled price volatility, flexible and predictable tariffs; liquid markets for trading of energy and grid services;

- **Interoperability of European electricity networks**: supporting the implementation of the internal market; efficient management of cross border and transit network congestion; improving the long-distance transport and integration of renewable energy sources; strengthening European security of supply through enhanced transfer capabilities;

- **Distributed generation (DG) and renewable energy sources (RES)**: local energy management, losses and emissions reduction, integration within power networks;

- **Central generation**: renewal of the existing power-plants, development of efficiency improvements, increased flexibility towards the system services, integration with RES and DG;

- **Environmental issues**: reaching Kyoto Protocol targets; evaluate their impact on the electricity transits in Europe; reduce losses; increasing social responsibility and sustainability; optimising visual impact and land-use; reduce permission times for new infrastructure;

- **Demand response and demand side management (DSM)**: developing strategies for local demand modulation and load control by electronic metering and automatic meter management systems;

- **Politics and regulatory aspects**: continuing development and harmonisation of policies and regulatory frameworks in the European Union (EU) context;

- **Social and demographic aspects**: considering changed demand of an ageing society with increased comfort and quality of life.

According to the International Energy Agency (IEA), European electricity **consumption is projected to increase** at an average annual rate of 1.4% up to 2030 and **the share of renewables in Europe's electricity generation will double**; from 13% now to 26% in 2030.

SmartGrids is a necessary response to the environmental, social and political demands placed on energy supply.

SmartGrids will use revolutionary new technologies, products and services to create a strongly user-centric approach for all customers.

A broad spectrum of stakeholders

As markets across Europe become more liberalised and dynamic, an increasing number of people are implicated in the future of electricity supply. From government members to everyday users, every stakeholder will help to shape the SmartGrids system. What are the different needs and responsibilities that will feed into the project design?

Users: Users' needs include quality of service and **value for money**. In the coming years, users' expectations will broaden and will include value added services, energy services on demand and total connectivity. They will be asking for connection of in-house generation, the ability to sell surplus generation back to the grid, real time tariffs and the freedom to choose their suppliers.

Electricity network companies: Network owners and operators are called upon to fulfil customers' expectations in an efficient and cost effective way. They are required to undertake necessary investments to guarantee high levels of **power quality and system security**, while assuring adequate remuneration for their shareholders. Investment remuneration and stable regulatory frameworks will be necessary for a "level playing field" competition in a liberalised market.

Customers, providers, researchers and lawmakers are all implicated in the future of electricity provision.

Energy service companies: Companies will have to satisfy the growing needs of users. Some users will seek simple "turnkey" products. Cost efficiencies and savings will need to be made visible, in monetary terms. This must be accompanied by **an increase in services delivered** and a reduction of intrusion upon the customer, such as for maintenance of the system. In general, a trend will be observed from the present "infrastructure-driven" to progressive "service-driven" paradigms in the European electricity supply industry.

Technology providers: Significant technology and business changes lie ahead and equipment manufacturers will be key players in developing innovative solutions and in achieving their effective deployment by working with the grid companies. As with grid companies, technology providers will have important investment decisions to make. A shared vision will be critical to ensuring sound strategic developments that provide **open access, long-term value and integration** with existing infrastructure. Innovation will be needed in relation to networks, demand, and for generation, both distributed and centralised, as grid system operational characteristics change.

Researchers: The research community has a critical role to play: without research there is no innovation and without innovation there is no development. Cooperation among universities and research centres, utilities, manufacturers, regulators and legislators must be fostered, not only for the **successful development** of new technologies but also to overcome non-technical barriers.

Traders: Free trade throughout Europe will be facilitated by **open markets**, harmonised rules and transparent trading procedures. Congestion management and reserve power must be resolved for a fully integrated European market. Customers will benefit from the opportunity to choose the energy supplier that best suits their requirements.

Generators: Electricity grids are complex, integrated systems and there is a **sensitive interaction** between generators, the grid systems, and the demands. It will be important for the future to ensure the continuing close involvement of generation companies, understanding the electrical characteristics of their equipment, and their operational dynamics.

Thanks to SmartGrid technologies, products and services, European Companies will be able to get ahead in international business.

Regulators: The European market for energy and related services should be supported by a stable and clear regulatory framework, with well-established and **harmonised rules** across Europe. Regulatory frameworks should have aligned incentives which secure a grid with increasingly open access, a clear investment remuneration system and keep transmission and distribution costs as low as possible. Effective and efficient innovation should be rewarded.

Governmental agencies: Governments and lawmakers will have to prepare **new legislation** to take into account apparently contradictory goals. Increasing competition is expected to keep a downward pressure on energy prices, but a more environmentally friendly energy mix may bring cost challenges. Legislation will be affected by innovative technologies, the evolution of grid organisations, the requirement for greater flexibility and increased cross-border trading and by the need to ensure economic development, greater competitiveness, job creation and high quality security of supply (both short and long term) in the EU.

Advanced electricity service and solution providers: New businesses will be provided with the choice between own (on-site) generation, including sales of surplus to the grid, and the purchase of electricity from supplier companies. They will have the opportunity to offer demand side response products and services to the grid. In the case of electricity-intensive industries, their decisions will be influenced by market price changes. Thus businesses will be seeking **a wider range of solutions** than is currently available.

Preparing adequate workforce and continuous education: Power engineering is perceived to be old-fashioned. Particular attention will need to be addressed to solve the shortage of **skilled staff** with manufacturers, grid operators, regulators, etc. A multidisciplinary approach (engineering, economic, regulatory-legislation) has to be envisaged.

Co-ordination between actors is essential in maintaining a secure supply, an efficient network operation and a transparent market. Common technical rules and tools need to be adopted by the different players regarding data exchange, modelling grids, ancillary services and their users. They must also share a vision of electrical system performance. A pan European approach is essential since, even if the technology is available and the vision and motivation exist, a smart power grid will not be implemented unless there can be **a collective evolution into the future**.

SmartGrids: The Vision

Europe's electricity networks in 2020 and beyond will be:

- **Flexible**: Fulfilling customers' needs whilst responding to the changes and challenges ahead;
- **Accessible**: Granting connection access to all network users, particularly for RES 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;
- **Economic**: Providing best value through innovation, efficient energy management and 'level playing field' competition and regulation.

Looking to the future

Whilst current networks presently fulfil their function, they will not be sufficient to meet current challenges and policy imperatives. It is essential that, right across Europe, actors are able to agree upon a vision of the future that will ensure needs are addressed. It is essential that clear objectives are defined and a strategy for making vision reality is adopted. What do the different players hope to achieve?

KEY AIM: To develop a strategy for research, development and demonstration

Today's electricity networks provide an essential service for society, built to ensure access for every single electricity customer. They form **a vertically integrated scheme with centralised generation**; distributed consumption; limited interconnection capabilities between the control areas; and commercial and regulatory frameworks that are not harmonised for mutual advantage.

In response to new challenges and opportunities, electricity networks have begun to evolve. The aim is that they accommodate **more decentralised generation services**, with many actors involved in the generation, transmission, distribution and operation of the system. At the same time, centralised generation and high voltage bulk-transmission of electricity will continue to play a major role for the foreseeable future.

A shared vision

In order to manage changes successfully, a shared vision must be created. This will encapsulate the possibilities and areas where Research and Technological Development will bring significant benefits.

A shared vision of the opportunities for all stakeholders remains an essential ingredient in successfully achieving efficient liberalised markets. Such a vision is fully compatible with a competitive commercial environment: it reduces investment risk;

SmartGrids: Objectives

- To develop a **shared vision** for the future which encourages the engagement of multiple, independent parties;
- To identify **research needs** and build support for an increased public and private research effort on 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 implementation of the strategic research agenda and deployment plan.

Commercialisation, whether in Europe or internationally, can only take place when innovation has been proved in the demanding world of real operational service.

ETP-SmartGrids has been structured to ensure that cutting edge research is rapidly evaluated and deployed.

encourages the development of common technical protocols and standards for open access; and avoids the likelihood of stranded assets and technology "dead ends".

The vision will be made real using the latest technologies, within commercial and regulatory frameworks. The process will require a trans- European approach along with harmonised frameworks and standards that promote innovation and its deployment.

It is important to recognise the scope of the ambitions for SmartGrids: it is not a purely technical venture. The overall goal of the project is **to develop a strategy for research, development and demonstration**. This will empower network companies, allowing them to respond to the considerable challenges that they will face in the coming decades.

It is essential to have an integrated approach covering technical, commercial and regulatory factors along with the development of a shared vision. This will minimise risk and allow business decisions to be made by independent companies in an environment of stability.

Networks are evolving: SmartGrids incorporates the latest technologies to ensure that they will be flexible, accessible, reliable and economical.

SmartGrids:
Why take action now?

New technologies- for generation, networks, energy storage, load efficiency, control and communications, liberalised markets and environmental challenges- require a shared vision and strategic implementation plan for Europe's grids. This will ensure that the networks of the future meet the needs of tomorrow's customers and a broader spectrum of stakeholders.

The driving factors requiring action now are:
- Increasing **participation of customers** in the energy field;
- **European and national policies** encouraging lower carbon generation, new and renewable energy sources and more efficient use of heat energy;
- The need to understand and manage the technical challenges and opportunities for **integrating new generation technologies** into Europe's grids;
- The **need for investment** in end-of-life grid renewal in an innovative way to better position the networks for the next 50 years of operation;
- The need to **handle grid congestions** with market based methods;
- The desire to deliver benefits to customers at the earliest opportunity;
- The need to **reduce uncertainty** and risk to businesses making investment decisions;
- The **progress in technology**, which allows improvements in operation and new services at reasonable costs.

Successful development and deployment of a vision for electricity grids has application beyond Europe. There is significant benefit for jobs in Europe and for European businesses internationally. A prerequisite is the adequate technical staff trained by high level universities and other technical schools.

SmartGrids Vision: Recognising its scope

The SmartGrids vision goes far beyond a technical proposition:
- It's not about academic research alone;
- It's not a centralised plan for Europe's grids;
- Its not only concerned with distribution grids;
- It's not just about the trans-European electricity network;
- It's not a vision for specific infrastructure projects or about the details of investment funding and risk management;
- It's not about emission trading markets or addressing security of primary fuel;
- It's not about detailed research proposals, but is rather about research themes and topics.

3. Driving factors in the move towards SmartGrids

The current climate demands change in the way electricity is supplied. As the internal market develops, European citizens will start to benefit from greater choice and lower costs. Fossil fuels are running out and the security of electricity supplies is under threat. Environmental issues have moved to the fore and the EU must meet targets set. Precisely which factors must future grids accommodate and how will they do so?

Global investments required in the energy sector for 2003-2030 are an estimated $16 trillion, according to the IEA. **In Europe alone**, some **€500 billion** worth of investment will be needed to upgrade the electricity transmission and distribution infrastructure.

- **The European Internal Market**: This market evolution, associated with an efficient regulatory framework, will **promote economic growth** and play a key role in the EU's competitiveness strategy. Increasing competition will encourage efficiency and spur on technological progress and innovation. As a result, the internal market is expected to provide **benefits to the European citizens** such as a wider choice of services and downward pressure on electricity prices.

- **Security and Quality of Supply**: Modern society **depends critically** on a secure supply of energy. Countries without adequate reserves of fossil fuels are facing increasing concerns for primary energy availability. Furthermore, the ageing infrastructure of Europe's electricity transmission and distribution networks is increasingly threatening security, reliability and quality of supply.

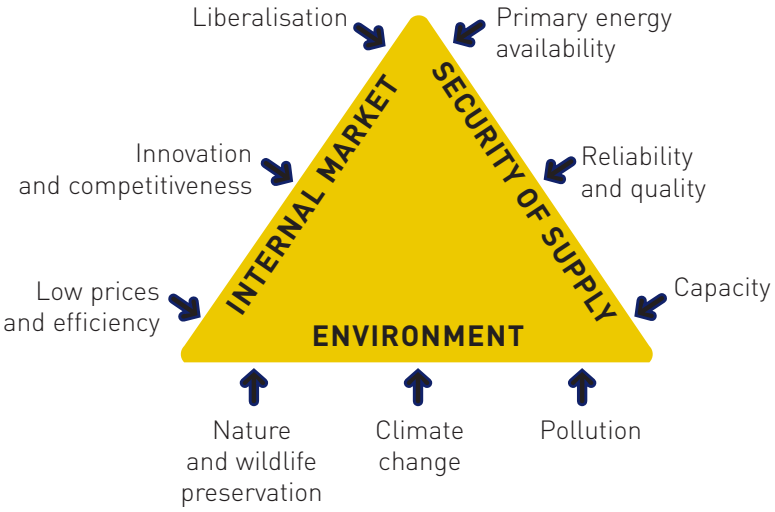
  It is time to redesign electricity grids which take account of new roles and challenges. Significant investment will be required to develop and renew these infrastructures: the most efficient way to achieve this is by **incorporating innovative solutions**, technologies and grid architectures.

- **The Environment**: Besides issues of primary energy supply, the major disadvantage of fossil fuels is that they emit CO_2, SO_2, NO_X and other pollutants when burnt to generate electricity. The greenhouse gases contribute to climate change, which is recognised to be one of the greatest environmental and economic challenges facing humanity. Research is needed to help identify the most cost-effective technologies and measures that will enable the EU to **meet its targets** under the Kyoto Protocol and beyond.

The electricity network of the future must be secure, cost-effective and gentle on the environment.

New generation technologies

Hydro- and nuclear power plants are well established methods of generation with nearly zero greenhouse gas emissions. Accommodating change may be possible by incorporating new generation technologies. One successful example of this is the **wind farm** and there are many other distributed generation technologies that are either already commercial or close to being on the market. These have to be introduced into existing transmission and distribution networks, which were not initially designed to incorporate these kinds of generation technology in the scale that is required today.



These forms of generation have **different characteristics** from traditional plants. Apart from large wind farms- possibly off-shore- and large hydropower plants, this type of generation tends to have much smaller electricity outputs than the traditional type. Some of the newer technologies also exhibit greater intermittency.

It is difficult to predict the impact of distributed generation on the future energy mix. However, if EU energy policy continues to promote the increased use of DG there is an urgent need to transform Europe's grids to allow for the **larger scale deployment** of these new technologies. Distributed generation can have a material impact on local grids, causing reversal of power flows and variation of local grid voltages and other technical parameters necessary for secure operation. Effective and economic solutions to these issues have yet to be developed.

Targets to be reached

Meeting these challenges requires intensified and prolonged research efforts. The Lisbon Strategy, a major priority of the European Union, outlined the intention to boost competitiveness, job creation, social cohesion and **environmental sustainability** throughout the continent. Both research and energy are key elements of this Strategy. The 2002 Barcelona European Council goal of increased RTD expenditures from the present 1.8% of EU GDP to 3% of EU GDP by 2010, increasing the private funding proportion from 55% to two-thirds, was put in place to **close the competitiveness gap** between the EU and its major competitors.

Eliminating uncertainty

There is uncertainty in many aspects of future grids:

- In the primary energy mix
- In the electricity flows created by the liberalised market
- Of the instantaneous power output of many RES
- In regulatory frameworks and investment remuneration in innovation

The best strategy for managing these uncertainties is to build **flexibility and robustness** into the networks. This will be achieved through the research and development of SmartGrids and will also allow the identification and address of any regulatory uncertainty in a systematic way.

SmartGrids:
Enhancing grid flexibility & robustness

- Create a **toolbox of proven technical solutions** that can be deployed rapidly and cost-effectively, enabling existing grids to accept power injections from distributed energy resources without contravening critical operational limits (such as voltage control, switching equipment capability and power flow capacity);
- Establish **interfacing capabilities** that will allow new designs of grid equipment and new automation/control arrangements to be successfully interfaced with existing, traditional, grid equipment;
- Ensure **harmonisation of regulatory and commercial frameworks** in Europe to facilitate cross-border trading of both power and grid services (such as reserve power, for instance Nordic hydropower), ensuring that they will accommodate a wide range of operating situations without creating perverse incentives or other unintended consequences;
- Establish shared technical standards and protocols that will **ensure open access**, enabling the deployment of equipment from any chosen manufacturer without fear of lock-in to proprietary specifications. This applies to grid equipment, metering systems, and control/automation architectures;
- Develop **information, computing and telecommunication** systems that enable businesses to utilise innovative service arrangements to improve their efficiency and enhance their services to customers.

A united front

Coordination at regional, national and European levels is needed to reform and strengthen the public research and innovation systems; facilitate public-private partnerships; ensure a favourable regulatory environment; help to develop supportive financial markets; and create attractive education, training and career conditions to achieve this goal.

In this way, research and innovation performance will be boosted and will lead to **more growth, jobs and competitiveness** for Europe. In addition, research and innovation will improve the sustainability of the EU, leading to win-win solutions for economic growth, social development and environmental protection.

Research is needed to help identify the most cost-effective technologies and measures. This would enable Europe to meet its targets under the Kyoto protocol and beyond.

Coordination across Europe will boost research and innovation performance, leading to more growth, jobs and competitiveness.

4. From today to tomorrow

Important changes must be incorporated into the nature of electricity supply, as demand rises and traditional resources are depleted. Major players have been brought together to define a clear vision of the future, but these ideas must be translated into practical solutions. The present grid system has served well, so what will be different about the new networks?

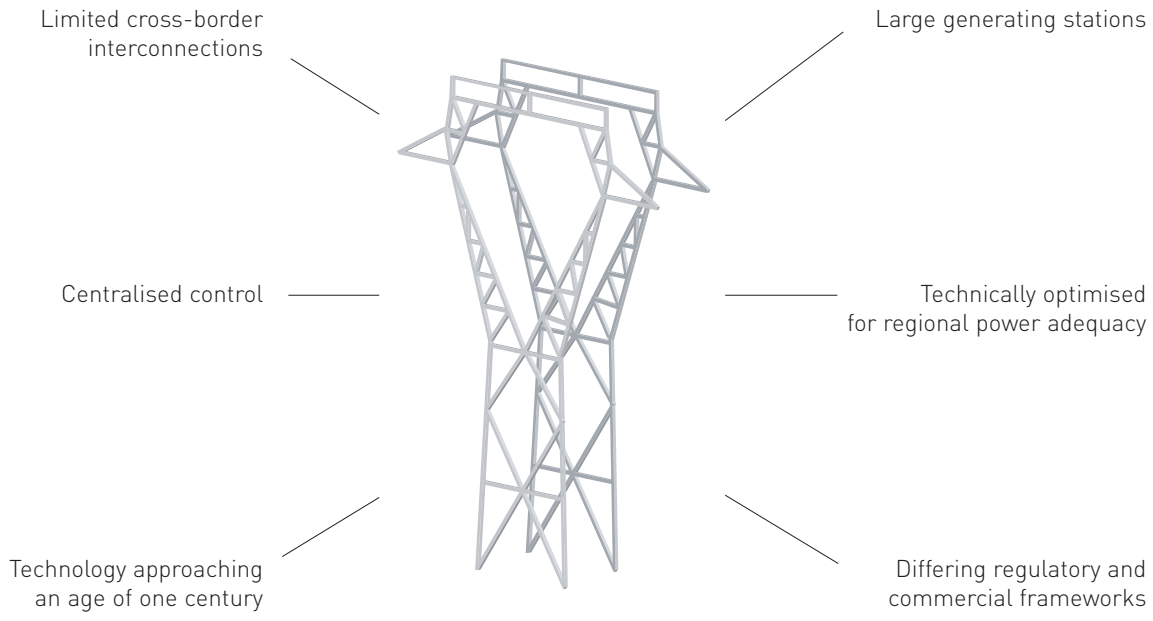
Today's grids are predominantly based on **large central power stations** connected to high voltage transmission systems which, in turn, supply power to medium and low-voltage local distribution systems. The transmission and distribution systems are commonly run by natural monopolies (national or regional bodies) under energy authorities' control. In contrast, the generation sector is increasingly competitive.

Future models for electricity grids have to allow for changes in technology, values, the environment and commerce.

The overall picture is still one of **power flow in one direction** from the power stations, via the transmission and distribution systems, to the final customer. Dispatching of power and network control is typically the responsibility of centralised facilities, controlling several regions from one place. There is little or no consumer participation and no end-to-end communications.

Traditional grid design has evolved through economies of scale in **large centralised generation** and the geographical distribution of generation resources (locations near coalfields, cooling water, hydro resources, etc). The grids were optimised for regional

The Traditional Grid

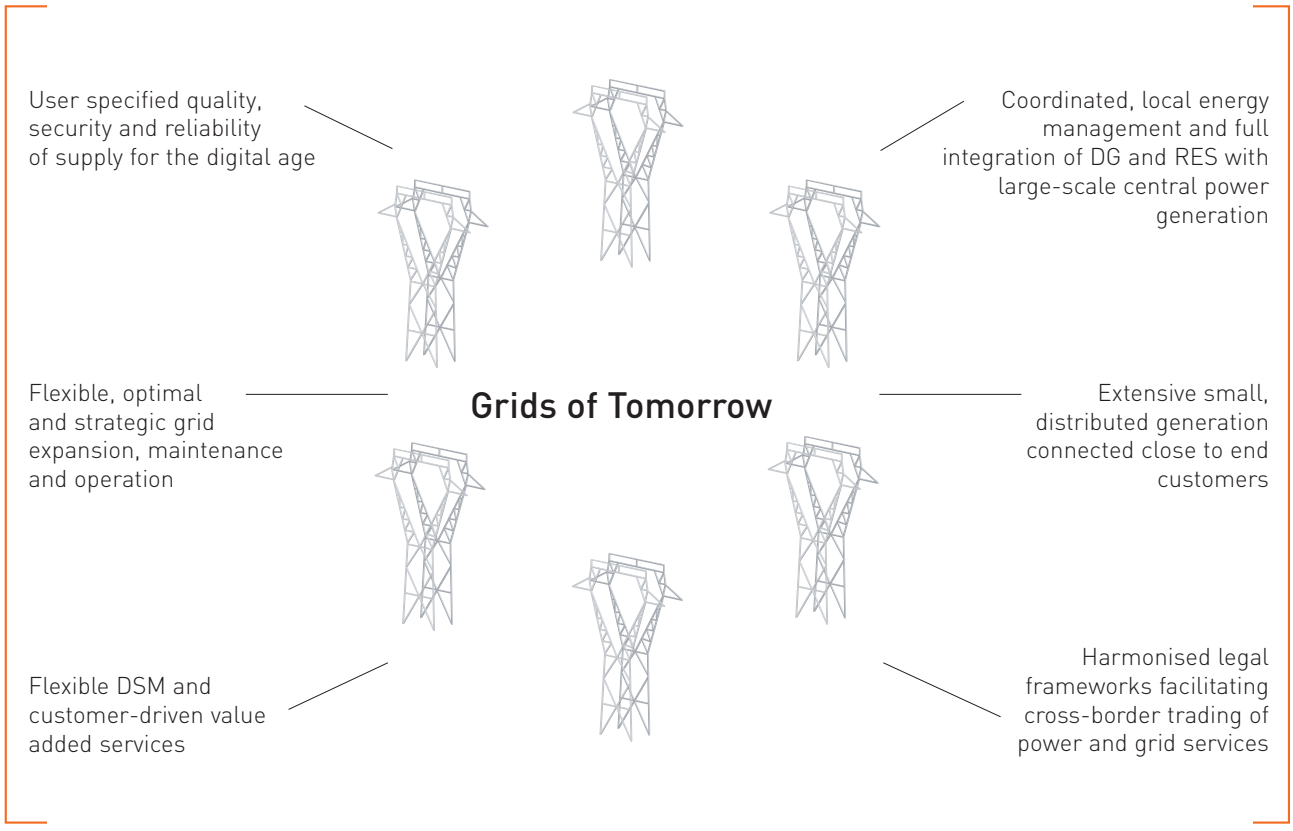


or national adequacy. Interconnections were originally developed for mutual support between countries and regions in emergency situations, but they are increasingly being used for trading between states.

The transmission grid provides an arena that has traditionally enhanced the overall reliability of power supply. The existing grid system **provides an excellent foundation** from which future challenges and opportunities can be met. However, the change should be accomplished through an incremental rather than a revolutionary approach and so the design **of a long-term strategy** is indispensable.

Future grids

Distribution grids will become active and will have to accommodate **bi-directional power flows**. The European electricity systems have moved to operate under the framework of a market model in which generators are dispatched according to market forces and the grid control centre undertakes an overall supervisory role (active power balancing and ancillary services such as voltage stability). Distribution networks, on the other hand, have seen little change and tend to be radial with mostly unidirectional power flows and "passive" operation. Their primary role is energy delivery to end-users.



Future models for the electricity grids have to meet the changes in technology, in the values in society, in the environment and in commerce. Thus security, safety, environment, power quality and cost of supply are all being examined in new ways and energy efficiency in the system is taken ever more seriously for a variety of reasons.

New technologies should also demonstrate **reliability, sustainability and cost effectiveness** in response to changing requirements in a liberalised market environment across Europe.

Future electricity markets

The **liberalisation** of electricity markets is an important factor to take into account. It affects the business framework of companies in a fundamental way and, when implemented well, it can bring the **benefits of competition, choice and incentives** for an efficient development.

The change might be better described as a revision of the traditional monopoly-based regulation of electricity supply. It has been accompanied by a trend towards an open market in power, meaning **free choice of power supplier** by electricity consumers. In addition, liberalisation has separated the responsibility for the secure transmission and distribution operation from the electricity generation business.

The whole electricity sector business is in a fundamentally changed commercial, regulatory and environmental context.

Needs must

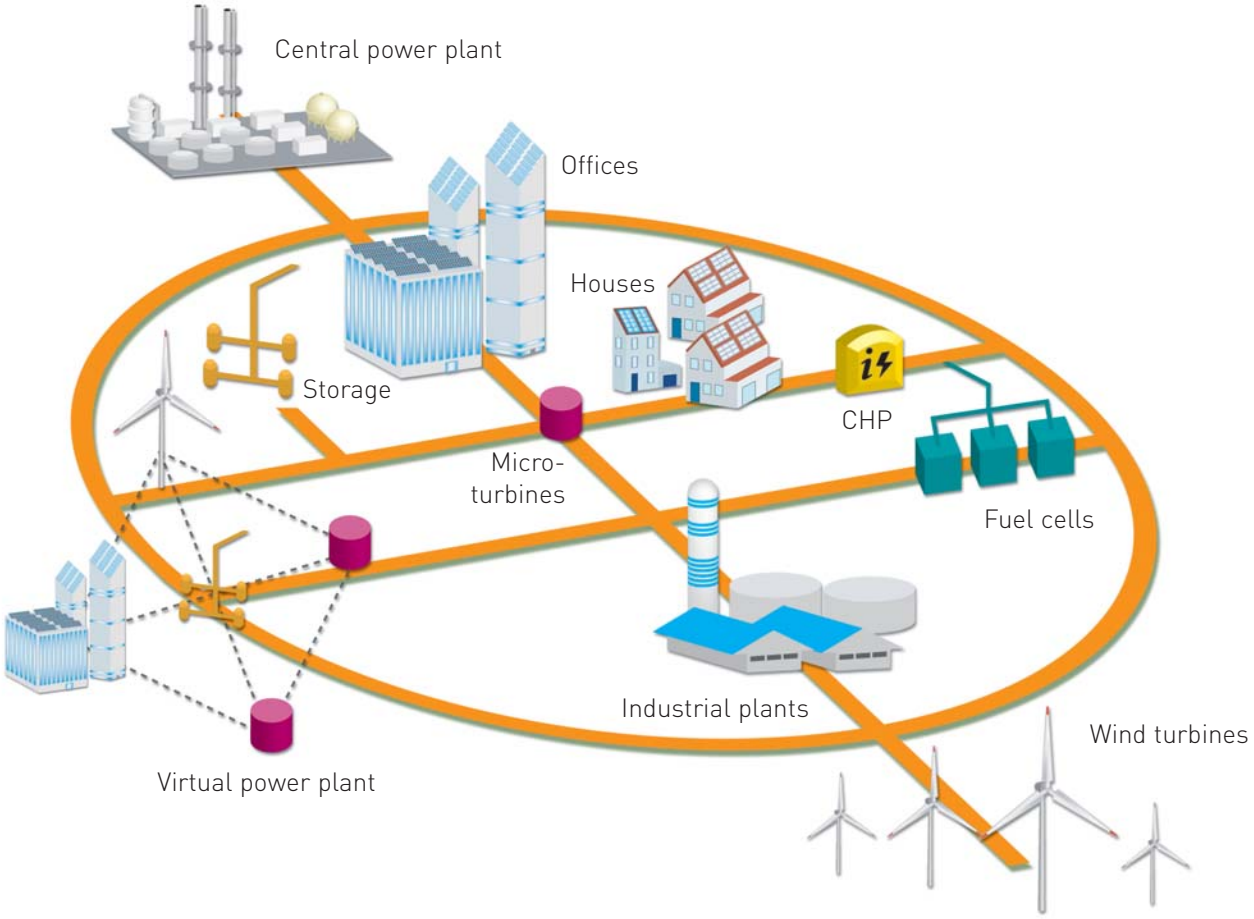
Liberalisation is not the only challenge for how networks will evolve in the future. The organisation of the network in the future will be affected by the dynamics of energy markets. **Scarcity of primary energy sources** on one hand and **climate change** on the other is likely to greatly affect decisions on new investments in generation. It is not so much the case of playing central versus distributed solutions, but much more to take advantage of a wide energy technology portfolio and the coexistence of many possible solutions.

A wide range of energy technologies will be employed to meet the challenges of a liberalised market and a changing climate.

How many people in 1960 would have believed that wind power was to become an important source of energy?

Yet, thanks to a combination of aerodynamic, blade material and power converter breakthroughs, this has become an **accepted reality**. And the evolution continues.

As the powers of computers advance rapidly, new technologies will be tested, evaluated and modified on-line before physical equipment is constructed.



***Future:** Operation of system will be shared between **central and distributed generators**. Control of distributed generators could be aggregated to form microgrids or 'virtual' power plants to facilitate their integration both in the physical system and in the market.*

Future networks

A proportion of the electricity generated by large conventional plants will be displaced by distributed generation; renewable energy sources; demand response; demand side management; and energy storage.

Additional **stand-by capacity** might be required, which could be called upon whenever the intermittent RES ceases to generate power. It may be **economically efficient** to seek a European solution for balancing power rather than national ones.

For instance, the massive amount of **fast-controllable hydro power** in the Nordic and other mountainous countries of Europe could be used as real-time balancing power for those areas in central Europe, where a large part of electricity generation could be provided by non-controllable primary energy. Efficient integration of DG is unlikely to be made without changes to **transmission and distribution network structure**, planning and operating procedures. Indeed it is envisaged that there will be less of a distinction between these network types, as distribution networks become more active and share many of the responsibilities of transmission.

5. Setting up Smart Power Grids

Electricity grids of the future are Smart in several ways. Firstly, they allow the customer to take an active role in the supply of electricity. Demand management becomes an indirect source of generation and savings are rewarded. Secondly, the new system offers greater efficiency as links are set up across Europe and beyond to draw on available resources and enable an efficient exchange of energy. In addition, environmental concerns will be addressed, thanks to the exploitation of sustainable energy sources. The potential benefits are impressive, but how will they be achieved?

Today, most users are passive receivers of electricity without further participation in the operational management of the generation sources and the grid. Each user node is simply a 'sink' for electricity.

A landmark evolution in the concept of grid operational management may now become a reality, enabled by modern technological developments.

However, in the last decade many countries have started the process of liberalisation of their electric systems, **opening access** to transmission and distribution grids. The process has been accompanied by a rapidly growing presence of DG of various technologies, some of it in the form of RES. This responds to the climate change challenge, the need to improve fuel diversity and provide affordable electricity with high quality of supply.

There has been rapid development of renewable energy technologies and co-generation and increased interest in other distributed energy resources and energy storage technologies. **Smart metering**, with two way communications capability and greatly improved user information, is now a reality and deployment is already taking place in some European countries.

Benefits all round

These developments change the trend in 50 years of grid evolution. They present significant opportunities and challenges for all stakeholders: for example, multilateral participation in the real-time balance between supply and demand.

These developments buck the trend of a 50-year grid evolution. Information exchange is developed and customers take on an active role.

Conceptually, a demand reduction is equivalent to a generation increase in the balancing process: avoidance of usage or local generation enables each user node in the future network to behave as both **sink and source**. Extending the definition of generation to commercial and industrial demand customers and individual households allows demand management to be treated as **a form of indirect generation**. This landmark change in the concept of grid operational management may now become a reality, enabled by modern technological developments **including end user communications access**.

Future Network Vision


Value added services
Forecast information
Off-shore wind
Biomass
control
mmunication
Microgrid
Wave energy
H_2 production and filling sation
H2
Demand side management
HP
Fuel cells
Compressed hydrogen storage

Across Europe and beyond

Europe's future electricity system will provide all consumers with a **highly reliable, cost-effective power supply**. Sustainable electricity production will be achieved through power sources having zero or low emission of greenhouse gases combined with maximum conversion efficiency. Bulk electricity transport and power balance will be facilitated by trans-European grids that are developed to recognise the SmartGrids principles. This will have the potential to exploit fully the use of both large, transmission connected generators and smaller distributed power sources throughout Europe.

SmartGrids will help to achieve sustainable development through using efficient, environmentally-friendly power sources.

The aim of SmartGrids is to help achieve **sustainable development** and a more efficient transmission grid will contribute by improving the opportunities for RES and DG. It will facilitate the **interconnection of regions** that have different but complementary renewable generation resources (such as wind power and pumped storage hydropower). An increasingly liberalised market will encourage trading opportunities to be identified and developed. In addition to energy trades between Member States, it can be expected that electricity exchange will be provided with systems in the East of Europe and towards Africa.

An interactive grid

Just like the internet, the electricity grid will be interactive for both power generation sources and power consumption sinks (loads). In 2020, energy service companies will let **everyone to have access** to the provision of electricity supply services such as the demand management capabilities. Enabled by smart metering, electronic control technologies, modern communications means and the increased awareness of customers, local electricity supply management will play a key part in establishing new services that will **create value** for the parties involved.

In this context, **metering services will represent the gateway** for access to the grid of the future and will have a critical consequence on power demand evolution. For this reason, electronic meters, automated meter management systems and telecommunications – together with other communications systems that use electricity supply networks as their delivery infrastructure – will serve as enabling technologies. **Information and Communication Technology** (ICT) and business process integration will be valuable tools in the real time management of the value chain across suppliers, active networks, meters, customers and corporate systems.

Wide area monitoring and protection (WAM & WAP) systems will be applied to manage the congestions in the transmission systems in a way that improves the security and reliability of grid operation.

Supporting new initiatives

Distribution companies will deal with **customers who are more aware** of the possibilities offered by the market and their on-line response. These include flexible and competitive tariffs; local generation; supporting schemes for renewable energies; cost-effective energy saving programs; demand side management and converging utilities; communication and billing services.

Regulatory bodies will develop **harmonised rules** to favour competition on a non-discriminatory basis in the EU context. This will guarantee open access at all levels, ensuring the removal of unnecessary barriers and ensure access to common benefits and incentives.

Grids will become intelligent systems with flexible, controlled power flows supported by advanced information technology.

Harmonised regulation will underpin a common EU energy strategy. This will provide the basis for establishing a **Europe-wide market for energy**, real-time balancing power and ancillary services open to both power producers and load management operators. Free trade throughout Europe will be facilitated by standardised, open communication means, transparent rules and a liquid cross-border trading. Congestion management will be handled by a market-based system.

Increasing efficiency

Advanced power electronics will allow variable-speed operation of electric generators and motors to increase the overall efficiency of the electricity supply chain as well as to increase the quality of the power supply. They may also extend the application of HVDC lines- for example with superconducting cables- which could **enhance transmission and distribution**. Broadband communications will be used to access virtually all power producers and loads on every power level and with very low cost.This will permit new strategies to be implemented, such as the realisation of virtual power plants or the establishment of markets even for small producers or consumers.

Working it out together

For a successful transition to a future sustainable energy system all the relevant stakeholders must become involved: governments, regulators, consumers, generators, traders, power exchanges, transmission companies, distribution companies, power equipment manufactures and ICT providers.

There is a strong need for **pilot projects**, not only in the technical sense but also at the markets and organisational level. For example, regulatory regimes should be revised, based on new knowledge about how regulation should work to provide incentives for innovation. New organisational structures can be implemented and monitored for the benefit of all parties, for example allowing network companies to conduct limited commercial activities with respect to long time investments.

Grids are being transformed into an elaborate, interconnected network that will provide European citizens with a secure and cost-effective electricity supply.

Grids are being transformed into millions of interconnected nodes, integrated across Europe at all levels of transmission and distribution.
Bulk transmission and distributed generation will **coexist on interconnected grids** where the distinction between traditional transmission and distribution is becoming increasingly blurred. This unified European electricity grid will provide Europe's industry and European citizens with a **highly secure** electricity supply on a most **cost-effective** basis with minimum damage to the environment, in line with European related policies.

SmartGrids: Ensuring success

The ETP-SmartGrids is aware of the realities facing the development of a new electricity supply network.
It has identified the pitfalls it must avoid:

- It will not introduce like-for-like replacement of time-expired infrastructure, which is ineffective in meeting the needs of tomorrow's European customers and businesses;
- It will guard against a lack of harmonisation of European technical standards, regulatory and commercial frameworks;
- It will address confidentiality constraints with insufficient data transparency;
- Since grids are highly complex with multiple connection points, it is recognised that isolated developments will be ineffective in such complex value chains;
- It will tackle the issue of an insufficient availability of skilled staff, particularly to achieve the development and deployment of innovative technologies.

Shaping up for the future

Throughout the development of the new grids, communication at every level is essential. Effective dialogue between stakeholders will ensure that relevant information influences the system design. The latest technologies will be incorporated into the network and the approach will remain flexible to accommodate further developments. Once the networks are up and running, two-way flows will exist between provider and user. This type of exchange has characterised the popularity of the internet- how is SmartGrids preparing for success?

Many factors will shape future electricity networks and the actions and decisions taken today will influence longer-term outcomes. It is therefore important to recognise that a flexible approach and **regular interaction** with stakeholders is required to respond to future challenges and opportunities.

Future work should adopt a techno-economic system approach for a trans-European network. This calls for the development of:

- distribution grids **accessible to distributed generation and renewable energy sources**, either self-dispatched or dispatched by local distribution system operators;
- distribution grids enabling local energy demand management to interact with end users through **smart metering** systems;
- distribution grids that facilitate **dynamic control techniques** and high levels of power security, quality, reliability and availability;
- transmission grids with **minimum negative side-effects** on the environment and the society;
- **secure transmission grids** that can comply with different forms of generation including large and small, controllable and non-controllable, variable and intermittent sources;
- transmission grids that can **accommodate** central and non-central, multi-product markets.

Internet-style inspiration

One possible model for the electricity network of the future would be analogous to the internet, in the sense that **decision-making is distributed** and that **flows are bi-directional**. Applying this concept to the electricity networks would lead to control is being distributed across nodes spread throughout the system. Not only could the supplier of power for a given consumer vary from one time period to the next but also the network use could vary as the network self-determines its configuration.

Such a system would require advanced hardware and management protocols for connections, whether for suppliers of power, for consumers or for network operators. The market structures and regulatory mechanisms need to be in place to provide the necessary incentives.

A two-way flow of energy and information between customer and supplier will heighten efficiency and lead to cleaner electricity generation.

This type of network would ease the participation of DG, RES, DSM and flexible energy storage and would also create opportunities for **novel types of equipment and services**, all of which would need to respect the protocols and standards adopted. New business and trading opportunities can be envisaged- based on new power sources, new power consumption habits and new regulation, all of which favour cleaner and more efficient generation and consumption as well as the development of a flexible, multi-user connected network which establishes power and communication transfer possibilities among all players.

Keeping it real

It is important to emphasise the role of ICT – in particular telecommunications – in adapting electricity networks to the real time actions and managing control distributed in the network, which may not be fully supported by the present internet generation.

Even if the internet protocol is universal, a serious effort is needed to effectively use communications equipment for a distributed real-time control of electricity networks. The **real time performance** of the internet as communication means is known to be very difficult to assess and it is critical given the power balance needed at any instant in time.

It is possible to conceive such a network but the real hardware, protocols, standards and markets at all levels are more difficult to realise. The question of international regulation must be addressed, not only at the technical but also at the political level.

A period of transition

In managing the transition to the internet-like model, it may be useful to consider concepts under development in a number of projects under the European Commission's Framework Programmes: for example, **active distribution networks**.

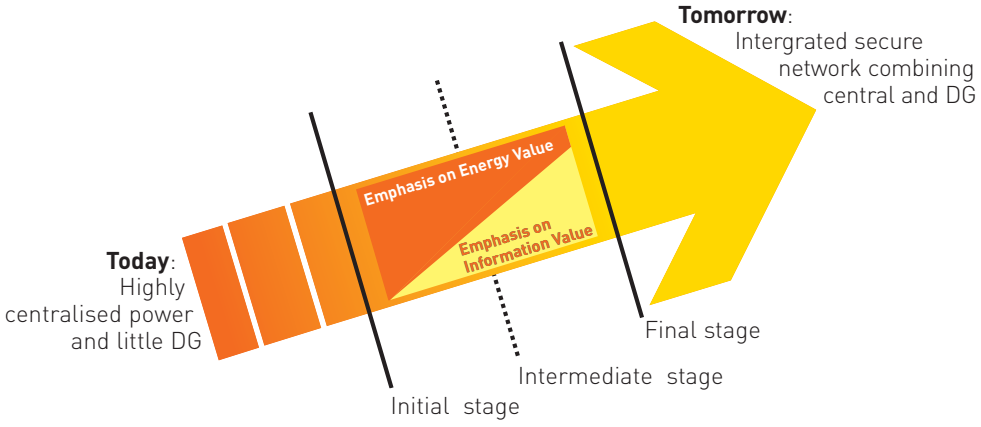
The function of the active distribution network is to efficiently **link power sources with consumer demands**, allowing both to decide how best to operate in real time. The level of control required to achieve this is much greater than in current distribution systems. It includes power flow assessment, voltage control and protection require cost-competitive technologies as well as new communication systems with more sensors and actuators than presently in the distribution system.

The increase in required control leads to **a dramatic rise in information traffic** derived from status and ancillary data. This, along with the ability to re-route power, means that the active network represents a step towards the internet-like model.

Active management

The evolution of active management, summarised in the next figure, can be described as follows:

- **Initial stage**: Extension of DG and RES monitoring and remote control to facilitate **greater connection activity**. Some connections will rely on bilateral contracts with distributed generators for ancillary services. Rules will have to be defined to outline physical and geographical boundaries of contracting.
- **Intermediate stage**: A **management regime** capable of accommodating significant amounts of DG and RES has to be defined: local and global services and trading issues, adaptability without information overload, control issues.
- **Final stage**: Full active power management. A distribution network management regime using **real-time communication and remote control** to meet the majority of the network services requirement. The transmission and distribution networks are both active, with harmonised and real-time interacting control functions and efficient power flow.



When the final stage is achieved, the users of the network will expect a responsive system. They will experience connection according to simple and defined standards. They will also expect **accurate billing** – to pay for what they use and to be paid for what they supply. Plug and play with real-time trading and accounting will result.

New networks, new systems

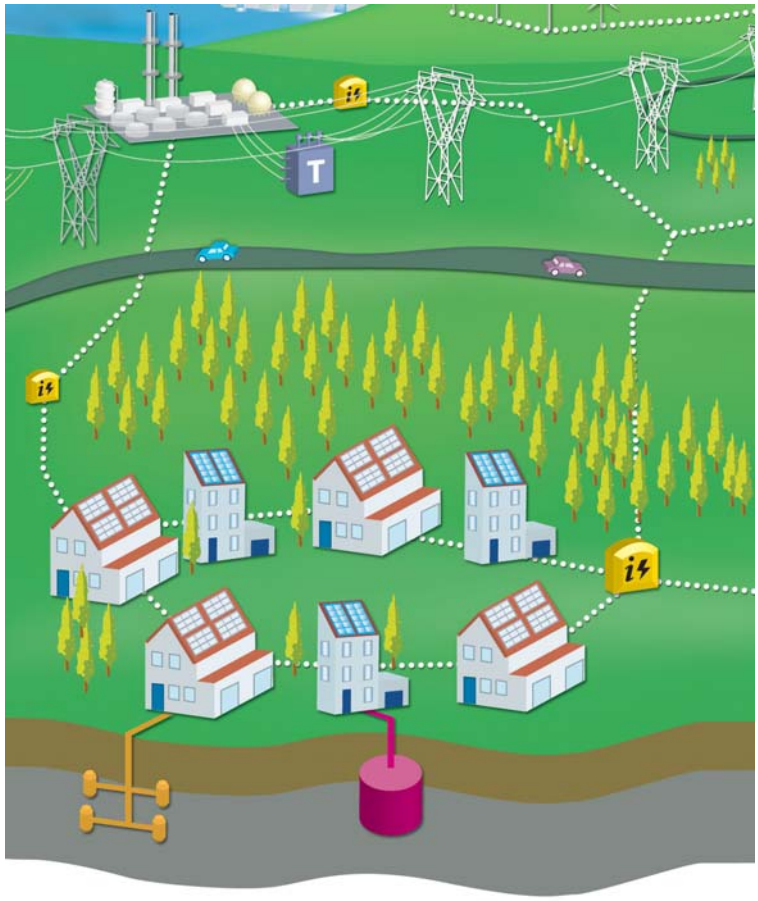
The realisation of such active distribution network technologies will allow radically new system concepts to be implemented. The two proposed examples are:

- **Microgrids**
- **Virtual utilities**

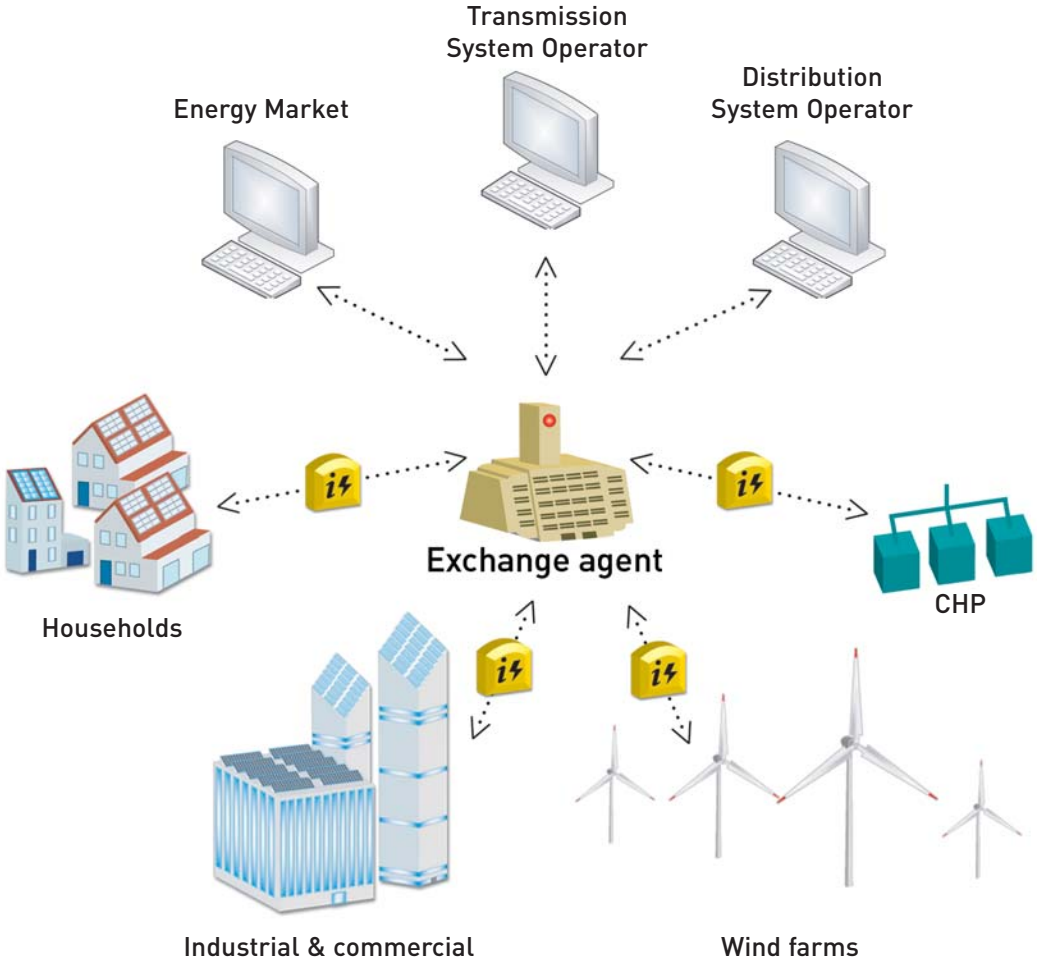
These are not fixed, discrete or unique solutions.

- **Microgrids** are generally defined as **low voltage networks with DG sources**, together with local storage devices and controllable loads (e.g. water heaters and air conditioning). They have a total installed capacity in the range of between a few hundred kilowatts and a couple of megawatts. The unique feature of microgrids is that, although they operate mostly connected to the distribution network, they can be automatically transferred to **islanded 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 which can be operated as a single aggregated load or generator and, given attractive remuneration, as a small source of power or as ancillary services supporting the network.



- **Virtual utilities** (or virtual electricity market) adopt the structure of the **internet-like model** and its information and trading capability, rather than any hardware. Power is purchased and delivered to agreed points or nodes. Its source, whether a conventional generator, RES or from energy storage is determined by the supplier. The system is enabled by modern information technology, advanced power electronic components and efficient storage.



SmartGrids: 'Enabling' technologies

- Active distribution networks, revealing characteristics of today's transmission grids;
- New network technologies that facilitate increased power transfers and losses reduction (e.g. GIL, superconductivity, high operating temperatures, FACTS technologies, etc.);
- Wide deployment of communications to enable grid automation, on-line services, active operation, demand response and DSM;
- Power electronic technologies for quality of supply;
- Stationary energy storage devices.

Technologies to make it happen

Analysing system architectures is an important early step in setting the direction for future grid development. Delivering an **adequate architecture** will require the development of a number of 'enabling' technologies. Many of these are already available to some extent; some are currently being employed in other sectors.

Other new technologies currently available are further away from commercialisation and widespread deployment on grid systems. The resources needed to bring totally new products into use in grid systems are often significant.

In these situations, success will most likely be achieved through combining efforts and resources within a co-operative research, development and demonstration programme. In the absence of a central planning regime, this can only be accomplished if all stakeholders form **a shared vision for future grids** and develop an implementation framework that is consistent with the liberalised business model.

Points to consider

To enable the concepts for change to be realised and the **benefits to become a reality**, the change of the electricity supply structure towards progressively more DG, RES and active grids requires that a number of wider and disparate factors be addressed. These include:

- Improvements of **security standards** in the context of critical infrastructures;
- **Integration** of both central and distributed generation;
- Integration of **innovative technologies** into existing grids;
- Harmonisation of equipment standards to allow "plug-and-play";
- **Increased funding** for large research incentives, including public and private sharing;
- The impact of neighbouring electricity systems on the **European network**;
- Higher **education and skills** issues.

A holistic approach to energy supply ensures that all relevant factors are considered in the system development. The flexible framework enables appropriate modifications to be made.

With regards to education and skills, it is already evident that an insufficient number of well-trained engineers are being produced in the power engineering field. In order to develop, operate and maintain future networks, cross-functional, intra-disciplinary **educational strategies must be adopted**. Recruitment strategies must be enhanced to meet the skill sets needed. Multidisciplinary curricula should include not only power engineering and information technologies, but also economics & market, regulatory & legal and environmental aspects. **A skills shortfall is a key risk to the successful adoption of the SmartGrids vision for Europe**.

A flexible framework

The diagram on page 30 summarises the proposed **flexible framework approach** that seeks to ensure that the special features of innovation on grids are addressed **in a holistic way**. The Framework is designed to ensure that the outcomes of successful research are, from the start, developed in a way that recognises the realities faced by grid companies and other parties who have the responsibilities for adoption of innovation in operational business circumstances.

The diagram shows (in a simplified way) how needs would be matched with potential innovative solutions. An impact assessment would then be undertaken to confirm a cost/benefit business case, following which viable solutions would be evaluated and proven by projects on live operational grid networks.

Key elements of the Flexible Framework

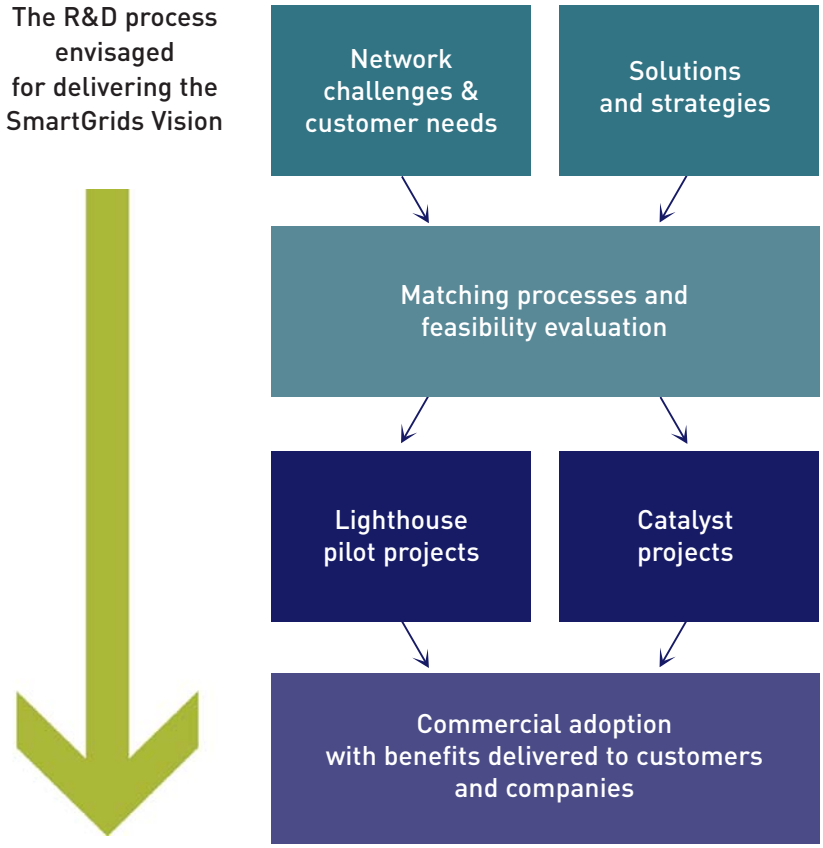
- Future **network challenges and customer needs** will be identified and matched;
- **Solutions and strategies** – technical, commercial and regulatory – will be identified;
- Challenges and solutions will be tested for **feasibility and commercial viability**;
- Solutions that withstand this process will be taken forward as pilot projects with the aim of widespread adoption;
- **Catalyst projects** will be undertaken in parallel with pilot projects to address any barriers that had been identified to wide-scale commercial adoption, such as developments needed to regulatory or legal 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** will be **disseminated** to the wider market place to generate awareness of and confidence in new technologies;
- The perceived risk of adopting new technology will be mitigated and **commercial adoption** will follow when companies **know it works.**

Rules and regulations

A further distinguishing feature of grid innovation, particularly in a liberalised sector, is the regulatory and legal environment in which grid companies operate.
It is recognised that innovative approaches may from time to time be hindered by unintended **regulatory or legal barriers**. To address this aspect, the Flexible Framework proposes that 'catalyst projects' would be undertaken to address any barriers to wide commercial deployment.

Successful demonstration and catalyst projects open the way to full deployment on operational grids. It is only through wide deployment (sometimes called 'roll out') that benefits will be seen by European customers and that international market opportunities will be released.

Simplified Representation of the Proposed Flexible Framework



6. The Technology Platform

Behind the SmartGrids initiative is the SmartGrids Platform. This group of individuals is working together under the common goal of transforming electricity provision, from the conception to the realisation of a new system. In order to achieve its aims, ETP-SmartGrids must ensure widespread cooperation and sufficient investment to fund extensive research. It is divided into different bodies, each of which has defined roles. How does the platform function?

As in other ETPs, a group of high-level stakeholders came together with one primary objective: to define **a coherent and unified industry-driven approach** to tackling major economic, technological and societal challenges, of vital importance for Europe's future competitiveness and economic growth.

More specifically, an **Advisory Council** has been established to develop and consolidate a joint Vision and put forward a Strategic Research Agenda that sets RTD priorities for the medium to long-term.

Platform objectives

The platform has agreed its initial objectives and is committed to bringing forward relevant high quality research, combined with mechanisms, to mobilise the **private and public investments** required for the implementation of the RTD strategies.
In this respect, integrated research and demonstration projects in electricity networks are envisaged, as these are key to a successful adoption strategy in the industrial context of an increasingly liberalised and competitive market.

Platform actions

The platform must mobilise private and public investments to allow crucial research to be carried out.

The primary purpose of the SmartGrids European Technology Platform is to **enhance the level of coherence** between the European, national and regional programmes addressing the challenges of future networks. This will ensure that the challenges and opportunities ahead are responded to efficiently for the benefit of all stakeholders in Europe.

It will do this in a number of ways.

- It will propose, promote, discuss and refine **a vision for the future** development of Europe's grids;
- Based on this vision, it will propose a **Strategic Research Agenda** in 2006 that will provide an initial framework for future European R&D activities;
- It will form **links with equivalent bodies** in other countries, particularly North America and Japan, to ensure that international development paths are complementary and consistent with the development of commercial products;
- It will establish **Working Groups** to focus on specific aspects of system development and to pursue the goal of R&D coherence at this level;

SmartGrids: How will transition be achieved?

- Jointly addressing **technical, commercial and regulatory** issues;
- **A flexible framework** approach that is responsive to emerging needs, stimulates R&D and deploys lighthouse pilot projects to facilitate innovative solutions;
- A **pan-European** approach that maximises the benefits to European citizens, including cross border exchanges of electric energy and grid services;
- A strategic approach to developing a range of **new and innovative grid architectures** that can be deployed on distribution and transmission grids as the situations demand.

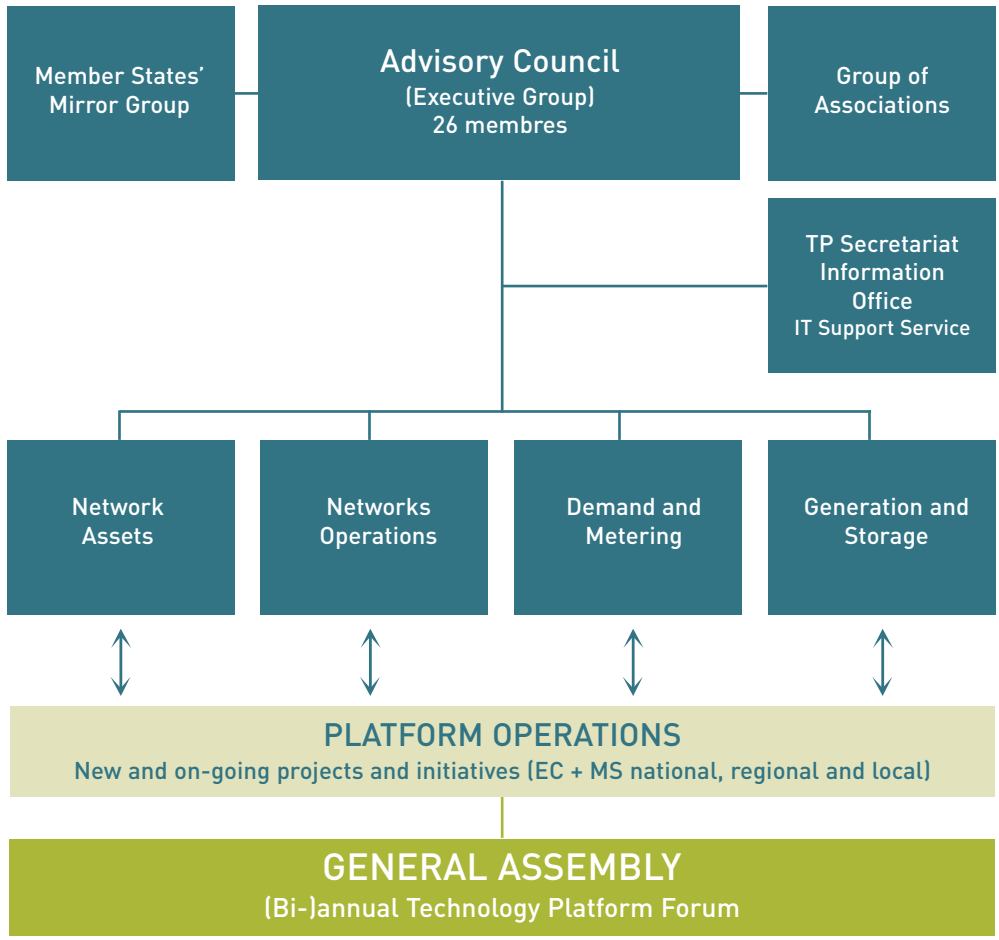
ETP-SmartGrids unites high-level stakeholders in defining a vision of the future development of grids. The platform leads the way in facilitating the construction of a new and effective network.

- It will provide the basis for **centres of excellence** in future grid issues and consider how it might best employ this expertise in the delivery of **lighthouse pilot projects**;
- SmartGrids will not be a purely technical venture. It is recognised that commercial and regulatory issues must be addressed in parallel with technical development and the challenge of **achieving coherence** requires these three elements to be addressed together;
- SmartGrids projects will be developed on a **flexible basis** and particularly will respond to the unique features of innovation on electricity grids.

SmartGrids: Unique features of grid innovation

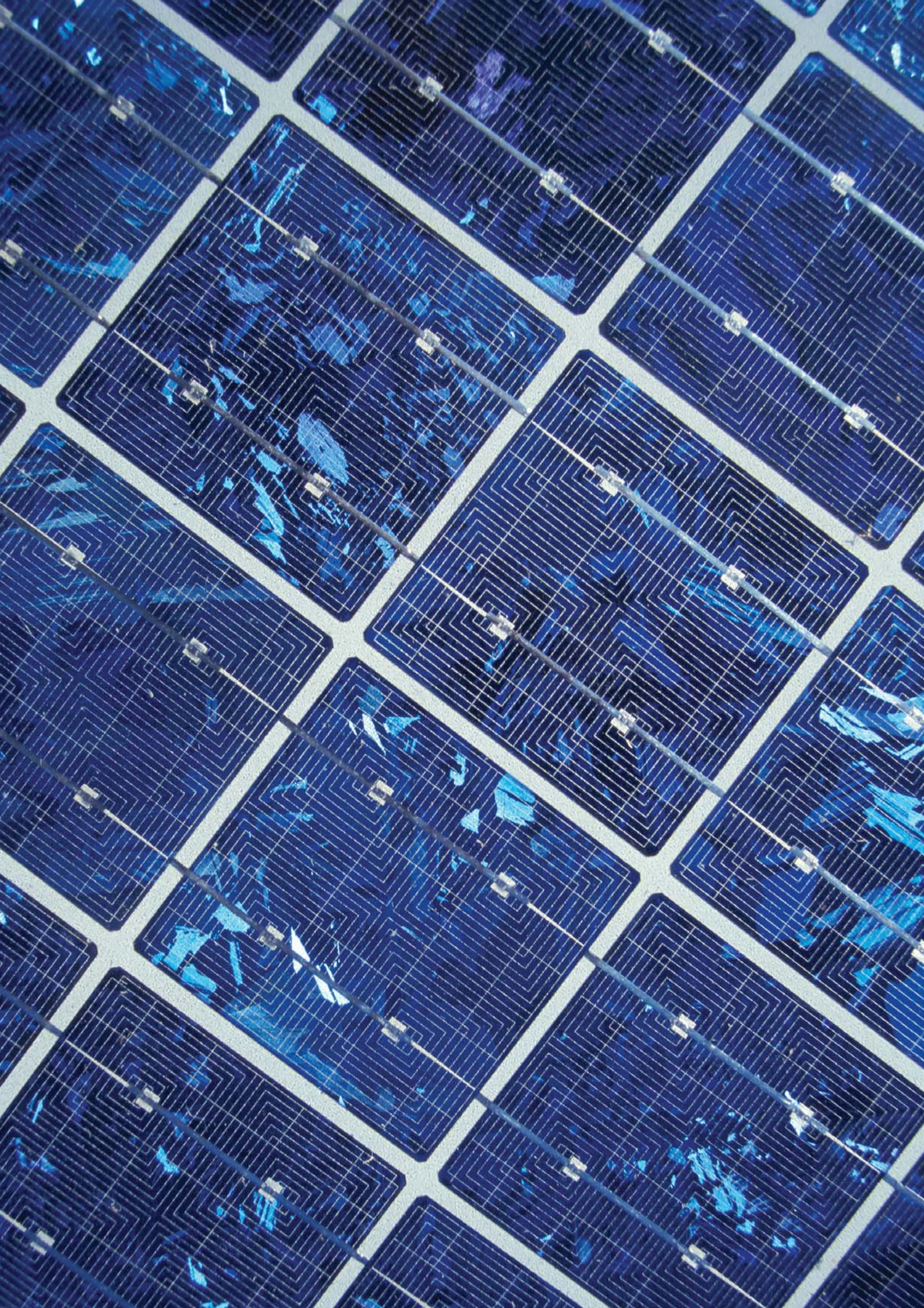
- Unlike business innovation, technology innovation cannot be done in-house;
- The supply chain is not the same as the procurement chain;
- By definition it brings risks by and these have to be managed;
- The risk profile varies significantly across the innovation chain and its stages;
- New grid technology cannot be fully proven in the laboratory or on a simulator;
- Pilot operation, in a controlled situation on a real grid is a prerequisite for adoption;
- There is little value in one-off new technology installations;
- Wide area adoption, through commercial mechanisms, is needed to attain its benefits.

The **structure of the ETP SmartGrids** is shown in the following diagram:



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**: enable participation of associations of stakeholders.



List of Acronyms

AC	Alternating Current
CHP	Combined Heat and Power
CO_2	Carbon Dioxide
DG	Distributed Generation
DSM	Demand Side Management
ETP	European Technology Platform
EU	European Union
FACTS	Flexible AC Transmission Systems
GDP	Gross Domestic Product
GIL	Gas Insulated Line
HVDC	High Voltage Direct Current
ICT	Information and Communication Technology
IEA	International Energy Agency
NO_x	Nitrogen Oxides
R&D	Research and Development
RES	Renewable Energy Source
RTD	Research and Technological Development
SO_2	Sulphur Dioxide

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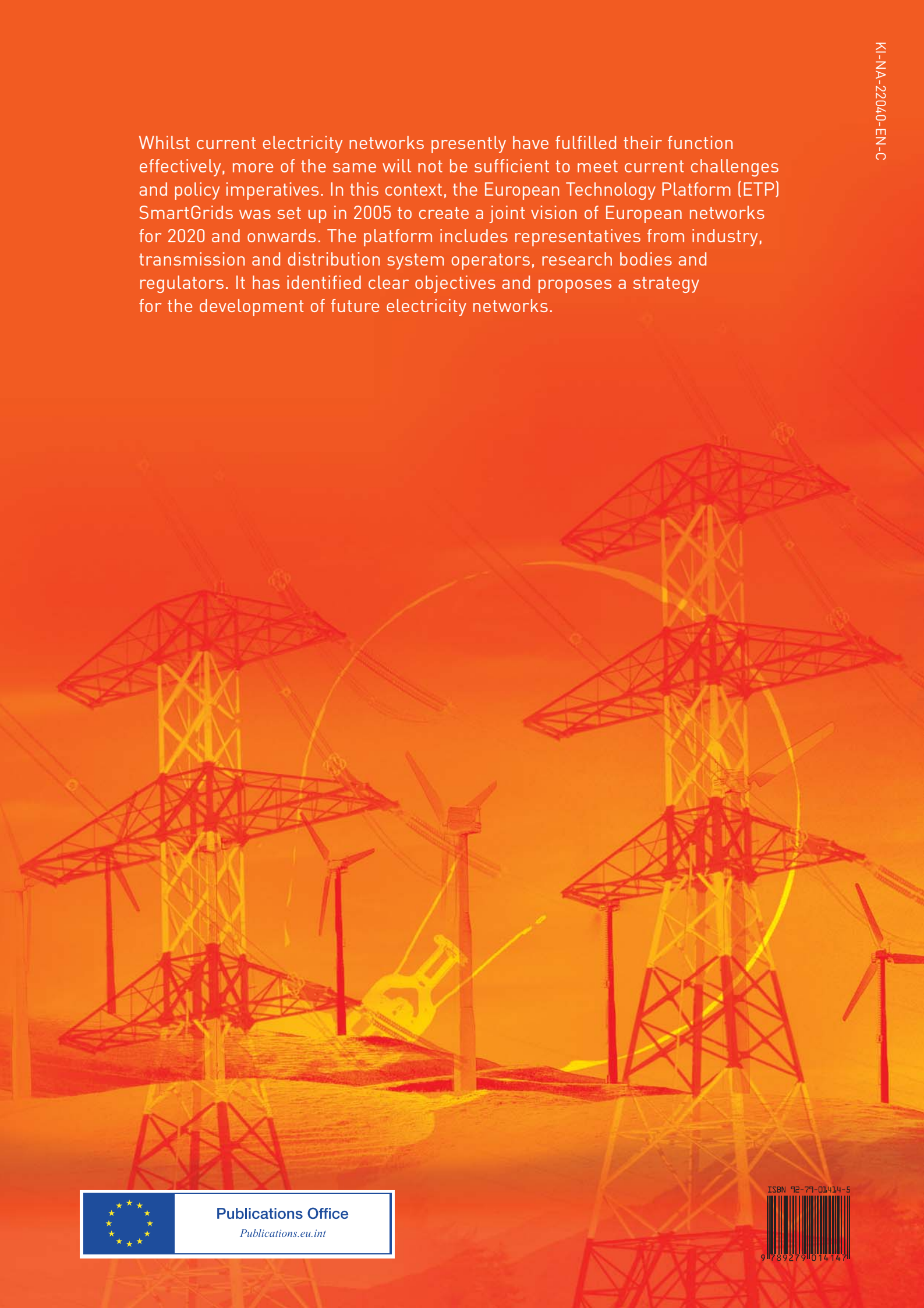
Whilst current electricity networks presently have fulfilled their function effectively, more of the same will not be sufficient to meet current challenges and policy imperatives. In this context, the European Technology Platform (ETP) SmartGrids was set up in 2005 to create a joint vision of European networks for 2020 and onwards. The platform includes representatives from industry, transmission and distribution system operators, research bodies and regulators. It has identified clear objectives and proposes a strategy for the development of future electricity networks.



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