Directorate-General for Energy and Transport

EUROPEAN COMMISSION

European Strategic Energy Technology Plan

On 22 November, the European Commission will present the European Strategic Energy Technology Plan (SET-Plan) (see IP/07/1750). Low carbon technologies will play a vital role in reaching our energy and climate change targets. The main goal of the SET-Plan is to accelerate the development and implementation of these technologies. This background note sets out the details of the SET Plan. Its rationale accompanied by some useful background figures and charts is set out in MEMO/07/494.

Technology is vital for reaching energy and climate change objectives

The inter-related challenges of climate change, security of energy supply and competitiveness are multifaceted and require a coordinated response. We are piecing together a far-reaching jigsaw of policies and measures: binding targets for 2020 to reduce greenhouse gas emissions by 20% and ensure 20% of renewable energy sources in the EU energy mix; a plan to reduce EU global primary energy use by 20% by 2020; carbon pricing through the Emissions Trading Scheme and energy taxation; a competitive Internal Energy Market; an international energy policy.

Technology is vital in reaching all the above-mentioned objectives. We need a dedicated policy to accelerate the development and deployment of cost-effective low carbon technologies. To meet the 2020 targets, we need to lower the cost of clean energy and put EU industry at the forefront of the rapidly growing low carbon technology sector. In the longer term, if we are to meet the greater ambition of reducing our greenhouse gas emissions by 60-80% by 2050, new generations of technologies have to be developed through breakthrough in research. The transition to a low carbon economy will take decades and touch every sector of the economy, but we cannot afford to delay action. Decisions taken over the next 10-15 years will have profound consequences for energy security, for climate change, for growth and jobs in Europe.

Weaknesses in energy innovation today

Since the oil price shocks in the 70s and 80s, Europe has enjoyed inexpensive and plentiful energy supplies. The easy availability of resources, no carbon constraints and the commercial imperatives of market forces have not only left us dependent on fossil fuels, but have also tempered the interest for innovation and investment in new energy technologies. In short, there is neither a natural market appetite nor a short-term business benefit for such technologies. This market gap between supply and demand is often referred to as the 'valley of death' for low carbon energy technologies. Public intervention to support energy innovation is thus both necessary and justified.

Public and private energy research budgets in the EU have declined substantially since 1980s. This has led to an accumulated under-investment in energy research capacities and infrastructures. If EU governments were investing today at the same rate as in 1980, the total EU public expenditure for the development of energy technologies would be four times the current level of investment.

The energy innovation process, from initial conception to market penetration, also suffers from unique structural weaknesses. It is characterised by long lead times, often decades, to mass market due to the scale of the investments needed and the technological and regulatory inertia inherent in existing energy systems. New technologies are generally more expensive than those they replace while not providing a better energy service.

Key technology challenges for the next 10 years

To achieve the 2020 targets a twin-track approach is needed. Reinforced research has to lower costs and improve performance. Pro-active support measures are to create business opportunities, stimulate market development and address the non-technological barriers that discourage innovation and the market deployment of efficient and low carbon technologies.

To achieve the 2050 vision, towards complete decarbonisation, we need to develop a new generation of technologies through major breakthroughs. Even if some of these technologies will have little impact by 2020, it is vital that we reinforce efforts today to ensure that they come on-stream as early as possible. We also have to plan for major organisational and infrastructure changes.

Key EU technology challenges for the next 10 years to **meet the 2020 targets:**

- Make second generation biofuels competitive alternatives to fossil fuels, while respecting the sustainability of their production;
- Enable commercial use of technologies for CO_2 capture, transport and storage through demonstration at industrial scale, including whole system efficiency and advanced research;
- Double the power generation capacity of the largest wind turbines, with off-shore wind as the lead application;
- Demonstrate commercial readiness of large-scale Photovoltaic (PV) and Concentrated Solar Power;

- Enable a single, smart European electricity grid able to accommodate the massive integration of renewable and decentralised energy sources;

- Bring to mass market more efficient energy conversion and end-use devices and systems, in buildings, transport and industry, such as poly-generation and fuel cells;

- Maintain competitiveness in fission technologies, together with long-term waste management solutions;

Key EU technology challenges for the next 10 years to **meet the 2050 vision**:

- Bring the next generation of renewable energy technologies to market competitiveness;

- Achieve a breakthrough in the cost-efficiency of energy storage technologies;

- Develop the technologies and create the conditions to enable industry to commercialise hydrogen fuel cell vehicles;

- Complete the preparations for the demonstration of a new generation (Gen-IV) of fission reactors for increased sustainability;

- Complete the construction of the ITER fusion facility and ensure early industry participation in the preparation of demonstration actions;

- Elaborate alternative visions and transition strategies towards the development of the Trans-European energy networks and other systems necessary to support the low carbon economy of the future;

- Achieve breakthroughs in enabling research for energy efficiency: e.g. materials, nano-science, information and communication technologies, bio-science and computation.

What is the Commission proposing?

The SET-Plan proposes to deliver the following results: **a new joint strategic planning**, a more **effective implementation**, an increase in **resources**, and a new and reinforced approach to **international cooperation**.

1) **Joint strategic planning** will enable a better orientation of efforts and would be the seed to bring together our researcher and our industry.

   Early 2008 the Commission will establish a **Steering Group on Strategic Energy Technologies** to steer the implementation of the SET-Plan, reinforcing the coherence between national, European and international efforts. The Group, chaired by the Commission, will be composed of high level government representatives from Member States.

   In the first half of 2009, to review progress the Commission will organise a **European Energy Technology Summit** that will bring together all stakeholders in the entire innovation system, from industry to customers, as well as representatives of the European institutions, the financial community and our international partners.

   To support the definition of energy technology objectives, as well as to build consensus around the SET-Plan programme, the Commission will establish an open-access information and knowledge management system on energy technologies.

2) For **effective implementation** we need more powerful mechanisms that can leverage the potential of European industry and researchers.

   In 2008 the Commission proposes to launch six new **European Industrial Initiatives** that will target sectors for which working at Community level will add most value – technologies for which the barriers, the scale of the investment and risk involved can be better tackled collectively.

The initiatives are as follows:

- European Wind Initiative: focus on large turbines and large systems validation and demonstration (relevant to on and off-shore applications).

- Solar Europe Initiative: focus on large-scale demonstration for photovoltaics and concentrated solar power

- Bio-energy Europe Initiative: focus on 'next generation' biofuels within the context of an overall bio-energy use strategy.

- European CO2 capture, transport and storage initiative: focus on the whole system requirements, including efficiency, safety and public acceptance, to prove the viability of zero emission fossil fuel power plants at industrial scale.

- European electricity grid initiative: focus on the development of the smart electricity system, including storage, and on the creation of a European Centre to implement a research programme for the European transmission network.

- Sustainable nuclear fission initiative: focus on the development of Generation-IV technologies

Several initiatives that are already being implemented, or are well advanced in their preparation, serve as illustrative examples: the European fusion research programme and its flagship 'ITER'; the Single European Sky air traffic management research programme (SESAR); the proposed Joint Technology Initiative on Fuel Cells and Hydrogen; and the proposed 'Clean Sky' Joint Technology Initiative on the environmental impacts of aviation.

To bring about a move from today's model of collaborating on projects towards a new paradigm of implementing programmes and to align these programmes with the SET-Plan priorities, the Commission proposes to create a **European Energy Research Alliance**.

The **European Institute of Technology** could provide an appropriate vehicle to realise this ambition, through a Knowledge and Innovation Community on energy and climate change.

The Commission proposes to initiate in 2008 an action on **European energy infrastructure networks and systems transition planning**. It will contribute to optimise and harmonise the development of low carbon integrated energy systems across the EU and its neighbouring countries. It will help the development of tools and models for European level foresight in areas such as smart, bi-directional electricity grids, CO_2 transport and storage and hydrogen distribution.

3) **Resources**

Implementation of the SET-Plan will help overcome the fragmentation of the European research and innovation base, leading to a better overall balance between cooperation and competition. Encouraging more focus and coordination between different funding schemes and sources will help to optimise investment.

Two challenges need to be addressed: **mobilising additional financial resources**, for research and related infrastructures, industrial-scale demonstration and market replication projects; and **education and training** to deliver the quantity and quality of human resources required to take full advantage of the technology opportunities that the European energy policy will create

At the end of 2008 the Commission intends to present a *Communication on financing low carbon technologies* that will address resource needs and sources, examining all potential avenues to leverage private investment, including private equity and venture capital, enhance coordination between funding sources and raise additional funds

4) **International cooperation** should be a fundamental pillar in our European strategy.

We need to take our international cooperation on energy technology to a new dimension. The measures proposed in the SET-Plan (e.g. the Steering Group, European Industrial Initiatives and the European Energy Research Alliance) should bring about a reinforced international cooperation strategy. We also need to ensure that the EU increasingly speaks with one voice in international fora, where appropriate, to achieve a more coherent and stronger partnership effect.

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Annex 1

The advantages and disadvantages of different sources of electrical energy

Energy sources	**Technology considered for the cost estimate**	**2005 Cost (€ / MWh)**	**Projected Cost 2030 (€ / MWh with €20-30/tCO2)**	**GHG emissions (Kg CO2eq/MWh)**	**EU-27 Import dependency 2005**	**EU-27 Import dependency 2030**	**Efficiency**	**Fuel price sensitivity**	**Proven reserves / Annual production**
		Source IEA							
Natural gas	Open cycle gas turbine	**45 – 70**	**55 - 85**	440	57%	84%	40%	Very high	64 years
	CCGT (Combined Cycle Gas Turbine)	**35 – 45**	40 - 55	400			50%	Very high	
Oil	Diesel engine	**70 – 80**	80 - 95	550	82%	93%	30%	Very high	42 years
Coal	PF (Pulverised Fuel with flue gas desulphurisation)	**30 – 40**	45 - 60	800	39%	59%	40-45%	medium	155 years
	CFBC (Circulating fluidized bed combustion)	**35 – 45**	50 - 65	800			40-45%	medium	
	IGCC (Integrated Gasification Combined Cycle)	**40 – 50**	55 - 70	750			48%	medium	
Nuclear	Light water reactor	**40 – 45**	40 - 45	15	Almost 100% for uranium ore		33%	Low	Reasonable reserves: 85 years
Biomass	Biomass generation plant	**25 – 85**	25 - 75	30	nil		30 - 60%	medium	
Wind	On shore	**35 – 175**	28 - 170	30			95-98%	nil	Renewable
		35 – 110	28 – 80						
	Off shore	**50 – 170**	50 - 150	10			95-98%		
		60 – 150	40 – 120						
Hydro	Large	**25 – 95**	25 - 90	20			95-98%		
	Small (<10MW)	**45 – 90**	40 - 80	5			95-98%		
Solar	Photovoltaic	**140 - 430**	55 -260	100			/		

Annex 2

Summary table of the Technology Map

The purpose of the Technology Map is to underpin the SET-Plan Communication. Based on it the SET-Plan proposes actions to accelerate low carbon energy technology development and deployment through European Industrial Initiatives. The Technology Map provides a quantification of the potential contributions of key technologies to: Environment - CO2 emission reductions; Security of Energy Supply - fossil fuel savings; and Competitiveness - changes in the cost of energy.

The following table from the Technology Map summarises for each technology: the **description** of the current status and the anticipated developments; the current and future **potential** share in the European energy demand; the quantified **impacts** of technology penetration (*Environment - Greenhouse gas emissions; Security of supply; and Competitiveness);* the **barriers** to penetration in the European energy market; the **needs** to realise its potential and the synergies with other technologies and sectors.

TECHNOLOGY AVENUE	DESCRIPTION	POTENTIAL	ADDITIONAL IMPACT				BARRIERS	NEEDS
	1) Sector 2) Current market share 3) State of the Art	1) Baseline scenario 2) Potential penetration 3) Potential breakthroughs	Environment		SES	Competiti-veness		
			CO_2 avoided (Mt)	Mitigation cost (€/t CO_2)	Fossil fuel savings (Mtoe)	Additional cost of energy (%)		
WIND POWER	1) Power generation 2) 3% of demand ~50 GWe installed capacity 3) Onshore wind: commercialised Offshore wind: Starting deployment	1) 2020: 120 GWe 2030: 148 GWe 2) 2020: 120÷180 GWe 2030: 168÷300 GWe 3) Large scale testing to commercialisation, particularly for offshore environments	0÷100 (2020) 2÷250 (2030) 10÷2400 (2010-2030) Need (with increasing levels of wind) for increased use of reserves and additional back-up capacity not taken into account in calculations	(-5)÷0 (2020) (-20)÷5 (2030) (-10)÷5 (2010-2030)	0÷35 (2020) 1÷75 (2030) 5÷700 (2010-2030)	(-0.3)÷0 (2020) (-2)÷0 (2030)	Inflexible grid infrastructure Lack of large-scale testing facilities Under-developed storage mechanisms Disparate level of financial support Lack of social acceptance Lack of skilled professionals	Upgrading of grid infrastructures and appropriate EU regulations for grid integration Large-scale test facilities / RD&D for upscaling Better coordination of financial support schemes across the EU Specialised education programmes Support of innovation in SMEs

Technology Avenue	Description	Potential	Additional Impact				Barriers	Needs
			Environment		SES	Competitiveness		
	1) Sector 2) Current market share 3) State of the Art	1) Baseline scenario 2) Potential penetration 3) Potential breakthroughs	CO_2 avoided (Mt)	Mitigation cost (€/t CO_2)	Fossil fuel savings (Mtoe)	Additional cost of energy (%)		
Solar Photovoltaics	1) Power generation 2) 0.1% of demand 3.4 GWp installed capacity 3) Small scale: commercialised Large scale: Development Thin films: Development	1) 2020: 9 GWp 2030: 16 GWp 2) 2020: 65÷125 GWp 2030: 300÷665 GWp 3) Integration of thin films in buildings High concentration devices for large systems	30÷60 (2020) 140÷320 (2030) 980÷2230 (2010-2030)	240 (2020) 125 (2030) 160 (2010-2030)	9÷20 (2020) 42÷100 (2030) 300÷690 (2010-2030)	3÷7 (2020) 8÷17 (2030)	High cost of electricity Techno-economic issues Building integration Lack of skilled professionals Access to grid Regulations and administration	R&D Development of a liberalised market Financial incentives Framework to facilitating exports
Concentrated Solar Power	1) Power generation 2) 0% of demand < 100 MW installed and/or under construction capacity 3) Parabolic trough : commercialised Central receiver: commercialised Dish receiver: Demonstrated	1) 2020–2030: 0 GWe 2) 2020: 1.8 GWe in EU27 → 1.8 GWe with 55 TWhe imports 2030: 4.6 GWe in EU27 → 4.6 GWe with 216 TWhe imports 3) Higher temperature systems, low cost heat storage Process scale-up > 100 MWe Trans Mediterranean Grid infrastructure	5÷35 (2020) 15÷130 (2030) 145÷1035 (2010-2030)	15÷55 (2020) 5÷45 (2030) 10÷50 (2010-2030)	2÷10 (2020) 5÷40 (2030) 45÷315 (2010-2030)	0.2÷0.3 (2020) 0.3 (2030)	High cost of electricity Lack of feed-in support in most EU country Equity shortage for demonstrating first of a kind project Investments in grid infrastructure	Expansion of feed-in tariffs for CSP in the EU Risk sharing financing mechanisms for large scale demonstration and commercialisation projects R&D and Demonstration Open EU market to CSP imports Investment in a trans-European and trans-Mediterranean Super grid Framework to build-up a global market
Solar Heating and Cooling	1) Heat generation 2) 2% of demand 13 GWth installed capacity 3) Small scale for hot water: commercialised Combi-systems: Demonstrated Cooling systems: Development Medium temperature industrial systems: development	1) 2020: 52 GWth 2030: 135 GWth 2) 2020: 90÷320 GWth 2030: 200÷700 GWth 3) Integration in buildings Cooling Medium temperature systems for industrial applications	4÷30 (2020) 8÷65 (2030) 80÷600 (2010-2030)	270÷330 (2020) 80 (2030) 170÷220 (2010-2030)	25÷35 (2020) 50÷55 (2030) 65÷480 (2010-2030)	0.3÷2 (2020) 0.1÷ 1 (2030)	Heat storage Lack of financial incentives Building integration Lack of skilled professionals Regulations and administration	R&D in energy storage and materials research Financial incentives for the deployment of the technology

Technology Avenue	Description	Potential	Additional Impact				Barriers	Needs
	1) Sector 2) Current market share 3) State of the Art	1) Baseline scenario 2) Potential penetration 3) Potential breakthroughs	Environment		SES	Competitiveness		
			CO_2 avoided (Mt)	Mitigation cost (€/t CO_2)	Fossil fuel savings (Mtoe)	Additional cost of energy (%)		
Hydropower Generation: **Large HPP**	1) Power generation 2) 9% of demand about 95 GW installed capacity (non pumped storage) 3) Large scale: commercialised	1) 2020: 100 GW 2030: 100 GW 2) 2020: 101÷108 GW (refurbishment from 2005 park: 25÷50%) 2030: 104÷112 GW (refurbishment achieved from 2005 park: 55÷85%) 3) Large scale refurbishment of existing facilities Power electronics for dynamic operations (e.g. pumped hydro storage)	3.5÷15 (2020) 7.5÷20 (2030) 70÷270 (2010-2030)	25 (2020) 10÷20 (2030) 20÷25 (2010-2030)	1÷5 (2020) 2÷6.5 (2030) 20÷80 (2010-2030)	0.05÷0.2 (2020) 0.04÷0.2 (2030)	Lack of institutional support Complex regulations and administration Lack of support for R&D and Demonstration Equity shortage for R&D development and Demonstration Social acceptance	Increased R&D and Demonstration public support Focussed and co-ordinated R&D and Demonstration programme at the EU level Coherent, harmonised and conducive regulation and administration frameworks across the EU
Hydropower Generation: **Small HPP**	1) Power generation 2) 1% of demand 11 GW installed capacity 3) Small scale: commercialised Very small scale: Development	1) 2020: 14.5 GW 2030: 15.5 GW 2) 2020: 14.5÷18 GW 2030: 16.5÷19 GW 3) Advanced low/very low head turbines Power electronics	0.5÷7.5 (2020) 1.5÷6.5 (2030) 15÷110 (2010-2030)	5÷10 (2020) 5÷7 (2030) 5÷8 (2010-2030)	0.2÷2.5 (2020) 0.4÷2 (2030) 3.5÷35 (2010-2030)	~0 (2020) ~0 (2030)	Lack of institutional support Complex regulations and administration Lack of support for R&D and Demonstration Equity shortage of SMEs for R&D development and Demonstration Social acceptance	Increased R&D and Demonstration public support Focussed and co-ordinated R&D and Demonstration programme at the EU level Coherent, harmonised and conducive regulation and administration frameworks across the EU
Geothermal	1) Heat and power generation 2) Less than 1% of demand 3) Heat pumps commercialised DH commercialised Enhanced geothermal power system RD&D	1) 2020: 1,0 GWe 2030: 1,3 GWe (heat not available) 2) 2020: 1÷6 GWe 2030: 1÷8 GWe 2030: 38÷42 GWth 2030: 60÷70 GWth	15÷35 (2020) 20÷50 (2030) 300÷700 (2010-2030)	0÷100 (2020) (-10)÷80 (2030) (-10)÷90 (2010-2030)	5÷12 (2020) 8÷16 (2030) 100÷200 (2010-2030)	0.2 (2020) (-0.3)÷ 0.3 (2030)	Lack of appropriate legislation Lack of financial incentives Lack of clarity in administrative procedures, long permit time Lack of skilled professionals Lack of social acceptance Fragmentation of existing knowledge	Coherent financial support mechanisms Additional incentives Appropriate regulations, standards, permit procedures RD&D support International collaboration and centralisation of existing knowledge Vocational and training programmes

TECHNOLOGY AVENUE	DESCRIPTION	POTENTIAL	ADDITIONAL IMPACT					BARRIERS	NEEDS
			Environment		SES	Competitiveness			
	1) Sector 2) Current market share 3) State of the Art	1) Baseline scenario 2) Potential penetration 3) Potential breakthroughs	CO_2 avoided (Mt)	Mitigation cost (€/t CO_2)	Fossil fuel savings (Mtoe)	Additional cost of energy (%)			
OCEAN WAVE POWER	1) Power generation 2) Null 3) Large scale systems : Demonstrated < 1 MW, on-going up to a few MWs	1) 2020: 0,9 GWe 2030: 1,7 GWe 2) 2020: 5÷10 GWe 2030: 10÷16 GWe 3) Large scale testing to commercialisation Off-shore grid infrastructure	10÷15 (2020) 15÷25 (2030) 140÷275 (2010-2030)	70÷150 (2020) 70÷150 (2030) 70÷150 (2010-2030)	2÷5 (2020) 5÷10 (2030) 40÷80 (2010-2030)	0.5 (2020) 0.7÷0.9 (2030)		Cost competitiveness of ocean electricity High cost of technology learning Lack of dedicated engineering capacities and of private investments Cost of off-shore grid and unavailability of on-shore grid Administrative and legislative Coastal use	R&D and Demonstration Coordinated approach at EU level Long term feed-in tariff and capital investment support Coastal management at EU level
COGENERATION OF HEAT AND POWER	1) Power generation / District heating / Industry 2) 10% of demand ~95 GWe installed capacity 3) Large/medium scale: commercialised Micro-CHP, fuel cells: R&D evaluation	1) 2020: 160 GWe 2030: 169 GWe 2) 2020: 165÷185 GWe 2030: 195÷235 GWe 3) Large/medium scale overhaul/replacement with higher electrical and overall efficiency Biomass based CHP Heat storage/cooling	50÷85 (2020) 50÷95 (2030) 1000÷1400 (2010-2030)	15÷30 (2020) 30÷70 (2030) 15÷40 (2010-2030)	20÷30 (2020) 20÷35 (2030) 400÷500 (2010-2030)	0.5÷1 (2020) 1÷3 (2030)		Lack of coherent policies in some MS Market liberalisation exposes short term profitability projects Market uncertainties about fuel and electricity prices Many (older) installations now operate with lower efficiency and uncompetitive costs level Correlation of heat and electricity demand Slow progress on micro-CHP development	Improved efficiency across the sectors, especially electrical Improvements in bio-CHP technology Innovations on thermal (heat) storage technologies and improved cooling systems Performance improvement (technology & economics) for heat distribution infrastructure for DH R&D, demonstration and financing small scale CHP (fuel cells and micro-CHP) that lead to their mass introduction Support transition to decentralised energy supply

TECHNOLOGY AVENUE	DESCRIPTION	POTENTIAL	ADDITIONAL IMPACT				BARRIERS	NEEDS
			Environment		SES	Competiti-veness		
	1) Sector 2) Current market share 3) State of the Art	1) Baseline scenario 2) Potential penetration 3) Potential breakthroughs	CO_2 avoided (Mt)	Mitigation cost (€/t CO_2)	Fossil fuel savings (Mtoe)	Additional cost of energy (%)		
ZERO EMISSION FOSSIL FUEL POWER PLANTS	1) Power generation 2) Null 3) Individual components commercialised in smaller scales Overall, in advanced research and validation phase, ready to embark on large scale demonstration	1) 2020: 0 GWe 2030: 0 GWe 2) 2020: 5÷30 GWe 2030: 90÷190 GWe 3) Successful large scale demonstration projects by 2015	20÷120 (2020) 330÷700 (2030) 1800÷4700 (2010-2030)	30 (2020) 16÷18 (2030) 18÷20 (2010-2030)	(-3)÷(-15) (2020) (-40)÷(-90) (2030) (-230)÷(-600) (2010-2030)	0.3÷2 (2020) 2÷6 (2030)	Technology not demonstrated at large scale High cost of first-of-a-kind plants Unfavourable market and regulatory conditions Lack of supportive fiscal measures Lack of CO_2 transmission and storage infrastructure Public acceptance	Research and development Large scale demonstration projects Development of a suitable regulatory and market framework Development of CO_2 transport and storage infrastructure
NUCLEAR FISSION POWER	1) Power generation (Gen-IV with heat generation) 2) 31% of demand ~135 GWe installed capacity 3) Gen-III: Mature technology. Gen-IV: depends on concept. Basic research still required for all designs leading to strategic decisions by 2012 at the latest. First of a kind and demo plants (VHTR and SFR) by 2020	1) 2020: 114 GWe 2030: 100 GWe 2) 2020: 127÷150 GWe 2030: 127÷200 GWe 3) To maintain market share requires c. 100GWe new build over next 25 years (Gen-III) Development of fast reactors and fuel cycles will enable much greater sustainability	55÷160 (2020) 100÷400 (2030) 1100÷3800 (2010-2030) No account taken of possible market insertion of VHTR (process heat) Current annual savings by existing nuclear plants accounts for about 800 Mt of CO_2 and 250 Mtoe of fossil fuel (not included in above figures)	(-5) (2020) (-10) (2030) (-10)÷(-5) (2010-2030)	15÷50 (2020) 35÷125 (2030) 300÷1200 (2010-2030)	(-0.5)÷(-0.1) (2020) (-2)÷(-0.5) (2030)	Lack of overall EU nuclear strategy Lack of harmonised regulations and standards Public/political acceptance Insufficient public R&D funding for Gen-IV Future availability of suitably qualified scientists and engineers	A stable and predictable regulatory / economic / political environment. Clear EU nuclear strategy Increased support for RDD&D on Gen-IV; more public funding, public-private partnerships, Joint Undertakings, etc. Better public and stakeholder information and dialogue on nuclear energy Promote education and training in scientific disciplines in general and nuclear technology in particular
NUCLEAR FUSION POWER GENERATION	1) Power generation 2) None 3) Committed construction of ITER as prototypic experiment aimed at demonstrating the technological feasibility	1) N.A. before 2030 2) After 2030 3) Operation of DEMO as demonstration fusion power plant	N.A.	N.A.	N.A.	N.A.	Limited industrial contributions to the financial sources due to the long-term nature Low availability of suitable trained engineers and scientists S&T challenges on frontier technologies	Strengthen the organisation of fusion development with reinforced industrial participation, in particular within the DEMO design group Reinforcement of education and training programmes

TECHNOLOGY AVENUE	DESCRIPTION	POTENTIAL	ADDITIONAL IMPACT				BARRIERS	NEEDS
			Environment		SES	Competitiveness		
	1) Sector 2) Current market share 3) State of the Art	1) Baseline scenario 2) Potential penetration 3) Potential breakthroughs	CO_2 avoided (Mt)	Mitigation cost (€/t CO_2)	Fossil fuel savings (Mtoe)	Additional cost of energy (%)		
	of fusion energy		No CO_2 or other air pollutants during operation Huge potential fossil fuel savings with water and lithium as largely available inexpensive fuels Cost of energy is expected to be balanced by the outstanding improvement of the competitiveness of European industry					Strong political will for shortening the timescale of fusion development through EU l and international resources
ELECTRICITY NETWORKS (SMART GRIDS)	1) Power transmission / distribution 2) 75÷85% of generation at transmission level 7÷10% of electricity consumed lost at transmission and distribution levels 3) Long overhead lines Centralised network control	1) New generation partially constrained by network bottlenecks 2) 2020: 1% losses reduction 2030: 2.5% losses reduction 3) HVDC, FACTS,WAMS Active network management of distributed generation systems	20÷30 (2020) 50÷60 (2030) 500÷600 (2010-2030)	N.A. N.A. N.A.	5÷10 (2020) 15÷25 (2030) 150÷250 (2010-2030)	N.A. N.A.	How to define/share reinforcement and connection cost between stakeholders under discussion Regulatory framework Social oppositions Lack of coordinated research efforts	EU Member States need to invest at least 400-450 b€ in transmission and distribution infrastructures over the next three decades Depending upon distance between new generation and a robust grid (e.g. off-shore wind, concentrated solar power), a further 10 to 25% share of connection costs may add to the global grid investment Shared design for integrating new generation technologies ICT for control and monitoring Standard rules and guidelines
			An integrated electricity grid fosters EU market competitiveness, in terms of impact on electricity prices and support to liberalisation The mitigation costs are not evaluated here because it is not quantifiable which part of the investments results in losses reduction and which part in the below listed further benefits Key benefit of grids coordinated and integrated development is the relief of cost-effective generation capped by bottlenecks. In this assessment it is assumed that each generation sector can inject into a reinforced grid nearly the maximum power Further benefits include network investment deferral, reduction of outages, increase in quality of supply					

Technology Avenue	Description	Potential	Additional Impact				Barriers	Needs
	1) Sector 2) Current market share 3) State of the Art	1) Baseline scenario 2) Potential penetration 3) Potential breakthroughs	Environment		SES	Competitiveness		
			CO_2 avoided (Mt)	Mitigation cost (€/t CO_2)	Fossil fuel savings (Mtoe)	Additional cost of energy (%)		
Biofuels	1) Transport 2) 3.9 Mt of biofuels in 2005 3) 1st generation: Commercialised 2nd generation: pilot scale demonstrated	1) 2020: 7.5% of transport petrol & diesel demand 2030: 9.5% of transport petrol & diesel demand 2) 2020: 10÷14% of transport petrol & diesel demand 2030: 15÷20% of transport petrol & diesel demand 3) 2nd generation large scale demonstration by 2015	15÷40 (2020) 45÷75 (2030) 375÷810 (2010-2030)	150÷160 (2020) 90 (2030) 120÷125 (2010-2030)	10÷25 (2020) 20÷40 (2030) 190÷450 (2010-2030)	1.5÷3.5 (2020) 2.0÷3.5 (2030)	No structural barriers Biomass availability and sustainability (including allocation between energy sectors and competition with non-energy sector)	Reinforced and focused public support for R&D at national and EU levels Funding mechanisms for large scale demonstration initiatives Harmonisation of markets, regulations and policies at EU levels
Hydrogen and Fuel Cells	1) Transport and Power generation 2) Null 3) Large scale hydrogen production: commercialised or under development Small scale H_2: Demonstration/Commercialised Fuel cells: Demonstration	1) 2020 – 2030: 0% of passenger cars 2) 2020: 1.5% of passenger cars 2030: 6% to 12% of passenger cars 3) Low cost, reliable and durable fuel cells High capacity hydrogen storage Low cost and large scale carbon free/lean H_2 supply	5 (2020) 30÷60 (2030) 185÷330 (2010-2030) Impacts only for passenger cars	475 (2020) 100÷240 (2030) 145÷290 (2010-2030)	2.5 (2020) 10÷20 (2030) 80÷135 (2010-2030)	0.3 (2020) 0.7÷0.8 (2030)	Long term and disruptive mitigation option Lack of end-use deployment support Regulation and Code and Standards High up-front infrastructure investments for hydrogen production and supply Shortage of equity for SMEs High cost of fuel cells Pending issue of primary resources allocation for hydrogen production	Focussed R&D and large scale Demonstration and market preparation efforts at EU level Long term public and private partnership Establishment of regulatory and financial support schemes Education