3. SECURE, CLEAN AND EFFICIENT ENERGY

3.1. Reducing energy consumption and carbon footprint through smart and sustainable usage

The energy sources and consumption patterns of Europe's industries, transport, buildings, towns and cities are largely unsustainable, leading to significant environmental and climate change impacts. The development of near-zero-emission buildings, highly efficient industries and mass take-up of energy-efficient approaches by companies, individuals, communities and

cities will require not only technological advances, but also non-technological solutions such as new advisory, financing and demand management services. In this way energy efficiency may provide one of the most cost effective ways to reduce energy demand, thereby enhancing security of energy supply, reducing environmental and climate impacts and boosting competitiveness.

3.1.1. Bring to mass market technologies and services for a smart and efficient energy use

Reducing energy consumption and eliminating energy waste, while providing the services that society and economy need, requires not only that more, efficient, cost-competitive, environmentally-friendly, and smarter products and services are brought to mass market but also the integration of components and devices in such a way that they cooperate to optimise the overall energy use of buildings, services and industry.

To ensure full adoption and full benefits for consumers (including the possibility for them to monitor their own consumption), energy performance of these technologies and services needs to be customised and optimised for and in their application environments. This requires not only researching, developing and testing innovative Information and Communication Technologies (ICT) and monitoring and control techniques but also large-scale demonstration projects and pre-commercial deployment activities to ensure interoperability and scalability. Such projects should aim to develop common procedures to collect, collate and analyse energy consumption and emissions data to improve the measurability, transparency, social acceptability, planning and visibility of energy use and its environmental impacts.

3.1.2. Unlock the potential of efficient and renewable heating-cooling systems

A substantial share of energy is consumed for heating or cooling purposes across the Union and the development of cost-effective and efficient technologies, system integration techniques e.g. network connectivity with standardised languages and services in this area would have a major impact in reducing energy demand. This requires research and demonstration of new systems and components for industrial as well as residential applications, for example in decentralised and district supply of hot water, space heating and cooling. This should encompass different technologies: solar thermal, geothermal, biomass, heat pumps, combined heat and power etc, and meet the requirements of near-zero energy buildings and districts. Further breakthroughs are needed, in particular, in thermal storage from renewable energy sources and to foster the development and deployment of efficient combinations of hybrid heating and cooling systems, for centralised and de-centralised applications.

3.1.3. Foster European Smart cities and Communities

Urban areas are one of the largest consumers of energy in the Union and emit a correspondingly large share of greenhouse gases, while generating a substantial amount of air pollutants. At the same time, urban areas are affected by decreasing air quality and climate change and have to develop their own mitigation and adaptation strategies. Finding innovative energy solutions (energy efficiency, electricity and heating and cooling supply systems), integrated with transport, waste and water treatment as well as ICT solutions for the urban environment are therefore crucial in the transformation towards a low carbon society. Targeted initiatives in support to the convergence of industrial value chains of the energy, transport and ICT sector for smart urban applications need to be envisaged. At the same time, new technological, organisational, planning and business models need to be developed and

tested at full scale according to the needs and means of cities and communities. Research is also needed to understand the social, economic and cultural issues that are involved in this transformation.

3.2. Low-cost, low-carbon electricity supply

Electricity will play a central role in the establishment of an environmentally sustainable low-carbon economy. The uptake of low-carbon electricity generation is too slow due to the high costs involved. There is a pressing need to find solutions that reduce costs significantly, with enhanced performance and sustainability, to accelerate the market deployment of low carbon electricity generation. In particular to:

3.2.1. Develop the full potential of wind energy

The objective for wind energy is to reduce the cost of electricity production of onshore and offshore wind by up to about 20 % by 2020 compared to 2010, to increasingly move offshore, and to enable proper integration in the electricity grid. The focus will be on the development, testing and demonstration of next generation wind energy conversion systems of larger scale, higher conversion efficiencies and higher availabilities for both on- and off-shore (including remote locations and hostile weather environments) as well as new serial manufacturing processes.

3.2.2. Develop efficient, reliable and cost-competitive solar energy systems

The cost of solar energy, covering photovoltaics (PV) and concentrating solar power (CSP), should be halved by 2020 compared to 2010, if it is to gain share of the electricity market.

For PV, this will need long term research on novel concepts and systems, demonstration and testing of mass production with a view to large-scale deployment.

For CSP, the focus will be on developing ways to increase efficiency while reducing costs and environmental impact, enabling industrial up-scaling of demonstrated technologies by building first-of-a-kind power plants. Solutions to efficiently combine the production of solar electricity with water desalination will be tested.

3.2.3. Develop competitive and environmentally safe technologies for CO2 capture, transport and storage

Carbon capture and storage (CCS) is a key option that has to be widely deployed on a commercial scale at global level to meet the challenge of a decarbonised power generation and low carbon industry by 2050. The objective is to minimise the extra-cost of CCS in the power sector for coal-fired and gas-fired power plants compared to equivalent plants without CCS and energy intensive industrial installations.

Support will be given, in particular, to demonstrate the full CCS chain for a representative portfolio of different capture, transport and storage technology options. This will be accompanied by research to further develop these technologies and to deliver more competitive capture technologies, improved components, integrated systems and processes, safe geological storage and rational solutions for the large-scale re-use of captured CO_2 to enable the commercial deployment of CCS technologies for fossil fuel power plants and other carbon-intensive industries going into operation after 2020.

3.2.4. Develop geothermal, hydro, marine and other renewable energy options

Geothermal, hydro, and marine energy as well as other renewable energies can contribute to the decarbonisation of the European energy supply while enhancing its flexibility to variable production and use of energy. The objective is to bring to commercial maturity cost-effective and sustainable technologies, enabling large-scale deployment at an industrial scale including grid integration. Ocean energies such as tidal, current or wave energy offer truly zero-emission, predictable energy. Research activities should include laboratory scale innovative research into low-cost reliable components and materials in a high corrosion, biofouling environment as well as demonstrations under the varied conditions found in European waters.

3.3. Alternative fuels and mobile energy sources

Meeting Europe's energy and CO_2 reduction goals also requires the development of new fuels and mobile energy sources. This is particularly important to meet the challenge of smart, green and integrated transport. Value chains for these technologies and alternative fuels are not sufficiently developed and must be accelerated to demonstration scale.

3.3.1. Make bio-energy competitive and sustainable

The objective for bio-energy is to bring to commercial maturity the most promising technologies, to permit large-scale, sustainable production of advanced second generation biofuels of different value chains for transport, and highly efficient combined heat and power from biomass, including CCS. The aim is to develop and demonstrate the technology for different bio-energy pathways at different scales, taking account of differing geographical and climate conditions and logistical constraints. Longer term research will support the development of a sustainable bio-energy industry beyond 2020. These activities will complement upstream (feedstock, bio-resources) and downstream (integration into vehicle fleets) research activities carried out in other relevant Societal Challenges.

3.3.2. Reducing time to market for hydrogen and fuel cells technologies

Fuel cells and hydrogen have a great potential to contribute to addressing energy challenges facing Europe. Bringing these technologies to market competitiveness will require significant cost decrease. As an illustration the cost of fuel cell systems for transportation will have to be reduced by a factor 10 over the next 10 years. To do so, support will be given to large scale demonstrations and pre-commercial deployment activities for portable, stationary, transport applications and the related services, as well as long-term research and technology development to build up a competitive fuel cell chain and a sustainable hydrogen production and infrastructure across the Union. Strong national and international cooperation is needed to enable market breakthroughs of a sufficient scale, including the development of appropriate standards.

3.3.3. New alternative fuels

There is a range of new options with long term potential, such as powdered metal fuel, fuel from photosynthetic microorganisms (in water and land environments) and from artificial photosynthesis mimics. These new paths may offer potential for more efficient energy conversion, more cost-competitive and sustainable technologies, and almost neutral "greenhouse gases" emitting processes that do not compete for agricultural lands. Support will

be given notably to bring these new and other potential technologies from laboratory to demonstration scale size in view of pre-commercial demonstration by 2020.

3.4. A single, smart European electricity grid

Electricity networks have to respond to three interrelated challenges to enable a consumer friendly and increasingly decarbonised electricity system: creating a pan-European market; integrating a massive increase of renewable energy sources; and managing interactions between millions of suppliers and customers (where increasingly households will be both), including owners of electrical vehicles. Future electricity networks will play a key role for the transition to a fully decarbonised electricity system, while providing additional flexibility and cost benefits to the consumers. The overriding goal by 2020 is to transmit and distribute about 35 % of electricity from dispersed and concentrated renewable energy sources.

A strongly integrated research and demonstration effort will support the development of new components and technologies which will respond to the particularities of both the transmission and distribution side of the grid, as well as storage.

All options to successfully balance energy supply and demand must be considered to minimise emissions and costs. New power systems technologies and a bi-directional digital communication infrastructure must be researched and integrated into the electricity grid. This will contribute to better plan, monitor, control and securely operate networks in normal and emergency conditions as well as to manage the interactions between suppliers and customers and to transport, manage and trade energy flow. For the deployment of future infrastructure, indicators and cost benefit analysis should take into account energy system-wide considerations. In addition, synergies between smart grids and telecommunication networks will be maximised in order to avoid duplication of investments and to accelerate the take up of smart energy services

Novel energy storage means (including both large scale and batteries) and vehicle systems will provide the required flexibility between production and demand. Improved ICT technologies will further increase the flexibility of electricity demand by providing customers (industrial, commercial and residential) with the necessary automation tools.

New planning, market and regulatory designs need to drive the overall efficiency and cost-effectiveness of the electricity supply chain and interoperability of infrastructures as well as the emergence of an open and competitive market for smart grid technologies, products and services. Large-scale demonstration projects are needed to test and validate solutions and assess the benefits for the system and for individual stakeholders, before deploying them across Europe. This should be accompanied by research to understand how consumers and businesses react to economic incentives, behavioural changes, information services and other innovative opportunities provided by smart grids.

3.5. New knowledge and technologies

Novel, more efficient and cost-competitive technologies will be required for the long term. Progress should be accelerated through multi-disciplinarily research to achieve scientific breakthroughs in energy related concepts and enabling technologies (e.g. nano-science, material science, solid state physics, ICT, bio-science, computation, space); as well as the development of innovations in future and emerging technologies.

Advanced research will also be needed to provide solutions to adapt energy systems to changing climatic conditions. Priorities may be adjusted to new scientific and technological needs and opportunities or newly-observed phenomena which could indicate promising developments or risks to society and that may emerge during the course of implementation of Horizon 2020.

3.6. Robust decision making and public engagement

Energy research should support and be strongly aligned with the energy policy. Extensive knowledge of energy technologies and services, infrastructure, markets (including regulatory frameworks) and consumer behaviour is required to provide policy makers with robust analyses. Support will be given, in particular in the frame of the European Commission's Information System of the SET-Plan, to develop robust and transparent tools, methods and models to assess the main economic and social issues related to energy; to build databases and scenarios for an enlarged Union and the assessment of the impact of energy and energy-related policies on security of supply, the environment and climate change, society and competitiveness of the energy industry; to carry out socio-economic research activities.

Taking advantage of the possibilities offered by web and social technologies, consumer behaviour including that of vulnerable consumers like persons with disabilities and behavioural changes will be studied in open innovation platforms such as the Living Labs and large scale demonstrators for service innovation.

3.7. Market uptake of energy innovation, empowering markets and consumers

Innovative market uptake and replication solutions are essential to rollout new energy technologies in time and through a cost effective implementation. In addition to technology-driven research and demonstration, this requires actions with clear Union added value aiming to develop, apply, share and replicate non-technological innovations with a high leverage factor in Union's sustainable energy markets across disciplines and levels of governance.

Such innovations will focus on creating favourable market conditions at the regulatory, administrative and financing level for low-carbon, renewable and energy efficiencies technologies and solutions. Support will be given to measures facilitating the energy policy implementation, preparing the ground for rollout of the investments, supporting the capacity building and acting on public acceptance.

Research and analysis repeatedly confirms the crucial role of the human factor in the success and failure of sustainable energy policies. Innovative organisational structures, the dissemination and exchange of good practices and specific training and capacity building actions will be encouraged.

3.8. Specific implementation aspects

The priority setting for the implementation of the activities in this challenge is led by the need to strengthen the European dimension of energy research and innovation. A main aim will be to support the implementation of the research and innovation agenda of the Strategic Energy Technology Plan (SET Plan)[24] to achieve the objectives of the Union's energy and climate change policy. The SET-Plan roadmaps and implementation plans will therefore provide a

[24] COM(2007) 723

valuable input for the formulation of the work programmes. The SET Plan governance structure will be used as a principle basis for strategic priority setting and the coordination of Energy Research and innovation across the Union.

The non-technological agenda will be guided by the Union's energy policy and legislation. The enabling environment for mass deployment of demonstrated technological and service solutions, processes and policy initiatives for low-carbon technologies and energy efficiency across the Union shall be supported. This may involve support to technical assistance for development and roll-out of energy efficiency and renewable energy investments.

Partnering with European stakeholders will be important to share resources and implement jointly. It may be envisaged, on a case by case basis, that existing European Industrial Initiatives of the SET Plan are turned into formalised public-private partnerships, if considered appropriate, to increase the level and coherence of national funding and to stimulate joint research and innovation actions among Member States. Consideration will be given to provide support, including with Member States, to alliances of public research performers, in particular, the European Energy Research Alliance established under the SET Plan to pool public research resources and infrastructures to address critical research areas of European interest. International coordination actions shall support the SET Plan priorities according to the variable geometry principle, taking account of countries capabilities and specificities.

The European Commission's Information System of the SET-Plan will be mobilised to develop, together with stakeholders, key performance indicators (KPIs) to monitor the progress of implementation and which will be revised on a regular basis to account of the latest developments. More broadly, implementation under this Challenge will seek to improve the coordination of relevant Union Programmes, initiatives and policies, such as Cohesion policy, in particular through the national and regional strategies for smart specialisation, and the Emission Trading Scheme mechanisms, for example concerning support to demonstration projects.