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Impact Assessment

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Energy Roadmap 2050

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Annex 1 Scenarios – assumptions and results

PART B: DECARBONISATION SCENARIOS

1. ASSUMPTIONS

1.1 Macroeconomic and demographic assumptions

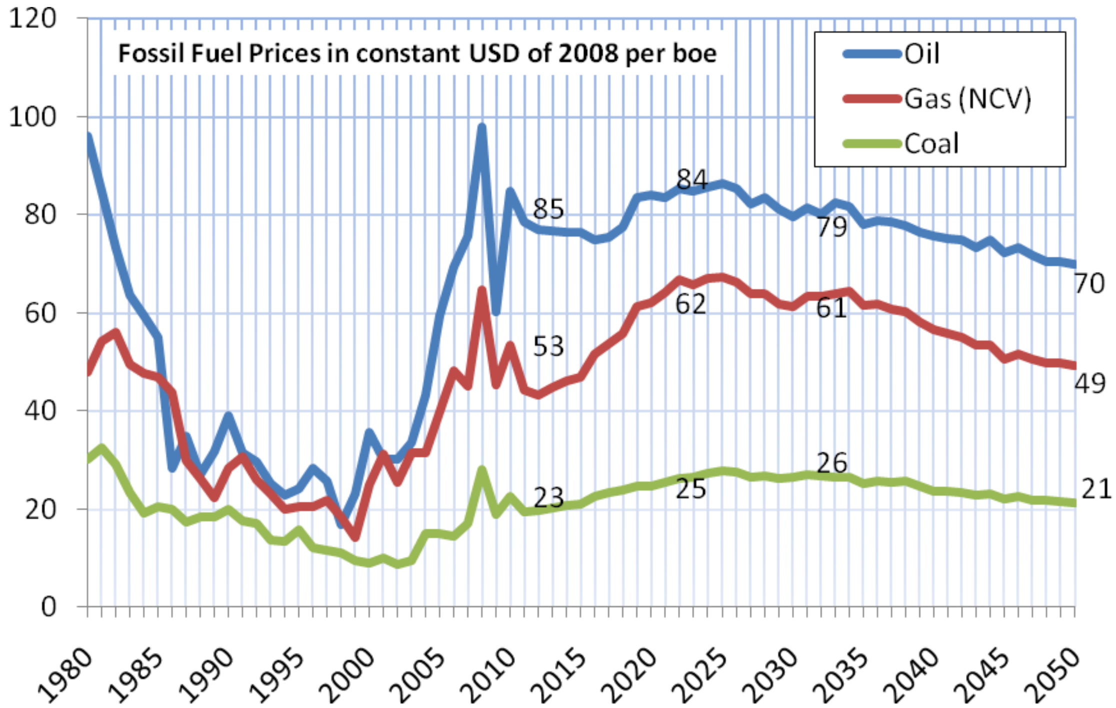
On the basis of the European Council's objective for EU decarbonisation of at least 80% below 1990 by 2050 in the context of necessary reductions by developed countries as a group[1] it is assumed that competitiveness effects throughout decarbonisation would be rather limited. Therefore, the decarbonisation scenarios are based on the same demographic and macroeconomic assumptions as the Reference scenario and Current Policy Initiatives scenario. Such an assumption also facilitates comparison of the energy results across scenarios. These macro-economic (sectoral production) assumptions also hold for energy intensive industries. However, under fragmented action, measures against carbon leakage may be necessary. The analysis of this particular case (see below) deals with energy and emission effects of such measures, but does not address potential changes in sectoral production levels under fragmented action. The aim of measures against carbon leakage is indeed to avoid such relocation of energy intensive production.

1.2 Energy import prices

The decarbonisation scenarios are based on "global climate action" price trajectories for oil, gas and coal[2] reflecting that global action on decarbonisation will reduce fossil fuel demand worldwide and will therefore have a downward effect on fossil fuel prices. Oil, gas and coal prices are therefore lower than in the Reference scenario and Current Policy Initiative scenario. Their trajectories are an outcome of the global analysis in the Low carbon Economy Roadmap, which is similar to recent IEA projections that assessed the impacts of ambitious climate policies[3].

[1] European Council, 29/30 October 2009.
[2] See Impact assessment accompanying Communication on Low Carbon Economy Roadmap SEC(2011)288
[3] International Energy Agency, World Energy Outlook 2009, Energy Technology Perspectives 2010

Figure 18: Fossil fuel prices in the decarbonisation scenarios



1.3 Policy assumptions

In addition to policy assumptions in the Current Policy Initiatives scenario, the following policies and measures were added to scenarios:

Table 15 Measures included in all decarbonisation scenarios

1	Climate policies for respecting carbon constraints to reach 85% energy related CO2 reductions by 2050 (40% by 2030), consistent with 80% reduction of total GHG emissions according to the "Roadmap for moving to a competitive low carbon economy in 2050" (including achievement of cumulative carbon cap) in a cost effective way	Supplementary to specific energy policies in the scenario, ETS prices and carbon values for non ETS sectors are determined in such a way as to reach the 2050 reduction goal; ETS and non ETS sectors use equal carbon prices/values (from 2025 onwards); cumulative emissions are similar across scenarios
2	Stronger RES facilitation policies	Represented by higher RES-values in the model. These facilitating RES policies include for example the availability of more sites for RES, easier licensing of RES installations, greater acceptance and support deriving from the improvement of local economies and industrial development; operational aids remain at the same level as in the REF/CPI scenarios.
3	Transport measures	Energy efficiency standards, internal market, infrastructure, pricing and transport planning measures leading to more fuel-efficient transport means and some modal shift Encourage the deployment of clean energy carriers by establishing the necessary supporting infrastructures[4]

[4] The decarbonisation scenarios reflect the transport policy measures included in the White Paper "Roadmap to a Single Transport Area – Towards a competitive and resource efficient transport system" (COM (2011) 144) with highest impact on energy demand in transport.

4	Guarantee funds for all low carbon generation technologies	The model reflects support to early demonstration and first of a kind commercial plants for all innovative low-carbon technologies in the energy sector (nuclear, RES and their infrastructure needs, CCS, etc.).
5	Storage and interconnections	Higher penetration of variable generation leading occasionally to excess electricity is dealt with by increased pump storage and more interconnection capacity. Moreover, large parts of such excess electricity generation from variable sources is transformed into hydrogen, which is fed, up to a certain degree, into the natural gas grid, thereby providing a means for (indirect) storage of electricity and reducing the carbon content of gas delivered to final consumers enabling deeper emission cuts. Where for technical or economic reasons, simulated in the model, feeding into the natural gas grid is not feasible, excess electricity (mainly from RES) is stored in form of hydrogen at times of excess supply and transformed back into electricity when demand exceeds supply. (Hydrogen storage is used to a different degree in various decarbonisation scenarios, see also measures under Scenario 4).

Scenario 2: High energy efficiency

This scenario is driven by a political commitment of very high primary energy savings by 2050. It includes a very stringent implementation of the Energy Efficiency Plan and aims at reaching close to 20% energy savings by 2020. Strong energy efficiency policies are also pursued thereafter.

Table 16 Policies/measures included (in addition to measures in table 15):

	Measure	How it is reflected in the model
1	Additional strong minimum requirements for appliances	Progressive adaptation of modelling parameters for different product groups. As requirements concern only new products, the effect will be gradual.
2	High renovation rates for existing buildings due to better/more financing and planned obligations for public buildings (more than 2% refurbishment per year)	Change of drivers (ESCOs, energy utilities obligation, energy audits) influence stock – flow parameters in the model reflecting higher renovation rates (higher than 2% pa), with account being taken of tougher requirements for public sector through specific treatment of the non-market services sector
3	Passive houses standards after 2020	All new houses after 2020 comply with passive house standards - around 20-50 KWh/m2 (depending on the country) which might to a large extent be of renewable origin
4	Marked penetration of ESCOs and higher financing availability	Enabling role of ESCOs is reflected in lower discount rates for household consumers (from 17.5% to 16% in 2015, 14% in 2020, 13% in 2025 and **12%** from 2030 onwards) and for industry, agriculture and services (from 12% to 11% by 2015 and to **10%** from 2020 onwards)
5	Obligation of utilities to achieve energy savings in their customers' energy use over 1.5% per year (up to 2020)	Induce more energy efficiency mainly in residential and tertiary sectors by imposing an efficiency value for grid bound energy sources

		(electricity, gas, heat)
6	Strong minimum requirements for energy generation, transmission and distribution including obligation that existing energy generation installations are upgraded to the BAT every time their permit needs to be updated	Higher efficiency of power plants through removing less efficient items from the generation portfolio, allowing however for efficiency losses where CCS is deployed Less transmission and distribution losses
7	Full roll-out of smart grids, smart metering	Enabling more efficiency and decentralised RES; Reflected as costs in the distribution grid costs, electricity prices and overall costs of the energy system
8	Significant RES highly decentralised generation	More advanced power dispatching and ancillary services to support reliability of power supply Higher penetration of small wind, solar and hydro

Scenario 3: Diversified supply technologies scenario

This option is mainly driven by carbon prices and carbon values (equal for ETS and non ETS sectors). Carbon values are a still undefined proxy for policy measures that bring about emission reduction. They do not represent a cost to economic actors outside EU ETS (where they coincide with the EU ETS price), but are economic drivers that change decision making of the modelled agents. Yet, the changes triggered by carbon values may entail costs (e.g. for investment in energy savings or for fuel switching), which are accounted for in the modelling framework. They are applied to all sectors and greenhouse gas emissions, covering ETS and Non ETS sectors. As economic drivers, they influence technology choices and demand behaviour. Their respective level is not an assumption but a result of the modelling depending among other things on the level of ambition in GHG reduction. The modelling applies equal carbon values across sectors and ensures thereby efficient reductions across sectors.

This option assumes acceptance of nuclear and CCS and development of RES facilitation policies. It reproduces the "Effective and widely accepted technologies" scenario used in the Low Carbon Economy Roadmap and Roadmap on Transport on the basis of scenario 1bis.

Table 17 Policies/measures included (in addition to measures in table 15):

	Measure	**How it is reflected in the model**
1	MS and investors have confidence in CCS as a credible and commercially viable technology; acceptance of storage and CO2 networks is high	
2	MS, investors and society at large have confidence in nuclear as safety is considered adequate and waste issues are solved	Applicable for all countries that have not ruled out the use of nuclear, i.e. Germany and Belgium for the longer term and the currently non-nuclear countries except for Poland

Scenario 4: High RES

This scenario aims at achieving very high overall RES share and very high RES penetration in power generation (around 90% share and close to 100% related to final consumption). Recalling security of supply objectives, this would be based on increasing domestic RES supply including off-shore wind from the North Sea; significant CSP and storage development, increased heat pump penetration for heating and significant micro power generation (PV, small scale wind, etc.). Regarding assumptions for the demand sectors, scenario 4 is similar to scenario 3, with the exception that RES are more intensively facilitated.

Table 18 Policies/measures included (in addition to measures in table 15):

	Measure	**How it is reflected in the model**
1	Facilitation and enabling policies (permitting, preferential access to the grid)	Represented by significantly higher RES-values in the model than in other decarbonisation scenarios; these RES facilitating policies include for example lower lead times in construction, and involve greater progress on learning curves (e.g. small scale PV and wind) based on higher production.
2	Market integration allowing for more RES trade	Use of cooperation mechanisms or convergent support schemes coupled with declining costs/support result in optimal allocation of RES development, depending also on adequate and timely expansion of interconnection capacity (point 4);
3	Stronger policy measures in the power generation, heating and transport sectors in order to achieve high share of RES in overall energy consumption in particular in household micro power generation and increased power production at the distribution level.	Higher use of heat pumps, significant penetration of passive houses with integrated RES reflected through faster learning rates (cost reductions), higher penetration rates (e.g. due to RES building/refurbishing requirements)
4	Infrastructure, back-up, storage and demand side management	Substantial increase in interconnectors and higher net transfer capacities including DC lines from North Sea to the centre of Europe. Back-up functions done by biomass and gas fired plants. Sufficient storage capacity is provided (pumped storage, CSP, hydrogen). Smart metering allows time and supply situation dependent electricity use (peak/off-peak) reducing needs for storing variable RES electricity. All these measures allow for exploiting greater potentials for off-shore wind in the North Sea.

Scenario 5: Delayed CCS

The delayed CCS scenario shows consequences of a delay in the development of CCS, reflecting acceptance difficulties for CCS regarding storage sites and transport; large scale development of CCS is therefore assumed feasible only after 2040.

Table 19 Policies/measures included (in addition to measures in table 15):

	Measure	**How it is reflected in the model**
1	**Acceptance difficulties for CCS regarding storage sites and transport, which allow large scale development only after 2040.**	Shift of cost-potential curves to the left (higher costs reflecting delays and public opposition). The learning curve for CCS is also delayed accordingly, resulting in higher capital costs for CCS than in scenario 3
2	MS , investors and society at large have confidence in nuclear as safety is considered adequate and waste issues are solved	Low risk premiums for nuclear Applicable for all countries that have not ruled out the use of nuclear, i.e. Germany and Belgium for the longer term and the currently non-nuclear countries except for Poland

Scenario 6: Low nuclear

This scenario shows consequences of a low public acceptance of nuclear power plants leading to cancellation of investment projects that are currently under consideration and no life time extension after 2030. This leads to higher deployment of the substitute technologies CCS from fossil fuels on economic grounds.

Table 20 Policies/measures included (in addition to measures in table 15):

	Measure	How it is reflected in the model
1	**Political decisions based on perceived risks associated with waste and safety (especially in the aftermath of the Fukushima accident) leading to no new nuclear plants being build besides the ones presently under construction: 1600 MWe in Finland, 2x1600 MWe in France and 2x505 MWe in Slovakia. Moreover, the recourse to deciding instead on nuclear lifetime extension is available only up to 2030.**	No extension of nuclear lifetime on economic grounds after 2030 No new nuclear plants are being built besides reactors under construction : 1600 MW in FIN; 2*1600 MW in FR and 2*505 MW in SK
2	MS and investors have confidence in CCS as a credible and commercially viable technology; acceptance of storage and CO2 networks is high	Low risk premiums for CCS

1.4 Assumptions about energy infrastructure development

Infrastructure modelling for decarbonisation scenarios was done similarly to the approach described in Part A, section 1.4 for the Reference and Current Policy initiatives scenarios.

For decarbonisation scenarios the analysis done showed that except for very high RES penetration, the 2020 interconnection capacity would allow for most intra-EU electricity trade provided that some bottlenecks would be dealt with. The identified bottlenecks concerns interconnections around Germany, in Austria-Italy-Slovenia, Balkans and Denmark-Sweden. Greater investment and capacity for these specific links were assumed.

For very high RES penetration, which involves much more RES based electricity trade, stronger growth of interconnection capacity will be required. Under the assumptions of this scenario, full exploitation of off-shore wind potential at North Sea is foreseen. It is assumed that a dense DC interconnection system will develop mainly offshore but also partly onshore, to facilitate power flows from the North Sea offshore wind parks to consumption centres. In this scenario, the links of Sweden with Poland, Sweden with Lithuania, Austria with Italy, France with Italy and links in the Balkan region appear to be congested and need to be reinforced mainly with DC lines.

For more details on the modelling approach and results see Attachment 2.

1.5 Technology assumptions

Many technology assumptions are the same as in the Reference scenario and Current Policy Initiatives scenario (with revised assumptions about nuclear). In the decarbonisation scenarios, however, there are additional features and mechanisms that produce high decarbonisation and technology penetration.

Whereas all decarbonisation scenarios rely on technologies that exist today, they might become commercially mature only over time supported also by decarbonisation requirements. The uptake of the technologies is endogenous in the scenarios with their large-scale deployment leading to lower cost and higher performance, which correspond to a fully mature commercial stage.

All scenarios simulate merit order dispatching for power generation with contribution of variable generation from renewables. Electricity balancing and reliability is ensured endogenously by various means such as import and export flows (in case of high RES it is facilitated by expanding interconnections), investment in flexible thermal units, pumped storage and if required hydrogen based storage. In this latter case, excess variable generation from RES at times of lower demand may be used to produce hydrogen via electrolysis which is then used to produce electricity in turbine based power plants when electricity demand exceeds production from RES and other available sources (e.g. in situations of high demand).

The modelling approach also considers the possibility to mix hydrogen produced through electrolysis in the low and medium pressure natural gas distribution system (up to 30%) in order to reduce the average emission factor of the supplied blend, thereby contributing to the decarbonisation of final energy consumption.

Photovoltaic in High RES Scenario evolves along more optimistic trajectories than in the Reference scenario, as it is presumed that the higher penetration of the technology leads to stronger learning by doing. The higher uptake of RES technologies is driven mainly by the lower cost potentials for RES power, which are due to policies facilitating access to resources and sites.

A further change is in the Delayed CCS scenario where the development of CCS is delayed, and does not reach the same levels of development as in the other scenarios.

There is also faster progress in energy efficiency related technologies due to bigger scale and carbon prices effects. The energy technologies on the demand side follow a different development from the Reference scenario variants. In any situation there are different choices to consumers regarding the energy performance of appliances, buildings and equipment (evident from e.g. energy labelling where such transparency is provided by legislation). In decarbonisation scenarios, there are stronger shifts towards the more efficient technology vintages, which improve the average energy efficiency of a given energy use (e.g. of the average lighting appliance) compared to the Reference scenario variants. Energy efficiency progress is therefore supported by consumer choice effects similar to increased learning by doing driven by consumers opting for the more efficient available technologies.

The assumptions on the battery costs for the transport sector were developed along the lines of the White Paper on a Roadmap to a Single Transport Area. Efficiency improvements of ICE vehicles also occur in response to carbon values, making the overall vehicle fleet more efficient than in the Reference scenario and its variants. However, the following decarbonisation scenarios do not produce the same energy related transport outcome due to the fact that these scenarios do not handle the same transport details and that the overall framework conditions are different according to the scenario. In particular, the penetration of some alternative propulsion technologies (electric vehicles, hydrogen, etc.) might be somewhat different.

1.6 Drivers

An internal greenhouse gas emission reduction contribution of around 80% in 2050 is taken as the key constraint for exploring different scenarios. To ensure that decarbonisation efforts are comparable across options and scenarios, the equalisation of cumulative emissions across scenarios is used as an additional constraint, underlining the importance of the climate impacts of cumulative emissions over the whole period until 2050 (and beyond). The corresponding decarbonisation effort from energy related CO2 emissions is 85% CO2 reductions compared to 1990, as demonstrated by the modelling underlying the Low Carbon Economy Roadmap of March 2011.

Common carbon values applied to all sectors and greenhouse gas emissions, covering ETS and Non ETS sectors, are used as key driver to reach the emission reductions and to ensure cost efficient reductions across sectors. As economic drivers, they influence technology choices and demand behaviour, in addition to the energy policies mirrored in the various scenarios for the Energy Roadmap. The respective level of carbon values is not an assumption but a result of the modelling.

Another important driver concerns international energy prices. Given that these scenarios assume global action, significantly lower fossil fuel prices are assumed than those in the reference and Current Policy Initiatives scenarios. Their order of magnitude has been set at a similar level as the results of the global analysis done for the Low Carbon economy Roadmap and recent IEA projections which assessed the impacts of ambitious climate policies.

To increase the penetration of renewable energy sources the RES-value was increased compared to the Reference scenario. In 2050, the RES-value in the decarbonisation scenarios is twice as high as in the current trend cases: instead of 35 €/MWh in Reference and CPI it amounts to 71 €/MWh in all decarbonisation scenarios, except for the high RES scenario, in which RES support is much more pronounced (RES-value of 382 €/MWh). The RES-value is a modelling tool used to reflect the marginal value of not explicitly modelled facilitation RES policies. These facilitating RES policies include for example the availability of more sites for RES, easier licensing of RES installations, benefits deriving from the improvement of local economies and industrial development. In High RES scenario the RES-value is the shadow value associated with the additional target of maximisation of the RES share in power generation and in the overall energy mix.

2. RESULTS

2.1 Overview: outcome for the four main strategic directions to decarbonisation

Decarbonisation can be achieved through energy efficiency, renewables, nuclear or CCS. Pursuing each of these main directions can bring the energy system a long way towards the decarbonisation objective of reducing energy related CO2 emissions by 85% below 1990 by 2050. The policy options (scenarios) proposed explore 5 different combinations of the four decarbonisation options. Decarbonisation options are never explored in isolation as interaction of different elements will necessarily be included in any scenario that evaluates the entire energy system. Moreover, the climate change issue is about atmospheric concentrations of GHG, i.e. with the long lifetimes of gases involved it is essentially about cumulative emissions. All scenarios achieve also the same level of cumulative GHG emissions. This makes energy, environmental and economic impacts comparable across the scenarios.

Energy Efficiency

Energy Efficiency is a key ingredient in all the decarbonisation pathways examined. Its contribution is most important in the Energy Efficiency scenario (Scenario 2). Energy savings in 2050 from 2005 (virtually the peak energy consumption year) amount to 41%, while GDP more than doubles over the same period of time (+104%). The lowest contribution from energy efficiency towards decarbonisation comes in the Delayed CCS scenario, having a high nuclear contribution, in which primary energy consumption declines 32% between 2005 and 2050. As GDP does not change between scenarios, these energy savings from 2005 are entirely due to energy efficiency gains in a broad sense (including structural change), but not involving income losses.

In the Energy Efficiency scenario, one unit of GDP in 2050 requires 71% less energy input than in 2005. The average annual improvement in energy intensity (primary energy consumption / GDP) amounts to 2.7% pa, which is almost a doubling from historical trends (1.4% pa in 1990 to 2005 including the major efficiency raising restructuring in former centrally planned economies). All the decarbonisation scenarios have energy intensity improvements around 2.5% pa given e.g. synergies between energy efficiency and RES.

Energy savings in the High RES scenario are almost as high as in the Energy Efficiency case (minus 38% for energy consumption in 2050 compared to 2005 instead of minus 41%), this is however achieved by different means: the energy efficiency scenario focuses on direct impacts on final demand, whereas energy savings in the high RES case come largely through highly efficient RES technologies replacing less efficient nuclear and fossil fuel technologies.

A clear result concerning the strategic energy efficiency direction is that a substantial speeding up of energy efficiency improvements from historical trends is crucial for achieving the decarbonisation objective.

RES

RES, too, are a key ingredient in any decarbonisation strategy. The RES share in gross final energy consumption (i.e. the definition for the existing 20% target) rises to at least 55% in 2050.

In the High RES scenario the RES share in gross final energy consumption reaches 75%, up 65 percentage points from current levels. The RES share in transport increases to 73%. The RES share in power generation reaches 86%. RES in electricity consumption account for even 97% given that electricity consumption calculated in line with the procedure for the calculation of the overall RES share excludes losses related to pump storage and hydrogen storage of electricity, the latter being necessary to accommodate all the available RES electricity in particular at times when electricity demand is lower than RES generation.

The second highest RES contribution (58%) materialises in the Low nuclear scenario. The RES share is also rather high under strong energy efficiency policies (57%).

The High RES scenario is the most challenging scenario regarding the restructuring of the energy system including major investments in power generation with RES capacity in 2050 reaching over 1900 GW, which is more than 8 times the current RES capacity and also more than twice today's total generation capacity (including nuclear, all fossil fuels and RES) (for more details see under power generation)

Nuclear

There is also a rather wide range with regard to the contribution of nuclear towards decarbonisation. The nuclear share is highest in the scenario that models the delayed availability of CCS (Scenario 4), given in particular issues arising with transport and storage of CO2 and has no additional policies on renewables and energy efficiency giving rise to an 18% share for nuclear in primary energy demand in 2050, which is 4 percentage points more than is projected under Current Policy Initiatives.

Least use of the nuclear option is made in the Low Nuclear Scenario (Scenario 6), which mirrors a hypothetical Europe-wide sceptical approach to nuclear deployment and investment. This scenario has still a nuclear share in primary energy of 3% in 2050 for reaching 85% CO2 reduction in 2050 similar to all the other decarbonisation scenarios.

The Diversified supply technology scenario (the other scenario, in which technologies compete on their economic merits alone) for reaching decarbonisation has a nuclear share in 2050 of 16% despite of nuclear phase-out in some Member States, which is still slightly higher than the current share. The High RES scenario would leave only little room for nuclear, bringing its share down to 4% in primary energy supply.

CCS

The energy contribution of CCS towards decarbonisation is contingent upon the level of fossil fuel consumption[5] in sufficiently large units to justify economically the deployment of this technology. Hence the CCS share in e.g. gross electricity generation is limited by the degree of energy efficiency and decentralisation of energy supply as well as by the level of RES and nuclear penetration.

The highest share of CCS materialises in the Low Nuclear scenario (scenario 6). This case gives rise to a 32% share of CCS in gross electricity generation in 2050. CCS can substitute for nuclear in the case that this option was available only to a very limited extent. The CCS share would be particularly small in a scenario, in which almost all power generation stems from RES, i.e. Scenario 3, in which the CCS share drops to a mere 7%. The other scenarios have around 19-24% CCS share in gross electricity generation in 2050, with the lower end of the range stemming from delays in CCS technology introduction (mainly linked to storage issues).

Decarbonisation requires substantial progress on both energy intensity and carbon intensity

The 4 decarbonisation dimensions, explored in 5 decarbonisation scenarios, can also be expressed in terms of energy and carbon intensity. Energy efficiency reduces energy intensity (energy consumption divided by GDP) while the other three options (RES, nuclear and RES) impact overwhelmingly on carbon intensity (CO2 divided by energy consumption). Substantial progress needs to be made on both indicators- energy and carbon intensity –

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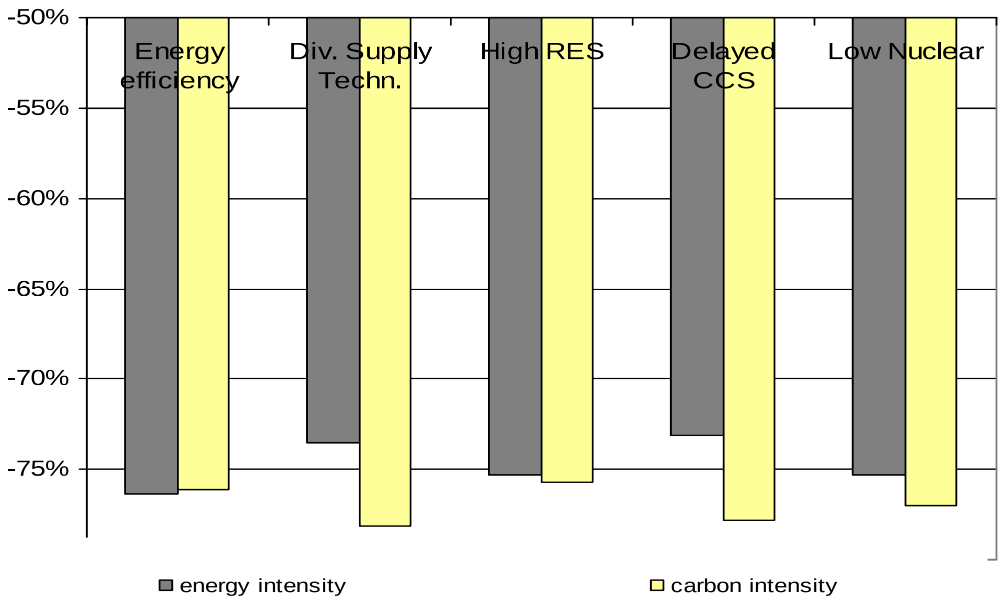
5 The discussion here does not deal with CCS used for mitigation of industrial process emissions that do not stem from fossil fuel burning. These considerations exclude also potential removal of CO2 from the atmosphere through fitting CCS to biomass power plants, in which case the atmospheric removal of CO2 during plant growth is not undone by later emissions of CO2 from burning the biomass, with the CO2 from biomass burning being stored instead.

which are to some degree substitutes for each other. The more successful policies to reduce energy consumption are the less needs to be done on fuel switching towards zero/low carbon energy sources, and vice versa[6] (see Figure 19). The five decarbonisation scenarios show substantial improvements in energy intensity which sinks 67%-71% compared with 2005 and 73%-76% compared with the higher 1990 level in terms of energy intensity (1990 had lower energy consumption, but also much lower GDP). Fuel switching continues in the decarbonisation scenarios up to 2050 and carbon intensity would improve substantially falling 76%-78% from 1990 (73%-75% from 2005).

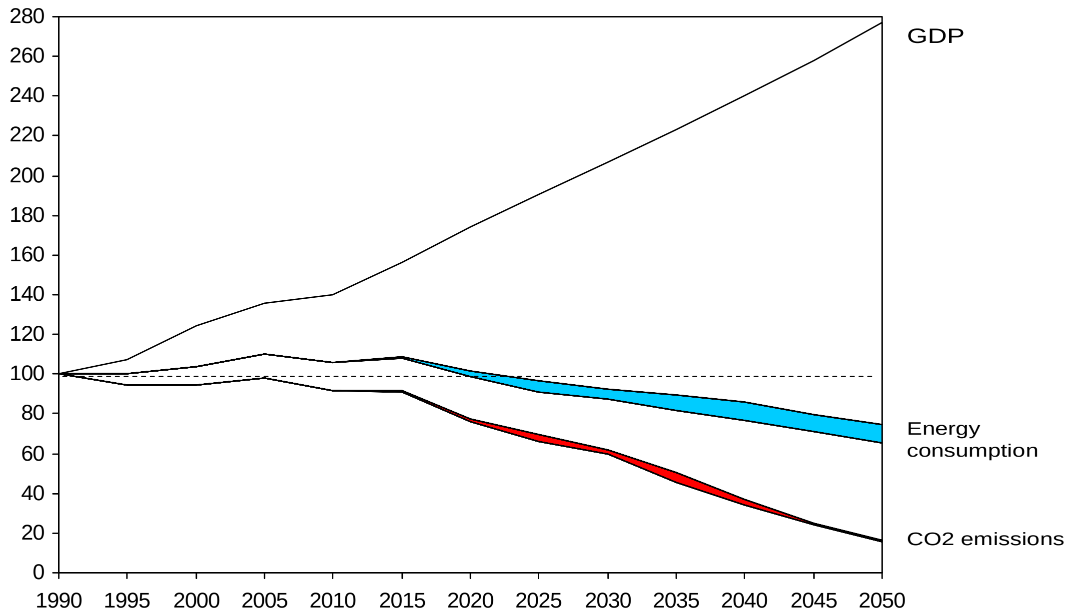
Figure 19: Decarbonisation scenarios: Improvements in carbon and energy intensities (reductions from 1990)



With ongoing economic growth, decarbonisation poses a formidable challenge given that meeting higher demand for energy services (heating and cooling, lighting, cooking, process energy, mobility, communication, etc) is part of increasing welfare. Upward pressure on energy consumption and CO2 emissions from economic growth is substantial given that GDP might increase almost threefold between 1990 and 2050 (see figure 20). The 80% GHG reductions objective by 2050 will however require deep cuts into energy related CO2 emissions, which in turn require energy consumption to decrease substantially as well.

Figure 20: Decarbonisation scenarios: development of GDP, primary energy consumption and energy related CO2 emissions: 1990 = 100

[6] In this respect, carbon intensity is a summary indicator for the fuel mix, while energy intensity captures the efficiency of energy consumption and the composition of economic activity (e.g. share of services versus (heavy) industry).



2.2 Energy consumption and supply structure

Primary energy consumption is significantly lower in all decarbonisation scenarios as compared to the Reference scenario. This is also true for the Current Policy Initiatives scenario that shows 6 and 8% lower demand in 2030 and 2050, respectively than in the Reference scenario reflecting effects of energy efficiency measures in the Energy Efficiency Plan. The biggest decline of primary energy consumption comes in Energy Efficiency scenario (-16% in 2030 and -38% in 2050) showing effects of stringent energy efficiency policies and smart grid deployment. Compared with the actual outcome for 2005, primary energy consumption shrinks by 41%. The decrease in energy consumption compared with Reference for the decarbonisation scenarios spans a range from 11% - 16% in 2030 and from 30% to 38% in 2050. Energy efficiency is therefore an essential building block in all decarbonisation scenarios.

Table 21: Total Primary energy consumption, changes compared to the Reference scenario

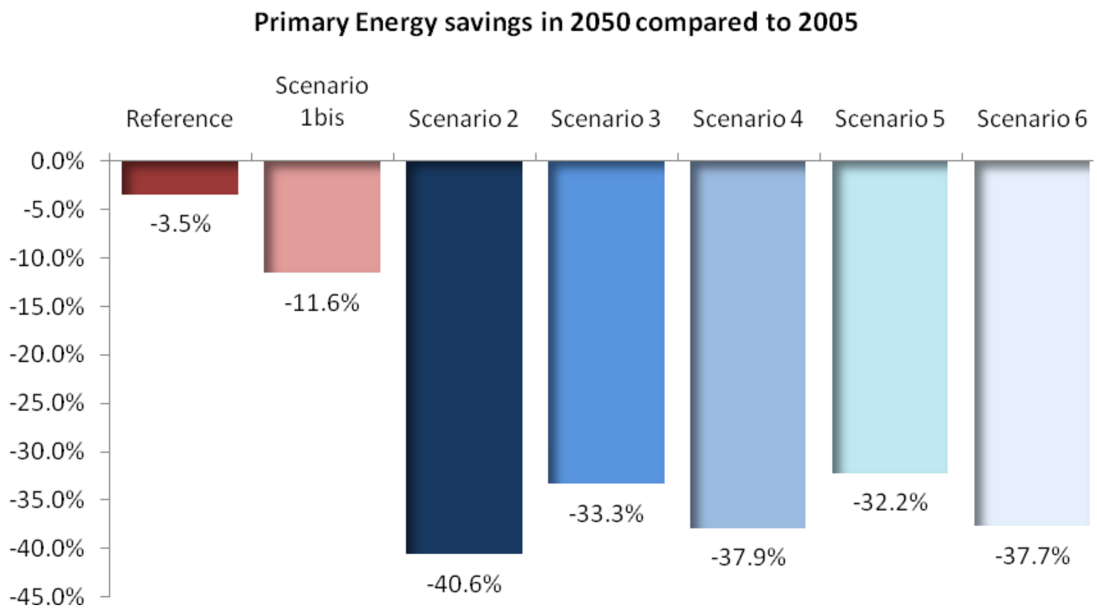
(Mtoe)	2020	2030	2050
Reference	**1790**	**1729**	**1763**
Current policy Initiatives	1700	1629	1615
% difference to Reference	*-5.0%*	*-5.8%*	*-8.4%*
Energy efficiency	1644	1452	1084
% difference to Reference	*-8.1%*	*-16.0%*	*-38.5%*
Diversified supply technologies	1681	1534	1217
% difference to Reference	*-6.1%*	*-11.3%*	*-31.0%*
High RES	1679	1510	1134
% difference to Reference	*-6.2%*	*-12.7%*	*-35.7%*
Delayed CCS	1682	1532	1238
% difference to Reference	*-6.1%*	*-11.4%*	*-29.8%*
Low nuclear	1687	1489	1137
% difference to Reference	*-5.8%*	*-13.9%*	*-35.5%*

It is important to note that these levels of reduced primary energy demand do not come from reduced activity levels (which remains the same across all scenarios). Instead they are mainly the result of technological changes on the demand and also supply side: from more efficient buildings, appliances, heating systems and vehicles and from electrification in transport and heating, which combines very efficient demand side technologies (plug-in hybrids, electric vehicles and heat pumps) with a largely decarbonised power sector. Some changes related especially to fuel switching also contribute to reducing primary energy demand, such as switching from lignite or nuclear power generation to gas or wind based electricity production, which is associated with higher conversion efficiencies. In addition, behavioural change, triggered by e.g. changes in prices, information, energy saving obligations, etc, contributes to better energy efficiency.

Energy intensity of GDP (primary energy divided by GDP) reduces by 53% between 2005 and 2050 in the Reference scenario; the CPI scenario scores significantly better by improving energy intensity 57%. Energy intensity diminishes further in all decarbonisation scenarios: by at least 67% in the delayed CCS scenario. It improves 70% in the high RES and the low nuclear scenarios and even 71% in the energy efficiency scenario. Under decarbonisation, a unit of GDP in 2050 requires only one third of the energy needed today (or slightly less under e.g. a strong energy efficiency focus). By 2030, energy intensity would improve around 45% from current levels under decarbonisation, while this improvement would amount to some 40% under current policies.

Absolute energy savings, not considering the doubling of GDP between now and 2050, show still impressing numbers. Compared with the recent peak in energy consumption in 2005/6, the energy efficiency scenario depicts 41% less energy consumption, which means a substantial energy saving with respect to the levels reached just before the economic crisis.

Figure 21: Primary energy savings in 2050 compared to 2005

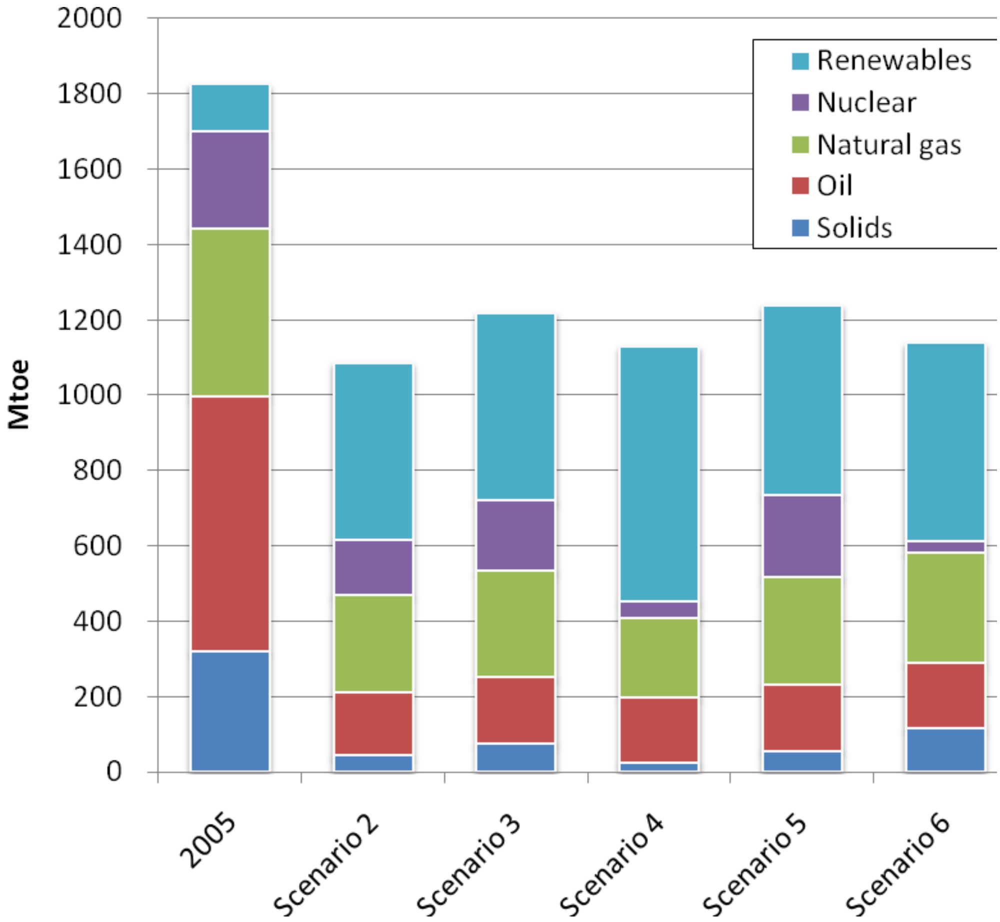


It is important to note that these levels of reduced primary energy demand do not come from reduced GDP or sectoral production levels (which remain the same in all scenarios). Instead they are mainly the result of technological changes on the demand and supply side, coming from more efficient buildings, appliances, heating systems and vehicles and from electrification in transport and heating. All decarbonisation scenarios over-achieve the 20% energy saving objective in the decade 2020-2030.

The scenarios are based on model assumptions, which are consistent with the input for the 2050 Low Carbon Economy Roadmap. Recognising the magnitude of the decarbonisation challenge, which implies a reversal of a secular trend towards ever increasing energy consumption, this Energy Roadmap has adopted a rather conservative approach as regards the effectiveness of policy instruments in terms of behavioural change. However, the Roadmap results should not be read as implying that the 20% energy efficiency target for 2020 cannot be reached effectively. Greater effects of the Energy Efficiency Plan are possible if the Energy Efficiency Directive is adopted swiftly and completely, followed up by vigorous implementation and marked change in the energy consumption decision making of individuals and companies.[7]

Not only the amount, but also the composition of energy mix would differ significantly in a decarbonised energy system. Figure 22 shows total energy consumption as well as its composition in terms of fuels in 2050 for the various scenarios.

Figure 22: Total Primary Energy in 2050, by fuel



[7] In modelling terms this means a significant lowering of the discount rate used in energy consumption decision making of hundreds of millions of consumers.

Low and zero carbon content energy sources are strongly encouraged by going the various decarbonisation routes, each of them focusing on different aspects. This has different repercussions on the fuel mix. Energy efficiency encourages primary sources that can be used with small losses (e.g. many renewables or gas) and electricity at the level of final demand. CCS strategies affect the fuel mix by largely neutralising the high carbon content of fossil fuels, notably coal and lignite, through removal of the associated emissions. RES and nuclear routes are directly targeting the fuel mix. The modelling leads to rather wide ranges for primary energy sources with these fuel mixes in the decarbonisation cases all satisfying the decarbonisation requirement by 2050. Moreover, the development of all the fuel mixes under decarbonisation give rise to the same cumulative GHG emissions from 2011 to 2050.

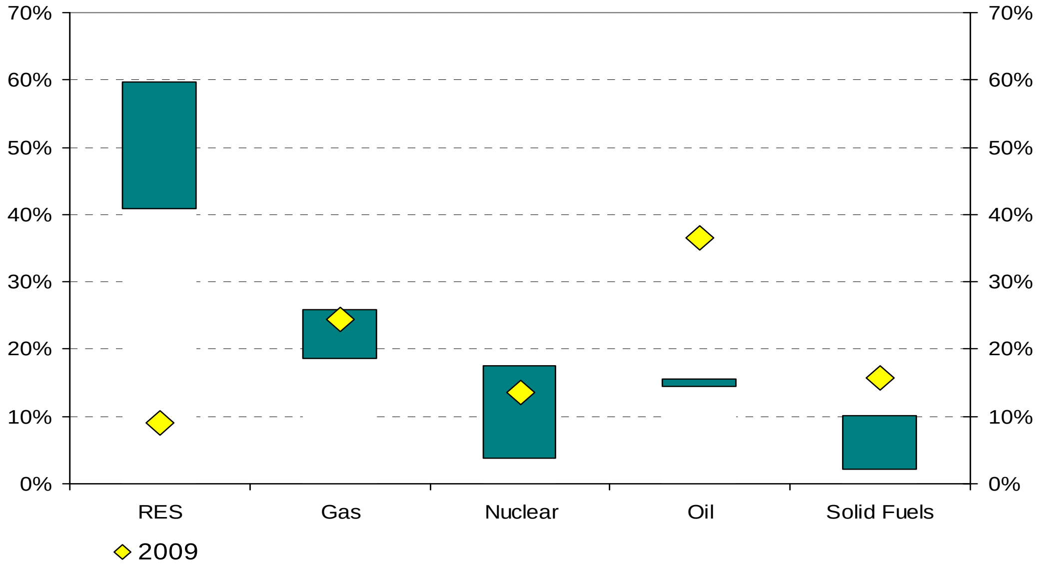
Table 22: Share of fuels in primary energy consumption in %

		Reference scenario		Current Policy Initiatives		Decarbonisation scenarios	
	2005	2030	2050	2030	2050	2030	2050
Solids	17.5	12.4	11.4	12.0	9.4	7.2-9.1	2.1-10.2
Oil	37.1	32.8	31.8	34.1	32.0	33.4-34.4	14.1-15.5
Gas	24.4	22.2	20.4	22.7	21.9	23.4-25.2	18.6-25.9
Nuclear	14.1	14.3	16.7	12.1	13.5	8.4-13.2	2.6-17.5
Renewables	6.8	18.4	19.9	19.3	23.3	21.9-25.6	40.8-59.6

Renewables increase their share significantly under adopted policies and would substantially rise in all decarbonisation scenarios to reach at least 22% of primary energy consumption by 2030 and 41% by 2050. The RES share is comparably low in those scenarios, in which nuclear plays a rather strong role (scenarios 4 and 5). The RES share is highest in High RES scenario reaching 60% in primary energy by 2050. It is also pretty high (44% and 46% in primary energy in 2050) in the Energy Efficiency and Low nuclear scenarios, respectively.

The RES share is higher when calculated in gross final energy consumption (indicator used for the 20% RES target). It represents at least 28% (2030) and 55% (2050) in all decarbonisation scenarios and rises up to 75% in 2050 in the High RES scenario.

Figure 23: Range of Fuel Shares in Primary Energy in 2050 compared with 2009 outcome



Nuclear developments have been significantly affected by the policy reaction in Member States after the nuclear accident in Fukushima (abandoning substantial nuclear plans in Italy, revision of nuclear policy in Germany). These reactions and the forthcoming nuclear stress tests have been reflected in the modelling assumptions for the Current Policy Initiatives scenario (1bis). The downward effects for nuclear penetration in CPI are also present in the decarbonisation scenarios, since the modelling of these cases also included the recent policy adjustments on nuclear.

The share of nuclear varies depending on assumptions taken. In the scenario without new nuclear investment (except for plants under construction) and extension of lifetime only in this and the next decade, the nuclear share declines gradually to 3% by 2050. In the most ambitious nuclear scenario - Delayed CCS, the share rises to 18%[8].

The share of gas under Current Policy Initiatives is higher than in the Reference scenario reflecting abandon of the nuclear programme in Italy, no new nuclear power plants in Belgium and higher costs for new plants and retrofitting. The gas share increases slightly to 26% in 2050 in the Low nuclear scenario where the CCS share in power generation is around 32%.

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[8] This share is considerably lower than in decarbonisation scenarios of DG CLIMA. There are three main explanations:

1. Decarbonisation scenarios and Current Policy Initiatives scenario are based on revised assumptions on nuclear (abandon of nuclear programme in Italy, no new nuclear plants in Belgium and upwards revision of costs for nuclear power plants).
2. Electricity demand is lower than in the Low Carbon Economy Roadmap Scenarios due to stringent energy efficiency measures.
3. Revised assumptions on the potential of electricity in transport compared to the DG CLIMA decarbonisation scenarios, following more closely the scenarios developed in the White Paper on Transport leading to lower utilisation rate of nuclear power plants than in the Low Carbon Economy Roadmap Scenarios. Electric vehicles flatten electricity demand and thus incentivise base load power generation.

The <u>oil</u> share declines only slightly until 2030 (and even 2040) due to high dependency of transport on oil based fuels. However, the decline is significant in the last decade 2040-2050 where oil in transport is replaced by biofuels and electric vehicles. The oil share drops to around 15% in 2050 when following any of the examined main directions towards decarbonisation.

The share of <u>solid fuels</u> continues its long standing downward trend already under Reference and CPI developments. Under substantial decarbonisation the solids share shrinks further to reach levels as low as 2% in the High RES scenario in 2050 and only 4% and 5% under Energy efficiency and Delayed CCS, respectively. The solids share would remain rather high only in the Low nuclear scenario (10% in 2050) with a high CCS contribution which allows a continued use of solids in a decarbonisation context.

Final energy demand declines similarly to primary energy demand. Current Policy Scenario shows around 5% decrease (in 2020-2050) compared to the Reference scenario. In the Energy Efficiency scenario the reduction on Reference in final energy demand is -14% in 2030 and -40% in 2050. The decrease in the decarbonisation scenarios is at least -8% in 2030 and -34% in 2050. Compared with actual 2005 outcome, final energy consumption decreases in 2050 by 37% in the High Energy Efficiency scenario and by around 32% in all the other decarbonisation scenarios.

Sectors showing higher reductions than the average are residential, tertiary and generally also transport.

Table 23: Final energy demand, changes compared to the Reference scenario

	Reference scenario			Current Policy Initiatives			Energy efficiency			Diversified supply technologies		
	2020	2030	2050	2020	2030	2050	2020	2030	2050	2020	2030	2050
Final Energy Demand (Mtoe)	**1227**	**1187**	**1221**	**-6%**	**-4%**	**-5%**	**-9%**	**-14%**	**-40%**	**-7%**	**-9%**	**-34%**
Industry	330	333	369	-4%	-5%	-5%	-4%	-5%	-30%	-4%	-5%	-26%
Residential	318	299	288	-9%	-6%	-4%	-13%	-20%	-43%	-9%	-12%	-35%
Tertiary	181	174	181	-8%	-5%	-7%	-13%	-25%	-53%	-8%	-15%	-42%
Transport	398	382	383	-4%	-2%	-6%	-7%	-12%	-40%	-7%	-9%	-38%

	High RES			Delayed CCS			Low nuclear		
	2020	2030	2050	2020	2030	2050	2020	2030	2050
Final Energy Demand (Mtoe)	**-7%**	**-8%**	**-34%**	**-7%**	**-10%**	**-35%**	**-6%**	**-10%**	**-35%**
Industry	-4%	-4%	-25%	-4%	-5%	-26%	-3%	-6%	-26%
Residential	-9%	-9%	-34%	-9%	-12%	-35%	-9%	-13%	-36%
Tertiary	-8%	-13%	-44%	-8%	-16%	-42%	-7%	-17%	-43%

Transport	-7%	-8%	-38%	-7%	-9%	-39%	-7%	-9%	-39%

There is a lot of structural change in the fuel composition of final energy demand. Given its high efficiency and emission free nature at use, electricity makes major inroads already under current policies (increase by 9 pp between 2005 and 2050 in CPI).

The electricity share soars further in decarbonisation scenarios reaching 36% - 39% in 2050, reflecting also its important role in decarbonising further final demand sectors such as heating and services and in particular transport. The electricity share would almost double by 2050. The crucial issue for any decarbonisation strategy is therefore the full decarbonisation of power generation (see below).

Table 24: Final energy consumption by fuel in various scenarios

		Reference/CPI		Decarbonisation scenarios	
	2005	2030	2050	2030	2050
Electricity	20,2%	24,5% - 25,1%	29,1% - 29,4%	25,2% - 26,0%	36,1% - 38,7%
RES (direct)	4,9%	9,1% - 9,2%	9,0% - 9,4%	8,5% - 10,5%	23,8% - 30,0%
Oil	42,2%	36,1% - 36,8%	35,0% - 35,5%	33,2% - 34,6%	14,9% - 15,6%
Gas	24,2%	18,7% - 19,1%	16,1% - 16,6%	19,4% - 20,0%	11,9% - 12,7%
Heat	3,8%	7,3% - 7,5%	8,2% - 8,6%	7,1% - 8,0%	6,7% - 10,0%
Solid fuels	4,6%	3,2% - 3,3%	2,9% - 3,1%	2,5% - 3,0%	0,3% - 0,4%

Also RES make major inroads under current policies including the 2009 RES Directive. The direct use of RES in final demand (i.e. not counting here the RES input to power and distributed heat generation) rises strongly to 2030 coming close to a doubling of the share. However, without additional policy push beyond the current RES/climate change measures, this RES share could be stagnant. On the contrary, in decarbonisation scenarios the share of directly used RES (e.g. biomass, solar thermal) would go up to 24% in 2050 in almost all decarbonisation cases, except for the high RES scenario, where this share reaches even 30%.

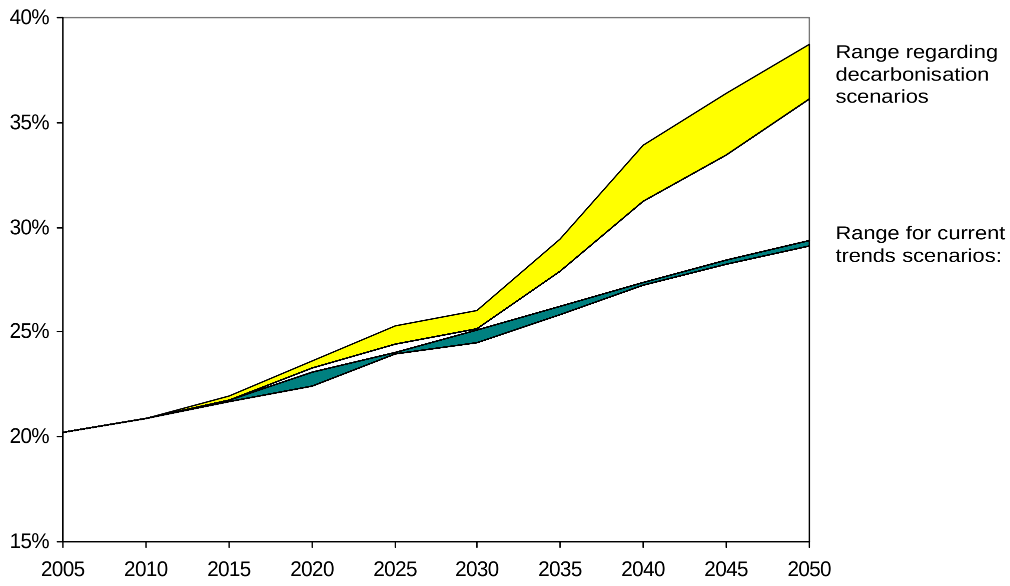
Oil has been dominating final energy for many years and might continue doing so until 2030 even in the decarbonisation scenarios, when is would still account for one third of energy deliveries to final consumers. The big changes come after 2030 when more and more parts of final energy consumption based on oil, especially in transport, are replaced by electricity (e.g. electric and plug in hybrid vehicles, heat pumps). The oil share in 2050 would drop to around 15%.

The gas share has been declining in recent years and would be lower than today under both current policies and decarbonisation in 2030, when gas would account for not more than a fifth in final demand. The gas share after 2030 would be decreasing further in particular in decarbonisation scenarios, which is due to the greater role of electricity in both heating and for providing energy in productive sectors.

Distributed heat would deliver 7-8% of final energy demand in 2030 under both current policies and decarbonisation, raising its share substantially from current levels. The heat share in 2050 would be highest (10%) in the Low nuclear scenario where high electricity production is ensured by CCS equipped generation from gas and solids, often in a CHP mode.

Solid fuels become rather obsolete in final energy demand under current policies (falling to around 3% in 2030-2050). The decline of the solids share reflects higher use of electricity and gas in heating and industry. Solid fuels become marginal under decarbonisation, especially by 2050, when most solids base processes have been replaced by electricity or other fuels. The solid fuel share in 2050 would shrink to 0.3-0.4%.

Figure 24: Shares of Electricity in Current Trend and Decarbonisation Scenarios



2.3 Power generation

Electricity demand increases in all scenarios compared to 2005 levels, following greater penetration of electricity using appliances, heating and propulsion systems. The increased use of electric devices is partly compensated by the increased energy efficiency of electric appliances as well as increased thermal integrity in the residential and service sectors and more rational use of energy in all sectors, but overall the effect from emerging new electricity uses at large scale for heating and transport is decisive. The development of electricity consumption varies between sectors.

Transport electricity demand increases strongest. The increase of electricity use in transport is due to the electrification of road transport, in particular private cars, which can either be plug-in hybrid or pure electric vehicle; almost 80% of private passenger transport activity is carried out with these kinds of vehicles by 2050. Despite substantial progress regarding energy efficiency of appliances and for efficient heating systems, such as heat pumps, household electricity demand in 2050 under decarbonisation exceeds the current level given the additional deployment of electricity in heating and cooling.

Electricity demand in the other sectors decreases or remains flat under decarbonisation. Electricity demand in services/agriculture diminishes in all decarbonisation scenarios as a result of strong energy efficiency policies, although there is a substitution from other energy carriers to more efficient electric devices e.g. heat pumps. . Industrial electricity demand remains broadly at the current level by 2050 under decarbonisation.

Table 25: Electricity final energy demand

	2005	2050		
		Reference	Scenario 1bis	Scenario 2
Final energy demand (in TWH)	2762	4130	3951	3203
Industry	1134	1504	1426	1109
Households	795	1343	1230	913
Tertiary	759	1184	1041	518
Transport	74	100	255	663
	2050			
	Scenario 3	Scenario 4	Scenario 5	Scenario 6
Final energy demand (in TWh)	3618	3377	3585	3552
Industry	1211	1169	1201	1191
Households	1026	938	1019	1013
Tertiary	707	605	696	677
Transport	675	664	669	671

Power generation: level and structure by fuel

Given the assumed limited electricity import possibilities from third countries, the increased electricity demand will have to be generated nearly exclusively within the EU. Moreover, electricity production has to cover also power plant own consumption (e.g. for desulphurisation), the consumption of the other energy producing sectors (energy branch) as well as transmission and distribution losses. Furthermore, additional electricity generation is appropriate under strong decarbonisation objectives to produce hydrogen mixed in low and medium pressure gas networks (bringing down emission factors in final demand) and for producing hydrogen, which is used for balancing in the case of high RES scenarios. Therefore, similar to electricity demand there is a strong increase from current levels for power generation in all scenarios. Under decarbonisation, power generation will be lower in 2050 compared with Reference and CPI scenarios. The highest electricity generation level in 2050 among the decarbonisation cases comes about in case of CO2 reduction focussing particularly strongly on RES.

The structure of power generation changes substantially between the scenarios. The Reference scenario and the Current Policy Initiatives scenario show renewable shares in 2050 reaching 40 and 49% respectively and fossil fuels still having a share of 33 and 31% respectively. Among the decarbonisation scenarios, only the Low nuclear scenario has a share of fossil fuels above 30%, as it makes substantial use of CCS. In the other scenarios the fossil fuel share lies below 25% and is particularly low in High RES scenario, where fossil fuels account for under 10% of electricity generation.

Under decarbonisation, power generation in 2050 is based on renewables for at around 60%-65%, except for the high RES case, in which this share is much higher. Wind alone accounts for about one third of power generation in most decarbonisation scenarios. In the high RES case, the wind share reaches even close to 50% in 2050. The nuclear share falls from the present level in all decarbonisation scenarios. This share is highest in 2050 under delayed CCS, in which case it is around 20%. On the contrary, in the low nuclear scenario, nuclear would account for just 2.5% of power generation.

Table 26: Power generation

		2005	2050		
			Reference	Scenario 1bis	Scenario 2
Electricity generation	TWh	**3274**	**4931**	**4620**	**4281**
Nuclear energy	Shares (%)	30.5	26.4	20.6	14.2
Renewables		14.3	40.3	48.8	64.2
Hydro		*9.4*	*7.6*	*8.5*	*9.2*
Wind		*2.2*	*20.1*	*24.7*	*33.2*
Solar, tidal etc.		*0.0*	*5.1*	*7.0*	*10.6*
Biomass & waste		*2.6*	*7.3*	*8.4*	*10.9*
Geothermal heat		*0.2*	*0.2*	*0.2*	*0.3*
Fossil fuels		55.2	33.3	30.6	21.6
Coal and lignite		*30.0*	*15.2*	*11.1*	*4.8*
Petroleum products		*4.1*	*2.2*	*2.1*	*0.0*
Natural gas		*20.3*	*15.1*	*16.7*	*16.7*
Coke & blast-furnace gasses		*0.9*	*0.7*	*0.7*	*0.0*
Other fuels (hydrogen, methanol)		0.0	0.0	0.0	0.0
		2050			
		Scenario 3	Scenario 4	Scenario 5	Scenario 6
Electricity generation	TWh	**4912**	**5141**	**4872**	**4853**
Nuclear energy	Shares (%)	16.1	3.5	19.2	2.5
Renewables		59.1	83.1	60.7	64.8
Hydro		*8.0*	*7.7*	*8.1*	*8.1*
Wind		*31.6*	*48.7*	*32.4*	*35.6*
Solar, tidal etc.		*9.9*	*16.4*	*9.9*	*10.8*
Biomass & waste		*9.3*	*9.6*	*9.9*	*9.8*
Geothermal heat		*0.3*	*0.6*	*0.4*	*0.4*
Fossil fuels		24.8	9.6	20.1	32.7
Coal and lignite		*8.1*	*2.1*	*5.1*	*13.1*
Petroleum products		*0.0*	*0.0*	*0.0*	*0.1*
Natural gas		*16.6*	*7.5*	*14.9*	*19.5*
Coke & blast-furnace gasses		*0.0*	*0.0*	*0.0*	*0.0*
Other fuels (hydrogen, methanol)		0.0	3.9	0.0	0.0

NB: power generation is presented in the most comprehensive way in this table involving in a sense some "double counting" in the denominator of shares for the high RES scenario: first electricity generation from RES is counted including those parts of RES based generation that, in case supply exceeds demand, are transformed into hydrogen for later use by producing electricity for a second time from these original renewables sources. This specific representation for showing also the magnitude of hydrogen based RES electricity storage (4% in

2050) leads to total electricity generation numbers that are in a sense inflated, which in turn gives rise to lower RES share numbers in this specific representation that counts production from RES once as such and secondly under hydrogen based generation (shown separately) for the part that is not lost in transformations into hydrogen and back from hydrogen to electricity.

Power plant investments by fuel type (e.g. RES, nuclear, fossils with CCS, fossil without CCS)

The installed capacity increases in all scenarios compared to the Reference scenario due to the additional balancing and power reserve capacities needed for the variable RES which increase in all scenarios. The scenario with the least increase is Energy Efficiency scenario which requires the least amount of electricity and therefore also the least amount of installed capacity. All scenarios still have fossil fuel fired power plants as installed capacity, which are used mainly as back-up.

The share of CCS capacity in thermal power plants for the decarbonisation scenarios ranges from 48% in Low nuclear scenario to 12% in High RES scenario. The share in the other scenarios is between 35 and 44%.

Table 27: Installed power capacity

		2005	2050		
			Reference	Scenario 1bis	Scenario 2
Net Installed Power Capacity	GWe	**715**	**1454**	**1502**	**1473**
Nuclear energy		134	161	117	79
Renewables (without biomass/geothermal)		147	681	784	1012
Hydro (pumping excluded)		*105*	*121*	*122*	*125*
Wind power		*41*	*382*	*432*	*548*
Wind on-shore		*40*	*262*	*291*	*370*
Wind off-shore		1	120	140	177
Solar		*2*	*171*	*224*	*330*
Other renewables (tidal etc.)		*0*	*6*	*7*	*9*
Thermal power		*434*	*613*	*601*	*382*
Solids fired		*187*	*131*	*104*	*70*
Oil fired		62	168	38	15
Gas fired		167	226	366	187
Biomass-waste fired		*18*	*87*	*92*	*108*
Hydrogen plants		*0*	*0*	*0*	*0*
Geothermal heat		*1*	*1*	*1*	*2*
		2050			
		Scenario 3	Scenario 4	Scenario 5	Scenario 6
Net Installed Power Capacity	GWe	**1621**	**2219**	**1639**	**1721**
Nuclear energy		102	41	127	16
Renewable (without biomass/geothermal)		1081	1749	1093	1193
Hydro (pumping excluded)		*126*	*131*	*126*	*127*
Wind power		*595*	*984*	*609*	*674*

Wind on-shore		398	612	408	452
Wind off-shore		197	373	200	222
Solar		351	603	348	381
Other renewables (tidal etc.)		10	30	10	11
Thermal power		439	429	419	513
Solids fired		94	62	73	125
Oil fired		19	19	18	18
Gas fired		218	182	210	255
Biomass-waste fired		106	163	115	112
Hydrogen plants *		0	0	0	0
Geothermal heat		2	4	2	2

		2005	2050		
			Reference	Scenario 1bis	Scenario 2
Total CCS capacity	GWe	0	**101**	**39**	**149**
Solids		0	64	33	28
Oil		0	0	0	0
Gas		0	37	6	121
		2050			
		Scenario 3	Scenario 4	Scenario 5	Scenario 6
Total CCS capacity	GWe	**193**	**53**	**148**	**248**
Solids		50	18	30	79
Oil		0	0	0	0
Gas		142	34	118	169

* Hydrogen capacity in the above table refers only to plant technologies dedicated to specific hydrogen use, such as fuel cells. Capacity for generating electricity from hydrogen, serving only the purpose of storing RES based electricity that was previously produced at times when electricity supply exceeded demand, is accounted for under gas fired capacity, given that hydrogen would be burnt is such types of plants, including as a mixture with natural gas.

The high RES scenario is a particularly challenging scenario regarding the restructuring of the energy system involved; RES policy related challenges in this scenario include the following:

- Huge investments in RES power capacity need to be ensured with wind capacity alone reaching over 980 GW in 2050, this is 20% more than today's (2010) total power generation capacity (including nuclear, fossil fuels and all RES); similarly, solar capacity would need to soar to 600 GW, which amounts to almost three quarters of our present total generation capacity; all RES power generation capacity (Renewables + biomass/waste + geothermal in table 27) would need to increase to over 1900 GW, which is more than 8 times the current RES capacity and also more than twice today's total generation capacity.
- It might be a challenge to ensure the raw material needed for RES technologies and there may be upward pressure on e.g. steel prices, which could be a challenge to such a development (not modelled with the energy model); other logistic challenges would

relate to ensuring the maritime equipment to install and maintain the off-shore wind capacity that rises from just close to 5 GW today to over 370 GW in 2050;

- In order to accommodate RES production from remote sites with respect to consumption centres and to take advantage of the cost differences across Member States for cost-effectiveness reasons, the grid needs to be extended substantially and also smartened to deal with variable feed in from many dispersed sources (e.g. solar PV); the scenario analysis identified needs for grid extension beyond 2020 under a decarbonisation agenda and in addition a set of additional DC links (electricity highways) needed to accommodate a very high RES contribution to electricity supply (see attachment 2 to this Annex);
- Another challenge relates to the skilled workforce required, the lack of which can lead to a stalled development unless a major RES related education and training strategy is pursued taking account of ageing EU population over the next decades, which is even shrinking after 2035. Skilled workforce will also be needed for the construction of expanded, smart grids, which will also be necessary for the penetration of other low carbon technologies.
- In addition to economic, logistical, resource security and manpower challenges, there is the acceptance issue for new transmission lines and perhaps also regarding the substantial expansion of (on-shore) RES installations;

It will also be challenging in the other decarbonisation scenarios to ensure the required RES capacity in 2050 and to accommodate it by the grid. The Energy Efficiency scenario poses the least challenge given the lowest electricity demand, but nevertheless, RES power generation capacity would need to soar to 5 times the current level, exceeding today's total electricity generation capacity (nuclear, fossil fuel and RES combined) by more than a third. On the other hand, increased energy efficiency and decentralised RES might require more sophisticated solutions for distribution level.

Other scenarios pose also substantial challenges throughout the transition. For example, higher nuclear deployment in the delayed CCS scenario leads to more requirements for nuclear fuel and more nuclear waste that needs to be safely transported and stored. Electrification of passenger transport involves many changes in car production and infrastructure provision. A smooth transition from a petrol/diesel to an electricity based system for mainly urban transport requires a lot of logistical changes.

Widespread penetration of CCS will require dedicated CO2 transport grids that need to be financed, constructed and accepted. Acceptance challenges could be particularly pronounced for nuclear and CO2 storage. As carbon capture, transport and storage require significant quantities of electricity that need to be generated in addition to electricity for final use, there would be higher input demand also for fossil fuels. This effect would be particularly pronounced if global decarbonisation includes an important contribution from CCS for energy consumption and also for abatement of industrial process emissions. This could exert upward pressure on the level of world fossil fuel prices.

All scenarios involve substantial changes in production, transformation, smart transmission/distribution and consumption patters for energy, requiring a skilled workforce against the background of ageing population. Enhancement of the European capacity for innovation, appropriate RTD as well as education and training will be instrumental for a cost-effective transition to a low carbon economy that fosters competitiveness and security of supply.

Decarbonisation requires also considerable capacity for CCS, except for the high RES scenario. The other scenarios involve around 150 GW – 250 GW CCS capacity in 2050, with the upper end materialising in Low nuclear scenario, which is the case with the greatest use of CCS for power generation (32% share

In Table 28 the capacity investment per decade for the scenarios can be seen; as can be observed the highest investments take place in RES in all scenarios. As can be seen no new investment is undertaken in nuclear in Low nuclear scenario after 2030; only Delayed CCS sees higher nuclear investment than in the Reference scenario for the last two decades of the projection period. Investment continues in thermal power plants throughout the projection period in all scenarios; it is lowest in High RES and Energy efficiency scenarios. These investment numbers include lifetime extensions of existing plants, refurbishments and replacement investments on existing sites, which is particularly relevant for nuclear. These investment numbers must not be confused with additional new plants of e.g. nuclear.

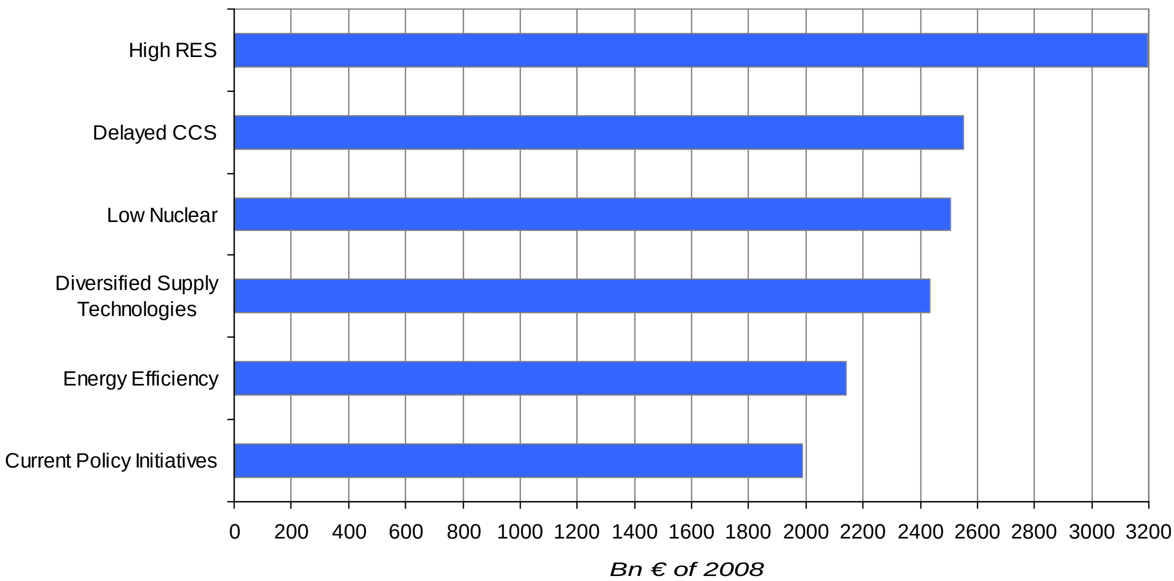
Table 28: Net Power Capacity Investment in GWe per decade

		2011-2020	2021-2030	2031-2040	2041-2050
Reference	Nuclear energy	15	64	46	62
	Renewable energy	192	169	192	259
	Thermal power fossil fuels	100	78	184	183
	of which: CCS	5	6	48	41
	Thermal power RES	37	17	14	24
Scenario 1 bis	Nuclear energy	12	42	41	49
	Renewable energy	187	169	245	309
	Thermal power fossil fuels	101	72	169	198
	of which: CCS	3	0	19	17
	Thermal power RES	38	17	13	29
Scenario 2	Nuclear energy	11	24	34	22
	Renewable energy	204	222	318	436
	Thermal power fossil fuels	86	23	92	92
	of which: CCS	3	0	56	90
	Thermal power RES	38	19	27	29
Scenario 3	Nuclear energy	12	46	36	35
	Renewable energy	214	250	348	463
	Thermal power fossil fuels	90	37	130	101
	of which: CCS	3	1	91	98
	Thermal power RES	40	20	27	25
Scenario 4	Nuclear energy	12	30	12	0
	Renewable energy	215	396	588	817
	Thermal power fossil fuels	88	35	66	91
	of which: CCS	3	0	19	30
	Thermal power RES	38	22	55	53

Scenario 5	Nuclear energy	12	47	56	39
	Renewable energy	214	256	354	464
	Thermal power fossil fuels	89	36	79	115
	of which: CCS	3	0	35	110
	Thermal power RES	39	20	37	23
Scenario 6	Nuclear energy	11	4	0	0
	Renewable energy	213	281	385	515
	Thermal power fossil fuels	90	50	163	121
	of which: CCS	3	5	121	118
	Thermal power RES	39	25	26	27

Investment in generation capacity entails substantial cumulative investment expenditure in all scenarios over the period 2011-2050. Cumulative investment expenditure for power generation is most pronounced in the high RES scenario amounting to over 3 trillion € in real terms up to 2050. Among the decarbonisation scenarios cumulative investment expenditure for power generation is lowest in the Energy Efficiency scenario given the marked savings in electricity consumption.

Figure 25: Cumulative investment expenditure in 2011-2050 for power generation (in € of 2008)



These investment expenditure results impact on electricity generation costs in the different scenarios (see below)

Impacts on infrastructure

Infrastructure requirements differ in scenarios. Decarbonisation scenarios require more and more sophisticated infrastructures (mainly electricity lines, smart grids and storage) than Reference and CPI scenarios. High RES scenario necessitates additional DC lines mainly to transport wind electricity from the North Sea to the centre of Europe and more storage. The biggest share of costs relate to the upgrade and improvement of distribution networks including smartening of the grid. Investments needed in transmission lines are much lower and new interconnectors represent only a fraction of these transmission costs.

Table 29: Grid investment costs

(Bn Euro'05)	Grid investment costs			
	2011-2020	2021-2030	2031-2050	2011-2050
Reference	292	316	662	1269
CPI	293	291	774	1357
Energy Efficiency	305	352	861	1518
Diversified supply technologies	337	416	959	1712
High RES	336	536	1323	2195
Delayed CCS	336	420	961	1717
Low nuclear	339	425	1029	1793

Euro'05	Transmission Grid investment (bEUR)				
	2011-2020	2021-2030	2031-2040	2041-2050	2011-2050
Reference	47.9	52.2	53.5	52.0	205.7
CPI	47.1	49.6	64.8	66.6	228.2
Energy Efficiency	49.0	63.1	80.3	80.1	272.5
Diversified supply technologies	52.8	70.2	88.0	86.8	297.8
High RES	52.8	95.5	137.8	134.4	420.4
Delayed CCS	52.7	71.0	88.6	87.6	299.9
Low nuclear	52.9	73.8	95.2	94.8	316.6

Euro'05	Distribution Grid investment (bEUR)				
	2011-2020	2021-2030	2031-2040	2041-2050	2011-2050
Reference	243.7	263.5	280.5	276.0	1063.7
CPI	245.0	239.3	317.6	325.9	1127.8
Energy Efficiency	256.3	289.1	408.4	291.8	1245.5
Diversified supply technologies	284.2	345.9	454.3	329.8	1414.1
High RES	283.5	440.0	619.8	431.5	1774.8
Delayed CCS	283.4	349.4	445.1	339.6	1417.5
Low nuclear	286.4	350.8	472.5	366.5	1476.3

Euro'08	Investments in new electricity interconnectors		
	2006-2020	2021-2030	2031-2050
Reference	13.1	0.3	0.0
CPI	21.9	9.7	0.6
High energy efficiency	21.9	9.7	0.6
Diversified supply technologies	21.9	9.7	0.6
High RES	21.9	21.2	50.8
Delayed CCS	21.9	9.7	0.6
Low nuclear	21.9	9.7	0.6

The model assumes that grid investments, that are prerequisites to the decarbonisation scenarios in this analysis, are undertaken and that costs are fully recovered in electricity prices. The reality might differ from this model situation in a sense that current regulatory regime might be more short to medium term cost minimisation oriented and might not provide sufficient incentives for long-term and innovative investments. There might also be less perfect foresight and lower coordination of investments in generation, transmission and distribution as the model predicts.

Power generation costs

Fixed operational and capital costs for power generation increase over time in all scenarios. The increase in capital costs is more pronounced in decarbonisation scenarios, notably in the High RES case. A substantial RES contribution (high RES scenario) leads to an increase of fixed and capital costs of 155% in 2050 compared with 2005 (81% rise by 2030) due to the additional investment needs in generation, grid, storage and back-up capacities. On the contrary, the increase in variable and fuel costs over time under Reference and CPI developments would be more or less cancelled in the decarbonisation cases. This effect of shifting variable and fuel costs towards capital costs is most pronounced in the High RES scenario. In this decarbonisation case, the substantial RES contribution leads to a decline of variable and fuel costs by 45% below Reference in 2050 and also a decrease by 21% on the 2005 level.

Unit costs of transmission and distribution increase substantially in all decarbonisation scenarios. The High RES case has the greatest increase. Due to the decarbonisation of the power sector in all scenarios in the last two decades of the projection period, the costs related to ETS auction payments decrease substantially.

These effects on cost components allow for a decrease in electricity prices between 2030 and 2050 in all decarbonisation scenarios, except for the High RES scenario. This is in stark contrast to the period up to 2030, in which electricity prices increase due notably to increases in capital cost, grid costs and auctioning payments. The High RES case is an exception from other cases because of the very high investment requirements combined with stronger requirements on the electricity grid extension, which is not fully compensated by savings in fuel and other variable costs.

Therefore the High RES case features the highest electricity prices among the decarbonisation scenarios, as it would not allow for the flattening out of the strong price increase up to 2030 (observed in all scenarios) but continues with major capital intensive changes to the power system.

Table 31: Electricity prices and cost structure [9]

(Euro'08 per MWhe)			Reference		Scenario 1bis		Scenario 2	
	2005		2030	2050	2030	2050	2030	2050
Fixed and capital costs	39.6		56.7	52.4	57.4	54.6	63.4	61.6
Variable and fuel costs	32.0		40.6	46.2	41.1	43.5	34.8	31.2
Tax on fuels and ETS payments	1.0		9.9	5.0	8.6	6.9	5.0	1.3
Grid and sales costs	22.8		25.9	25.8	26.7	28.7	28.6	29.5
Average price of electricity (pre-tax)(*)	95.4		133.2	129.4	133.7	133.6	131.7	123.5
Average price of electricity (After-tax) (*)	109.3		154.8	151.1	156.0	156.9	154.4	146.7
(Euro'08 per MWhe)	Scenario 3		Scenario 4		Scenario 5		Scenario 6	
	2030	2050	2030	2050	2030	2050	2030	2050
Fixed and capital costs	63.3	61.9	71.7	101.0	63.9	65.3	64.3	65.3
Variable and fuel costs	34.6	31.3	31.9	25.3	34.4	31.8	37.1	34.6
Tax on fuels and ETS payments	9.3	0.9	5.6	3.6	9.5	1.6	12.2	1.4
Grid and sales costs	29.1	29.1	31.5	41.2	29.3	29.9	30.7	31.9
Average price of electricity (pre-tax) (*)	136.4	123.2	140.7	171.0	137.1	128.6	144.3	133.2
Average price of electricity (After-tax) (*)	159.6	146.2	164.4	198.9	160.4	151.9	168.2	157.2

(*): Average price over all consumer types, including final consumers and energy branch

It is important to note that, as explained in the assumptions part, the PRIMES model makes sure that the full costs of electricity production and distribution are recovered through electricity prices. Both marginal costs and the appropriate portion of fixed capital and operation costs are allocated to the various sectors according to the Ramsey Boiteux methodology taking into account price elasticities in the allocation of fixed costs. This procedure is necessary to ensure a sustainable modelling solution because in internally consistent scenarios electricity sector investments need to be financed by the revenues from selling electricity.

However, power exchanges in wholesale markets work on the basis of marginal costs for determining spot prices with suppliers having lower marginal costs that the equilibrium price being able to cover (parts of) fixed costs. In a situation with a very high contribution of capital intensive low carbon technologies with marginal costs close to zero, such as RES, all suppliers succeeding to place bids might be bidders with such RES power plants and competition at power exchanges would drive this electricity price down close to zero. Obviously, close to zero prices over very long time segments every year would not be a sustainable solution in such a scenario, as the necessary capital expenditure and investment under such market structure could not be financed from selling revenues and such a scenario would not materialise. While PRIMES, presenting functioning scenarios, presents economically sustainable electricity prices, this issue appears to be an institutional challenge for the transition to a low carbon electricity system, especially for one that is nearly entirely based on RES.

9 Average electricity prices in this table relate to a somewhat different customer base compared with electricity prices shown in Part A by including also energy branch customers in addition to those in final demand sectors; this explains the slight differences in average prices (e.g. for 2005 between 109.3 €/MWh when including the energy branch and 110.1 €/MWh when excluding it).

2.4 Other sectors

Heating and cooling: distributed heat/steam and RES

Demand for distributed heat in the decarbonisation scenarios rises compared to current level but is 2%-10% lower by 2030 as compared to the Reference scenario, with the greatest decline occurring in the high RES scenario. The decrease is more pronounced towards 2050 with 46% decrease as compared to Reference scenario in the High RES scenario; 26% decrease in the Energy Efficiency scenario and at least -20% decrease in other decarbonisation scenarios. The High RES scenario shows lowest distributed heat demand after 2025 due to the highest penetration of RES in power generation which leads to decrease of CHP[10] and due to the shift towards electricity use for heating reducing especially district heating from fossil fuels.

When comparing results for distributed heat between Reference and decarbonisation scenarios, it is important to note that final energy demand in the decarbonisation scenarios is 34% - 40% lower in 2050 than under reference developments (around 10% lower in 2030).

The biggest decrease as compared to the Reference scenario in 2050 occurs in the residential sector (-63% in High RES scenario and -32-42% in all other decarbonisation scenarios) reflecting stringent energy efficiency policies in buildings. Demand stays at current levels of around 240 TWh until 2015 and then gradually declines to 69 TWh in the High RES scenario and 126 TWh in the Low nuclear by 2050, showing the higher distributed heat demand among the decarbonisation cases.

The decrease in the tertiary sector is important as well with -43% in the Energy Efficiency scenario and at least -31% in all other scenarios. The demand peaks in 2015 at 120 TWh and goes down to 52 TWh in Energy Efficiency scenario and around 60 TWh in other decarbonisation scenarios.

Contrarily to residential and tertiary, industrial demand for heat increases massively from 160 TWh in 2005 to reach 503 TWh in High RES scenario and up to 733 TWh in Low nuclear/High CCS scenario by 2050. Industrial demand is still lower as compared to Reference scenario by at least 17% in all decarbonisation scenarios and by -43% in High RES scenario. However, industry needs steam for some processes that can hardly be substituted by other fuels.

Heat consumption is also rising in the energy branch from 54 TWh in 2005 to 71-77 TWh in 2050, with the Energy Efficiency and delayed CCS scenarios at the lower end of the range and the Low Nuclear scenario at the upper one.

Following the diverging trends in different sectors the shares of sectors in total distributed heat changes significantly up to 2050.

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[10] CHP leads to emission reductions compared to conventional systems, but is only decarbonised when fired with biomass. The use of biomass in PRIMES is optimally allocated endogenously and might therefore not be used for CHP.

Table 32: Heat/steam final consumption

	2005		2050			
			Reference scenario		Decarbonisation scenarios	
Industry	161TWh	31%	880 TWh	76%	503 - 733 TWh	81- 80%
Households	240 TWh	46%	186 TWh	16%	69 - 126 TWh	11 - 13%
Tertiary	116 TWh	22%	92 TWh	8%	52 - 64 TWh	8 - 7%
Final demand	517 TWh	100%	1.159 TWh	100%	627 – 923 TWh	100%

With lower final energy demand under decarbonisation, the share of distributed heat in total heating in the residential, services and agriculture sectors rises somewhat from current level of slightly over 11% in most scenarios, except for the High RES scenario. This decrease in the share of distributed heat is compensated by the increased direct use of biomass for heating, which soars from approx. 13.5% in 2010 to approx. 33% in 2050 in the High RES scenario.

Table 33: Share of distributed heat in <u>total heating</u> for residential and tertiary

	2020	2030	2050
CPI	11.6%	12.0%	12.0%
Energy Efficiency	12.0%	12.8%	13.3%
Div. Supply Technology	11.6%	12.4%	13.4%
High RES	11.6%	11.4%	8.5%
Delayed CCS	11.6%	12.4%	12.4%
Low Nuclear	11.6%	12.5%	13.7%

Heat and steam generation

Heat from CHP rises from 473 TWh in 2005 to 1030 TWh by 2025 in the High RES scenario and then declines to 682 TWh by 2050. In other scenarios, including Energy Efficiency, the rise continues until 2035 with the highest CHP generation in the Low nuclear scenario at 1113, exhibiting a slight decline thereafter. CHP heat production in 2050 covers a range from 682 TWh in the high RES scenario to 1019 TWh in the low nuclear case. As in the Reference scenario the growth is driven by support policies resulting from the application of the CHP directive and ETS carbon prices.

CHP share in power generation is the highest in the Low nuclear scenario reaching 22% in 2030. This share in 2030 is the lowest in the High RES scenario at 19%. By 2050, CHP share decline in all scenarios to 18% in Low nuclear and to 11% in High RES scenarios reflecting higher penetration of wind and solar in power generation (no combined production of heat possible) and electrification of heating in combination with energy efficiency policies to reduce demand for heat.

District heating is already declining from its 2000 levels of almost 190 TWh and this decline continues in the Reference scenario as well as in decarbonisation scenarios to 109 TWh in the Reference scenario and 29 -52 TWh in decarbonisation scenarios. The development of district heating is due to its benefits in reducing emissions in the short and medium term but in the long run, similarly to CHP plants, if district heating boilers do not use biomass, they emit GHG.

RES in heating and cooling

The modelling of energy demand formation by sector includes heating and cooling requirements as well as a detailed coverage of various ways of satisfying these needs including distributed heating and cooling from co-generation and district heating. As can be seen from table 34, there is very significant progress in all decarbonisation cases regarding the share of RES in heating and cooling. The RES share in heating and cooling doubles between 2005 and 2020 in all scenarios, reaching at least 44% by 2050 under decarbonisation. The highest share of well over 50% in 2050 is achieved in the High RES scenario.

Table 34: Percentage share of RES in gross final consumption of heating and cooling

% share	2020	2030	2050
CPI	20.9	22.7	23.8
Energy Efficiency	21.0	23.3	44.9
Div. Supply Technology	20.9	23.8	44.0
High RES	20.9	26.8	53.5
Delayed CCS	20.9	24.2	44.9
Low Nuclear	20.8	24.3	44.6

Transport

In the decarbonisation scenarios, transport energy demand is projected to decline by close to 40% below Reference in 2050 due to active policies for tightening CO2 standards (essentially impacting on fuel efficiency), taxation, internal market and infrastructure measures11. The highest energy savings, in order of 155 Mtoe, are achieved in the Energy Efficiency scenario but all decarbonisation scenarios deliver savings in the same order of magnitude (around 150 Mtoe). Over 60% of these energy savings originate from passengers transport.

Energy intensity in passenger transport improves by slightly over 60% between 2005 and 2050 in the decarbonisation scenarios, mainly due to the enforcement of such efficiency standards. For freight transport, the efficiency standards together with measures encouraging a shift in modal choices lead to around 40% decrease in the energy intensity.

The EU transport system would remain extremely dependent on the use of fossil fuels in the Reference scenario. Oil products would still represent 88% of the EU transport sector final demand in 2030 and 2050 in the Reference scenario. Consumption of oil would decrease by 11% by 2050, relative to the Reference scenario, in the Current Policy Initiatives scenario mainly driven by the revision of the Energy Taxation Directive.

In the decarbonisation scenarios, final consumption of oil by transport is expected to decrease by almost 70% in 2050, relative to the Reference scenario; the oil share in final demand would amount to around 45%. This decline is compensated to a certain extent by the rise in the electricity demand by road and rail transport and the increased demand for biofuels, especially in aviation, inland navigation and long distance road freight, where electrification

[11] The decarbonisation scenarios reflect the transport policy measures included in the White Paper "Roadmap to a Single Transport Area – Towards a competitive and resource efficient transport system" (COM (2011) 144) with highest impact on energy demand in transport.

is not or less an option. Biofuels would represent slightly below 40% of energy consumption in aviation and inland navigation and 41% in long distance road freight by 2050. The role of biofuels in energy demand by passenger cars and light duty vehicles would be more limited, ranging between 13% and 15%. Electricity would provide around 65% of energy demand by passenger cars and light duty vehicles in all decarbonisation scenarios. Electro-mobility would need to be supported by the upgrade of Europe's networks towards a European super grid and decarbonisation of electricity sector.

As a result of the higher demand for electricity and sustainable biofuels, the share of renewables in transport would increase by 2050, ranging between 62% and 73%. This difference between the decarbonisation scenarios can be explained by the different power generation mix, despite similar shares of biofuels and electricity demand in energy consumption by transport mean. Therefore, the highest share of renewables in transport is achieved in the High RES scenario.

2.5 Security of supply

Import dependency in 2030 does not change substantially in decarbonisation scenarios as compared to Reference scenario and Current Policy Initiatives scenario due to decline in both gross inland consumption and imports. There is however a substantial decrease in 2050, driven by increased use of domestic resources, mainly renewables. Import dependency is only 35% in High RES scenario (compared to 58% in the Reference scenario and Current Policy Initiatives scenario) and 39-40% in all other decarbonisation scenarios besides Low nuclear scenario (45%) where it is higher due to significant use of fossil fuels with CCS. Decarbonisation will significantly reduce fossil fuel security risks.

Table 35: Import dependency

%	2009	2030	2050
1.Reference	53.9	56.4	57.6
1 bis Current Policy Initiatives		57.5	58.0
2. Energy efficiency		56.1	39.7
3. Diversified supply technologies		55.2	39.7
4. High RES		55.3	35.1
5. Delayed CCS		54.9	38.8
6. Low nuclear		57.5	45.1

Large scale electrification combined with more decentralised power generation from variable sources brings other challenges to high quality energy service at any time. An adequate stability of the grid is a precondition for the consistent modelling of all scenarios; that is why differences in indicators such as reserve margin are rather small.

Utilisation rates of electric capacities decrease from 49% in 2005 to 36% in 2050 in the Reference scenario and to a range of 25% (High RES) to 33% (Diversified supply technologies scenario) in decarbonisation scenarios. This reflects higher requirements for reserve power and balancing services in order to keep supply of electricity reliable and secure in all scenarios.

All scenarios see a high increase in the share of variable RES in the electricity supply; this naturally leads to higher balancing requirements in the system. In the long term the balancing is met to the greatest extent by increased pumped storage (to the extent there is still increased potential available), the development of flexible gas-based units, higher import-exports and in the case of very high RES penetration with hydrogen based balancing. Thermal power plants, mainly gas fired ones, remain available as reserve power and provide ancillary services. The reduction in utilisation rates of thermal power plants is driven by economic considerations, not by predetermined exogenous inputs.

Utilisation rates for steam stay stable in the Reference scenario at around 43% but decrease to a range of 26% (High RES) and 36% (Diversified supply technologies scenario) in decarbonisation scenarios. Energy savings and electrification in heating which takes place in the decarbonisation scenarios limits the scope for further expansion of distributed heat/steam and CHP, except in cases of production with carbon free (or very low carbon content) resources (e.g. biomass, gas mixed with hydrogen).

Import-export flows of electricity are also driven by economic considerations in the internal market, for which simulations were carried out separately for every scenario. This allows for trade between countries and therefore for optimal use of the interconnections and generation capacities across countries, taking into consideration the limits of the interconnector capacities, which have been adapted according to the challenges posed by the different scenarios. . The simulation thus allows for a better cost optimisation of the power generation system across the EU Member States in the context of stable grid operations at European level at any time.

It emerges clearly from table 36 that decarbonisation would involve greater electricity trade among Member States, which is most pronounced in the case that decarbonisation focuses overwhelmingly on RES.

Table 36: Grid stability related indicators

Power Reserve Margin (%) Ratio of dispatchable nominal capacities with RES contributing with (small) capacity credits divided by total peak demand (EU net imports not included)			
	2020	2030	2050
Reference	24,1	16,0	17,7
Scenario 1bis	26,8	19,1	22,0
Scenario 2	29,1	24,6	27,8
Scenario 3	25,7	21,2	23,8
Scenario 4	25,6	21,7	32,2
Scenario 5	25,7	21,7	25,9
Scenario 6	25,1	20,4	26,3

Volume of electricity trade (TWh) Sum of all export and import flows of electricity as simulated by the model (lower than in reality)			
	2020	2030	2050
Reference	212,1	217,6	222,3
Scenario 1bis	255,8	307,5	322,8
Scenario 2	303,1	450,8	618,9
Scenario 3	326,6	476,1	623,6
Scenario 4	304,4	602,8	1040,9
Scenario 5	322,8	489,0	648,6
Scenario 6	317,8	482,5	599,1

Contribution of electricity storage (%) Extraction of electricity from storage systems as percentage of gross final demand of electricity			
	2020	2030	2050
Reference	1,2	1,1	1,3
Scenario 1bis	1,1	1,1	1,1
Scenario 2	1,1	1,3	1,0
Scenario 3	1,1	1,2	1,0

Volume of electricity trade as % of gross final electricity demand Sum of all export and import flows of electricity as simulated by the model (lower than in reality) as percentage of gross final electricity demand			
	2020	2030	2050
Reference	6,0	5,7	4,9
Scenario 1bis	7,4	8,6	7,4
Scenario 2	9,0	13,7	15,4
Scenario 3	9,4	13,2	13,6

Scenario 4	1,1	1,2	6,5	Scenario 4	8,8	17,0	24,3
Scenario 5	1,1	1,2	1,0	Scenario 5	9,3	13,6	14,3
Scenario 6	1,1	1,2	1,1	Scenario 6	9,1	13,7	13,4

Share of decentralised power generation (%)			
Share of generation by small scale power plants which are connected to low voltage and medium voltage grid over total net power generation			
	2020	2030	2050
Reference	6,3	9,1	10,6
Scenario 1bis	6,5	10,0	13,9
Scenario 2	7,1	13,1	21,8
Scenario 3	7,2	13,0	20,9
Scenario 4	7,2	17,3	31,3
Scenario 5	7,2	13,1	21,4
Scenario 6	7,1	14,0	24,3

Investment in electricity grids (bn EUR'08)			
Investment expenditure on electricity networks over the indicated time period			
	2006-2020	2021-2030	2031-2050
Reference	389,9	308,0	649,0
Scenario 1bis	387,3	291,1	773,6
Scenario 2	405,4	352,2	860,5
Scenario 3	436,8	416,1	958,9
Scenario 4	434,4	535,5	1323,5
Scenario 5	436,2	420,4	960,9
Scenario 6	438,9	424,6	1029,0

2.6 Policy related indicators

Emissions and ETS prices

All decarbonisation scenarios achieve 80% GHG reduction and close to 85% energy related CO2 reductions (83.4-84.4%) in 2050 compared to 1990 as well as equal cumulative emissions over the projection period. In 2030, energy-related CO2 emissions are between 38-41% lower, and total GHG emissions reductions are lower by 40-42%. In 2040, energy related CO2 emissions are 63-66% below their 1990 level, while total GHG emission fall by 61-63%.

Power generation would be almost completely decarbonised with CO2 emissions in 2050 plummeting 96-99% compared with 1990. CO2 emission reductions by 2050 are particularly high (minus 86-88%) also in the services/agriculture sector as well as in households (minus 85-87%). Energy related CO2 emissions in industry fall 77-79% below their 1990 level. Transport CO2 emission are 60-62% lower in 2050 compared with 1990.

The ETS price rises moderately from current level until 2030 and significantly in the last two decades providing support to all low carbon technologies and energy efficiency. Concrete policy measures such as those pushing energy efficiency and/or those enabling penetration of renewables depress demand for ETS allowances which subsequently lead to lower carbon prices. Carbon prices are the lowest in the Energy Efficiency scenario where energy demand is the lowest followed by High RES scenario (second lowest in 2030 and 2040) and the Diversified supply technology scenario (second lowest in 2050). Delay in penetration of technologies (CCS) or unavailability of one decarbonisation option (nuclear) put an upwards pressure on demand for allowances and ETS prices.

Table 37: ETS prices in €'08/t CO_2

	2020	2030	2040	2050
Reference scenario	18	40	52	50
Current Policy Initiatives	15	32	49	51
Energy Efficiency	15	25	87	234
Diversifies supply technologies	25	52	95	265
High RES	25	35	92	285
Delayed CCS	25	55	190	270
Low nuclear	20	63	100	310

The same carbon value as in the ETS applies also to non-ETS sectors after 2020 assuring cost-efficient emissions abatement in the whole economy.

CCS storage needs

Making use of the CCS option will require considerable storage capacities for CO_2 over time. The Reference scenario developments, including a more optimistic picture on CCS demonstration and availability of storage sites, would require storage capacity for the cumulative CO_2 emissions captured up to 2050 of 8 billion tonnes of CO_2.

In the CPI scenario, CCS penetration is more moderate leading to storage requirements of 3 bn t CO_2 up to 2050. The lowest storage needs come about under high RES scenario, in which case the additional storage requirements over CPI amount to 0.5 bn t CO_2. The highest storage needs comes in the Low nuclear scenario leading to considerable CCS penetration, which requires almost 13 bn t CO_2 storage capacity up to 2050. Also the Diversified Supply Technology scenario would require considerable storage capacity.

Table 38: CCS storage needs for power generation and industrial processes up to 2050 (in bn t CO_2)

	power generation	process related CO2	total CO2
Reference	7,95	0,00	7,95
CPI	3,00	0,00	3,00
Energy Efficiency	4,08	1,52	5,59
Div. Supply Techn.	6,80	2,18	8,98
RES	1,77	1,72	3,50
delayed CCS	4,06	0,62	4,68
low nuclear	10,45	2,35	12,80

RES targets and biomass

The Reference scenario assumes that the RES target is reached in 2020. The RES share (as % of gross final energy consumption according to the definition of the RES directive) is slightly higher in all decarbonisation scenario in 2020 (21%), rises to at least 28% in 2030 and 55% in 2050. In the High RES scenario this share is at 31% in 2030 and 75% in 2050.

The share of renewables in power generation is even higher and stands at 86% in 2050 in the High RES scenario. The share in consumption is even higher, since with much more variable supply and demand some electricity produced needs to be stored and losses linked to such storage processes lead to lower consumption compared to production, i.e. reducing significantly the denominator of such a share. When calculating the RES-E share in line with the calculation of the overall RES share in gross final energy consumption, i.e. excluding energy losses linked to pump storage and hydrogen storage of electricity, the RES share in electricity consumption amounts to 97% in 2050 in the High RES case.

The share of renewables in transport (target of 10% for 2020 in the RES directive) is 1 percentage point higher in all decarbonisation scenarios in 2020; it rises to 19%-20% in 2030 and to 62%-73% in 2050. The share of renewables in transport in the High RES scenario is 20% in 2030 and even 73% in 2050. The increase between 2030 and 2050 as well as the difference to the Reference scenario and Current Policy Initiatives scenario of almost 50 percentage points in 2050 for the decarbonisation scenarios is remarkable and shows the importance of RES based decarbonisation of transport, either directly via biofuels or indirectly via RES based electricity. Decarbonisation efforts and RES share in transport are rather moderate till 2030 but rise significantly from 2030 to 2050.

The large share of RES in the scenarios is driven by a strong support for RES in the form of an implicit facilitation of RES in the scenarios. These lead to shifts in RES potential curves in the decarbonisation scenarios, allowing for more RES exploitation at a given deployment cost level, compared to the Reference scenario. This includes facilitation policies such as:

- For biomass: agricultural policies stimulating the production of energy crops, increased residue collection, and/or increased yield of crops;

- For wind: regarding on-shore it comprises the availability of more land area and a facilitation of the licensing requirements; for off-shore it also represents a facilitation of licensing and the development of technologies that allow placing off-shore power plants in deeper areas or further offshore; and

- For small scale solar PV and wind: development of smart grids and other facilitation policies.

The total use of biomass in the various scenarios is shown in table 39. Whereas the Reference and CPI scenarios have about 100 Mtoe more biomass use in 2050 compared with today's level, there is around 70-80 Mtoe additional biomass use in most decarbonisation scenarios in 2050, except for the high RES case, in which the additional biomass use amounts to around 120 Mtoe.

Table 39: Use of biomass and biofuels

ktoe	2005	Reference scenario		Current policy Initiatives	
		2030	2050	2030	2050
Total domestic biomass	86285	179649	185863	175987	188914
of which biofuels	*3129*	*35255*	*36957*	*34295*	*38912*
Biofuels in bunkers	0	0	0	133	2325
Total use of biomass	86285	179649	185863	176120	191239
		Energy efficiency		Diversified supply technologies	
		2030	2050	2030	2050
Total domestic biomass		162716	241476	172145	253209
of which biofuels		*25033*	*68393*	*26174*	*71047*
Biofuels in bunkers		553	18062	553	17995
Total use of biomass		163268	259538	172698	271204
		High RES		Delayed CCS	
		2030	2050	2030	2050
Total domestic biomass		188675	301805	172953	252893
of which biofuels		*26296*	*72453*	*26112*	*69370*
Biofuels in bunkers		553	18060	552	17523
Total use of biomass		189227	319865	173505	270415
		Low nuclear			
		2030	2050		
Total domestic biomass		175360	257226		
of which biofuels		*26135*	*70794*		
Biofuels in bunkers		553	17981		
Total use of biomass		175913	275206		

Biofuel consumption rises by a factor of more than ten between 2005 and 2050 under current policies to reach 37-39 Mtoe in 2050. Decarbonisation of transport requires substantially greater biofuels use, which increases to 68-72 Mtoe in 2050, with the highest levels being reached in the High RES and Diversified Supply Technology scenarios.

2.7 Overall system costs, competitiveness and other socio-economic impacts

This section deals with the costs for providing the energy services to the EU economy and society. One key element of such costs is the external fuel bill, i.e. the amount of money that they EU economy has to pay to the outside world for procuring all the net imports of oil, gas and solid fuels from the rest of the world.

The **external fuel bill** arising from the net imports of fossil fuels decreases below 2005 levels in all decarbonisation scenarios by 2050. This result stems from the pursuit of this major decarbonisation as a part of a global effort with industrial countries as a group reducing GHG emissions by 80%. In such a global setting, fossil fuel import prices will be much lower (see part on assumptions) and actual imports of fossil fuel will be much lower, too. These both effects reduce the expenditure for each of the fossil fuels and thereby the total external fuel bill of the EU. The decrease of the fuel bill in the decarbonisation scenarios is smallest in the

Low Nuclear scenario at 31% and highest in the high RES scenario with 43% with RES replacing most fossil fuels.

Compared with current level, all decarbonisation scenarios increase the external fuel bill in 2030, but to much lower levels than the Reference and Current Policy Initiative scenarios. While the external fuel bill would double between 2005 and 2030 under Reference and Current Policy Initiatives developments, this increase would be limited to around 40% under these decarbonisation policies.

Table 40: External fossil fuel bill (in bn € (08))

	2005	Reference		CPI	
		2030	2050	2030	2050
Bn. EUR'08	269.1	549.2	752.2	531.9	704.2
Diff. to 2005		104%	180%	98%	162%
		Energy Efficiency		Diversified supply technologies	
		2030	2050	2030	2050
Bn. EUR'08		364.5	165.7	379.0	180.1
Diff. to 2005		35%	-38%	41%	-33%
		High RES		Delayed CCS	
		2030	2050	2030	2050
Bn. EUR'08		374.8	154.2	377.0	180.4
Diff. to 2005		39%	-43%	40%	-33%
		Low nuclear			
		2030	2050		
Bn. EUR'08		382.0	186.4		
Diff. to 2005		42%	-31%		

Savings in the external fuel bill are most striking in 2050. Compared with Current Policy Initiatives, the EU economy could save in 2050 between 518 and 550 bn € (08) by going this strong decarbonisation route under global climate action. The largest energy bill savings come about in the high RES scenario. Such fuel bill savings have strong impacts on overall energy system costs.

Total costs for the entire energy system include capital costs (for energy installations such as power plants and energy infrastructure, energy using equipment, appliances and vehicles), fuel and electricity costs and direct efficiency investment costs (house insulation, control systems, energy management, etc), the latter being also expenditures of capital nature. Capital costs are expressed in annuity payments. Total costs exclude disutility and auction payments.

Auction payments are expenditures for individual actors/sectors that are not costs for the economy as a whole, since the auctioning revenues are recycled back to the economy. Disutility costs are a concept that captures losses in utility from adaptations of individuals to policy impulses or other influences through changing behaviour and energy consumption patterns that might bring them on a lower level in their utility function. Such disutility costs correspond to a monetary estimation (income compensating variation) of lower utility from useful energy services (lighting, heating, mobility, etc.) resulting from a more rational use behaviour by consumers who for example adjusts thermostats, switch lighting off or travel less in order to adapt to higher costs of useful energy services. Such costs monetisation captures relevant issues regarding new consumption patterns especially for a short to medium time horizon, but becomes more challenging and uncertain in the long term, given that monetisation requires the comparison with a counterfactual development assuming unchanged tastes, habits and values over up to 40 years.[12]

[12] The PRIMES model having a micro-economic foundation, deals with utility maximisation and can calculate such perceived utility losses via the concept of compensating variations. However, this

Table 41: Energy system costs

Average annual energy system costs 2011-2050

Bn. EUR'08	Ref	CPI	High Energy effic.	Div. supply techn.	High RES	Delayed CCS	Low nuclear
Capital cost	955	995	1115	1100	1089	1094	1104
Energy purchases	1622	1611	1220	1295	1355	1297	1311
Direct efficiency inv. costs *	28	36	295	160	164	161	161
Total system cost excl. all auction payments and disutility **	2582	2619	2615	2535	2590	2525	2552

Absolute Difference to Reference

Bn. EUR'08	High Energy effic.	Div. supply techn.	High RES	Delayed CCS	Low nuclear
Δ Capital cost	160	145	134	139	149
Δ Energy purchases	-402	-327	-267	-325	-312
Δ Direct efficiency inv. costs *	267	132	135	133	133
Δ Total system cost excl. all auction payments and disutility **	33	-47	8	-57	-29

Absolute Difference to CPI

Bn. EUR'08	High Energy effic.	Div. supply techn.	High RES	Delayed CCS	Low nuclear
Δ Capital cost	120	105	94	99	109
Δ Energy purchases	-391	-316	-256	-314	-300
Δ Direct efficiency inv. costs *	260	125	128	126	125
Δ Total system cost excl. all auction payments and disutility **	-4	-84	-29	-94	-67

Percentage change to Reference

%	High Energy effic.	Div. supply techn.	High RES	Delayed CCS	Low nuclear
Capital cost	16,8	15,2	14,0	14,6	15,6
Energy purchases	-24,8	-20,2	-16,5	-20,0	-19,2
Direct efficiency inv. costs *	937,3	462,4	475,0	466,9	465,5
Total system cost excl. all auction payments and disutility **	1,3	-1,8	0,3	-2,2	-1,1

Percentage change to CPI

%	High Energy effic.	Div. supply techn.	High RES	Delayed CCS	Low nuclear

concept has to assume that preferences and values remain the same, even over 40 years, and has to compare utility with a hypothetical state of no policy or no change in framework conditions. Examples of such decreases are lowering thermostat in space heating, reducing cooling services in offices, switching light off, staying home instead of travelling, using a bicycle instead of a car, etc.

Capital cost	12,0	10,5	9,5	10,0	10,9
Energy purchases	-24,3	-19,6	-15,9	-19,5	-18,6
Direct efficiency inv. costs *	729,5	349,8	359,9	353,4	352,2
Total system cost excl. all auction payments and disutility **	-0,1	-3,2	-1,1	-3,6	-2,5

* Include costs for insulation, double/triple glazing and for efficiency enhancing changes in production processes not accounted for under energy capital and fuel/electricity purchase costs;

** These macroeconomic costs do not include ETS auctioning payments that represent a cost from the individual economic actors point of view, but do not present a cost to society given that auctioning revenues are recycled back to the economy (societal perspective); auctioning payments are partly included in energy purchase costs (e.g. in electricity prices) and partly paid directly by actors subject to ETS; total costs in table 41 differ from the sum of the items shown; table 42 on additional information below gives more detail

Table 42: Additional information on auctioning payments, disutility and total costs from the individual economic actor's point of view (bn € (08) per year on average in 2011-2050)

Bn. EUR'08	***Ref***	***CPI***	***High Energy effic.***	***Div. supply techn.***	***High RES***	***Delayed CCS***	***Low nuclear***
Auctioning payments	30	28	20	27	24	36	30
Total energy system cost (a)	2612	2647	2635	2562	2614	2561	2583
Disutility costs (b)	92	112	153	174	181	211	190
Total energy system costs including auction payments and disutility (c)	2704	2759	2788	2735	2795	2773	2772

(a) From the individual economic actors' point of view, including direct and indirect (via purchase of e.g. electricity) auctioning costs, but excluding disutility costs;

(b) Disutility costs are costs stemming from behavioural change, such as changing lighting quality, lowering thermostat temperature, replacing fuel consuming mobility with other types of mobility (e.g. bikes) or telecommunication that are not accounted for by expenditure flows in the model, but change the level of utility of consumers; such changes are linked to carbon values in non-ETS (which do not represent a cost in cash terms), but are a proxy for policy measures bringing about such behavioural change; direct costs of such change in terms of investment and fuel bills are accounted for in the normal modelling procedure; given the long time horizon and possibly changing preference, the estimation of disutility costs is surrounded with uncertainty.

(c) From the individual economic actors' point of view, including direct and indirect (via purchase of e.g. electricity) auctioning costs as well as disutility costs;

NB: The lower system cost (without auctioning revenue and disutility) in the Delayed CCS scenario compared with the Diversified supply technologies scenario (that is unrestricted regarding technology) is not present when auctioning revenues and disutility costs are included, i.e. the point of view of the economic actors is taken (numbers denoted with (c) above). In this case, the Diversified Supply Technology scenario has the lowest costs. The modelling approach simulates the system from the point of view of economic actors, who perceive auctioning payments and disutility as cost to them that they want to minimise. Disutility costs are however surrounded with uncertainty given the long time horizon and their dependence on preferences and values. Moreover they represent a monetary equivalent in terms of imputed income compensation of changes in utility and are not associated with payments represented in the process of modelling (e.g. energy purchases, investment sums). Given the uncertain and somewhat controversial nature of disutility costs for a 40 year time horizon this long term assessment of economic impacts reports on costs without disutility. Furthermore, taking a macro-economic perspective auctioning revenues can be seen as transfers as they are supposed to be recycled, justifying their exclusion from the macro-economic cost evaluation.

The average additional energy system cost per year from 2011 to 2050 compared with the Reference and Current Policy Initiatives scenario are rather small due to the pursuit of this major decarbonisation as a part of a global effort. Given that the Current Policy Initiatives scenario is the most up to date current trend scenario and that all decarbonisation scenarios base themselves on this updated baseline, the following comparison starts from the CPI scenario (1bis).

The Delayed CCS scenarios and the Diversified Supply Technologies have the lowest level of average annual energy system costs, representing even a cost saving compared with CPI (of 94 bn €(08) and 84 bn €(08), respectively) given the large fossil fuel import cost savings discussed above. These are scenarios, in which there is a rather high nuclear penetration in addition to substantial RES penetration and strong energy efficiency progress. Given these fossil fuel import bill effects, also the Low Nuclear Scenario would produce average annual fuel bill savings of 67 bn € (08) when compared with CPI. The High RES scenario gives rise to a annual energy system cost saving of 29 bn € (08) when compared with CPI, while the annual cost savings for the Energy Efficiency scenario amount to 4 bn €(08).

The cost savings in the Energy Efficiency scenario are smaller (4 bn €) given that very high energy efficiency progress requires strong action on the building stock entailing major expenditure for accelerated building renovation, in addition to costs for other energy efficient equipment including the costly transition to electric and plug in hybrid vehicles. High renovation rates are one of the salient features of the energy efficiency scenario. Electro-mobility also provides for greater energy efficiency in the system. However, this higher cost does not disqualify energy efficiency policies as such, as strong energy efficiency policies leading to substantial improvements and energy savings, are present in all scenarios. The Energy efficiency scenario just shows that there are certain limits from where on other decarbonisation routes are less costly than further reductions of energy consumption.

All scenarios show higher annual costs in the last two decades 2031-2050 reflecting mainly increased investments in transport equipment as the major transition to electric and plug in hybrids vehicles is projected after 2030. In High RES scenario costs are also linked to significant expansion of RES based power generation capacity.

Cumulative auction payments are lowest in Energy efficiency scenario due to the reduced energy consumption, decreasing emissions and therefore the necessity to buy ETS permits. The scenario with the highest auction revenues is Delayed CCS where the delay in the use of CCS leads to high carbon prices in the long-term to ensure the achievement of the decarbonisation target via the uptake of this technology in these later years. The PRIMES model works with perfect foresight in the supply side module, therefore the high carbon prices are expected, influencing choices already in previous years. The auction revenues represent an equivalent of around 1% of total cumulative energy system costs.

When relating the cumulative costs to the GDP (which remains constant in these scenarios) the **ratio of costs to GDP** is similar across the scenarios (around 14.1% to 14.6%) exhibiting costs at the low end of the range in case of diversified supply technologies and delayed CCS.

Table 43: Energy system costs (without auction payments and disutility) related to GDP

	Cumulative costs as percentage of GDP (*)
Reference	14.37%
CPI	14.58%

Energy Efficiency	14.56%
Diversified Supply Technology	14.11%
High RES	14.42%
Delayed CCS	14.06%
Low Nuclear	14.21%

Change in cost structure: fixed costs versus variable costs

The composition of energy costs changes over time and varies across scenarios. The share of fixed cost (capital costs including for e.g. insulation) rises in all scenarios. Following larger capital expenditure for e.g. power generation, grids, energy efficiency investment over time energy, the progress in energy efficiency, greater use of technologies with low operating costs (most RES) and lower world fossil fuel prices in the decarbonisation scenarios bring lower fuel and emission allowances costs. Consequently, the share of capital costs increases over time, especially in the Energy Efficiency and High RES scenarios, which have the highest fixed cost shares (see table 44).

Table 44: Share of fixed costs* in total energy costs (averages over the time periods indicated)**

	2011-2030	2031-2050	2011-2050
Reference	44%	53%	49%
Current Policy Initiatives	45%	54%	50%
Energy Efficiency	52%	74%	65%
Diversified Supply Technologies	50%	70%	62%
High RES	50%	71%	63%
Delayed CCS	50%	70%	62%
Low Nuclear	50%	70%	62%

* capital costs for equipment, appliances, and energy efficiency investment (e.g. insulation), more efficient and cleaner vehicles
** total energy cost from the economic actors' point of view: including auctioning costs

Energy related costs for companies

Energy related costs in relation to sectoral value added rise from 5.8% in 2005 to 7.8% in 2030 in the Reference/CPI cases and to around 7.5% in the decarbonisation scenarios. In 2050, under current policies, this indicator declines to 7.5% and even more so in the decarbonisation scenarios falling to under 7%. Long term energy costs relative to value added of companies under decarbonisation are lower in the decarbonisation cases than under current policies thanks to substantial global decarbonisation efforts. Whereas relative costs for stationary use (heating, process energy, appliances, lighting, etc) in the decarbonisation scenarios remain at the current level by 2030, there is a strong increase in costs related to value added for transport services. After 2030, both stationary and transport energy costs decline somewhat when related to value added. Overall, energy costs relative to value added in 2050 are only somewhat higher than they were in 2005 under decarbonisation, whereas there would be a much more pronounced increase of such costs in the absence of such decarbonisation under significant global climate action.

Table 15: Energy related costs of companies

%	2005	Reference		Scenario 1 bis	
		2030	2050	2030	2050
Ratio of energy related costs to value added	5.8	7.8	7.5	7.8	7.5
of which stationary uses	4.3	4.8	4.5	4.6	4.3
of which transportation uses	1.5	3.0	2.9	3.1	3.1
		Scenario 2		Scenario 3	
		2030	2050	2030	2050
Ratio of energy related costs to value added		7.6	6.6	7.4	6.4
of which stationary uses		4.4	3.9	4.2	3.8
of which transportation uses		3.2	2.7	3.1	2.6
		Scenario 4		Scenario 5	
		2030	2050	2030	2050
Ratio of energy related costs to value added		7.3	6.9	7.4	6.3
of which stationary uses		4.3	4.1	4.2	3.8
of which transportation uses		3.0	2.7	3.2	2.5
		Scenario 6			
		2030	2050		
Ratio of energy related costs to value added		7.5	6.5		
of which stationary uses		4.3	3.8		
of which transportation uses		3.2	2.7		

Energy intensive industries face particularly high energy costs for their highly energy consuming production processes. Five industrial sectors (iron and steel, non-ferrous metals, non metallic mineral products, chemicals, paper and pulp industries) have such high energy costs and are therefore particularly concerned by potential changes from decarbonisation in the energy component of their costs. Table 46 shows for these energy intensive industries combined the ratio of energy related costs for production processes and other stationary use, on the one hand, and their value added, on the other.

Table46: Ratio of energy related costs to value added for energy intensive industries

	2005	2030	2050
Reference	33.7%	40.8%	40.5%
CPI		39.4%	39.5%
Energy Efficiency		35.6%	30.6%
Diversified Supply Technologies		36.4%	32.4%
High RES		36.1%	34.8%
Delayed CCS		36.5%	33.2%
Low Nuclear		37.1%	33.5%

Energy costs of energy intensive industries relative to value added would increase under Reference and CPI developments. This development stems also from rising world fossil fuel prices under current trends. It is worth noting that under global climate action bringing with it lower energy import prices and due to substantial energy efficiency progress, the ratio of energy costs to value added in energy intensive industries would decline in all decarbonisation scenarios – most markedly in the Energy Efficiency scenario

Effects of fragmented climate action: competitiveness and energy consequences of safeguards for energy intensive industries

This Energy Roadmap has assumed the implementation of the European Council's decarbonisation objective that includes similar efforts by industrialised countries as a group. The analysis presented focuses on energy consequences. A more comprehensive analysis of different global paths to decarbonisation was presented in the Low Carbon Economy Roadmap 2050[13] exploring impacts of three global climate situations: a) business as usual; b) global climate action and c) fragmented action. Fragmented action assumes strong EU climate action that is however followed globally only by the low end of Copenhagen pledges up to 2020 and afterwards the ambition level of the pledges is assumed to stay constant. It analyses impacts on energy intensive industries (EII) both in a global macroeconomic modelling framework to address carbon leakage issues and by means of energy system modelling to address effects of fragmented action, including electricity costs for companies. Electricity costs are, in fact, higher in the fragmented action scenarios as compared to global action scenarios due to higher energy import prices. On the other hand, carbon prices are lower under fragmented action.

A "fragmented" action scenario including measures against carbon leakage was not analysed in this IA report as the challenges for the energy sector arising from decarbonisation are the biggest under "global climate action" assumption, given that fragmented action with measures against carbon leakage will deliver lower GHG reductions by 2050. Decarbonisation scenarios that accommodate action against carbon leakage under fragmented action would either go for lower ambitions in terms of GHG reduction or would have measures included that imply such lower efforts for energy intensive industries and consequently for the total energy system[14]. With action on carbon leakage the challenge for the transition in the energy system would be smaller given lower efforts in parts of the system. Such results are however modified through countervailing effects from lower world fossil fuel prices under global action that encourage somewhat higher energy consumption and emissions. In any case, the implementation of measures will be crucial. The real difference for industrial and thereby climate policy might come from the concrete design of policy instruments that is not discussed in this Energy Roadmap Impact Assessment (e.g. special provisions on ETS for EII).

From the analysis undertaken for the Low Carbon Economy Roadmap it can be concluded that under fragmented action with the EU reducing emissions much more than other regions, certain industries supplying low carbon technologies would benefit from improved competitiveness due to higher internal demand and first mover advantages. However, EII would suffer from higher costs for allowances and/or significant mitigation costs in order to avoid the need to purchase such allowances. Furthermore, under fragmented action they

[13] Impact assessment report SEC(2011)288 final, section 5

would not benefit from the fuel and electricity price reductions stemming from a global climate deal that lowers world fossil fuel prices.

This situation of fragmented action might require countervailing action to combat carbon leakage, which was investigated in the Low Carbon Economy Roadmap, notably by exploring a scenario, in which energy intensive industries (iron and steel, non-ferrous metals, chemicals, non metallic minerals, paper and pulp industries) would benefit from the same ETS prices that prevail in the reference scenario, whereas other sectors would be exposed to higher carbon costs. These provisions have only a limited impact on the CO2 emission reduction of all sectors, which instead of reaching minus 86% on 1990 under fragmented action (85% under global action) would amount to 78% with these specific provisions for EII. Clearly, the CO2 emission reduction for EII, i.e. their level of effort, would be reduced more markedly, falling from 87% reduction below 1990 under fragmented action (88% under global action) to only 51% by 2050.

These measures keeping the ETS price for energy intensive industries at the reference case levels lead to significant cost savings for purchasing fuel, electricity, steam and energy using equipment. Compared with the reference case situation with no additional climate action, the average costs in 2011-2050 decrease by 6 bn € (08) annually over 40 years. Higher energy, especially electricity prices from decarbonisation action together with the still significant carbon price signal lead to significant energy savings in energy intensive industries (22.7% in 2050 from Reference).

These cost savings take into account that electricity prices rise significantly under fragmented action (7% in 2050 compared with Reference) and this to a higher degree than under global action given that the cost reducing effect through lower fossil fuel input prices (global action reducing world fossil fuel demand) would not materialise. Electricity prices in 2050 would be 6 % lower on average under global climate action compared with fragmented action with specific measures for EII.

Under global action, the energy saving effect of energy intensive industries is reinforced through higher carbon prices, entailing even greater energy savings. Combined with lower fossil fuel import and therefore final consumer prices, there would be additional cost savings, amounting to 21 bn € per year from 2011 to 2050 when comparing global climate action with fragmented action with less effort for EII.[15]

Table 47 compares the energy related results of decarbonisation scenario under fragmented action with specific carbon leakage measures for energy intensive industries with the Reference case. It includes also a comparison between global action and fragmented action with these specific measures for energy intensive industries. The energy results for this analysis are taken from the energy modelling results for the Low Carbon Economy Roadmap, which includes, in addition to the Reference scenario, the Fragmented action, effective technology and less effort for EII scenario and the Effective Technology Global Action scenario.

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[15] The energy modelling did not include possible changes in value added of energy intensive industries as a reaction to climate policy measures. However, the low carbon economy roadmap includes a complementary analysis of macroeconomic and industrial competitiveness effects of a fragmented action scenario (SEC (2011)650, section 5.1.3) which provides further insights on these issues.

The effective technology scenarios are driven by carbon prices and assume the absence of significant obstacles for technology penetration, especially CCS and nuclear, as well as the absence of specific strong push for RES and energy efficiency. The rationale of these scenarios is similar to the Diversified Supply Technologies scenario, which includes however recent policy initiatives, especially on energy efficiency and energy taxation as well as recent changes in nuclear policies. The most relevant comparison of energy results when dealing with carbon leakage in the case of Fragmented action, effective technology and less effort for EII is therefore in relation to Reference (no additional climate action), on the one hand, and Effective Technology under global climate action, on the other.

Table 47: Comparison of energy results for 2050* between fragmented action with specific measures for energy intensive industries (FAEII) and Reference as well as between global action and FAEII

	Less effort for EII compared with Reference	Global action compared with less effort for EII
Final energy consumption		
EII	-22.7%	-11.2%
Other sectors	-33.6%	+1.6%
Primary energy consumption	-24.1%	+2.5%
Gross electricity generation **	+10.3%	+6.6%
Average electricity prices	+7.2%	-5.7%
Energy related CO2 emissions	-72.4%	+1.2%
Import dependency	-26.2 pp	+1.3 pp
RES share in gross final energy demand	+26.6 pp	-0.3 pp
Cumulative investment expenditure in power generation	+30.1%	+1.2%
Average annual fuel, electricity and equipment costs	-6 bn	-21 bn

* For investment expenditure and costs this comparison relates to the 40 year period up to 2050

** including new uses, such as hydrogen as a means for electricity storage and for feeding into the gas grid thereby contributing to decarbonisation by lowering the carbon content of the gas supplied

Climate action with specific measures for EII against carbon leakages leads to quite significant energy consequences in 2050 compared to reference regarding energy consumption, fuel and electricity costs, prices and emissions. Import dependency would fall strongly, whereas the RES share would rise to a large extent. Investment in power generation would also need to rise strongly while average costs would fall significantly.

Energy consumption of EII would drop further significantly when undertaking decarbonisation in the context of global action, as EII would face higher carbon prices in this case (the same as other sectors). The small increase of energy consumption and emission levels (outside EII) when moving to global action stem from the markedly lower fossil fuel prices under globally reduced demand. Energy related results are either reinforced, if the policy response to climate change moved from fragmented action with specific carbon leakage measures for EII to global action without such measures, or they are modified reflecting the impacts from lower fossil fuel prices.

Energy related expenditures of households

Affordability of energy services as regards fuel and electricity costs but also equipment (insulation, more efficient appliances, etc) is one of the essential elements of the analysis. The sector that is mostly concerned is households. All decarbonisation scenarios show significant fuel savings compared to the Reference and CPI scenarios but also higher costs for energy appliances, boilers and insulation. Energy related expenditures for heating and cooling of households as well as for lighting and appliances almost double from around 2000 EUR'08/year today to 3800 to 3900 EUR'08 in 2050 in the Reference and CPI scenarios reflecting rising fuel and electricity prices and increasing direct household investments in energy efficiency. Expenditures per household amount to some 4500 EUR'08 in most decarbonisation scenarios in 2050, with expenditure per household reaching some 4800 € (08) and almost 4900 € (08) in the Energy Efficiency and high RES scenarios respectively.

It is important to note that per capita income in 2050 will also almost double from today's level, but also that households will be composed of fewer members reflecting aging and changing lifestyles. Energy costs per household exceed the Reference/CPI case level by 16-17% in 2050 in most decarbonisation scenarios. They are 25-27% higher in the Energy Efficiency and High RES scenarios, as these scenarios are particularly intensive in investment. While these costs might be affordable by an average household, vulnerable consumers might need specific support to cope with increased expenditures due to decarbonisation.

Households spend money on transport services, too. Such costs concern expenses on tickets for rail, bus, metro, air and other travel as well as costs for purchasing privately owned vehicles and paying for other fuel and operational expenses. These transport costs per household would even almost triple by 2050 reaching 3900 € (08) and 4100 € (08) in the Reference and CPI case, respectively. The strong growth of such costs reflects rising oil prices as well as changes in the vehicle fleet towards more efficient cars (hybrids, plug in hybrids, electric cars) that involve higher costs[16]. In the decarbonisation scenarios, transport related energy costs per households are lower in 2050 than under Reference or CPI developments, markedly so (broadly around 10%) under Diversified Supply Technologies and delayed CCS, given substantial improvements in energy efficiency in transport and limited price increases with respect to reference for transport fuel.

Relating the costs of households for stationary energy use (heating, appliances, etc) plus those for transport to household expenditure gives the following picture. The share of energy in household expenditure rises over time in all scenarios from 10% in 2005 to around 16% in 2030, decreasing thereafter to around 15-16% by 2050. Among the decarbonisation scenarios, the Delayed CCS and the Diversified Supply Technology scenarios have costs at the lower end of this range, whereas the High RES and Energy efficiency scenarios show 2050 costs at the upper end of the range.

[16] It should be noted that costs of engines and propulsion cannot be separated from the rest of vehicle costs and that these numbers include therefore the costs for owning the entire vehicle.

Table 48: Energy related expenditures of household for stationary use and transport

%	2005	Reference		Scenario 1 bis	
		2030	2050	2030	2050
Share of energy related costs in household expenditure	9.9	15.9	14.6	16.1	15.1
of which stationary uses	5.7	8.0	7.3	7.9	7.3
of which transportation uses	4.2	7.9	7.3	8.2	7.8
		Scenario 2		Scenario 3	
		2030	2050	2030	2050
Share of energy related costs in household expenditure		16.5	16.1	15.9	15.4
of which stationary uses		7.9	9.1	7.5	8.4
of which transportation uses		8.6	7.0	8.4	6.9
		Scenario 4		Scenario 5	
		2030	2050	2030	2050
Share of energy related costs in household expenditure		15.8	16.4	15.9	15.1
of which stationary uses		7.7	9.2	7.5	8.5
of which transportation uses		8.1	7.1	8.4	6.6
		Scenario 6			
		2030	2050		
Share of energy related costs in household expenditure		16.1	15.5		
of which stationary uses		7.5	8.5		
of which transportation uses		8.6	7.0		

Whereas companies enjoy long term energy costs relative to value added that are lower (or at most as high) as such costs under current policy initiatives, the 2050 energy costs of households relative to household expenditure generally exceed such costs without strong decarbonisation albeit only to a rather small extent, especially under Delayed CCS and Diversified Supply Technologies.

Electricity prices

Another important indicator on costs relates to final consumer prices especially the prices of electricity for industrial, household and services consumers as well as the average price. Electricity prices are calculated in such a way that total costs of power generation, balancing, transmission and distribution are recovered, ensuring that investments can be financed. Table 49 shows the average price for electricity in the EU27 for different sectors; the residential sector has the highest user price and industry the lowest as it is currently the case. In 2050, average electricity costs are highest in High RES scenario reaching 199 €/MWh. The lowest electricity prices are in Diversified supply and Energy efficiency scenario, with prices below the Reference and Current Policy Initiatives scenarios because of cheaper procurement of fossil fuels under global climate action.

Average prices of electricity are rising compared to current levels until 2030 and continue increasing in the High RES scenario. In the Energy Efficiency and Diversified Supply Technology scenarios, electricity prices remain similar to those in the Reference/CPI scenario up to 2030 thanks to lower fossil fuel input costs with lower world market prices. With somewhat higher investment or ETS costs, the other decarbonisation scenarios have slightly higher costs in 2030, exceeding Reference/CPI by around 5%. By 2050, the average price exceeds reference/CPI level markedly in the High RES scenario (around 30%) to recover costs for the high generation capacity needs including for back-up and for greater grid and storage capacities, while it remains almost at that level in the Low nuclear case (+4%). In the Diversified Supply Technologies and Energy Efficiency scenarios, electricity prices in 2050 are even below those in the Reference/CPI cases, whereas beneficial effects from lower import prices are compensated by effects from restricted choices on nuclear or delayed penetration of CCS in the respective scenarios. Electricity prices are already slightly higher than reference in Current policy Initiatives scenario reflecting less nuclear in power generation at somewhat higher costs.

It should also be noted that prices rise strongly up to 2020/30, but that after 2030 prices either fall or show an average annual price increase that is much smaller than in the period 2005-2030, which applies in particular for the High RES scenario.

Table 49: EU27 average electricity prices [17]

(Euro'08 per MWhe)		Reference		Scenario 1bis	
	2005	2030	2050	2030	2050
Average price(*)	109.3	154.8	151.1	156.0	156.9
Industry	*74.7*	*107.0*	*104.2*	*105.4*	*102.4*
Households	*140.7*	*207.2*	*201.3*	*211.7*	*212.3*
Services	*131.3*	*173.1*	*166.3*	*173.9*	*172.7*

(Euro'08 per MWhe)	Scenario 2		Scenario 3	
	2030	2050	2030	2050
Average price(*)	154.4	146.7	159.6	146.2
Industry	*106.8*	*110.5*	*111.2*	*108.8*
Households	*206.4*	*195.3*	*208.0*	*194.5*
Services	*168.9*	*161.5*	*171.8*	*159.8*

(Euro'08 per MWhe)	Scenario 4		Scenario 5	
	2030	2050	2030	2050
Average price(*)	164.4	198.9	160.4	151.9
Industry	*112.6*	*134.9*	*111.7*	*114.1*
Households	*215.6*	*285.6*	*209.1*	*200.9*
Services	*176.9*	*223.8*	*172.8*	*165.4*

(Euro'08 per MWhe)	Scenario 6	
	2030	2050
Average price(*)	168.2	157.2
Industry	*118.8*	*119.2*
Households	*218.4*	*208.3*
Services	*180.9*	*171.6*

(*): Average price over all consumer types, including final consumers and energy branch

Diesel prices

Another pertinent indicator on costs across scenarios is the price of diesel, which is relevant for both passenger transport (in private cars and buses/coaches) and freight transport.

Prices for diesel in transport in CPI and the decarbonisation scenarios reflect the new energy taxation directive as well as different bio-diesel blends. The energy system changes between scenarios cause only limited changes to end-user diesel prices. The strong decline in diesel prices between CPI and decarbonisation scenarios in 2030 reflects oil and product import price savings. This effect is compensated in 2050 by the impact of a significantly higher biofuel penetration in the diesel market.

[17] Average electricity prices in this table relate to a somewhat different customer base compared with electricity prices shown in Part A by including also energy branch customers in addition to those in final demand sectors; this explains the slight differences in average prices (e.g. for 2005 between 109.3 € when including the energy branch and 110.1 € when excluding it).

Table 50: Average EU27 diesel (including blended biodiesel) end –user prices for private transport[18]

		2005	2030	2050
Reference	(EUR(08)/toe)	1271	1877	2250
CPI	% diff. to Reference	0%	20%	16%
Energy Efficiency		0%	3%	17%
Diversified Supply Technology		0%	3%	19%
High RES		0%	3%	21%
Delayed CCS		0%	2%	18%
Low Nuclear		0%	3%	22%

2.8 Conclusions

The Commission services conducted a model-based analysis of decarbonisation scenarios exploring energy consequences of the European Council's objective to reach 80% GHG reductions by 2050 (as compared to 1990), provided that industrialised countries as a group undertake similar efforts. These scenarios explore also the energy security and competitiveness dimension of such energy developments. Businesses as usual projections show only half the GHG emission reductions needed; increased import dependency, in particular for gas; and rising electricity prices and energy costs. Several decarbonisation scenarios highlighting the implications of pursuing each of the four main decarbonisation routes for the energy sector – energy efficiency, renewables, nuclear and CCS - were examined by modelling a high and low end for each of them. The model relies on a series of input assumptions and internal mechanisms to provide the outputs.

The most relevant assumptions and mechanisms of the model

- All scenarios were conducted under the hypothesis that the whole world is acting on climate change which leads to lower demand for fossil fuel prices and subsequently lower prices.
- The model assumes perfect foresight regarding, policy thrust, energy prices and technology developments which assures a very low level of uncertainty for investors, enabling them to make particular cost-effective investment choices without stranded investments. There is also no problem with uncertainty on whether all the infrastructure and other interrelated investment (e.g. grid connections) needed to make a particular investment work will be in place in time.
- Regulatory framework in model allows for investments to be built and costs fully recovered.
- The model assumes a "representative" or average household or consumer while in reality there is a more diversified picture of investors and consumers.
- The model assumes continuous improvements of technologies.

The model-based analysis has shown that decarbonisation of the energy sector is feasible; that it can be achieved through various combinations of energy efficiency, renewables, nuclear and CCS contributions; and that the costs are affordable. The aim of the analysis was not to pick preferred options, a choice that would be surrounded with great uncertainty, but to show some prototype of pathways to decarbonise the energy system while improving energy security and competitiveness and identify common features from scenario analysis.

[18] The average EU price of diesel is calculated with the weighted average of country prices; differences between scenarios are therefore also due to different amounts of diesel used in the countries per scenario; in addition there are different blending ratios; the different taxation regime between the Reference scenario and the other scenarios including CPI reflecting the new proposal for the energy taxation directive.

Common elements to scenario analysis

- There is a need for an integrated approach, e.g.; decarbonisation of heating and transport relies heavily on the availability of decarbonised electricity supply, which in turn depends on very low carbon investments in generation capacity as well as significant grid expansions and smartening.
- Electricity (given its high efficiency and emission free nature at use) makes major inroads in decarbonisation scenarios reaching a 36-39% share in 2050 (almost doubling from current level and becoming the most important final energy source). Decarbonisation in 2050 will require a virtually carbon free electricity sector in the EU, and around 60% CO2 reduction by 2030.
- Significant energy efficiency improvements happen in all decarbonisation scenarios. One unit of GDP in 2050 requires around 70% less energy input compared with 2005. The average annual improvement in energy intensity amounts to around 2.5% pa.
- The share of renewables rises substantially in all scenarios**,** achieving at least 55% in gross final energy consumption in 2050, up 45 percentage points from the current level (a high RES case explores the consequences of raising this share to 75%).
- The increased use of renewable energy as well as energy efficiency improvements require modern, reliable and smart infrastructure including electrical storage.
- Nuclear has a significant role in decarbonisation in Member States where it is accepted, especially if CCS deployment were delayed.
- CCS contributes significantly towards decarbonisation in most scenarios with a particularly strong role in case there were problems with nuclear investment and deployment. Developing CCS can be also seen as an insurance against energy efficiency, RES and nuclear (in some Member States) delivering less or not that quickly.
- All scenarios show a transition from high fuel/operational expenditures to high capital expenditure.
- Substantial changes in the period up to 2030 will be crucial for a cost-efficient long term transition to a decarbonised world[19]. Economic costs are manageable if action starts early so that the restructuring of the energy system goes in parallel with investment cycles thereby avoiding stranded investment as well as costly lock-ins of medium carbon intensive technology.
- The costs of such deep decarbonisation are low in all scenarios given lower fuel procurement costs with cost savings shown mainly in scenarios relying on all four main decarbonisation options.
- Costs are unequally distributed across sectors, with households shouldering the greatest cost increase due to higher costs of direct energy efficiency expenditures in appliances, vehicles and insulation.
- The external EU energy bill for importing oil, gas and coal will be substantially lower under decarbonisation due to substantial reduction in import quantities and prices dependent on global climate action lowering world fossil fuel demand substantially.

When considering these scenario results it might be useful to consider as well that energy supply structures are being transformed. Today we have, for the most part, concentrated rather invisible items, such as mines, import terminals, large power plants outside towns, and underground pipelines for energy dense fossil fuels and nuclear energy. Under decarbonisation we would increasingly have well visible land consuming configurations, such as very large numbers of wind turbines, solar devices, biomass plantation, and additional transmission lines. This might raise issues with **public acceptance** and local opposition.

Deployment of nuclear technologies is fraught with acceptance problems in a large number of Member States. CCS is already now experiencing local opposition in some Member States. Temporary delays in CCS were modelled but not the complete unavailability of this option. Permanent unavailability of CCS could mean that decarbonisation would almost entirely hinge upon very strong progress with RES penetration (and energy efficiency) given the

[19] Scenarios for the Low Carbon Economy Roadmap of March 2011 show the additional costs of delayed action.

existing limitations to nuclear with many Member States having opted out. In the high RES scenario with much energy efficiency (discussed above), the CCS role is very small, given the predominance of RES, requiring in turn large efforts in terms of financing and finding accepted sites for very substantial investments in production and transmission.

Some policy relevant conclusions can be drawn based both on the results of the scenario analysis as well as on a comparison of the hypothetical situation of ideal market and technological conditions needed for modelling purposes and what is found in the much more complex reality.

Implications for future policy making

- Successful decarbonisation while preserving competitiveness of the EU economy is possible. Without global climate action, carbon leakage might be an issue and appropriate instruments could be needed to preserve the competitiveness of energy intensive industries.
- Predictability and stability of policy and regulatory framework creates a favourable environment for low carbon investments. While the regulatory framework to 2020 is mainly given, discussions about policies for 2020-2030 should start now leading to firm decisions that provide certainty for long-term low-carbon investments. Uncertainty can lead to a sub-optimal situation where only investment with low initial capital costs is realised.
- A well functioning internal market is necessary to encourage investment where it is most cost-effective. However, the process of decarbonisation brings new challenges in the context, for example, of. electricity price determination in power exchanges: deep decarbonisation increases substantially the bids based on zero marginal costs leading in many instances to prices rather close to zero, not allowing cost recovery in power generation. Similarly, the necessary expansion and innovation of grids for decarbonisation may be hampered if regulated transmission and distribution focuses on costs minimisation alone. Building of adequate infrastructure needs to be assured and supported either by adequate regulation and/or public funding (e.g. financed by auctioning revenues).
- Energy efficiency tends to show better results in a model than in reality. Energy efficiency improvements are often hampered by split incentives, cash problems of some group of customers; imperfect knowledge and foresight leading to lock-in of some outdated technologies, etc. There is thus a strong need for targeted support policies and public funding supporting more energy efficient consumer choices.
- Strong support should be given to R&D in order to bring down costs of low-carbon technologies.
- Due attention should be given to public acceptance of all low carbon technologies and infrastructure as well willingness of consumers to undertake implied changes and bear higher costs. This will require the engagement of both the public and private sectors early in the process.
- Social policies might need to be considered early in the process given that households shoulder large parts of the costs. While these costs might be affordable by an average household, vulnerable consumers might need specific support to cope with increased expenditures. In addition, transition to a decarbonised economy may involve shifts to more highly skilled jobs, with a possibly difficult adaptation period.
- Flexibility. The future is uncertain and nobody can predict it. That is why preserving flexibility is important for a cost efficient approach, but certain decisions are needed already at this stage in order to start the process that needs innovation and investment, for which investors require a reasonable degree of certainty from reduced policy and regulatory risk.
- External dimension, in particular relations with energy suppliers, should be dealt with pro-actively and at an early stage given the implications of global decarbonisation on fossil fuel export revenues and the necessary production and energy transport investments during the transition phase to decarbonisation; new areas for co-operation could include renewable energy supplies and technology development.

Attachments

ATTACHMENT 1: NUMERICAL RESULTS

1. Reference scenario

EU27: Reference scenario with updated world energy prices														SUMMARY ENERGY BALANCE AND INDICATORS (A)					
ktoe	1990	1995	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050	'90-'00	'00-'10	'10-'20	'20-'30	'30-'40	'40-'50
														Annual % Change					
Production	**936047**	**950181**	**941860**	**900326**	**844792**	**805284**	**789524**	**780783**	**778102**	**783807**	**795430**	**794964**	**772011**	**0,1**	**-1,1**	**-0,7**	**-0,1**	**0,2**	**-0,3**
Solids	366477	277810	213423	196277	182257	167613	148129	140256	118616	109353	117163	118171	115722	-5,3	-1,6	-2,1	-2,2	-0,1	-0,1
Oil	129551	171052	173006	134290	104398	74104	49136	40242	36706	31989	25325	17092	8469	2,9	-4,9	-7,3	-2,9	-3,6	-10,4
Natural gas	162447	188965	207559	188677	164866	129069	110851	90833	74513	63722	51825	38563	29267	2,5	-2,3	-3,9	-3,9	-3,6	-5,6
Nuclear	202589	223028	243761	257360	238923	239158	222988	231786	247611	268937	283439	298546	294933	1,9	-0,2	-0,7	1,1	1,4	0,4
Renewable energy sources	74984	89326	104111	123722	154349	195340	258420	277667	300657	309806	317677	322592	323620	3,3	4,0	5,3	1,5	0,6	0,2
Hydro	25101	28054	30374	26395	27808	28635	29328	30145	30668	31048	31418	31756	32023	1,9	-0,9	0,5	0,4	0,2	0,2
Biomass & Waste	46473	57201	67982	85129	102433	122385	152662	158880	162784	160925	162098	161497	157972	3,9	4,2	4,1	0,6	0,0	-0,3
Wind	67	350	1913	6061	13850	27580	47984	57378	70750	77239	80764	83535	85243	39,8	21,9	13,2	4,0	1,3	0,5
Solar and others	153	274	421	807	3425	9348	19507	22078	27031	30808	33323	35658	38139	10,7	23,3	19,0	3,3	2,1	1,4
Geothermal	3190	3447	3421	5331	6832	7393	8940	9186	9424	9785	10073	10145	10243	0,7	7,2	2,7	0,5	0,7	0,2
Net Imports	**756079**	**738600**	**826299**	**986048**	**980012**	**1054520**	**1053827**	**1043130**	**1006495**	**1001103**	**1008427**	**1028026**	**1049689**	**0,9**	**1,7**	**0,7**	**-0,5**	**0,0**	**0,4**
Solids	81846	79338	98645	126639	121822	122965	114982	118206	96064	82294	78558	81785	84511	1,9	2,1	-0,6	-1,8	-2,0	0,7
Oil	535645	512185	533039	599851	581600	610760	619288	609026	586837	588234	592904	601403	610189	0,0	0,9	0,6	-0,5	0,1	0,3
- Crude oil and Feedstocks	508460	494000	513725	581995	579010	612729	625088	619901	602209	604393	609655	618641	628328	0,1	1,2	0,8	-0,4	0,1	0,3
- Oil products	27185	18185	19314	17856	2590	-1970	-5800	-10875	-15372	-16159	-16750	-17239	-18140	-3,4	-18,2				
Natural gas	135121	145288	192531	257366	272497	314077	301734	302919	308809	314094	317843	322968	329585	3,6	3,5	1,0	0,2	0,3	0,4
Electricity	3323	1508	1686	971	264	-544	-1754	-1942	-2080	-2327	-2342	-2395	-2487	-6,6	-16,9				
Renewable energy forms	144	279	397	1222	3829	7262	19577	14921	16865	18808	21463	24266	27892	10,7	25,4	17,7	-1,5	2,4	2,7
Gross Inland Consumption	**1660159**	**1662517**	**1723099**	**1825989**	**1774753**	**1807688**	**1790021**	**1769445**	**1728783**	**1728020**	**1746001**	**1764359**	**1762783**	**0,4**	**0,3**	**0,1**	**-0,3**	**0,1**	**0,1**
Solids	452940	364248	321007	319922	304079	290578	263112	258462	214680	191647	195722	199956	200233	-3,4	-0,5	-1,4	-2,0	-0,9	0,2
Oil	631058	650858	658727	676859	635947	632747	615094	594800	567728	563333	560374	559863	559741	0,4	-0,4	-0,3	-0,8	-0,1	0,0
Natural gas	294905	333268	393417	445998	437362	443147	412585	393752	383322	377816	369668	361531	358852	2,9	1,1	-0,6	-0,7	-0,4	-0,3
Nuclear	202589	223028	243761	257360	238923	239158	222988	231786	247611	268937	283439	298546	294933	1,9	-0,2	-0,7	1,1	1,4	0,4
Electricity	3323	1508	1686	971	264	-544	-1754	-1942	-2080	-2327	-2342	-2395	-2487	-6,6	-16,9				
Renewable energy forms	75343	89606	104501	124880	158178	202602	277997	292587	317522	328614	339140	346857	351512	3,3	4,2	5,8	1,3	0,7	0,4
as % in Gross Inland Consumption																			
Solids	27,3	21,9	18,6	17,5	17,1	16,1	14,7	14,6	12,4	11,1	11,2	11,3	11,4						
Oil	38,0	39,1	38,2	37,1	35,8	35,0	34,4	33,6	32,8	32,6	32,1	31,7	31,8						
Natural gas	17,8	20,0	22,8	24,4	24,6	24,5	23,0	22,3	22,2	21,9	21,2	20,5	20,4						
Nuclear	12,2	13,4	14,1	14,1	13,5	13,2	12,5	13,1	14,3	15,6	16,2	16,9	16,7						
Renewable energy forms	4,5	5,4	6,1	6,8	8,9	11,2	15,5	16,5	18,4	19,0	19,4	19,7	19,9						
Gross Electricity Generation in GWh_e	**2562823**	**2712209**	**2991720**	**3274121**	**3410155**	**3615644**	**3766750**	**3987027**	**4066714**	**4284467**	**4539591**	**4761463**	**4931154**	**1,6**	**1,3**	**1,0**	**0,8**	**1,1**	**0,8**
Nuclear	794718	881662	944823	997519	926564	928349	871028	920581	995206	1089783	1154633	1246116	1303832	1,7	-0,2	-0,6	1,3	1,5	1,2
Hydro & wind	292648	330306	375545	378836	501839	686819	967260	1108094	1313567	1428648	1500812	1564161	1615455	2,5	2,9	6,8	3,1	1,3	0,7
Thermal (incl. biomass)	1475456	1500241	1671352	1897765	1981751	2000476	1928462	1958352	1757941	1766036	1884147	1951186	2011867	1,3	1,7	-0,3	-0,9	0,7	0,7
Fuel Inputs for Thermal Power Generation	**383492**	**362334**	**382613**	**424208**	**434230**	**431464**	**413869**	**417433**	**379617**	**365574**	**374301**	**378407**	**383164**	**0,0**	**1,3**	**-0,5**	**-0,9**	**-0,1**	**0,2**
Solids	263837	230040	223012	229245	232681	220385	196207	193344	154957	135202	139484	143039	143607	-1,7	0,4	-1,7	-2,3	-1,0	0,3
Oil (including refinery gas)	54404	51463	39294	29780	17242	16281	11177	14071	14919	17125	20185	22924	23179	-3,2	-7,9	-4,2	2,9	3,1	1,4
Gas	56754	67806	102408	134637	143444	139931	125482	121522	116857	119958	119786	118254	120825	6,1	3,4	-1,3	-0,7	0,2	0,1
Biomass & Waste	5724	10033	14960	25901	35036	48979	74871	81932	85857	85982	87223	86510	87817	10,1	8,9	7,9	1,4	0,2	0,1
Geothermal heat	2774	2992	2939	4645	5828	5888	6132	6564	7027	7307	7623	7681	7737	0,6	7,1	0,5	1,4	0,8	0,1
Hydrogen - Methanol	0	0	0	0	0	0	0	0	0	0	0	0	0						
Fuel Input in other transformation proc.	**839073**	**814654**	**827098**	**842975**	**794117**	**805120**	**800342**	**784837**	**759949**	**756205**	**754190**	**754073**	**753750**	**-0,1**	**-0,4**	**0,1**	**-0,5**	**-0,1**	**0,0**
Refineries	679426	705954	735244	758152	718853	722167	708598	693191	670478	667636	665791	666042	666769	0,8	-0,2	-0,1	-0,6	-0,1	0,0
Biofuels and hydrogen production	2	202	610	3129	12210	19624	30328	31995	35283	36667	37229	37256	36990	79,6	34,9	9,5	1,5	0,5	-0,1
District heating	32960	23240	19323	16212	15609	15836	15578	15568	13831	13509	12932	11659	11451	-5,2	-2,1	0,0	-1,2	-0,7	-1,2
Others	126685	85258	71921	65482	47445	47493	45838	44083	40357	38392	38238	39115	38540	-5,5	-4,1	-0,3	-1,3	-0,5	0,1
Energy Branch Consumption	**82379**	**88696**	**88176**	**96033**	**92203**	**90715**	**89395**	**88187**	**82583**	**83526**	**87023**	**89342**	**89820**	**0,7**	**0,4**	**-0,3**	**-0,8**	**0,5**	**0,3**
Non-Energy Uses	**97931**	**110541**	**112495**	**117477**	**111512**	**115317**	**117892**	**118700**	**119686**	**120719**	**121626**	**122538**	**123283**	**1,4**	**-0,1**	**0,6**	**0,2**	**0,2**	**0,1**
Final Energy Demand	**1068710**	**1069989**	**1112989**	**1173676**	**1165873**	**1215397**	**1227169**	**1206870**	**1187036**	**1192289**	**1201689**	**1214718**	**1220944**	**0,4**	**0,5**	**0,5**	**-0,3**	**0,1**	**0,2**
by sector																			
Industry	365650	328513	326949	326308	312402	322907	330271	332209	332530	337637	347017	357606	369219	-1,1	-0,5	0,6	0,1	0,4	0,6
- energy intensive industries	234722	214526	213112	210991	193227	196685	198535	196310	193411	192595	194763	196810	198992	-1,0	-1,0	0,3	-0,3	0,1	0,2
- other industrial sectors	130928	113987	113837	115317	119175	126222	131736	135899	139120	145042	152254	160796	170228	-1,4	0,5	1,0	0,5	0,9	1,1
Residential	264307	280418	286784	308104	308364	320385	317623	303962	299095	296158	293213	292149	288195	0,8	0,7	0,3	-0,6	-0,2	-0,2
Tertiary	158484	160442	159866	176859	175095	182934	181325	176861	173822	175990	178125	180740	180850	0,1	0,9	0,4	-0,4	0,2	0,2
Transport	280269	300617	339389	362405	370012	389172	397950	393838	381589	382505	383333	384224	382680	1,9	0,9	0,7	-0,4	0,0	0,0
by fuel																			
Solids	125031	84977	61454	54486	47419	46274	44102	42716	38479	36813	36731	37803	37714	-6,9	-2,6	-0,7	-1,4	-0,5	0,3
Oil	444429	456959	478882	495857	476505	477401	467526	451334	428648	426107	424509	425057	422388	0,7	0,0	-0,2	-0,9	-0,1	-0,1
Gas	227902	245996	265552	283524	265060	271959	253998	234748	227256	217035	207872	201799	196468	1,5	0,0	-0,4	-1,1	-0,9	-0,6
Electricity	184145	193367	216403	237537	248412	264598	274801	290291	297955	312733	328782	343339	355216	1,6	1,4	1,0	0,8	1,0	0,8
Heat (from CHP and District Heating) [(A)]	48610	44616	40061	44441	59328	71796	78280	83792	86854	92259	94996	97320	99656	-1,9	4,0	2,8	1,0	0,9	0,5
Other	38592	44073	50640	57832	69149	83367	108462	103990	107845	107343	108800	109399	109503	2,8	3,2	4,6	-0,1	0,1	0,1
CO_2 Emissions (Mt of CO_2 - sec approach)	**4030,6**	**3800,1**	**3810,6**	**3946,6**	**3771,6**	**3713,4**	**3442,0**	**3273,4**	**2982,8**	**2755,5**	**2565,5**	**2451,4**	**2400,4**	**-0,6**	**-0,1**	**-0,9**	**-1,4**	**-1,5**	**-0,7**
Power generation/District heating	1484,3	1321,2	1320,8	1381,1	1365,6	1304,8	1124,2	1066,8	890,6	715,2	561,6	463,8	434,0	-1,2	0,3	-1,9	-2,3	-4,5	-2,5
Energy Branch	152,2	171,0	170,2	181,6	157,3	146,0	135,6	124,4	113,8	100,4	90,6	79,7	78,9	1,1	-0,8	-1,5	-1,7	-2,3	-1,4
Industry	781,4	678,1	623,0	581,9	490,5	475,1	459,1	440,7	420,4	407,6	406,5	416,3	424,8	-2,2	-2,4	-0,7	-0,9	-0,3	0,4
Residential	499,4	481,6	466,2	486,7	465,3	465,8	426,2	382,4	361,1	345,6	328,0	315,3	297,5	-0,7	0,0	-0,9	-1,6	-1,0	-1,0
Tertiary	300,5	275,3	242,0	262,2	244,5	238,3	220,3	200,5	187,2	179,0	170,5	165,5	158,3	-2,1	0,1	-1,0	-1,6	-0,9	-0,7
Transport	812,7	872,9	988,5	1053,1	1048,3	1083,3	1076,7	1058,5	1009,7	1007,7	1008,3	1010,7	1007,0	2,0	0,6	0,3	-0,6	0,0	0,0
CO_2 Emissions Index (1990=100)	**100,0**	**94,3**	**94,5**	**97,9**	**93,6**	**92,1**	**85,4**	**81,2**	**74,0**	**68,4**	**63,7**	**60,8**	**59,6**						
CO_2 Emissions (Mt of CO_2 - ref approach)	**4172,0**	**3950,7**	**3922,7**	**4087,6**	**3837,5**	**3780,3**	**3511,3**	**3342,5**	**3053,6**	**2824,8**	**2632,9**	**2516,8**	**2470,2**	**-0,6**	**-0,2**	**-0,9**	**-1,4**	**-1,5**	**-0,6**

EU27: Reference scenario with updated world energy prices														SUMMARY ENERGY BALANCE AND INDICATORS (B)					
	1990	1995	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050	'90-'00	'00-'10	'10-'20	'20-'30	'30-'40	'40-'50
														Annual % Change					
Main Energy System Indicators																			
Population (Million)	470,388	477,010	481,072	489,211	499,389	507,727	513,838	517,811	519,942	520,654	520,103	518,362	515,303	0,2	0,4	0,3	0,1	0,0	-0,1
GDP (in 000 MEuro'05)	8142,7	8748,4	10107,2	11063,1	11385,6	12750,3	14164,0	15503,7	16824,7	18157,1	19527,9	21002,9	22560,0	2,2	1,2	2,2	1,7	1,5	1,5
Gross Inl. Cons./GDP (toe/MEuro'05)	203,9	190,0	170,5	165,1	155,9	141,8	126,4	114,1	102,8	95,2	89,4	84,0	78,1	-1,8	-0,9	-2,1	-2,0	-1,4	-1,3
Gross Inl. Cons./Capita (toe/inhabitant)	3,53	3,49	3,58	3,73	3,55	3,56	3,48	3,42	3,32	3,32	3,36	3,40	3,42	0,1	-0,1	-0,2	-0,5	0,1	0,2
Electricity Generated/Capita (kWh gross/inhabitant)	5448	5686	6219	6693	6829	7121	7331	7700	7821	8229	8728	9186	9569	1,3	0,9	0,7	0,7	1,1	0,9
Carbon intensity (t of CO_2/toe of GIC)	2,43	2,29	2,21	2,16	2,13	2,05	1,92	1,85	1,73	1,59	1,47	1,39	1,36	-0,9	-0,4	-1,0	-1,1	-1,6	-0,8
CO_2 Emissions/Capita (t of CO_2/inhabitant)	8,57	7,97	7,92	8,07	7,55	7,31	6,70	6,32	5,74	5,29	4,93	4,73	4,66	-0,8	-0,5	-1,2	-1,5	-1,5	-0,6
CO2 Emissions to GDP (t of CO2/MEuro'05)	495,0	434,4	377,0	356,7	331,3	291,2	243,0	211,1	177,3	151,8	131,4	116,7	106,4	-2,7	-1,3	-3,1	-3,1	-3,0	-2,1
Import Dependency %	44,6	43,5	46,8	52,5	53,7	56,7	57,2	57,2	56,4	56,1	55,9	56,4	57,6						
Energy intensity indicators (2000=100)																			
Industry (Energy on Value added)	130,3	115,2	100,0	95,1	90,3	84,6	78,3	72,4	67,4	63,7	61,2	59,0	57,0	-2,6	-1,0	-1,4	-1,5	-1,0	-0,7
Residential (Energy on Private Income)	114,4	113,2	100,0	97,5	96,9	89,5	80,3	70,9	64,8	58,8	54,3	50,0	46,2	-1,3	-0,3	-1,9	-2,1	-1,8	-1,6
Tertiary (Energy on Value added)	126,5	117,0	100,0	99,4	94,7	87,5	77,8	69,0	62,2	58,3	54,6	51,3	47,6	-2,3	-0,5	-1,9	-2,2	-1,3	-1,4
Transport (Energy on GDP)	102,5	102,3	100,0	97,6	96,8	90,9	83,7	75,7	67,5	62,7	58,5	54,5	50,5	-0,2	-0,3	-1,4	-2,1	-1,4	-1,4
Carbon Intensity indicators																			
Electricity and Steam production (t of CO_2/MWh)	0,46	0,40	0,37	0,35	0,32	0,28	0,23	0,21	0,17	0,13	0,10	0,08	0,07	-2,1	-1,5	-3,3	-3,0	-5,5	-3,3
Final energy demand (t of CO_2/toe)	2,24	2,16	2,08	2,03	1,93	1,86	1,78	1,73	1,67	1,63	1,59	1,57	1,55	-0,7	-0,8	-0,8	-0,6	-0,5	-0,3
Industry	2,14	2,06	1,91	1,78	1,57	1,47	1,39	1,33	1,26	1,21	1,17	1,16	1,15	-1,1	-1,9	-1,2	-0,9	-0,8	-0,2
Residential	1,89	1,72	1,63	1,58	1,51	1,45	1,34	1,26	1,21	1,17	1,12	1,08	1,03	-1,5	-0,7	-1,2	-1,1	-0,8	-0,8
Tertiary	1,90	1,72	1,51	1,48	1,40	1,30	1,21	1,13	1,08	1,02	0,96	0,92	0,88	-2,2	-0,8	-1,4	-1,2	-1,2	-0,9
Transport	2,90	2,90	2,91	2,91	2,83	2,78	2,71	2,69	2,65	2,63	2,63	2,63	2,63	0,0	-0,3	-0,5	-0,2	-0,1	0,0
Electricity and steam generation																			
Net Generation Capacity in MW_e			**654125**	**715732**	**820281**	**920809**	**1018597**	**1069239**	**1162174**	**1238790**	**1314335**	**1391288**	**1454012**		**2,3**	**2,2**	**1,3**	**1,2**	**1,0**
Nuclear energy			133923	134409	127038	126752	124429	117209	127795	136577	142452	153196	160858		-0,5	-0,2	0,3	1,1	1,2
Renewable energy			112878	147262	209088	280972	400578	455824	541519	589897	622197	652622	680536		6,4	6,7	3,1	1,4	0,9
Hydro (pumping excluded)			99714	104505	107315	110842	114160	115738	117577	119002	119221	120141	121342		0,7	0,6	0,3	0,1	0,2
Wind			12793	40584	86217	141700	231311	269594	325287	350074	364179	375326	382452		21,0	10,4	3,5	1,1	0,5
Solar			371	2172	15307	27855	53437	67626	94508	116353	133969	151728	170533		45,1	13,3	5,9	3,6	2,4
Other renewables (tidal etc.)			0	1	249	575	1671	2866	4146	4468	4828	5427	6209			21,0	9,5	1,5	2,5
Thermal power			407324	434061	484156	513084	493590	496206	492860	512315	549685	585469	612618		1,7	0,2	0,0	1,1	1,1
of which cogeneration units			75917	85934	100379	114000	119045	126780	134574	154672	172095	191977	205866		2,8	1,7	1,2	2,5	1,8
of which CCS units			0	0	0	0	5394	10402	11430	26581	59417	86779	100632				7,8	17,9	5,4
Solids fired			194165	186620	183811	182974	165025	149886	133605	127041	135136	133954	130555		-0,5	-1,1	-2,1	0,1	-0,3
Gas fired			129444	167173	219327	238701	230438	228610	238767	264227	272783	259334	225849		5,4	0,5	0,4	1,3	-1,9
Oil fired			71058	62082	56064	48367	37993	49411	47586	46700	62480	108459	168042		-2,3	-3,8	2,3	2,8	10,4
Biomass-waste fired			12051	17502	24170	42257	59315	67422	71964	73373	78271	82698	87142		7,2	9,4	2,0	0,8	1,1
Hydrogen plants			0	0	0	0	0	0	0	0	0	0	0						
Geothermal heat			605	684	783	786	818	876	937	974	1016	1024	1031		2,6	0,4	1,4	0,8	0,1
Load factor for net electric capacities (%)			49,1	49,1	45,1	42,8	40,3	40,5	38,1	37,6	37,2	36,6	36,3						
Indicators for gross electricity production																			
Efficiency for thermal electricity production (%)			37,6	38,5	39,2	39,9	40,1	40,3	39,8	41,5	43,3	44,3	45,2						
CHP indicator (% of electricity from CHP)			11,4	11,7	15,0	17,9	18,6	18,6	18,5	21,3	21,9	22,8	23,5						
CCS indicator (% of electricity from CCS)			0,0	0,0	0,0	0,0	1,4	2,7	2,9	6,2	12,4	16,6	17,8						
Non fossil fuels in electricity generation (%)			45,8	44,8	45,9	49,9	56,4	58,8	65,0	66,8	66,4	66,6	66,7						
- nuclear			31,6	30,5	27,2	25,7	23,1	23,1	24,5	25,4	25,4	26,2	26,4						
- renewable energy forms and industrial waste			14,2	14,3	18,7	24,2	33,3	35,8	40,5	41,3	40,9	40,4	40,3						
Indicators for renewables (excluding industrial waste) (%) [(B)]																			
RES in gross final energy demand (%)			7,6	8,6	11,4	14,6	20,1	21,5	23,9	24,5	25,0	25,1	25,5						
RES in transport (%)			0,5	1,4	4,3	6,6	10,1	10,9	12,5	13,1	13,2	13,3	13,2						
Transport sector																			
Passenger transport activity (Gpkm)	**4880,7**	**5307,7**	**5892,2**	**6240,3**	**6511,3**	**7160,9**	**7652,0**	**8090,4**	**8495,8**	**8838,1**	**9131,6**	**9385,8**	**9576,4**	**1,9**	**1,0**	**1,6**	**1,1**	**0,7**	**0,5**
Public road transport	544,0	504,0	517,6	526,0	545,0	575,5	602,9	625,6	644,1	659,4	672,1	682,2	689,3	-0,5	0,5	1,0	0,7	0,4	0,3
Private cars and motorcycles	3501,1	3986,3	4428,1	4686,5	4866,1	5315,2	5614,5	5864,7	6095,9	6299,9	6458,0	6587,0	6663,3	2,4	0,9	1,4	0,8	0,6	0,3
Rail	472,5	421,7	447,9	461,0	482,5	525,4	566,7	607,0	643,6	679,8	715,3	745,7	769,2	-0,5	0,7	1,6	1,3	1,1	0,7
Aviation	317,3	351,3	456,9	527,3	576,9	702,4	824,1	947,9	1065,7	1151,6	1237,8	1321,7	1404,7	3,7	2,4	3,6	2,6	1,5	1,3
Inland navigation	45,8	44,4	41,7	39,5	40,8	42,4	43,9	45,2	46,5	47,5	48,4	49,2	49,8	-0,9	-0,2	0,7	0,6	0,4	0,3
Travel per person (km per capita)	10376	11127	12248	12756	13039	14104	14892	15624	16340	16975	17557	18107	18584	1,7	0,6	1,3	0,9	0,7	0,6
Freight transport activity (Gtkm)	**1848,4**	**1942,4**	**2195,7**	**2494,6**	**2662,6**	**2972,7**	**3167,8**	**3339,1**	**3487,1**	**3618,9**	**3740,3**	**3843,7**	**3918,4**	**1,7**	**1,9**	**1,8**	**1,0**	**0,7**	**0,5**
Trucks	1060,4	1288,7	1518,7	1800,3	1940,3	2184,8	2325,3	2451,7	2563,8	2663,3	2755,5	2836,0	2892,9	3,7	2,5	1,8	1,0	0,7	0,5
Rail	526,3	386,1	403,7	414,1	440,5	489,1	526,4	556,0	579,8	601,7	622,4	639,1	653,6	-2,6	0,9	1,8	1,0	0,7	0,5
Inland navigation	261,6	267,6	273,3	280,2	281,9	298,8	316,1	331,3	343,5	354,0	362,4	368,5	371,9	0,4	0,3	1,2	0,8	0,5	0,3
Freight activity per unit of GDP (tkm/000 Euro'05)	227	222	217	225	234	233	224	215	207	199	192	183	174	-0,4	0,7	-0,4	-0,8	-0,8	-1,0
Energy demand in transport (ktoe)	**280269**	**300617**	**339389**	**362405**	**370012**	**389172**	**397950**	**393838**	**381589**	**382505**	**383333**	**384224**	**382680**	**1,9**	**0,9**	**0,7**	**-0,4**	**0,0**	**0,0**
Public road transport	5197	4732	4914	5039	5182	5328	5313	5219	5085	5073	5039	4895	4702	-0,6	0,5	0,2	-0,4	-0,1	-0,7
Private cars and motorcycles	154395	166321	182974	187736	186451	185653	183670	175456	165143	162006	159567	156684	154057	1,7	0,2	-0,2	-1,1	-0,3	-0,4
Trucks	74969	79037	90951	105104	111606	124230	128407	130491	130086	132613	135058	136789	138085	2,0	2,1	1,4	0,1	0,4	0,2
Rail	9560	9452	9600	9436	9598	10162	10028	9697	8529	8431	8552	8598	8579	0,0	0,0	0,4	-1,6	0,0	0,0
Aviation	29038	34112	45395	49703	51709	58103	64570	66757	66345	67834	68452	70517	70495	4,6	1,3	2,2	0,3	0,3	0,3
Inland navigation	7110	6963	5555	5386	5466	5695	5964	6218	6400	6547	6666	6740	6762	-2,4	-0,2	0,9	0,7	0,4	0,1
Efficiency indicator (activity related)																			
Passenger transport (toe/Mpkm)	39,6	39,5	40,3	39,5	38,0	35,3	33,7	31,1	28,4	27,1	26,0	25,2	24,4	0,2	-0,6	-1,2	-1,7	-0,9	-0,6
Freight transport (toe/Mtkm)	47,1	46,8	46,3	46,5	46,1	45,8	44,3	42,6	40,4	39,6	39,0	38,4	38,1	-0,2	-0,1	-0,4	-0,9	-0,3	-0,2

Reference scenario with Low energy import prices

EU27: Reference scenario with low world energy prices														SUMMARY ENERGY BALANCE AND INDICATORS (A)					
ktoe	1990	1995	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050	'90-'00	'00-'10	'10-'20	'20-'30	'30-'40	'40-'50
														Annual % Change					
Production	**936047**	**950181**	**941860**	**900326**	**844956**	**806743**	**774724**	**751351**	**744210**	**744394**	**741954**	**734990**	**708730**	**0,1**	**-1,1**	**-0,9**	**-0,4**	**0,0**	**-0,5**
Solids	366477	277810	213423	196277	182280	164596	141188	132111	109418	97710	98461	96608	94609	-5,3	-1,6	-2,5	-2,5	-1,0	-0,4
Oil	129551	171052	173006	134290	104398	72796	47932	39066	35740	30959	24367	16344	8048	2,9	-4,9	-7,5	-2,9	-3,8	-10,5
Natural gas	162447	188965	207559	188677	164866	128886	110612	89928	74766	63734	51574	37757	28571	2,5	-2,3	-3,9	-3,8	-3,6	-5,7
Nuclear	202589	223028	243761	257360	238969	238621	211913	219161	233511	255202	264660	280156	273839	1,9	-0,2	-1,2	1,0	1,3	0,3
Renewable energy sources	74984	89326	104111	123722	154443	201844	263080	271084	290775	296788	302892	304123	303663	3,3	4,0	5,5	1,0	0,4	0,0
Hydro	25101	28054	30374	26395	27808	28667	29384	30172	30686	31046	31438	31763	32030	1,9	-0,9	0,6	0,4	0,2	0,2
Biomass & Waste	46473	57201	67982	85129	102533	125584	154190	153488	156021	151788	151961	148643	144551	3,9	4,2	4,2	0,1	-0,3	-0,5
Wind	67	350	1913	6061	13850	28183	49055	56866	68578	74921	77976	80382	81533	39,8	21,9	13,5	3,4	1,3	0,4
Solar and others	153	274	421	807	3421	11577	21121	21807	26354	29679	31944	33731	35899	10,7	23,3	20,0	2,2	1,9	1,2
Geothermal	3190	3447	3421	5331	6831	7832	9330	8752	9136	9354	9573	9604	9650	0,7	7,2	3,2	-0,2	0,5	0,1
Net Imports	**756079**	**738600**	**826299**	**986048**	**980090**	**1051609**	**1078844**	**1098644**	**1060765**	**1072010**	**1100097**	**1131483**	**1165250**	**0,9**	**1,7**	**1,0**	**-0,2**	**0,4**	**0,6**
Solids	81846	79338	98645	126639	122164	116566	105939	117078	90957	81132	82882	84342	89999	1,9	2,2	-1,4	-1,5	-0,9	0,8
Oil	535645	512185	533039	599851	581355	597240	616521	612915	587072	593828	607030	620899	640530	0,0	0,9	0,6	-0,5	0,3	0,5
- Crude oil and Feedstocks	508460	494000	513725	581995	578837	602248	623376	623292	602837	609643	622423	636129	655377	0,1	1,2	0,7	-0,3	0,3	0,5
- Oil products	27185	18185	19314	17856	2517	-5008	-6855	-10377	-15765	-15815	-15393	-15230	-14846	-3,4	-18,4				
Natural gas	135121	145288	192531	257366	272452	329264	337551	356119	368775	381532	392415	406919	412529	3,6	3,5	2,2	0,9	0,6	0,5
Electricity	3323	1508	1686	971	264	-544	-1754	-1942	-2080	-2327	-2342	-2395	-2487	-6,6	-16,9				
Renewable energy forms	144	279	397	1222	3856	9083	20587	14474	16042	17845	20112	21719	24679	10,7	25,5	18,2	-2,5	2,3	2,1
Gross Inland Consumption	**1660159**	**1662517**	**1723099**	**1825989**	**1774995**	**1806264**	**1799631**	**1794481**	**1748222**	**1758104**	**1782256**	**1805519**	**1812059**	**0,4**	**0,3**	**0,1**	**-0,3**	**0,2**	**0,2**
Solids	452940	364248	321007	319922	304443	281163	247127	249190	200375	178842	181343	180950	184608	-3,4	-0,5	-2,1	-2,1	-1,0	0,2
Oil	631058	650858	658727	676859	635701	617947	610515	596467	566059	566488	571602	576289	586657	0,4	-0,4	-0,4	-0,8	0,1	0,3
Natural gas	294905	333268	393417	445998	437318	458150	448164	446048	443541	445266	443990	444676	441099	2,9	1,1	0,2	-0,1	0,0	-0,1
Nuclear	202589	223028	243761	257360	238969	238621	211913	219161	233511	255202	264660	280156	273839	1,9	-0,2	-1,2	1,0	1,3	0,3
Electricity	3323	1508	1686	971	264	-544	-1754	-1942	-2080	-2327	-2342	-2395	-2487	-6,6	-16,9				
Renewable energy forms	75343	89606	104501	124880	158300	210927	283667	285558	306817	314633	323004	325842	328343	3,3	4,2	6,0	0,8	0,5	0,2
as % in Gross Inland Consumption																			
Solids	27,3	21,9	18,6	17,5	17,2	15,6	13,7	13,9	11,5	10,2	10,2	10,0	10,2						
Oil	38,0	39,1	38,2	37,1	35,8	34,2	33,9	33,2	32,4	32,2	32,1	31,9	32,4						
Natural gas	17,8	20,0	22,8	24,4	24,6	25,4	24,9	24,9	25,4	25,3	24,9	24,6	24,3						
Nuclear	12,2	13,4	14,1	14,1	13,5	13,2	11,8	12,2	13,4	14,5	14,8	15,5	15,1						
Renewable energy forms	4,5	5,4	6,1	6,8	8,9	11,7	15,8	15,9	17,6	17,9	18,1	18,0	18,1						
Gross Electricity Generation in GWh_e	**2562823**	**2712209**	**2991720**	**3274121**	**3409540**	**3579990**	**3696830**	**3910011**	**4002791**	**4206235**	**4459038**	**4677810**	**4840859**	**1,6**	**1,3**	**0,8**	**0,8**	**1,1**	**0,8**
Nuclear	794718	881662	944823	997519	926744	926184	827462	867959	937530	1033820	1076501	1167142	1206811	1,7	-0,2	-1,1	1,3	1,4	1,1
Hydro & wind	292648	330306	375545	378836	501839	694261	986726	1108021	1289057	1400094	1465847	1519821	1561038	2,5	2,9	7,0	2,7	1,3	0,6
Thermal (incl. biomass)	1475456	1500241	1671352	1897765	1980957	1959545	1882642	1934031	1776205	1772322	1916691	1990847	2073010	1,3	1,7	-0,5	-0,6	0,8	0,8
Fuel Inputs for Thermal Power Generation	**383492**	**362334**	**382613**	**424208**	**433918**	**421402**	**402095**	**411216**	**376607**	**364739**	**375750**	**379562**	**387716**	**0,0**	**1,3**	**-0,8**	**-0,7**	**0,0**	**0,3**
Solids	263837	230040	223012	229245	232690	210625	177884	179755	136173	118027	121339	120857	125456	-1,7	0,4	-2,7	-2,6	-1,1	0,3
Oil (including refinery gas)	54404	51463	39294	29780	17274	13069	9463	11650	14063	17353	20001	22883	23246	-3,2	-7,9	-5,8	4,0	3,6	1,5
Gas	56754	67806	102408	134637	142867	140128	130086	130096	132413	132211	131843	133444	135557	6,1	3,4	-0,9	0,2	0,0	0,3
Biomass & Waste	5724	10033	14960	25901	35260	51578	78413	83034	86815	89750	94852	94605	95629	10,1	9,0	8,3	1,0	0,9	0,1
Geothermal heat	2774	2992	2939	4645	5828	6002	6248	6680	7142	7399	7714	7772	7828	0,6	7,1	0,7	1,3	0,8	0,1
Hydrogen - Methanol	0	0	0	0	0	0	0	0	0	0	0	0	0						
Fuel Input in other transformation proc.	**839073**	**814654**	**827098**	**842975**	**793957**	**795764**	**800355**	**789915**	**760997**	**760282**	**765231**	**768953**	**776720**	**-0,1**	**-0,4**	**0,1**	**-0,5**	**0,1**	**0,1**
Refineries	679426	705954	735244	758152	718673	709499	704546	694320	668973	670763	676613	681957	693075	0,8	-0,2	-0,2	-0,5	0,1	0,2
Biofuels and hydrogen production	2	202	610	3129	12210	22098	31041	30036	32808	32930	31851	30343	28482	79,6	34,9	9,8	0,6	-0,3	-1,1
District heating	32960	23240	19323	16212	15391	16282	16195	16766	13946	12649	12385	11718	11220	-5,2	-2,2	0,5	-1,5	-1,2	-1,0
Others	126685	85258	71921	65482	47683	47885	48573	48793	45270	43940	44382	44935	43944	-5,5	-4,0	0,2	-0,7	-0,2	-0,1
Energy Branch Consumption	**82379**	**88696**	**88176**	**96033**	**92073**	**90331**	**89465**	**88531**	**82892**	**83756**	**87792**	**90666**	**92099**	**0,7**	**0,4**	**-0,3**	**-0,8**	**0,6**	**0,5**
Non-Energy Uses	**97931**	**110541**	**112495**	**117477**	**111488**	**115337**	**118650**	**120217**	**121239**	**122827**	**124273**	**125527**	**126852**	**1,4**	**-0,1**	**0,6**	**0,2**	**0,2**	**0,2**
Final Energy Demand	**1068710**	**1069989**	**1112989**	**1173676**	**1165917**	**1220192**	**1249573**	**1240531**	**1215419**	**1227393**	**1243913**	**1260655**	**1271891**	**0,4**	**0,5**	**0,7**	**-0,3**	**0,2**	**0,2**
by sector																			
Industry	365650	328513	326949	326308	312454	324447	333795	338272	339167	345310	354837	365648	377451	-1,1	-0,5	0,7	0,2	0,5	0,6
- energy intensive industries	234722	214526	213112	210991	193330	197669	201270	201148	198722	198885	201189	203183	205315	-1,0	-1,0	0,4	-0,1	0,1	0,2
- other industrial sectors	130928	113987	113837	115317	119124	126778	132525	137124	140445	146425	153648	162465	172136	-1,4	0,5	1,1	0,6	0,9	1,1
Residential	264307	280418	286784	308104	308342	323961	327748	318361	313344	312171	310506	309942	305872	0,8	0,7	0,6	-0,4	-0,1	-0,2
Tertiary	158484	160442	159866	176859	175109	183861	185722	185006	181447	185957	189860	193857	194991	0,1	0,9	0,6	-0,2	0,5	0,3
Transport	280269	300617	339389	362405	370012	387924	402308	398891	381461	383956	388710	391208	393577	1,9	0,9	0,8	-0,5	0,2	0,1
by fuel																			
Solids	125031	84977	61454	54486	47716	45211	43809	43651	39646	37714	37400	37901	37314	-6,9	-2,5	-0,9	-1,0	-0,6	0,0
Oil	444429	456959	478882	495857	476263	468996	467417	457110	429572	431142	436619	441663	447464	0,7	-0,1	-0,2	-0,8	0,2	0,2
Gas	227902	245996	265552	283524	265632	284726	282238	274985	269218	267413	263648	260587	256524	1,5	0,0	0,6	-0,5	-0,2	-0,3
Electricity	184145	193367	216403	237537	248325	262052	269809	284714	293227	307051	322625	336298	347174	1,6	1,4	0,8	0,8	1,0	0,7
Heat (from CHP and District Heating) [(A)]	48610	44616	40061	44441	58782	70830	77358	83767	84875	89632	91077	92866	93819	-1,9	3,9	2,8	0,9	0,7	0,3
Other	38592	44073	50640	57832	69199	88377	108942	96302	98882	94442	92544	91340	89596	2,8	3,2	4,6	-1,0	-0,7	-0,3
CO_2 Emissions (Mt of CO_2 - sec approach)	**4030,6**	**3800,1**	**3810,6**	**3946,6**	**3772,2**	**3666,1**	**3442,2**	**3356,5**	**3051,9**	**2871,4**	**2705,7**	**2587,3**	**2556,8**	**-0,6**	**-0,1**	**-0,9**	**-1,2**	**-1,2**	**-0,6**
Power generation/District heating	1484,3	1321,2	1320,8	1381,1	1364,1	1258,9	1057,7	1028,7	847,8	683,4	517,4	394,4	360,5	-1,2	0,3	-2,5	-2,2	-4,8	-3,5
Energy Branch	152,2	171,0	170,2	181,6	157,4	143,8	136,5	128,2	117,6	108,5	102,6	97,2	95,3	1,1	-0,8	-1,4	-1,5	-1,4	-0,7
Industry	781,4	678,1	623,0	581,9	492,9	482,0	478,6	472,9	459,9	455,9	460,2	470,0	483,0	-2,2	-2,3	-0,3	-0,4	0,0	0,5
Residential	499,4	481,6	466,2	486,7	465,1	470,5	451,4	426,8	405,2	397,8	386,0	375,5	359,0	-0,7	0,0	-0,3	-1,1	-0,5	-0,7
Tertiary	300,5	275,3	242,0	262,2	244,3	238,8	230,7	220,2	204,3	202,2	198,7	197,4	193,5	-2,1	0,1	-0,6	-1,2	-0,3	-0,3
Transport	812,7	872,9	988,5	1053,1	1048,3	1072,0	1087,3	1079,6	1017,1	1023,6	1040,8	1052,7	1065,6	2,0	0,6	0,4	-0,7	0,2	0,2
CO_2 Emissions Index (1990=100)	**100,0**	**94,3**	**94,5**	**97,9**	**93,6**	**91,0**	**85,4**	**83,3**	**75,7**	**71,2**	**67,1**	**64,2**	**63,4**						
CO_2 Emissions (Mt of CO_2 - ref approach)	**4172,0**	**3950,7**	**3922,7**	**4087,6**	**3838,2**	**3737,7**	**3519,7**	**3433,5**	**3131,3**	**2949,5**	**2782,0**	**2661,6**	**2634,4**	**-0,6**	**-0,2**	**-0,9**	**-1,2**	**-1,2**	**-0,5**

EU27: Reference scenario with low world energy prices													SUMMARY ENERGY BALANCE AND INDICATORS (B)						
	1990	1995	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050	'90-'00	'00-'10	'10-'20	'20-'30	'30-'40	'40-'50
														Annual % Change					
Main Energy System Indicators																			
Population (Million)	470,388	477,010	481,072	489,211	499,389	507,727	513,838	517,811	519,942	520,654	520,103	518,362	515,303	0,2	0,4	0,3	0,1	0,0	-0,1
GDP (in 000 MEuro'05)	8142,7	8748,4	10107,2	11063,1	11385,6	12750,3	14164,0	15503,7	16824,7	18157,1	19527,9	21002,9	22560,0	2,2	1,2	2,2	1,7	1,5	1,5
Gross Inl. Cons./GDP (toe/MEuro'05)	203,9	190,0	170,5	165,1	155,9	141,7	127,1	115,7	103,9	96,8	91,3	86,0	80,3	-1,8	-0,9	-2,0	-2,0	-1,3	-1,3
Gross Inl. Cons./Capita (toe/inhabitant)	3,53	3,49	3,58	3,73	3,55	3,56	3,50	3,47	3,36	3,38	3,43	3,48	3,52	0,1	-0,1	-0,1	-0,4	0,2	0,3
Electricity Generated/Capita (kWh gross/inhabitant)	5448	5686	6219	6693	6827	7051	7195	7551	7699	8079	8573	9024	9394	1,3	0,9	0,5	0,7	1,1	0,9
Carbon intensity (t of CO_2/toe of GIC)	2,43	2,29	2,21	2,16	2,13	2,03	1,91	1,87	1,75	1,63	1,52	1,43	1,41	-0,9	-0,4	-1,0	-0,9	-1,4	-0,7
CO_2 Emissions/Capita (t of CO_2/inhabitant)	8,57	7,97	7,92	8,07	7,55	7,22	6,70	6,48	5,87	5,52	5,20	4,99	4,96	-0,8	-0,5	-1,2	-1,3	-1,2	-0,5
CO2 Emissions to GDP (t of CO2/MEuro'05)	495,0	434,4	377,0	356,7	331,3	287,5	243,0	216,5	181,4	158,1	138,6	123,2	113,3	-2,7	-1,3	-3,1	-2,9	-2,7	-2,0
Import Dependency %	44,6	43,5	46,8	52,5	53,7	56,6	58,2	59,4	58,8	59,0	59,7	60,6	62,2						
Energy intensity indicators (2000=100)																			
Industry (Energy on Value added)	130,3	115,2	100,0	95,1	90,3	85,0	79,2	73,8	68,8	65,2	62,6	60,3	58,3	-2,6	-1,0	-1,3	-1,4	-0,9	-0,7
Residential (Energy on Private Income)	114,4	113,2	100,0	97,5	96,9	90,5	82,8	74,3	67,9	62,0	57,5	53,0	49,0	-1,3	-0,3	-1,6	-2,0	-1,6	-1,6
Tertiary (Energy on Value added)	126,5	117,0	100,0	99,4	94,7	88,0	79,7	72,2	65,0	61,6	58,2	55,0	51,3	-2,3	-0,5	-1,7	-2,0	-1,1	-1,3
Transport (Energy on GDP)	102,5	102,3	100,0	97,6	96,8	90,6	84,6	76,6	67,5	63,0	59,3	55,5	52,0	-0,2	-0,3	-1,3	-2,2	-1,3	-1,3
Carbon Intensity indicators																			
Electricity and Steam production (t of CO_2/MWh)	0,46	0,40	0,37	0,35	0,32	0,27	0,22	0,20	0,16	0,13	0,09	0,07	0,06	-2,1	-1,5	-3,7	-2,9	-5,8	-4,2
Final energy demand (t of CO_2/toe)	2,24	2,16	2,08	2,03	1,93	1,85	1,80	1,77	1,72	1,69	1,68	1,66	1,65	-0,7	-0,8	-0,7	-0,5	-0,2	-0,1
Industry	2,14	2,06	1,91	1,78	1,58	1,49	1,43	1,40	1,36	1,32	1,30	1,29	1,28	-1,1	-1,9	-1,0	-0,6	-0,4	-0,1
Residential	1,89	1,72	1,63	1,58	1,51	1,45	1,38	1,34	1,29	1,27	1,24	1,21	1,17	-1,5	-0,7	-0,9	-0,6	-0,4	-0,6
Tertiary	1,90	1,72	1,51	1,48	1,40	1,30	1,24	1,19	1,13	1,09	1,05	1,02	0,99	-2,2	-0,8	-1,2	-1,0	-0,7	-0,5
Transport	2,90	2,90	2,91	2,91	2,83	2,76	2,70	2,71	2,67	2,67	2,68	2,69	2,71	0,0	-0,3	-0,5	-0,1	0,0	0,1
Electricity and steam generation																			
Net Generation Capacity in MW_e			**654125**	**715732**	**820280**	**921348**	**1023474**	**1056112**	**1142278**	**1217909**	**1289022**	**1363389**	**1420771**		**2,3**	**2,2**	**1,1**	**1,2**	**1,0**
Nuclear energy			133923	134409	127038	126752	123686	112747	120786	129753	132911	142885	148596		-0,5	-0,3	-0,2	1,0	1,1
Renewable energy			112878	147262	209088	283884	411814	459889	534502	580889	610823	637242	661705		6,4	7,0	2,6	1,3	0,8
Hydro (pumping excluded)			99714	104505	107315	110988	114516	115937	117729	119058	119329	120119	121318		0,7	0,7	0,3	0,1	0,2
Wind			12793	40584	86217	144412	236694	268564	316027	340123	352348	362424	368159		21,0	10,6	2,9	1,1	0,4
Solar			371	2172	15307	27909	58929	72536	96607	117366	134433	149503	166320		45,1	14,4	5,1	3,4	2,2
Other renewables (tidal etc.)			0	1	249	575	1675	2851	4139	4343	4713	5195	5909			21,0	9,5	1,3	2,3
Thermal power			407324	434061	484154	510712	487974	483476	486990	507267	545287	583263	610470		1,7	0,1	0,0	1,1	1,1
of which cogeneration units			76231	85773	100282	113030	117658	126719	132441	146772	158341	177742	194205		2,8	1,6	1,2	1,8	2,1
of which CCS units			0	0	0	0	5394	10547	12181	27806	64438	102927	122123				8,5	18,1	6,6
Solids fired			194165	186620	183751	182050	160820	142964	126571	116771	122803	117902	115620		-0,5	-1,3	-2,4	-0,3	-0,6
Gas fired			129444	167173	219380	238037	229889	229407	244098	272068	281696	277550	245965		5,4	0,5	0,6	1,4	-1,3
Oil fired			71058	62082	56075	45479	34571	41608	42386	42493	59561	101212	157275		-2,3	-4,7	2,1	3,5	10,2
Biomass-waste fired			12051	17502	24165	44345	61860	68606	72982	74948	80199	85563	90566		7,2	9,9	1,7	0,9	1,2
Hydrogen plants			0	0	0	0	0	0	0	0	0	0	0						
Geothermal heat			605	684	783	801	834	891	952	986	1028	1036	1043		2,6	0,6	1,3	0,8	0,1
Load factor for net electric capacities (%)			49,1	49,1	45,1	42,3	39,4	40,2	38,2	37,6	37,2	36,7	36,3						
Indicators for gross electricity production																			
Efficiency for thermal electricity production (%)			37,6	38,5	39,3	40,0	40,3	40,4	40,6	41,8	43,9	45,1	46,0						
CHP indicator (% of electricity from CHP)			11,4	11,7	15,0	17,9	18,7	19,0	18,9	20,6	21,1	21,7	22,1						
CCS indicator (% of electricity from CCS)			0,0	0,0	0,0	0,0	1,5	2,9	3,1	6,4	13,4	19,4	21,5						
Non fossil fuels in electricity generation (%)			45,8	44,8	45,9	50,8	57,1	58,7	64,1	66,3	65,7	65,8	65,6						
- nuclear			31,6	30,5	27,2	25,9	22,4	22,2	23,4	24,6	24,1	25,0	24,9						
- renewable energy forms and industrial waste			14,2	14,3	18,8	24,9	34,8	36,5	40,6	41,8	41,6	40,9	40,6						
Indicators for renewables (excluding industrial waste) (%) [(B)]																			
RES in gross final energy demand (%)			7,6	8,6	11,4	15,2	20,2	20,4	22,5	22,9	23,2	23,1	23,2						
RES in transport (%)			0,5	1,4	4,3	7,4	10,3	10,3	11,9	11,9	11,5	11,0	10,3						
Transport sector																			
Passenger transport activity (Gpkm)	**4880,7**	**5307,7**	**5892,2**	**6240,3**	**6511,3**	**7140,9**	**7690,4**	**8182,1**	**8580,0**	**8972,1**	**9321,7**	**9617,5**	**9879,6**	**1,9**	**1,0**	**1,7**	**1,1**	**0,8**	**0,6**
Public road transport	544,0	504,0	517,6	526,0	545,0	574,2	602,4	625,8	644,2	660,1	673,6	684,2	692,3	-0,5	0,5	1,0	0,7	0,4	0,3
Private cars and motorcycles	3501,1	3986,3	4428,1	4686,5	4866,1	5297,5	5650,2	5949,8	6173,9	6423,4	6632,9	6800,4	6942,1	2,4	0,9	1,5	0,9	0,7	0,5
Rail	472,5	421,7	447,9	461,0	482,5	525,7	567,8	608,7	645,4	682,1	718,3	748,6	772,1	-0,5	0,7	1,6	1,3	1,1	0,7
Aviation	317,3	351,3	456,9	527,3	576,9	701,2	826,2	952,4	1070,1	1158,9	1248,3	1334,9	1423,0	3,7	2,4	3,7	2,6	1,6	1,3
Inland navigation	45,8	44,4	41,7	39,5	40,8	42,3	43,9	45,3	46,5	47,6	48,6	49,4	50,1	-0,9	-0,2	0,7	0,6	0,4	0,3
Travel per person (km per capita)	10376	11127	12248	12756	13039	14065	14967	15801	16502	17232	17923	18554	19172	1,7	0,6	1,4	1,0	0,8	0,7
Freight transport activity (Gtkm)	**1848,4**	**1942,4**	**2195,7**	**2494,6**	**2662,6**	**2961,6**	**3182,1**	**3379,3**	**3524,0**	**3678,5**	**3826,3**	**3949,6**	**4057,5**	**1,7**	**1,9**	**1,8**	**1,0**	**0,8**	**0,6**
Trucks	1060,4	1288,7	1518,7	1800,3	1940,3	2174,2	2339,1	2490,5	2599,1	2720,7	2838,4	2938,3	3027,8	3,7	2,5	1,9	1,1	0,9	0,6
Rail	526,3	386,1	403,7	414,1	440,5	489,1	526,9	557,0	580,9	603,0	624,1	640,9	655,2	-2,6	0,9	1,8	1,0	0,7	0,5
Inland navigation	261,6	267,6	273,3	280,2	281,9	298,3	316,0	331,8	343,9	354,8	363,8	370,4	374,5	0,4	0,3	1,1	0,8	0,6	0,3
Freight activity per unit of GDP (tkm/000 Euro'05)	227	222	217	225	234	232	225	218	209	203	196	188	180	-0,4	0,7	-0,4	-0,7	-0,7	-0,9
Energy demand in transport (ktoe)	**280269**	**300617**	**339389**	**362405**	**370012**	**387924**	**402308**	**398891**	**381461**	**383956**	**388710**	**391208**	**393577**	**1,9**	**0,9**	**0,8**	**-0,5**	**0,2**	**0,1**
Public road transport	5197	4732	4914	5039	5182	5319	5311	5226	5090	5082	5053	4936	4768	-0,6	0,5	0,2	-0,4	-0,1	-0,6
Private cars and motorcycles	154395	166321	182974	187736	186451	185094	184719	173681	160250	158300	156630	153803	151794	1,7	0,2	-0,1	-1,4	-0,2	-0,3
Trucks	74969	79037	90951	105104	111606	123709	129281	132593	131836	135348	138852	141269	143835	2,0	2,1	1,5	0,2	0,5	0,4
Rail	9560	9452	9600	9436	9597	10138	10045	9743	8560	8454	8584	8631	8608	0,0	0,0	0,5	-1,6	0,0	0,0
Aviation	29038	34112	45395	49703	51709	57983	66990	71421	69319	70206	72895	75789	77753	4,6	1,3	2,6	0,3	0,5	0,6
Inland navigation	7110	6963	5555	5386	5466	5681	5962	6228	6407	6566	6697	6780	6819	-2,4	-0,2	0,9	0,7	0,4	0,2
Efficiency indicator (activity related)																			
Passenger transport (toe/Mpkm)	39,6	39,5	40,3	39,5	38,0	35,4	34,0	31,1	27,9	26,5	25,6	24,8	24,2	0,2	-0,6	-1,1	-2,0	-0,8	-0,6
Freight transport (toe/Mtkm)	47,1	46,8	46,3	46,5	46,1	45,7	44,4	42,7	40,4	39,7	39,1	38,6	38,2	-0,2	-0,1	-0,4	-0,9	-0,3	-0,2

Reference scenario with High energy import prices

EU27: Reference scenario with high world energy prices														SUMMARY ENERGY BALANCE AND INDICATORS (A)					
ktoe	**1990**	**1995**	**2000**	**2005**	**2010**	**2015**	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**	**'90-'00**	**'00-'10**	**'10-'20**	**'20-'30**	**'30-'40**	**'40-'50**
														Annual % Change					
Production	**936047**	**950181**	**941860**	**900326**	**845064**	**817644**	**811737**	**802723**	**806224**	**819143**	**828965**	**830368**	**808009**	**0,1**	**-1,1**	**-0,4**	**-0,1**	**0,3**	**-0,3**
Solids	366477	277810	213423	196277	182270	168669	150313	143980	124519	118672	122786	125237	121804	-5,3	-1,6	-1,9	-1,9	-0,1	-0,1
Oil	129551	171052	173006	134290	104398	76134	50651	41472	37934	32861	26090	17729	8791	2,9	-4,9	-7,0	-2,8	-3,7	-10,3
Natural gas	162447	188965	207559	188677	164866	129314	111043	90249	73816	62450	50163	35926	28407	2,5	-2,3	-3,9	-4,0	-3,8	-5,5
Nuclear	202589	223028	243761	257360	238928	239919	232763	240570	259190	285393	299892	314633	307768	1,9	-0,2	-0,3	1,1	1,5	0,3
Renewable energy sources	74984	89326	104111	123722	154603	203608	266968	286451	310764	319767	330034	336842	341239	3,3	4,0	5,6	1,5	0,6	0,3
Hydro	25101	28054	30374	26395	27809	28656	29340	30157	30709	31057	31432	31770	32037	1,9	-0,9	0,5	0,5	0,2	0,2
Biomass & Waste	46473	57201	67982	85129	102686	129128	158774	165107	169467	166943	168423	168652	165401	3,9	4,2	4,5	0,7	-0,1	-0,2
Wind	67	350	1913	6061	13850	28279	48857	58566	72773	79868	84707	87539	91473	39,8	21,9	13,4	4,1	1,5	0,8
Solar and others	153	274	421	807	3426	9777	20392	22915	27915	31657	34964	38294	41603	10,7	23,3	19,5	3,2	2,3	1,8
Geothermal	3190	3447	3421	5331	6832	7769	9605	9706	9899	10242	10508	10588	10724	0,7	7,2	3,5	0,3	0,6	0,2
Net Imports	**756079**	**738600**	**826299**	**986048**	**979634**	**996340**	**976160**	**969612**	**934871**	**930538**	**939404**	**958614**	**976996**	**0,9**	**1,7**	**0,0**	**-0,4**	**0,0**	**0,4**
Solids	81846	79338	98645	126639	121083	125097	114259	119071	94503	75261	73956	80428	82826	1,9	2,1	-0,6	-1,9	-2,4	1,1
Oil	535645	512185	533039	599851	581740	570199	570016	574724	555108	565209	571220	578921	589646	0,0	0,9	-0,2	-0,3	0,3	0,3
- Crude oil and Feedstocks	508460	494000	513725	581995	579069	582182	587445	593537	577975	587962	594853	603766	614849	0,1	1,2	0,1	-0,2	0,3	0,3
- Oil products	27185	18185	19314	17856	2671	-11983	-17429	-18813	-22867	-22753	-23633	-24845	-25203	-3,4	-18,0				
Natural gas	135121	145288	192531	257366	272703	291744	270028	261629	269564	272811	274291	276043	277755	3,6	3,5	-0,1	0,0	0,2	0,1
Electricity	3323	1508	1686	971	264	-544	-1754	-1942	-2080	-2327	-2342	-2395	-2487	-6,6	-16,9				
Renewable energy forms	144	279	397	1222	3844	9844	23611	16129	17776	19584	22280	25618	29256	10,7	25,5	19,9	-2,8	2,3	2,8
Gross Inland Consumption	**1660159**	**1662517**	**1723099**	**1825989**	**1774646**	**1763688**	**1736895**	**1719762**	**1687461**	**1694492**	**1712132**	**1732055**	**1727780**	**0,4**	**0,3**	**-0,2**	**-0,3**	**0,1**	**0,1**
Solids	452940	364248	321007	319922	303353	293765	264572	263052	219023	193933	196742	205665	204631	-3,4	-0,6	-1,4	-1,9	-1,1	0,4
Oil	631058	650858	658727	676859	636086	596037	569665	563624	539408	542881	541072	539723	541212	0,4	-0,3	-1,1	-0,5	0,0	0,0
Natural gas	294905	333268	393417	445998	437569	421058	381071	351878	343380	335262	324454	311969	306162	2,9	1,1	-1,4	-1,0	-0,6	-0,6
Nuclear	202589	223028	243761	257360	238928	239919	232763	240570	259190	285393	299892	314633	307768	1,9	-0,2	-0,3	1,1	1,5	0,3
Electricity	3323	1508	1686	971	264	-544	-1754	-1942	-2080	-2327	-2342	-2395	-2487	-6,6	-16,9				
Renewable energy forms	75343	89606	104501	124880	158447	213452	290578	302580	328540	339351	352313	362460	370494	3,3	4,3	6,3	1,2	0,7	0,5
as % in Gross Inland Consumption																			
Solids	27,3	21,9	18,6	17,5	17,1	16,7	15,2	15,3	13,0	11,4	11,5	11,9	11,8						
Oil	38,0	39,1	38,2	37,1	35,8	33,8	32,8	32,8	32,0	32,0	31,6	31,2	31,3						
Natural gas	17,8	20,0	22,8	24,4	24,7	23,9	21,9	20,5	20,3	19,8	19,0	18,0	17,7						
Nuclear	12,2	13,4	14,1	14,1	13,5	13,6	13,4	14,0	15,4	16,8	17,5	18,2	17,8						
Renewable energy forms	4,5	5,4	6,1	6,8	8,9	12,1	16,7	17,6	19,5	20,0	20,6	20,9	21,4						
Gross Electricity Generation in GWh_e	**2562823**	**2712209**	**2991720**	**3274121**	**3407994**	**3649338**	**3829651**	**4022391**	**4103132**	**4315174**	**4551703**	**4780126**	**4952373**	**1,6**	**1,3**	**1,2**	**0,7**	**1,0**	**0,8**
Nuclear	794718	881662	944823	997519	926585	931441	909499	955534	1042329	1158788	1223333	1317803	1358930	1,7	-0,2	-0,2	1,4	1,6	1,1
Hydro & wind	292648	330306	375545	378836	501843	695188	981856	1126533	1343293	1465093	1561740	1637554	1723986	2,5	2,9	6,9	3,2	1,5	1,0
Thermal (incl. biomass)	1475456	1500241	1671352	1897765	1979566	2022709	1938295	1940325	1717510	1691293	1766629	1824769	1869457	1,3	1,7	-0,2	-1,2	0,3	0,6
Fuel Inputs for Thermal Power Generation	**383492**	**362334**	**382613**	**424208**	**433841**	**438221**	**416849**	**417554**	**375542**	**353660**	**356466**	**360088**	**362549**	**0,0**	**1,3**	**-0,4**	**-1,0**	**-0,5**	**0,2**
Solids	263837	230040	223012	229245	232197	226359	203525	204145	165170	141391	143479	150650	149576	-1,7	0,4	-1,3	-2,1	-1,4	0,4
Oil (including refinery gas)	54404	51463	39294	29780	17272	18159	10913	14759	16135	18128	20317	22824	23408	-3,2	-7,9	-4,5	4,0	2,3	1,4
Gas	56754	67806	102408	134637	143441	136528	122263	112413	103910	104935	100885	94232	96430	6,1	3,4	-1,6	-1,6	-0,3	-0,5
Biomass & Waste	5724	10033	14960	25901	35103	51226	73957	79613	83240	81838	84102	84642	85338	10,1	8,9	7,7	1,2	0,1	0,1
Geothermal heat	2774	2992	2939	4645	5828	5948	6192	6624	7087	7367	7683	7741	7796	0,6	7,1	0,6	1,4	0,8	0,1
Hydrogen - Methanol	0	0	0	0	0	0	0	0	0	0	0	0	0						
Fuel Input in other transformation proc.	**839073**	**814654**	**827098**	**842975**	**794172**	**776152**	**761745**	**754684**	**735363**	**739846**	**740552**	**741618**	**742387**	**-0,1**	**-0,4**	**-0,4**	**-0,4**	**0,1**	**0,0**
Refineries	679426	705954	735244	758152	718914	692861	670292	666502	645621	650704	650516	650617	652619	0,8	-0,2	-0,7	-0,4	0,1	0,0
Biofuels and hydrogen production	2	202	610	3129	12210	23763	35550	35146	39958	40788	41351	41636	41566	79,6	34,9	11,3	1,2	0,3	0,1
District heating	32960	23240	19323	16212	15753	15139	15502	14613	14811	14766	14058	13524	13189	-5,2	-2,0	-0,2	-0,5	-0,5	-0,6
Others	126685	85258	71921	65482	47295	44389	40401	38422	34973	33588	34627	35841	35013	-5,5	-4,1	-1,6	-1,4	-0,1	0,1
Energy Branch Consumption	**82379**	**88696**	**88176**	**96033**	**92137**	**87501**	**85947**	**84593**	**79313**	**81018**	**83550**	**85872**	**86160**	**0,7**	**0,4**	**-0,7**	**-0,8**	**0,5**	**0,3**
Non-Energy Uses	**97931**	**110541**	**112495**	**117477**	**111501**	**113287**	**112238**	**113456**	**114233**	**115811**	**116974**	**118021**	**118943**	**1,4**	**-0,1**	**0,1**	**0,2**	**0,2**	**0,2**
Final Energy Demand	**1068710**	**1069989**	**1112989**	**1173676**	**1165705**	**1174920**	**1175499**	**1160215**	**1146712**	**1160317**	**1171818**	**1186237**	**1192996**	**0,4**	**0,5**	**0,1**	**-0,2**	**0,2**	**0,2**
by sector																			
Industry	365650	328513	326949	326308	312250	318093	322166	323799	324906	331579	341702	353194	364625	-1,1	-0,5	0,3	0,1	0,5	0,7
- energy intensive industries	234722	214526	213112	210991	193108	193323	192248	190048	187681	188143	190297	193252	195353	-1,0	-1,0	0,0	-0,2	0,1	0,3
- other industrial sectors	130928	113987	113837	115317	119142	124770	129918	133752	137225	143435	151406	159943	169272	-1,4	0,5	0,9	0,5	1,0	1,1
Residential	264307	280418	286784	308104	308348	309577	302416	287509	283321	282620	281006	280748	277506	0,8	0,7	-0,2	-0,7	-0,1	-0,1
Tertiary	158484	160442	159866	176859	175094	175481	170920	167882	164661	167797	169952	172634	172323	0,1	0,9	-0,2	-0,4	0,3	0,1
Transport	280269	300617	339389	362405	370013	371769	379996	381024	373824	378321	379157	379661	378542	1,9	0,9	0,3	-0,2	0,1	0,0
by fuel																			
Solids	125031	84977	61454	54486	47150	45242	41185	39623	35511	34847	35271	37068	37325	-6,9	-2,6	-1,3	-1,5	-0,1	0,6
Oil	444429	456959	478882	495857	476489	445159	431408	426242	406172	410602	409732	409357	407578	0,7	-0,1	-1,0	-0,6	0,1	-0,1
Gas	227902	245996	265552	283524	265148	251152	223763	202020	199347	189879	183030	180174	173591	1,5	0,0	-1,7	-1,1	-0,9	-0,5
Electricity	184145	193367	216403	237537	248253	267293	279771	293982	301562	315775	331364	346422	358647	1,6	1,4	1,2	0,8	0,9	0,8
Heat (from CHP and District Heating) (A)	48610	44616	40061	44441	59296	74882	79075	84024	86377	91915	94315	96906	99536	-1,9	4,0	2,9	0,9	0,9	0,5
Other	38592	44073	50640	57832	69369	91192	120297	114324	117742	117298	118106	116311	116319	2,8	3,2	5,7	-0,2	0,0	-0,2
CO_2 Emissions (Mt of CO_2 - sec approach)	**4030,6**	**3800,1**	**3810,6**	**3946,6**	**3769,7**	**3573,0**	**3257,4**	**3163,1**	**2889,4**	**2675,0**	**2503,8**	**2397,4**	**2335,4**	**-0,6**	**-0,1**	**-1,4**	**-1,2**	**-1,4**	**-0,7**
Power generation/District heating	1484,3	1321,2	1320,8	1381,1	1364,3	1323,0	1142,1	1130,6	953,1	764,1	617,4	524,3	484,6	-1,2	0,3	-1,8	-1,8	-4,2	-2,4
Energy Branch	152,2	171,0	170,2	181,6	157,6	138,2	126,1	117,1	105,1	91,2	83,5	66,8	63,7	1,1	-0,8	-2,2	-1,8	-2,3	-2,7
Industry	781,4	678,1	623,0	581,9	489,9	449,0	418,1	396,0	382,3	373,3	377,1	396,3	404,9	-2,2	-2,4	-1,6	-0,9	-0,1	0,7
Residential	499,4	481,6	466,2	486,7	465,0	426,5	373,0	331,0	312,8	304,9	291,7	280,8	263,6	-0,7	0,0	-2,2	-1,7	-0,7	-1,0
Tertiary	300,5	275,3	242,0	262,2	244,5	217,6	190,9	177,9	163,8	158,9	150,9	145,4	137,8	-2,1	0,1	-2,4	-1,5	-0,8	-0,9
Transport	812,7	872,9	988,5	1053,1	1048,3	1018,8	1007,2	1010,5	972,2	982,6	983,2	983,8	980,8	2,0	0,6	-0,4	-0,4	0,1	0,0
CO_2 Emissions Index (1990=100)	**100,0**	**94,3**	**94,5**	**97,9**	**93,5**	**88,6**	**80,8**	**78,5**	**71,7**	**66,4**	**62,1**	**59,5**	**57,9**						
CO_2 Emissions (Mt of CO_2 - ref approach)	**4172,0**	**3950,7**	**3922,7**	**4087,6**	**3835,6**	**3637,6**	**3325,0**	**3227,5**	**2957,6**	**2741,6**	**2568,2**	**2459,9**	**2402,7**	**-0,6**	**-0,2**	**-1,4**	**-1,2**	**-1,4**	**-0,7**

EU27: Reference scenario with high world energy prices														SUMMARY ENERGY BALANCE AND INDICATORS (B)					
	1990	**1995**	**2000**	**2005**	**2010**	**2015**	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**	**'90-'00**	**'00-'10**	**'10-'20**	**'20-'30**	**'30-'40**	**'40-'50**
														Annual % Change					
Main Energy System Indicators																			
Population (Million)	470,388	477,010	481,072	489,211	499,389	507,727	513,838	517,811	519,942	520,654	520,103	518,362	515,303	0,2	0,4	0,3	0,1	0,0	-0,1
GDP (in 000 MEuro'05)	8142,7	8748,4	10107,2	11063,1	11385,6	12750,3	14164,0	15503,7	16824,7	18157,1	19527,9	21002,9	22560,0	2,2	1,2	2,2	1,7	1,5	1,5
Gross Inl. Cons./GDP (toe/MEuro'05)	203,9	190,0	170,5	165,1	155,9	138,3	122,6	110,9	100,3	93,3	87,7	82,5	76,6	-1,8	-0,9	-2,4	-2,0	-1,3	-1,3
Gross Inl. Cons./Capita (toe/inhabitant)	3,53	3,49	3,58	3,73	3,55	3,47	3,38	3,32	3,25	3,25	3,29	3,34	3,35	0,1	-0,1	-0,5	-0,4	0,1	0,2
Electricity Generated/Capita (kWh gross/inhabitant)	5448	5686	6219	6693	6824	7188	7453	7768	7892	8288	8752	9222	9611	1,3	0,9	0,9	0,6	1,0	0,9
Carbon intensity (t of CO_2/toe of GIC)	2,43	2,29	2,21	2,16	2,12	2,03	1,88	1,84	1,71	1,58	1,46	1,38	1,35	-0,9	-0,4	-1,2	-0,9	-1,6	-0,8
CO_2 Emissions/Capita (t of CO_2/inhabitant)	8,57	7,97	7,92	8,07	7,55	7,04	6,34	6,11	5,56	5,14	4,81	4,63	4,53	-0,8	-0,5	-1,7	-1,3	-1,4	-0,6
CO2 Emissions to GDP (t of CO2/MEuro'05)	495,0	434,4	377,0	356,7	331,1	280,2	230,0	204,0	171,7	147,3	128,2	114,1	103,5	-2,7	-1,3	-3,6	-2,9	-2,9	-2,1
Import Dependency %	44,6	43,5	46,8	52,5	53,7	54,9	54,6	54,7	53,7	53,2	53,1	53,6	54,7						
Energy intensity indicators (2000=100)																			
Industry (Energy on Value added)	130,3	115,2	100,0	95,1	90,2	83,3	76,4	70,6	65,9	62,6	60,3	58,2	56,3	-2,6	-1,0	-1,6	-1,5	-0,9	-0,7
Residential (Energy on Private Income)	114,4	113,2	100,0	97,5	96,9	86,5	76,4	67,1	61,4	56,1	52,0	48,0	44,5	-1,3	-0,3	-2,3	-2,2	-1,6	-1,6
Tertiary (Energy on Value added)	126,5	117,0	100,0	99,4	94,7	84,0	73,3	65,5	59,0	55,5	52,1	49,0	45,4	-2,3	-0,5	-2,5	-2,2	-1,2	-1,4
Transport (Energy on GDP)	102,5	102,3	100,0	97,6	96,8	86,8	79,9	73,2	66,2	62,1	57,8	53,8	50,0	-0,2	-0,3	-1,9	-1,9	-1,3	-1,4
Carbon Intensity indicators																			
Electricity and Steam production (t of CO_2/MWh)	0,46	0,40	0,37	0,35	0,32	0,28	0,23	0,22	0,18	0,14	0,11	0,09	0,08	-2,1	-1,5	-3,2	-2,5	-5,2	-3,1
Final energy demand (t of CO_2/toe)	2,24	2,16	2,08	2,03	1,93	1,80	1,69	1,65	1,60	1,57	1,54	1,52	1,50	-0,7	-0,8	-1,3	-0,6	-0,4	-0,3
Industry	2,14	2,06	1,91	1,78	1,57	1,41	1,30	1,22	1,18	1,13	1,10	1,12	1,11	-1,1	-1,9	-1,9	-1,0	-0,6	0,1
Residential	1,89	1,72	1,63	1,58	1,51	1,38	1,23	1,15	1,10	1,08	1,04	1,00	0,95	-1,5	-0,7	-2,0	-1,1	-0,6	-0,9
Tertiary	1,90	1,72	1,51	1,48	1,40	1,24	1,12	1,06	0,99	0,95	0,89	0,84	0,80	-2,2	-0,8	-2,2	-1,2	-1,1	-1,0
Transport	2,90	2,90	2,91	2,91	2,83	2,74	2,65	2,65	2,60	2,60	2,59	2,59	2,59	0,0	-0,3	-0,7	-0,2	0,0	0,0
Electricity and steam generation																			
Net Generation Capacity in MW_e			**654125**	**715732**	**820434**	**932620**	**1032788**	**1088775**	**1185453**	**1265492**	**1349640**	**1430349**	**1506216**		**2,3**	**2,3**	**1,4**	**1,3**	**1,1**
Nuclear energy			133923	134409	127038	126852	125074	121722	133458	144906	150509	161560	167287		-0,5	-0,2	0,7	1,2	1,1
Renewable energy			112878	147262	209099	284114	408330	464725	554444	604967	649863	690341	731802		6,4	6,9	3,1	1,6	1,2
Hydro (pumping excluded)			99714	104505	107315	110895	114221	115796	117764	119063	119318	120171	121417		0,7	0,6	0,3	0,1	0,2
Wind			12793	40584	86229	144788	234861	274238	333105	360201	378940	390489	405677		21,0	10,5	3,6	1,3	0,7
Solar			371	2172	15307	27855	57573	71822	99427	121232	146775	174191	198094		45,1	14,2	5,6	4,0	3,0
Other renewables (tidal etc.)			0	1	249	575	1675	2869	4149	4471	4831	5490	6613			21,0	9,5	1,5	3,2
Thermal power			407324	434061	484297	521655	499384	502328	497550	515619	549267	578448	607127		1,7	0,3	0,0	1,0	1,0
of which cogeneration units			75904	85934	100075	116174	120571	129350	132766	154717	170230	189330	199103		2,8	1,9	1,0	2,5	1,6
of which CCS units			0	0	0	0	5394	5394	5993	20336	44660	66821	80397				1,1	22,2	6,1
Solids fired			194165	186620	183838	184942	168479	153118	135450	130306	138607	143502	141235		-0,5	-0,9	-2,2	0,2	0,2
Gas fired			129444	167173	219347	240391	230027	229494	240992	264602	258102	234589	200906		5,4	0,5	0,5	0,7	-2,5
Oil fired			71058	62082	56158	51358	41013	51543	49191	47697	74720	115244	174538		-2,3	-3,1	1,8	4,3	8,9
Biomass-waste fired			12051	17502	24171	44170	59038	67290	70972	72031	76814	84081	89408		7,2	9,3	1,9	0,8	1,5
Hydrogen plants			0	0	0	0	0	0	0	0	0	0	0						
Geothermal heat			605	684	783	794	826	884	945	982	1024	1032	1039		2,6	0,5	1,4	0,8	0,1
Load factor for net electric capacities (%)			49,1	49,1	45,1	42,6	40,3	40,2	37,8	37,1	36,4	35,9	35,3						
Indicators for gross electricity production																			
Efficiency for thermal electricity production (%)			37,6	38,5	39,2	39,7	40,0	40,0	39,3	41,1	42,6	43,6	44,3						
CHP indicator (% of electricity from CHP)			11,4	11,7	15,0	18,2	18,2	18,4	18,0	20,9	21,4	22,0	22,6						
CCS indicator (% of electricity from CCS)			0,0	0,0	0,0	0,0	1,3	1,3	1,5	4,7	9,4	12,9	14,4						
Non fossil fuels in electricity generation (%)			45,8	44,8	46,0	49,9	56,8	59,5	66,0	68,4	68,7	69,2	69,6						
- nuclear			31,6	30,5	27,2	25,5	23,7	23,8	25,4	26,9	26,9	27,6	27,4						
- renewable energy forms and industrial waste			14,2	14,3	18,8	24,4	33,0	35,7	40,6	41,5	41,9	41,6	42,1						
Indicators for renewables (excluding industrial waste) (%) [(B)]																			
RES in gross final energy demand (%)			7,6	8,6	11,4	15,9	22,0	23,1	25,5	26,0	26,6	26,7	27,2						
RES in transport (%)			0,5	1,4	4,3	8,1	12,1	12,0	14,1	14,3	14,5	14,6	14,7						
Transport sector																			
Passenger transport activity (Gpkm)	**4880,7**	**5307,7**	**5892,2**	**6240,3**	**6511,3**	**6920,7**	**7346,1**	**7813,6**	**8179,2**	**8562,5**	**8856,9**	**9095,3**	**9278,9**	**1,9**	**1,0**	**1,2**	**1,1**	**0,8**	**0,5**
Public road transport	544,0	504,0	517,6	526,0	545,0	564,3	590,4	613,3	630,9	646,7	659,3	669,0	675,9	-0,5	0,5	0,8	0,7	0,4	0,2
Private cars and motorcycles	3501,1	3986,3	4428,1	4686,5	4866,1	5127,6	5371,6	5654,0	5853,2	6098,3	6261,0	6379,0	6453,3	2,4	0,9	1,0	0,9	0,7	0,3
Rail	472,5	421,7	447,9	461,0	482,5	522,2	562,7	603,3	640,2	676,6	712,3	742,7	765,3	-0,5	0,7	1,5	1,3	1,1	0,7
Aviation	317,3	351,3	456,9	527,3	576,9	665,1	778,5	898,8	1009,6	1094,4	1177,0	1256,4	1335,6	3,7	2,4	3,0	2,6	1,5	1,3
Inland navigation	45,8	44,4	41,7	39,5	40,8	41,5	42,9	44,2	45,4	46,5	47,4	48,1	48,7	-0,9	-0,2	0,5	0,6	0,4	0,3
Travel per person (km per capita)	10376	11127	12248	12756	13039	13631	14297	15090	15731	16446	17029	17546	18007	1,7	0,6	0,9	1,0	0,8	0,6
Freight transport activity (Gtkm)	**1848,4**	**1942,4**	**2195,7**	**2494,6**	**2662,6**	**2874,8**	**3043,7**	**3229,8**	**3361,7**	**3513,1**	**3635,9**	**3733,1**	**3806,0**	**1,7**	**1,9**	**1,3**	**1,0**	**0,8**	**0,5**
Trucks	1060,4	1288,7	1518,7	1800,3	1940,3	2094,4	2210,3	2351,1	2447,7	2566,2	2659,9	2734,4	2789,9	3,7	2,5	1,3	1,0	0,8	0,5
Rail	526,3	386,1	403,7	414,1	440,5	486,4	523,0	552,9	576,5	598,6	619,3	636,1	650,2	-2,6	0,9	1,7	1,0	0,7	0,5
Inland navigation	261,6	267,6	273,3	280,2	281,9	294,0	310,4	325,8	337,5	348,3	356,6	362,6	365,9	0,4	0,3	1,0	0,8	0,6	0,3
Freight activity per unit of GDP (tkm/000 Euro'05)	227	222	217	225	234	225	215	208	200	193	186	178	169	-0,4	0,7	-0,8	-0,7	-0,7	-1,0
Energy demand in transport (ktoe)	**280269**	**300617**	**339389**	**362405**	**370013**	**371769**	**379996**	**381024**	**373824**	**378321**	**379157**	**379661**	**378542**	**1,9**	**0,9**	**0,3**	**-0,2**	**0,1**	**0,0**
Public road transport	5197	4732	4914	5039	5182	5241	5217	5127	4996	5000	4954	4800	4611	-0,6	0,5	0,1	-0,4	-0,1	-0,7
Private cars and motorcycles	154395	166321	182974	187736	186451	179691	178111	177039	170966	168974	166164	163291	161068	1,7	0,2	-0,5	-0,4	-0,3	-0,3
Trucks	74969	79037	90951	105104	111606	119627	122608	125516	124745	128357	131002	132630	133993	2,0	2,1	0,9	0,2	0,5	0,2
Rail	9560	9452	9600	9436	9599	9909	9705	9480	8429	8381	8507	8559	8534	0,0	0,0	0,1	-1,4	0,1	0,0
Aviation	29038	34112	45395	49703	51709	51732	58532	57778	58429	61191	61993	63776	63710	4,6	1,3	1,2	0,0	0,6	0,3
Inland navigation	7110	6963	5555	5386	5466	5570	5823	6084	6258	6417	6537	6606	6626	-2,4	-0,2	0,6	0,7	0,4	0,1
Efficiency indicator (activity related)																			
Passenger transport (toe/Mpkm)	39,6	39,5	40,3	39,5	38,0	34,8	33,5	31,2	29,2	28,0	26,8	26,0	25,2	0,2	-0,6	-1,3	-1,4	-0,8	-0,6
Freight transport (toe/Mtkm)	47,1	46,8	46,3	46,5	46,1	45,6	44,1	42,4	40,2	39,5	39,0	38,4	38,1	-0,2	-0,1	-0,4	-0,9	-0,3	-0,2

Reference scenario with High GDP

EU27: Reference High Economic Growth scenario														SUMMARY ENERGY BALANCE AND INDICATORS (A)					
ktoe	1990	1995	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050	'90-'00	'00-'10	'10-'20	'20-'30	'30-'40	'40-'50
														Annual % Change					
Production	**936047**	**950181**	**941860**	**900326**	**844795**	**805982**	**796733**	**793722**	**804699**	**829870**	**845820**	**851510**	**837989**	**0,1**	**-1,1**	**-0,6**	**0,1**	**0,5**	**-0,1**
Solids	366477	277810	213423	196277	182261	166301	146303	139267	120159	117873	123351	127247	125408	-5,3	-1,6	-2,2	-1,9	0,3	0,2
Oil	129551	171052	173006	134290	104398	74368	49705	41001	37493	32839	26195	17846	8973	2,9	-4,9	-7,2	-2,8	-3,5	-10,2
Natural gas	162447	188965	207559	188677	164866	129073	110925	90885	74874	64386	52719	39166	29766	2,5	-2,3	-3,9	-3,9	-3,4	-5,6
Nuclear	202589	223028	243761	257360	238966	240206	228713	240108	263627	296309	317134	332743	333617	1,9	-0,2	-0,4	1,4	1,9	0,5
Renewable energy sources	74984	89326	104111	123722	154305	196035	261087	282462	308546	318464	326422	334508	340226	3,3	4,0	5,4	1,7	0,6	0,4
Hydro	25101	28054	30374	26395	27808	28644	29330	30146	30666	31053	31422	31760	32027	1,9	-0,9	0,5	0,4	0,2	0,2
Biomass & Waste	46473	57201	67982	85129	102388	122697	154221	162033	167512	165469	165881	167713	165312	3,9	4,2	4,2	0,8	-0,1	0,0
Wind	67	350	1913	6061	13850	27893	48425	58176	72406	79767	83465	86748	91095	39,8	21,9	13,3	4,1	1,4	0,9
Solar and others	153	274	421	807	3426	9356	20069	22772	28368	32197	35350	37880	41257	10,7	23,3	19,3	3,5	2,2	1,6
Geothermal	3190	3447	3421	5331	6833	7444	9041	9335	9594	9979	10304	10407	10535	0,7	7,2	2,8	0,6	0,7	0,2
Net Imports	**756079**	**738600**	**826299**	**986048**	**980018**	**1057089**	**1074775**	**1073938**	**1041883**	**1047990**	**1073402**	**1108378**	**1139953**	**0,9**	**1,7**	**0,9**	**-0,3**	**0,3**	**0,6**
Solids	81846	79338	98645	126639	121884	122639	115056	123838	94444	86849	95985	98324	104049	1,9	2,1	-0,6	-2,0	0,2	0,8
Oil	535645	512185	533039	599851	581718	611820	627907	623035	606259	613906	623192	638522	653294	0,0	0,9	0,8	-0,4	0,3	0,5
- Crude oil and Feedstocks	508460	494000	513725	581995	579041	613293	633140	632742	619281	627290	636576	651754	666926	0,1	1,2	0,9	-0,2	0,3	0,5
- Oil products	27185	18185	19314	17856	2678	-1473	-5233	-9706	-13021	-13384	-13384	-13233	-13633	-3,4	-17,9				
Natural gas	135121	145288	192531	257366	272319	315863	313499	313865	326151	330246	334777	348769	356333	3,6	3,5	1,4	0,4	0,3	0,6
Electricity	3323	1508	1686	971	264	-544	-1754	-1942	-2080	-2327	-2342	-2395	-2487	-6,6	-16,9				
Renewable energy forms	144	279	397	1222	3834	7311	20067	15142	17109	19317	21790	25158	28765	10,7	25,4	18,0	-1,6	2,4	2,8
Gross Inland Consumption	**1660159**	**1662517**	**1723099**	**1825989**	**1774762**	**1811013**	**1817263**	**1811162**	**1787554**	**1816497**	**1855568**	**1894099**	**1910524**	**0,4**	**0,3**	**0,2**	**-0,2**	**0,4**	**0,3**
Solids	452940	364248	321007	319922	304145	288940	261360	263105	214603	204722	219336	225571	229456	-3,4	-0,5	-1,5	-2,0	0,2	0,5
Oil	631058	650858	658727	676859	636065	634131	623367	607538	584725	585381	585733	590579	594848	0,4	-0,3	-0,2	-0,6	0,0	0,2
Natural gas	294905	333268	393417	445998	437184	444936	424424	404750	401026	394632	387496	387935	386099	2,9	1,1	-0,3	-0,6	-0,3	0,0
Nuclear	202589	223028	243761	257360	238966	240206	228713	240108	263627	296309	317134	332743	333617	1,9	-0,2	-0,4	1,4	1,9	0,5
Electricity	3323	1508	1686	971	264	-544	-1754	-1942	-2080	-2327	-2342	-2395	-2487	-6,6	-16,9				
Renewable energy forms	75343	89606	104501	124880	158139	203345	281154	297604	325654	337781	348212	359665	368991	3,3	4,2	5,9	1,5	0,7	0,6
as % in Gross Inland Consumption																			
Solids	27,3	21,9	18,6	17,5	17,1	16,0	14,4	14,5	12,0	11,3	11,8	11,9	12,0						
Oil	38,0	39,1	38,2	37,1	35,8	35,0	34,3	33,5	32,7	32,2	31,6	31,2	31,1						
Natural gas	17,8	20,0	22,8	24,4	24,6	24,6	23,4	22,3	22,4	21,7	20,9	20,5	20,2						
Nuclear	12,2	13,4	14,1	14,1	13,5	13,3	12,6	13,3	14,7	16,3	17,1	17,6	17,5						
Renewable energy forms	4,5	5,4	6,1	6,8	8,9	11,2	15,5	16,4	18,2	18,6	18,8	19,0	19,3						
Gross Electricity Generation in GWh_e	**2562823**	**2712209**	**2991720**	**3274121**	**3409095**	**3621318**	**3828968**	**4091878**	**4228912**	**4537561**	**4857644**	**5154945**	**5386239**	**1,6**	**1,3**	**1,2**	**1,0**	**1,4**	**1,0**
Nuclear	794718	881662	944823	997519	926731	932507	893541	953446	1060642	1206092	1298803	1400788	1475992	1,7	-0,2	-0,4	1,7	2,0	1,3
Hydro & wind	292648	330306	375545	378836	501839	690568	975998	1120891	1341556	1465426	1545707	1615257	1705595	2,5	2,9	6,9	3,2	1,4	1,0
Thermal (incl. biomass)	1475456	1500241	1671352	1897765	1980524	1998244	1959429	2017541	1826713	1866043	2013134	2138899	2204651	1,3	1,7	-0,1	-0,7	1,0	0,9
Fuel Inputs for Thermal Power Generation	**383492**	**362334**	**382613**	**424208**	**434107**	**430405**	**418618**	**427545**	**388791**	**383108**	**399468**	**411556**	**418690**	**0,0**	**1,3**	**-0,4**	**-0,7**	**0,3**	**0,5**
Solids	263837	230040	223012	229245	232504	218931	194258	198294	154921	146530	159714	163990	167715	-1,7	0,4	-1,8	-2,2	0,3	0,5
Oil (including refinery gas)	54404	51463	39294	29780	17334	16556	11415	14021	14737	17472	20189	23532	24049	-3,2	-7,9	-4,1	2,6	3,2	1,8
Gas	56754	67806	102408	134637	143332	139894	131289	125399	124477	124863	123931	126928	127935	6,1	3,4	-0,9	-0,5	0,0	0,3
Biomass & Waste	5724	10033	14960	25901	35109	49098	75487	83207	87570	86876	87928	89343	91171	10,1	8,9	8,0	1,5	0,0	0,4
Geothermal heat	2774	2992	2939	4645	5828	5925	6169	6624	7086	7366	7706	7763	7819	0,6	7,1	0,6	1,4	0,8	0,1
Hydrogen - Methanol	0	0	0	0	0	0	0	0	0	0	0	0	0						
Fuel Input in other transformation proc.	**839073**	**814654**	**827098**	**842975**	**794418**	**806148**	**810199**	**799928**	**779857**	**783664**	**787709**	**795474**	**800639**	**-0,1**	**-0,4**	**0,2**	**-0,4**	**0,1**	**0,2**
Refineries	679426	705954	735244	758152	718881	723084	717498	707606	689558	692938	695366	702005	708441	0,8	-0,2	0,0	-0,4	0,1	0,2
Biofuels and hydrogen production	2	202	610	3129	12210	19684	30839	32756	36418	38224	39050	39460	39487	79,6	34,9	9,7	1,7	0,7	0,1
District heating	32960	23240	19323	16212	15817	16087	16095	15726	14180	13407	12900	12828	12598	-5,2	-2,0	0,2	-1,3	-0,9	-0,2
Others	126685	85258	71921	65482	47510	47293	45766	43839	39701	39095	40393	41180	40113	-5,5	-4,1	-0,4	-1,4	0,2	-0,1
Energy Branch Consumption	**82379**	**88696**	**88176**	**96033**	**92198**	**90788**	**90471**	**89968**	**85921**	**88889**	**93395**	**96777**	**98155**	**0,7**	**0,4**	**-0,2**	**-0,5**	**0,8**	**0,5**
Non-Energy Uses	**97931**	**110541**	**112495**	**117477**	**111500**	**115433**	**119102**	**121307**	**123892**	**126644**	**129190**	**131854**	**134077**	**1,4**	**-0,1**	**0,7**	**0,4**	**0,4**	**0,4**
Final Energy Demand	**1068710**	**1069989**	**1112989**	**1173676**	**1165859**	**1218531**	**1246318**	**1234451**	**1225255**	**1245750**	**1266720**	**1294011**	**1310550**	**0,4**	**0,5**	**0,7**	**-0,2**	**0,3**	**0,3**
by sector																			
Industry	365650	328513	326949	326308	312372	322924	333322	339324	344326	356127	372071	389175	405600	-1,1	-0,5	0,7	0,3	0,8	0,9
- energy intensive industries	234722	214526	213112	210991	193231	196619	199939	199567	199113	201995	207814	212529	216414	-1,0	-1,0	0,3	0,0	0,4	0,4
- other industrial sectors	130928	113987	113837	115317	119142	126305	133383	139757	145213	154132	164258	176646	189186	-1,4	0,5	1,1	0,9	1,2	1,4
Residential	264307	280418	286784	308104	308383	322112	323297	309148	304520	302824	298664	298297	293592	0,8	0,7	0,5	-0,6	-0,2	-0,2
Tertiary	158484	160442	159866	176859	175093	183577	185456	184433	184752	190957	197191	203880	207732	0,1	0,9	0,6	0,0	0,7	0,5
Transport	280269	300617	339389	362405	370011	389918	404242	401547	391657	395841	398794	402658	403627	1,9	0,9	0,9	-0,3	0,2	0,1
by fuel																			
Solids	125031	84977	61454	54486	47491	46096	44227	42397	38492	37764	38962	41320	41896	-6,9	-2,5	-0,7	-1,4	0,1	0,7
Oil	444429	456959	478882	495857	476571	478214	474500	460227	440224	441351	442253	446490	446418	0,7	0,0	0,0	-0,7	0,0	0,1
Gas	227902	245996	265552	283524	264953	273631	258825	242087	237168	228479	221069	217048	213656	1,5	0,0	-0,2	-0,9	-0,7	-0,3
Electricity	184145	193367	216403	237537	248326	265073	279453	298023	309264	329949	350504	370481	386639	1,6	1,4	1,2	1,0	1,3	1,0
Heat (from CHP and District Heating) [(A)]	48610	44616	40061	44441	59517	71959	79203	85228	88610	95932	100990	104078	106474	-1,9	4,0	2,9	1,1	1,3	0,5
Other	38592	44073	50640	57832	69001	83557	110108	106489	111496	112276	112941	114593	115468	2,8	3,1	4,8	0,1	0,1	0,2
CO_2 Emissions (Mt of CO_2 - sec approach)	**4030,6**	**3800,1**	**3810,6**	**3946,6**	**3771,8**	**3714,7**	**3482,3**	**3342,8**	**3018,1**	**2804,4**	**2649,7**	**2560,6**	**2527,9**	**-0,6**	**-0,1**	**-0,8**	**-1,4**	**-1,3**	**-0,5**
Power generation/District heating	1484,3	1321,2	1320,8	1381,1	1365,6	1300,3	1130,7	1090,9	864,2	682,0	546,0	453,8	426,2	-1,2	0,3	-1,9	-2,7	-4,5	-2,4
Energy Branch	152,2	171,0	170,2	181,6	157,2	146,3	136,7	127,2	117,6	105,5	95,1	83,7	83,5	1,1	-0,8	-1,4	-1,5	-2,1	-1,3
Industry	781,4	678,1	623,0	581,9	490,8	474,8	462,5	448,2	433,7	428,4	439,7	458,0	475,7	-2,2	-2,4	-0,6	-0,6	0,1	0,8
Residential	499,4	481,6	466,2	486,7	465,3	468,7	434,1	389,3	368,3	353,7	333,9	322,6	303,4	-0,7	0,0	-0,7	-1,6	-1,0	-1,0
Tertiary	300,5	275,3	242,0	262,2	244,5	239,4	224,7	208,4	198,7	192,8	187,0	184,6	178,2	-2,1	0,1	-0,8	-1,2	-0,6	-0,5
Transport	812,7	872,9	988,5	1053,1	1048,3	1085,2	1093,5	1078,8	1035,7	1042,0	1048,0	1058,0	1060,8	2,0	0,6	0,4	-0,5	0,1	0,1
CO_2 Emissions Index (1990=100)	**100,0**	**94,3**	**94,5**	**97,9**	**93,6**	**92,2**	**86,4**	**82,9**	**74,9**	**69,6**	**65,7**	**63,5**	**62,7**						
CO_2 Emissions (Mt of CO_2 - ref approach)	**4172,0**	**3950,7**	**3922,7**	**4087,6**	**3837,8**	**3781,1**	**3552,7**	**3412,0**	**3090,1**	**2875,5**	**2719,7**	**2629,1**	**2600,6**	**-0,6**	**-0,2**	**-0,8**	**-1,4**	**-1,3**	**-0,4**

EU27: Reference High Economic Growth scenario													SUMMARY ENERGY BALANCE AND INDICATORS (B)						
	1990	1995	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050	'90-'00	'00-'10	'10-'20	'20-'30	'30-'40	'40-'50
														Annual % Change					
Main Energy System Indicators																			
Population (Million)	470,388	477,010	481,072	489,211	499,389	507,727	513,838	517,811	519,942	520,654	520,103	518,362	515,303	0,2	0,4	0,3	0,1	0,0	-0,1
GDP (in 000 MEuro'05)	8142,7	8748,4	10107,2	11063,1	11385,6	12801,7	14487,7	16165,8	17888,9	19687,4	21595,7	23690,1	25953,1	2,2	1,2	2,4	2,1	1,9	1,9
Gross Inl. Cons./GDP (toe/MEuro'05)	203,9	190,0	170,5	165,1	155,9	141,5	125,4	112,0	99,9	92,3	85,9	80,0	73,6	-1,8	-0,9	-2,1	-2,2	-1,5	-1,5
Gross Inl. Cons./Capita (toe/inhabitant)	3,53	3,49	3,58	3,73	3,55	3,57	3,54	3,50	3,44	3,49	3,57	3,65	3,71	0,1	-0,1	0,0	-0,3	0,4	0,4
Electricity Generated/Capita (kWh gross/inhabitant)	5448	5686	6219	6693	6827	7132	7452	7902	8133	8715	9340	9945	10453	1,3	0,9	0,9	0,9	1,4	1,1
Carbon intensity (t of CO_2/toe of GIC)	2,43	2,29	2,21	2,16	2,13	2,05	1,92	1,85	1,69	1,54	1,43	1,35	1,32	-0,9	-0,4	-1,0	-1,3	-1,7	-0,8
CO_2 Emissions/Capita (t of CO_2/inhabitant)	8,57	7,97	7,92	8,07	7,55	7,32	6,78	6,46	5,80	5,39	5,09	4,94	4,91	-0,8	-0,5	-1,1	-1,5	-1,3	-0,4
CO2 Emissions to GDP (t of CO2/MEuro'05)	495,0	434,4	377,0	356,7	331,3	290,2	240,4	206,8	168,7	142,4	122,7	108,1	97,4	-2,7	-1,3	-3,2	-3,5	-3,1	-2,3
Import Dependency %	44,6	43,5	46,8	52,5	53,7	56,7	57,4	57,5	56,4	55,8	55,9	56,6	57,6						
Energy intensity indicators (2000=100)																			
Industry (Energy on Value added)	130,3	115,2	100,0	95,1	90,3	84,2	77,7	71,7	66,7	63,1	60,7	58,4	56,2	-2,6	-1,0	-1,5	-1,5	-0,9	-0,8
Residential (Energy on Private Income)	114,4	113,2	100,0	97,5	96,9	89,6	80,2	70,9	64,8	58,8	54,3	50,0	46,2	-1,3	-0,3	-1,9	-2,1	-1,8	-1,6
Tertiary (Energy on Value added)	126,5	117,0	100,0	99,4	94,7	87,5	77,6	68,7	61,9	57,9	54,2	50,9	47,0	-2,3	-0,5	-2,0	-2,2	-1,3	-1,4
Transport (Energy on GDP)	102,5	102,3	100,0	97,6	96,8	90,7	83,1	74,0	65,2	59,9	55,0	50,6	46,3	-0,2	-0,3	-1,5	-2,4	-1,7	-1,7
Carbon Intensity indicators																			
Electricity and Steam production (t of CO_2/MWh)	0,46	0,40	0,37	0,35	0,32	0,28	0,23	0,21	0,16	0,12	0,09	0,07	0,06	-2,1	-1,5	-3,3	-3,6	-5,8	-3,3
Final energy demand (t of CO_2/toe)	2,24	2,16	2,08	2,03	1,93	1,86	1,78	1,72	1,66	1,62	1,59	1,56	1,54	-0,7	-0,8	-0,8	-0,7	-0,5	-0,3
Industry	2,14	2,06	1,91	1,78	1,57	1,47	1,39	1,32	1,26	1,20	1,18	1,18	1,17	-1,1	-1,9	-1,2	-1,0	-0,6	-0,1
Residential	1,89	1,72	1,63	1,58	1,51	1,46	1,34	1,26	1,21	1,17	1,12	1,08	1,03	-1,5	-0,7	-1,2	-1,0	-0,8	-0,8
Tertiary	1,90	1,72	1,51	1,48	1,40	1,30	1,21	1,13	1,08	1,01	0,95	0,91	0,86	-2,2	-0,8	-1,4	-1,2	-1,2	-1,0
Transport	2,90	2,90	2,91	2,91	2,83	2,78	2,71	2,69	2,64	2,63	2,63	2,63	2,63	0,0	-0,3	-0,5	-0,2	-0,1	0,0
Electricity and steam generation																			
Net Generation Capacity in MW_e			**654125**	**715732**	**820290**	**923627**	**1029084**	**1089097**	**1196428**	**1294316**	**1386766**	**1481291**	**1570140**		**2,3**	**2,3**	**1,5**	**1,5**	**1,2**
Nuclear energy			133923	134409	127038	126752	124722	120598	134152	149442	159029	171948	182410		-0,5	-0,2	0,7	1,7	1,4
Renewable energy			112878	147262	209088	282215	405981	462606	554904	605631	641787	674521	717321		6,4	6,9	3,2	1,5	1,1
Hydro (pumping excluded)			99714	104505	107315	110860	114167	115744	117580	119033	119293	120198	121500		0,7	0,6	0,3	0,1	0,2
Wind			12793	40584	86217	142925	233040	272784	331498	359395	374199	387366	404075		21,0	10,5	3,6	1,2	0,8
Solar			371	2172	15307	27855	57104	71209	101678	122732	143464	161404	185077		45,1	14,1	5,9	3,5	2,6
Other renewables (tidal etc.)			0	1	249	575	1671	2869	4148	4471	4831	5552	6669			21,0	9,5	1,5	3,3
Thermal power			407324	434061	484164	514659	498381	505893	507371	539243	585950	634823	670409		1,7	0,3	0,2	1,5	1,4
of which cogeneration units			75904	85934	100381	114328	119605	131172	137134	161453	186324	210378	227948		2,8	1,8	1,4	3,1	2,0
of which CCS units			0	0	0	0	5394	11086	17169	40385	77112	110122	126199				12,3	16,2	5,0
Solids fired			194165	186620	183827	183101	166344	152693	141300	140709	150515	149707	147538		-0,5	-1,0	-1,6	0,6	-0,2
Gas fired			129444	167173	219320	239092	231438	230128	239996	270827	283217	275309	239631		5,4	0,5	0,4	1,7	-1,7
Oil fired			71058	62082	56063	49370	39978	53722	52024	51793	71234	122299	192448		-2,3	-3,3	2,7	3,2	10,4
Biomass-waste fired			12051	17502	24170	42305	59797	68467	73107	74933	79957	86474	89751		7,2	9,5	2,0	0,9	1,2
Hydrogen plants			0	0	0	0	0	0	0	0	0	0	0						
Geothermal heat			605	684	783	791	823	884	945	982	1027	1035	1042		2,6	0,5	1,4	0,8	0,1
Load factor for net electric capacities (%)			49,1	49,1	45,1	42,7	40,5	40,8	38,4	37,9	37,5	37,1	36,5						
Indicators for gross electricity production																			
Efficiency for thermal electricity production (%)			37,6	38,5	39,2	39,9	40,3	40,6	40,4	41,9	43,3	44,7	45,3						
CHP indicator (% of electricity from CHP)			11,4	11,7	15,0	18,0	18,5	18,6	18,3	20,8	22,1	23,0	23,2						
CCS indicator (% of electricity from CCS)			0,0	0,0	0,0	0,0	1,4	2,8	4,2	8,8	14,9	19,2	20,3						
Non fossil fuels in electricity generation (%)			45,8	44,8	45,9	50,1	56,4	58,6	64,9	66,5	65,9	65,7	66,2						
- nuclear			31,6	30,5	27,2	25,8	23,3	23,3	25,1	26,6	26,7	27,2	27,4						
- renewable energy forms and industrial waste			14,2	14,3	18,7	24,3	33,0	35,3	39,8	39,9	39,2	38,5	38,8						
Indicators for renewables (excluding industrial waste) (%) [B]																			
RES in gross final energy demand (%)			7,6	8,6	11,4	14,6	20,1	21,4	23,7	24,1	24,3	24,4	24,9						
RES in transport (%)			0,5	1,4	4,3	6,6	10,1	10,9	12,5	13,1	13,2	13,3	13,2						
Transport sector																			
Passenger transport activity (Gpkm)	**4880,7**	**5307,7**	**5892,2**	**6240,3**	**6511,3**	**7186,5**	**7787,5**	**8227,1**	**8648,1**	**9035,3**	**9300,3**	**9581,3**	**9754,9**	**1,9**	**1,0**	**1,8**	**1,1**	**0,7**	**0,5**
Public road transport	544,0	504,0	517,6	526,0	545,0	576,1	613,5	636,3	655,6	673,9	684,6	696,5	702,5	-0,5	0,5	1,2	0,7	0,4	0,3
Private cars and motorcycles	3501,1	3986,3	4428,1	4686,5	4866,1	5341,1	5715,6	5965,4	6208,3	6441,8	6577,7	6726,0	6788,8	2,4	0,9	1,6	0,8	0,6	0,3
Rail	472,5	421,7	447,9	461,0	482,5	528,0	576,4	616,5	654,6	694,6	727,7	760,6	782,9	-0,5	0,7	1,8	1,3	1,1	0,7
Aviation	317,3	351,3	456,9	527,3	576,9	699,0	837,4	962,9	1082,5	1176,4	1260,9	1348,0	1429,9	3,7	2,4	3,8	2,6	1,5	1,3
Inland navigation	45,8	44,4	41,7	39,5	40,8	42,3	44,6	46,0	47,2	48,6	49,4	50,3	50,8	-0,9	-0,2	0,9	0,6	0,4	0,3
Travel per person (km per capita)	10376	11127	12248	12756	13039	14154	15155	15888	16633	17354	17882	18484	18930	1,7	0,6	1,5	0,9	0,7	0,6
Freight transport activity (Gtkm)	**1848,4**	**1942,4**	**2195,7**	**2494,6**	**2662,6**	**2980,3**	**3234,9**	**3473,5**	**3699,4**	**3915,2**	**4127,1**	**4325,5**	**4496,8**	**1,7**	**1,9**	**2,0**	**1,4**	**1,1**	**0,9**
Trucks	1060,4	1288,7	1518,7	1800,3	1940,3	2188,4	2372,4	2548,2	2717,3	2878,5	3037,6	3188,6	3317,0	3,7	2,5	2,0	1,4	1,1	0,9
Rail	526,3	386,1	403,7	414,1	440,5	492,3	539,8	580,3	617,4	653,5	689,4	722,0	752,7	-2,6	0,9	2,1	1,4	1,1	0,9
Inland navigation	261,6	267,6	273,3	280,2	281,9	299,5	322,8	345,1	364,7	383,2	400,1	414,9	427,1	0,4	0,3	1,4	1,2	0,9	0,7
Freight activity per unit of GDP (tkm/000 Euro'05)	227	222	217	225	234	233	223	215	207	199	191	183	173	-0,4	0,7	-0,5	-0,8	-0,8	-1,0
Energy demand in transport (ktoe)	**280269**	**300617**	**339389**	**362405**	**370011**	**389918**	**404242**	**401547**	**391657**	**395841**	**398794**	**402658**	**403627**	**1,9**	**0,9**	**0,9**	**-0,3**	**0,2**	**0,1**
Public road transport	5197	4732	4914	5039	5182	5334	5391	5284	5145	5147	5092	4956	4753	-0,6	0,5	0,4	-0,5	-0,1	-0,7
Private cars and motorcycles	154395	166321	182974	187736	186451	186412	186566	177813	167337	164525	161244	158521	155378	1,7	0,2	0,0	-1,1	-0,4	-0,4
Trucks	74969	79037	90951	105104	111606	124207	130639	135054	136977	142062	147194	151609	155668	2,0	2,1	1,6	0,5	0,7	0,6
Rail	9560	9452	9600	9436	9597	10196	10221	9997	8889	8890	9101	9246	9314	0,0	0,0	0,6	-1,4	0,2	0,2
Aviation	29038	34112	45395	49703	51709	58128	65393	67031	66684	68344	69089	71088	71173	4,6	1,3	2,4	0,2	0,4	0,3
Inland navigation	7110	6963	5555	5386	5466	5642	6033	6368	6625	6873	7074	7239	7341	-2,4	-0,2	1,0	0,9	0,7	0,4
Efficiency indicator (activity related)																			
Passenger transport (toe/Mpkm)	39,6	39,5	40,3	39,5	38,0	35,3	33,6	30,9	28,2	26,8	25,8	24,9	24,2	0,2	-0,6	-1,2	-1,7	-0,9	-0,7
Freight transport (toe/Mtkm)	47,1	46,8	46,3	46,5	46,1	45,6	44,1	42,4	40,0	39,2	38,5	37,8	37,3	-0,2	-0,1	-0,4	-1,0	-0,4	-0,3

Reference scenario with Low GDP

EU27: Reference Low Economic Growth scenario														SUMMARY ENERGY BALANCE AND INDICATORS (A)					
ktoe	**1990**	**1995**	**2000**	**2005**	**2010**	**2015**	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**	**'90-'00**	**'00-'10**	**'10-'20**	**'20-'30**	**'30-'40**	**'40-'50**
														Annual % Change					
Production	**936047**	**950181**	**941860**	**900326**	**844967**	**798425**	**774117**	**758145**	**735176**	**728353**	**728490**	**723698**	**704387**	**0,1**	**-1,1**	**-0,9**	**-0,5**	**-0,1**	**-0,3**
Solids	366477	277810	213423	196277	182279	164758	144498	136490	112424	100470	104565	104099	105717	-5,3	-1,6	-2,3	-2,5	-0,7	0,1
Oil	129551	171052	173006	134290	104398	72977	48126	39228	35670	30897	24132	16128	7824	2,9	-4,9	-7,5	-3,0	-3,8	-10,7
Natural gas	162447	188965	207559	188677	164866	129027	110780	90584	74147	62848	50575	36387	28338	2,5	-2,3	-3,9	-3,9	-3,8	-5,6
Nuclear	202589	223028	243761	257360	238973	238589	215041	219504	223045	237771	244630	260234	255129	1,9	-0,2	-1,0	0,4	0,9	0,4
Renewable energy sources	74984	89326	104111	123722	154452	193073	255672	272340	289890	296367	304588	306849	307379	3,3	4,0	5,2	1,3	0,5	0,1
Hydro	25101	28054	30374	26395	27808	28606	29328	30119	30642	31003	31403	31730	31998	1,9	-0,9	0,5	0,4	0,2	0,2
Biomass & Waste	46473	57201	67982	85129	102535	120731	150880	155817	156950	154394	156770	154579	151269	3,9	4,2	3,9	0,4	0,0	-0,4
Wind	67	350	1913	6061	13850	27166	47475	55790	67085	72196	75277	77925	78988	39,8	21,9	13,1	3,5	1,2	0,5
Solar and others	153	274	421	807	3427	9199	19127	21531	25900	29156	31241	32666	35097	10,7	23,3	18,8	3,1	1,9	1,2
Geothermal	3190	3447	3421	5331	6832	7372	8861	9083	9313	9619	9897	9949	10027	0,7	7,2	2,6	0,5	0,6	0,1
Net Imports	**756079**	**738600**	**826299**	**986048**	**979925**	**1028626**	**1011130**	**991603**	**959207**	**944014**	**938476**	**941536**	**944714**	**0,9**	**1,7**	**0,3**	**-0,5**	**-0,2**	**0,1**
Solids	81846	79338	98645	126639	121926	117364	103990	110841	97361	81198	69066	65468	62407	1,9	2,1	-1,6	-0,7	-3,4	-1,0
Oil	535645	512185	533039	599851	581615	598342	600353	585221	559786	554950	555216	558460	562003	0,0	0,9	0,3	-0,7	-0,1	0,1
- Crude oil and Feedstocks	508460	494000	513725	581995	578948	602707	609655	600707	580305	577397	579027	583528	588713	0,1	1,2	0,5	-0,5	0,0	0,2
- Oil products	27185	18185	19314	17856	2667	-4365	-9302	-15486	-20519	-22447	-23812	-25068	-26711	-3,4	-18,0				
Natural gas	135121	145288	192531	257366	272266	306353	289972	282741	287800	291897	295531	296951	296064	3,6	3,5	0,6	-0,1	0,3	0,0
Electricity	3323	1508	1686	971	264	-544	-1754	-1942	-2080	-2327	-2342	-2395	-2487	-6,6	-16,9				
Renewable energy forms	144	279	397	1222	3855	7112	18569	14741	16341	18296	21005	23052	26728	10,7	25,5	17,0	-1,3	2,5	2,4
Gross Inland Consumption	**1660159**	**1662517**	**1723099**	**1825989**	**1774841**	**1776206**	**1734308**	**1698742**	**1643155**	**1621172**	**1615915**	**1614511**	**1599130**	**0,4**	**0,3**	**-0,2**	**-0,5**	**-0,2**	**-0,1**
Solids	452940	364248	321007	319922	304204	282122	248488	247331	209785	181668	173631	169567	168124	-3,4	-0,5	-2,0	-1,7	-1,9	-0,3
Oil	631058	650858	658727	676859	635961	620474	597540	573443	544227	534653	528296	523865	519855	0,4	-0,4	-0,6	-0,9	-0,3	-0,2
Natural gas	294905	333268	393417	445998	437131	435380	400752	373325	361947	354745	346106	333338	324402	2,9	1,1	-0,9	-1,0	-0,4	-0,6
Nuclear	202589	223028	243761	257360	238973	238589	215041	219504	223045	237771	244630	260234	255129	1,9	-0,2	-1,0	0,4	0,9	0,4
Electricity	3323	1508	1686	971	264	-544	-1754	-1942	-2080	-2327	-2342	-2395	-2487	-6,6	-16,9				
Renewable energy forms	75343	89606	104501	124880	158307	200185	274242	287081	306231	314663	325594	329900	334107	3,3	4,2	5,6	1,1	0,6	0,3
as % in Gross Inland Consumption																			
Solids	27,3	21,9	18,6	17,5	17,1	15,9	14,3	14,6	12,8	11,2	10,7	10,5	10,5						
Oil	38,0	39,1	38,2	37,1	35,8	34,9	34,5	33,8	33,1	33,0	32,7	32,4	32,5						
Natural gas	17,8	20,0	22,8	24,4	24,6	24,5	23,1	22,0	22,0	21,9	21,4	20,6	20,3						
Nuclear	12,2	13,4	14,1	14,1	13,5	13,4	12,4	12,9	13,6	14,7	15,1	16,1	16,0						
Renewable energy forms	4,5	5,4	6,1	6,8	8,9	11,3	15,8	16,9	18,6	19,4	20,1	20,4	20,9						
Gross Electricity Generation in GWh_e	**2562823**	**2712209**	**2991720**	**3274121**	**3409804**	**3546574**	**3640517**	**3805418**	**3847929**	**3979537**	**4149864**	**4296838**	**4422136**	**1,6**	**1,3**	**0,7**	**0,6**	**0,8**	**0,6**
Nuclear	794718	881662	944823	997519	926760	926106	839746	869707	894285	960227	991575	1079581	1120310	1,7	-0,2	-1,0	0,6	1,0	1,2
Hydro & wind	292648	330306	375545	378836	501838	681666	961159	1088750	1265410	1360184	1423751	1476774	1521210	2,5	2,9	6,7	2,8	1,2	0,7
Thermal (incl. biomass)	1475456	1500241	1671352	1897765	1981205	1938802	1839613	1846961	1688233	1659125	1734538	1740483	1780616	1,3	1,7	-0,7	-0,9	0,3	0,3
Fuel Inputs for Thermal Power Generation	**383492**	**362334**	**382613**	**424208**	**434149**	**419199**	**395821**	**398462**	**366416**	**347988**	**348479**	**340828**	**341596**	**0,0**	**1,3**	**-0,9**	**-0,8**	**-0,5**	**-0,2**
Solids	263837	230040	223012	229245	232666	212875	183435	184448	151829	127468	120362	117510	117828	-1,7	0,4	-2,3	-1,9	-2,3	-0,2
Oil (including refinery gas)	54404	51463	39294	29780	17108	14834	10440	12597	14510	16582	19540	22211	22538	-3,2	-8,0	-4,8	3,3	3,0	1,4
Gas	56754	67806	102408	134637	143376	136764	121316	112813	108299	112591	113268	109781	108512	6,1	3,4	-1,7	-1,1	0,4	-0,4
Biomass & Waste	5724	10033	14960	25901	35172	48839	74498	82039	84752	84065	87709	83670	85006	10,1	8,9	7,8	1,3	0,3	-0,3
Geothermal heat	2774	2992	2939	4645	5828	5888	6132	6564	7026	7283	7598	7656	7712	0,6	7,1	0,5	1,4	0,8	0,1
Hydrogen - Methanol	0	0	0	0	0	0	0	0	0	0	0	0	0						
Fuel Input in other transformation proc.	**839073**	**814654**	**827098**	**842975**	**794312**	**793070**	**781338**	**760762**	**734148**	**723907**	**716872**	**711989**	**705504**	**-0,1**	**-0,4**	**-0,2**	**-0,6**	**-0,2**	**-0,2**
Refineries	679426	705954	735244	758152	718789	710799	691492	671673	645802	637512	631601	627440	623443	0,8	-0,2	-0,4	-0,7	-0,2	-0,1
Biofuels and hydrogen production	2	202	610	3129	12210	19254	29539	30956	33883	34869	35217	34918	34430	79,6	34,9	9,2	1,4	0,4	-0,2
District heating	32960	23240	19323	16212	15818	15954	15610	15606	15321	14660	13627	13260	12605	-5,2	-2,0	-0,1	-0,2	-1,2	-0,8
Others	126685	85258	71921	65482	47494	47063	44696	42526	39142	36866	36427	36370	35027	-5,5	-4,1	-0,6	-1,3	-0,7	-0,4
Energy Branch Consumption	**82379**	**88696**	**88176**	**96033**	**92227**	**89214**	**87026**	**83948**	**78533**	**76980**	**77640**	**78300**	**79205**	**0,7**	**0,5**	**-0,6**	**-1,0**	**-0,1**	**0,2**
Non-Energy Uses	**97931**	**110541**	**112495**	**117477**	**111506**	**113869**	**114247**	**112993**	**112051**	**111634**	**110888**	**110802**	**109755**	**1,4**	**-0,1**	**0,2**	**-0,2**	**-0,1**	**-0,1**
Final Energy Demand	**1068710**	**1069989**	**1112989**	**1173676**	**1165867**	**1194269**	**1192588**	**1162259**	**1132334**	**1124045**	**1122968**	**1122824**	**1117870**	**0,4**	**0,5**	**0,2**	**-0,5**	**-0,1**	**0,0**
by sector																			
Industry	365650	328513	326949	326308	312396	318694	318594	314412	309335	308420	310729	314529	319011	-1,1	-0,5	0,2	-0,3	0,0	0,3
- energy intensive industries	234722	214526	213112	210991	193236	194483	192043	186759	181214	177671	176330	175619	174559	-1,0	-1,0	-0,1	-0,6	-0,3	-0,1
- other industrial sectors	130928	113987	113837	115317	119160	124211	126551	127653	128121	130749	134399	138910	144452	-1,4	0,5	0,6	0,1	0,5	0,7
Residential	264307	280418	286784	308104	308367	314355	311436	298549	293725	289410	287820	286019	282827	0,8	0,7	0,1	-0,6	-0,2	-0,2
Tertiary	158484	160442	159866	176859	175093	179553	174102	166450	160488	159442	158306	157840	154982	0,1	0,9	-0,1	-0,8	-0,1	-0,2
Transport	280269	300617	339389	362405	370012	381667	388455	382848	368786	366772	366112	364437	361049	1,9	0,9	0,5	-0,5	-0,1	-0,1
by fuel																			
Solids	125031	84977	61454	54486	47428	45437	42767	41332	37414	35479	34747	34421	33170	-6,9	-2,6	-1,0	-1,3	-0,7	-0,5
Oil	444429	456959	478882	495857	476445	468217	455645	437218	412596	406540	402918	400377	395425	0,7	-0,1	-0,4	-1,0	-0,2	-0,2
Gas	227902	245996	265552	283524	265034	267981	245890	224175	215074	202873	192677	183372	177348	1,5	0,0	-0,7	-1,3	-1,1	-0,8
Electricity	184145	193367	216403	237537	248377	259589	265527	277752	281973	291640	303424	313299	320859	1,6	1,4	0,7	0,6	0,7	0,6
Heat (from CHP and District Heating) [A]	48610	44616	40061	44441	59478	71405	76954	81702	83418	86483	87578	88771	89161	-1,9	4,0	2,6	0,8	0,5	0,2
Other	38592	44073	50640	57832	69105	81640	105806	100081	101858	101030	101624	102583	101907	2,8	3,2	4,4	-0,4	0,0	0,0
CO_2 Emissions (Mt of CO_2 - sec approach)	**4030,6**	**3800,1**	**3810,6**	**3946,6**	**3771,6**	**3629,2**	**3314,9**	**3178,8**	**2912,7**	**2723,9**	**2571,6**	**2448,2**	**2322,3**	**-0,6**	**-0,1**	**-1,3**	**-1,3**	**-1,2**	**-1,0**
Power generation/District heating	1484,3	1321,2	1320,8	1381,1	1365,2	1263,1	1061,4	1050,4	907,3	788,9	683,5	601,9	513,4	-1,2	0,3	-2,5	-1,6	-2,8	-2,8
Energy Branch	152,2	171,0	170,2	181,6	157,5	143,4	131,4	119,7	108,8	93,3	84,2	72,0	68,5	1,1	-0,8	-1,8	-1,9	-2,5	-2,0
Industry	781,4	678,1	623,0	581,9	490,8	468,2	440,6	415,3	393,4	375,1	367,1	361,1	360,6	-2,2	-2,4	-1,1	-1,1	-0,7	-0,2
Residential	499,4	481,6	466,2	486,7	465,3	457,3	417,8	375,2	354,2	337,7	321,8	308,8	292,0	-0,7	0,0	-1,1	-1,6	-1,0	-1,0
Tertiary	300,5	275,3	242,0	262,2	244,5	234,9	212,6	189,1	172,6	162,0	151,2	144,6	136,5	-2,1	0,1	-1,4	-2,1	-1,3	-1,0
Transport	812,7	872,9	988,5	1053,1	1048,3	1062,3	1051,0	1029,3	976,4	967,0	963,8	959,8	951,3	2,0	0,6	0,0	-0,7	-0,1	-0,1
CO_2 Emissions Index (1990=100)	**100,0**	**94,3**	**94,5**	**97,9**	**93,6**	**90,0**	**82,2**	**78,9**	**72,3**	**67,6**	**63,8**	**60,7**	**57,6**						
CO_2 Emissions (Mt of CO_2 - ref approach)	**4172,0**	**3950,7**	**3922,7**	**4087,6**	**3837,6**	**3695,5**	**3382,8**	**3244,5**	**2979,3**	**2788,5**	**2634,7**	**2509,7**	**2388,3**	**-0,6**	**-0,2**	**-1,3**	**-1,3**	**-1,2**	**-1,0**

EU27: Reference Low Economic Growth scenario — SUMMARY ENERGY BALANCE AND INDICATORS (B)

	1990	1995	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050	'90-'00	'00-'10	'10-'20	'20-'30	'30-'40	'40-'50
														Annual % Change					
Main Energy System Indicators																			
Population (Million)	470,388	477,010	481,072	489,211	499,389	507,727	513,838	517,811	519,942	520,654	520,103	518,362	515,303	0,2	0,4	0,3	0,1	0,0	-0,1
GDP (in 000 MEuro'05)	8142,7	8748,4	10107,2	11063,1	11385,6	12503,7	13605,2	14595,0	15526,6	16426,8	17322,2	18267,5	19239,1	2,2	1,2	1,8	1,3	1,1	1,1
Gross Inl. Cons./GDP (toe/MEuro'05)	203,9	190,0	170,5	165,1	155,9	142,1	127,5	116,4	105,8	98,7	93,3	88,4	83,1	-1,8	-0,9	-2,0	-1,8	-1,3	-1,1
Gross Inl. Cons./Capita (toe/inhabitant)	3,53	3,49	3,58	3,73	3,55	3,50	3,38	3,28	3,16	3,11	3,11	3,11	3,10	0,1	-0,1	-0,5	-0,7	-0,2	0,0
Electricity Generated/Capita (kWh gross/inhabitant)	5448	5686	6219	6693	6828	6985	7085	7349	7401	7643	7979	8289	8582	1,3	0,9	0,4	0,4	0,8	0,7
Carbon intensity (t of CO_2/toe of GIC)	2,43	2,29	2,21	2,16	2,13	2,04	1,91	1,87	1,77	1,68	1,59	1,52	1,45	-0,9	-0,4	-1,1	-0,8	-1,1	-0,9
CO_2 Emissions/Capita (t of CO_2/inhabitant)	8,57	7,97	7,92	8,07	7,55	7,15	6,45	6,14	5,60	5,23	4,94	4,72	4,51	-0,8	-0,5	-1,6	-1,4	-1,2	-0,9
CO2 Emissions to GDP (t of CO2/MEuro'05)	495,0	434,4	377,0	356,7	331,3	290,2	243,7	217,8	187,6	165,8	148,5	134,0	120,7	-2,7	-1,3	-3,0	-2,6	-2,3	-2,0
Import Dependency %	44,6	43,5	46,8	52,5	53,7	56,3	56,6	56,7	56,6	56,4	56,3	56,5	57,3						
Energy intensity indicators (2000=100)																			
Industry (Energy on Value added)	130,3	115,2	100,0	95,1	90,3	84,8	78,5	72,6	67,7	64,2	61,7	59,5	57,6	-2,6	-1,0	-1,4	-1,5	-0,9	-0,7
Residential (Energy on Private Income)	114,4	113,2	100,0	97,5	96,9	89,6	80,3	70,9	64,8	58,8	54,3	50,0	46,2	-1,3	-0,3	-1,9	-2,1	-1,8	-1,6
Tertiary (Energy on Value added)	126,5	117,0	100,0	99,4	94,7	87,7	77,8	69,1	62,3	58,4	54,8	51,5	47,9	-2,3	-0,5	-1,9	-2,2	-1,3	-1,3
Transport (Energy on GDP)	102,5	102,3	100,0	97,6	96,8	90,9	85,0	78,1	70,7	66,5	62,9	59,4	55,9	-0,2	-0,3	-1,3	-1,8	-1,2	-1,2
Carbon Intensity indicators																			
Electricity and Steam production (t of CO_2/MWh)	0,46	0,40	0,37	0,35	0,32	0,28	0,22	0,21	0,18	0,15	0,13	0,11	0,09	-2,1	-1,5	-3,5	-2,1	-3,5	-3,3
Final energy demand (t of CO_2/toe)	2,24	2,16	2,08	2,03	1,93	1,86	1,78	1,73	1,67	1,64	1,61	1,58	1,56	-0,7	-0,8	-0,8	-0,6	-0,4	-0,3
Industry	2,14	2,06	1,91	1,78	1,57	1,47	1,38	1,32	1,27	1,22	1,18	1,15	1,13	-1,1	-1,9	-1,3	-0,8	-0,7	-0,4
Residential	1,89	1,72	1,63	1,58	1,51	1,45	1,34	1,26	1,21	1,17	1,12	1,08	1,03	-1,5	-0,7	-1,2	-1,1	-0,8	-0,8
Tertiary	1,90	1,72	1,51	1,48	1,40	1,31	1,22	1,14	1,08	1,02	0,96	0,92	0,88	-2,2	-0,8	-1,3	-1,3	-1,2	-0,8
Transport	2,90	2,90	2,91	2,91	2,83	2,78	2,71	2,69	2,65	2,64	2,63	2,63	2,63	0,0	-0,3	-0,5	-0,2	-0,1	0,0
Electricity and steam generation																			
Net Generation Capacity in MW_e			**654125**	**715732**	**820302**	**917001**	**1008635**	**1041998**	**1114218**	**1167080**	**1223532**	**1282130**	**1332260**		**2,3**	**2,1**	**1,0**	**0,9**	**0,9**
Nuclear energy			133923	134409	127038	126752	123736	113246	115835	122226	124174	132588	138575		-0,5	-0,3	-0,7	0,7	1,1
Renewable energy			112878	147262	209023	279278	397750	448906	522682	563776	591587	616938	643052		6,4	6,6	2,8	1,2	0,8
Hydro (pumping excluded)			99714	104505	107315	110765	114160	115440	117367	118744	119046	119875	121060		0,7	0,6	0,3	0,1	0,2
Wind			12793	40584	86153	140082	228571	263271	309575	329210	341594	352536	357648		21,0	10,2	3,1	1,0	0,5
Solar			371	2172	15307	27855	53352	67338	91599	111359	126122	139101	158252		45,1	13,3	5,6	3,2	2,3
Other renewables (tidal etc.)			0	1	249	575	1667	2857	4141	4463	4825	5425	6092			21,0	9,5	1,5	2,4
Thermal power			407324	434061	484241	510971	487149	479846	475701	481078	507771	532603	550632		1,7	0,1	-0,2	0,7	0,8
of which cogeneration units			75904	85934	100505	111834	115771	122900	127450	138698	154273	169250	172553		2,8	1,4	1,0	1,9	1,1
of which CCS units			0	0	0	0	5394	5434	6107	11077	25615	41330	60069				1,2	15,4	8,9
Solids fired			194165	186620	183870	182485	163133	146101	128524	114275	113957	110176	110793		-0,5	-1,2	-2,4	-1,2	-0,3
Gas fired			129444	167173	219348	238458	228127	224079	234770	255062	258866	245279	212265		5,4	0,4	0,3	1,0	-2,0
Oil fired			71058	62082	56070	47003	36127	41149	39971	38440	57337	95207	141825		-2,3	-4,3	1,0	3,7	9,5
Biomass-waste fired			12051	17502	24171	42238	58943	67641	71498	72330	76598	80921	84721		7,2	9,3	1,9	0,7	1,0
Hydrogen plants			0	0	0	0	0	0	0	0	0	0	0						
Geothermal heat			605	684	783	786	818	876	937	971	1013	1021	1028		2,6	0,4	1,4	0,8	0,1
Load factor for net electric capacities (%)			49,1	49,1	45,1	42,1	39,3	39,8	37,7	37,3	36,9	36,4	35,8						
Indicators for gross electricity production																			
Efficiency for thermal electricity production (%)			37,6	38,5	39,2	39,8	40,0	39,9	39,6	41,0	42,8	43,9	44,8						
CHP indicator (% of electricity from CHP)			11,4	11,7	15,0	17,8	18,8	18,8	18,6	20,2	21,4	22,3	22,0						
CCS indicator (% of electricity from CCS)			0,0	0,0	0,0	0,0	1,4	1,4	1,6	2,8	5,7	8,6	12,1						
Non fossil fuels in electricity generation (%)			45,8	44,8	45,9	50,6	57,3	59,8	64,7	66,7	66,9	67,7	67,9						
- nuclear			31,6	30,5	27,2	26,1	23,1	22,9	23,2	24,1	23,9	25,1	25,3						
- renewable energy forms and industrial waste			14,2	14,3	18,7	24,5	34,2	37,0	41,5	42,5	43,0	42,5	42,5						
Indicators for renewables (excluding industrial waste) (%) [(B)]																			
RES in gross final energy demand (%)			7,6	8,6	11,4	14,7	20,4	21,9	24,1	24,9	25,7	25,9	26,4						
RES in transport (%)			0,5	1,4	4,3	6,6	10,1	10,9	12,6	13,1	13,3	13,3	13,3						
Transport sector																			
Passenger transport activity (Gpkm)	**4880,7**	**5307,7**	**5892,2**	**6240,3**	**6511,3**	**7013,0**	**7503,5**	**7946,7**	**8344,0**	**8643,1**	**8964,8**	**9191,6**	**9398,3**	**1,9**	**1,0**	**1,4**	**1,1**	**0,7**	**0,5**
Public road transport	544,0	504,0	517,6	526,0	545,0	562,1	591,3	614,6	632,7	645,1	659,9	668,2	676,2	-0,5	0,5	0,8	0,7	0,4	0,2
Private cars and motorcycles	3501,1	3986,3	4428,1	4686,5	4866,1	5211,0	5505,7	5759,4	5986,6	6159,8	6340,8	6450,0	6539,2	2,4	0,9	1,2	0,8	0,6	0,3
Rail	472,5	421,7	447,9	461,0	482,5	515,6	555,5	596,2	631,8	664,9	701,9	729,8	754,6	-0,5	0,7	1,4	1,3	1,1	0,7
Aviation	317,3	351,3	456,9	527,3	576,9	683,0	808,0	932,1	1047,4	1127,1	1214,9	1295,5	1379,4	3,7	2,4	3,4	2,6	1,5	1,3
Inland navigation	45,8	44,4	41,7	39,5	40,8	41,2	42,9	44,5	45,5	46,3	47,4	48,0	48,8	-0,9	-0,2	0,5	0,6	0,4	0,3
Travel per person (km per capita)	10376	11127	12248	12756	13039	13813	14603	15347	16048	16601	17237	17732	18238	1,7	0,6	1,1	0,9	0,7	0,6
Freight transport activity (Gtkm)	**1848,4**	**1942,4**	**2195,7**	**2494,6**	**2662,6**	**2911,2**	**3038,4**	**3137,2**	**3212,2**	**3268,1**	**3311,5**	**3336,5**	**3334,5**	**1,7**	**1,9**	**1,3**	**0,6**	**0,3**	**0,1**
Trucks	1060,4	1288,7	1518,7	1800,3	1940,3	2137,7	2228,2	2301,2	2359,2	2402,5	2437,3	2459,4	2459,4	3,7	2,5	1,4	0,6	0,3	0,1
Rail	526,3	386,1	403,7	414,1	440,5	481,0	507,1	524,5	536,5	545,8	553,3	557,2	558,6	-2,6	0,9	1,4	0,6	0,3	0,1
Inland navigation	261,6	267,6	273,3	280,2	281,9	292,5	303,1	311,5	316,5	319,7	320,9	319,9	316,6	0,4	0,3	0,7	0,4	0,1	-0,1
Freight activity per unit of GDP (tkm/000 Euro'05)	227	222	217	225	234	233	223	215	207	199	191	183	173	-0,4	0,7	-0,5	-0,8	-0,8	-1,0
Energy demand in transport (ktoe)	**280269**	**300617**	**339389**	**362405**	**370012**	**381667**	**388455**	**382848**	**368786**	**366772**	**366112**	**364437**	**361049**	**1,9**	**0,9**	**0,5**	**-0,5**	**-0,1**	**-0,1**
Public road transport	5197	4732	4914	5039	5182	5223	5239	5161	5030	5003	4988	4835	4650	-0,6	0,5	0,1	-0,4	-0,1	-0,7
Private cars and motorcycles	154395	166321	182974	187736	186451	182339	180817	173226	163247	159731	158146	155069	152943	1,7	0,2	-0,3	-1,0	-0,3	-0,3
Trucks	74969	79037	90951	105104	111606	121467	123197	122945	120492	120737	120885	120408	119478	2,0	2,1	1,0	-0,2	0,0	-0,1
Rail	9560	9452	9600	9436	9597	9983	9722	9298	8103	7935	7972	7934	7843	0,0	0,0	0,1	-1,8	-0,2	-0,2
Aviation	29038	34112	45395	49703	51709	57141	63744	66294	65892	67281	67991	70062	70046	4,6	1,3	2,1	0,3	0,3	0,3
Inland navigation	7110	6963	5555	5386	5466	5514	5737	5924	6022	6085	6131	6129	6089	-2,4	-0,2	0,5	0,5	0,2	-0,1
Efficiency indicator (activity related)																			
Passenger transport (toe/Mpkm)	39,6	39,5	40,3	39,5	38,0	35,5	33,8	31,3	28,6	27,3	26,3	25,5	24,7	0,2	-0,6	-1,2	-1,7	-0,8	-0,6
Freight transport (toe/Mtkm)	47,1	46,8	46,3	46,5	46,1	45,7	44,3	42,7	40,6	39,9	39,5	39,0	38,7	-0,2	-0,1	-0,4	-0,9	-0,3	-0,2

1bis. Current Policy Initiatives scenario

EU27: Current Policy Initiatives scenario														SUMMARY ENERGY BALANCE AND INDICATORS (A)					
ktoe	1990	1995	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050	'90-'00	'00-'10	'10-'20	'20-'30	'30-'40	'40-'50
														Annual % Change					
Production	**936047**	**950181**	**941860**	**900326**	**837026**	**805387**	**776345**	**746662**	**716019**	**722881**	**723028**	**725625**	**702833**	**0,1**	**-1,2**	**-0,7**	**-0,8**	**0,1**	**-0,3**
Solids	366477	277810	213423	196277	177948	167710	142792	133720	108664	102483	94040	98126	97033	-5,3	-1,8	-2,2	-2,7	-1,4	0,3
Oil	129551	171052	173006	134290	104398	74031	47982	39510	36057	31092	24091	15949	7609	2,9	-4,9	-7,5	-2,8	-4,0	-10,9
Natural gas	162447	188965	207559	188677	164866	129037	110504	91051	76179	65307	54304	39637	30443	2,5	-2,3	-3,9	-3,7	-3,3	-5,6
Nuclear	202589	223028	243761	257360	235016	237233	223904	211481	197877	217023	224567	232068	218790	1,9	-0,4	-0,5	-1,2	1,3	-0,3
Renewable energy sources	74984	89326	104111	123722	154799	197376	251162	270899	297242	306976	326026	339846	348958	3,3	4,0	5,0	1,7	0,9	0,7
Hydro	25101	28054	30374	26395	30008	30230	30742	31447	31950	32393	32885	33307	33634	1,9	-0,1	0,2	0,4	0,3	0,2
Biomass & Waste	46473	57201	67982	85129	102157	123309	146810	154243	159433	156911	160094	164043	162408	3,9	4,2	3,7	0,8	0,0	0,1
Wind	67	350	1913	6061	12781	26970	46373	54479	69420	76665	85809	91856	98027	39,8	20,9	13,8	4,1	2,1	1,3
Solar and others	153	274	421	807	3449	9398	18597	21678	26902	31099	37025	40331	44463	10,7	23,4	18,4	3,8	3,2	1,8
Geothermal	3190	3447	3421	5331	6404	7468	8640	9053	9537	9908	10213	10309	10427	0,7	6,5	3,0	1,0	0,7	0,2
Net Imports	**756079**	**738600**	**826299**	**986048**	**965395**	**1049565**	**977353**	**982714**	**969153**	**960489**	**952968**	**956662**	**970866**	**0,9**	**1,6**	**0,1**	**-0,1**	**-0,2**	**0,2**
Solids	81846	79338	98645	126639	102078	115497	95406	96317	86298	71531	59790	53306	55097	1,9	0,3	-0,7	-1,0	-3,6	-0,8
Oil	535645	512185	533039	599851	580911	609332	595279	593366	574554	568907	564756	564377	565740	0,0	0,9	0,2	-0,4	-0,2	0,0
- Crude oil and Feedstocks	508460	494000	513725	581995	578386	611451	607203	607062	591933	587692	585536	586758	590001	0,1	1,2	0,5	-0,3	-0,1	0,1
- Oil products	27185	18185	19314	17856	2525	-2119	-11924	-13696	-17379	-18786	-20781	-22380	-24262	-3,4	-18,4				
Natural gas	135121	145288	192531	257366	277819	318023	271055	280810	293286	303378	309596	316761	323814	3,6	3,7	-0,2	0,8	0,5	0,5
Electricity	3323	1508	1686	971	696	-540	-1990	-2558	-1672	-1689	-2228	-2318	-2616	-6,6	-8,5				
Renewable energy forms	144	279	397	1222	3891	7253	17603	14779	16687	18362	21055	24536	28832	10,7	25,6	16,3	-0,5	2,4	3,2
Gross Inland Consumption	**1660159**	**1662517**	**1723099**	**1825989**	**1752370**	**1802836**	**1700364**	**1674909**	**1629357**	**1626479**	**1618141**	**1623657**	**1614786**	**0,4**	**0,2**	**-0,3**	**-0,4**	**-0,1**	**0,0**
Solids	452940	364248	321007	319922	280026	283208	238198	230037	194962	174014	153830	151432	152130	-3,4	-1,4	-1,6	-2,0	-2,3	-0,1
Oil	631058	650858	658727	676859	635257	631246	589927	578409	554930	543281	531352	522826	516760	0,4	-0,4	-0,7	-0,6	-0,4	-0,3
Natural gas	294905	333268	393417	445998	442685	447060	381559	371862	369465	368685	363900	356397	354256	2,9	1,2	-1,5	-0,3	-0,2	-0,3
Nuclear	202589	223028	243761	257360	235016	237233	223904	211481	197877	217023	224567	232068	218790	1,9	-0,4	-0,5	-1,2	1,3	-0,3
Electricity	3323	1508	1686	971	696	-540	-1990	-2558	-1672	-1689	-2228	-2318	-2616	-6,6	-8,5				
Renewable energy forms	75343	89606	104501	124880	158690	204629	268766	285678	313796	325165	346720	363253	375464	3,3	4,3	5,4	1,6	1,0	0,8
as % in Gross Inland Consumption																			
Solids	27,3	21,9	18,6	17,5	16,0	15,7	14,0	13,7	12,0	10,7	9,5	9,3	9,4						
Oil	38,0	39,1	38,2	37,1	36,3	35,0	34,7	34,5	34,1	33,4	32,8	32,2	32,0						
Natural gas	17,8	20,0	22,8	24,4	25,3	24,8	22,4	22,2	22,7	22,7	22,5	22,0	21,9						
Nuclear	12,2	13,4	14,1	14,1	13,4	13,2	13,2	12,6	12,1	13,3	13,9	14,3	13,5						
Renewable energy forms	4,5	5,4	6,1	6,8	9,1	11,4	15,8	17,1	19,3	20,0	21,4	22,4	23,3						
Gross Electricity Generation in GWh_e	**2562823**	**2712209**	**2991720**	**3274121**	**3312980**	**3613745**	**3645321**	**3762072**	**3780339**	**3990186**	**4222325**	**4447319**	**4620421**	**1,6**	**1,0**	**1,0**	**0,4**	**1,1**	**0,9**
Nuclear	794718	881662	944823	997519	911418	920491	871965	833383	782075	864300	898050	944006	952038	1,7	-0,4	-0,4	-1,1	1,4	0,6
Hydro & wind	292648	330306	375545	378836	514979	698335	967118	1093798	1316289	1445535	1620977	1735525	1855756	2,5	3,2	6,5	3,1	2,1	1,4
Thermal (incl. biomass)	1475456	1500241	1671352	1897765	1886583	1994918	1806239	1834891	1681975	1680351	1703298	1767788	1812628	1,3	1,2	-0,4	-0,7	0,1	0,6
Fuel Inputs for Thermal Power Generation	**383492**	**362334**	**382613**	**424208**	**410755**	**427883**	**389444**	**392044**	**361342**	**350349**	**339566**	**339866**	**343621**	**0,0**	**0,7**	**-0,5**	**-0,7**	**-0,6**	**0,1**
Solids	263837	230040	223012	229245	208913	212061	172763	167428	136756	118877	100480	98977	99662	-1,7	-0,7	-1,9	-2,3	-3,0	-0,1
Oil (including refinery gas)	54404	51463	39294	29780	15695	15188	8979	12402	12388	15436	17387	20231	20607	-3,2	-8,8	-5,4	3,3	3,4	1,7
Gas	56754	67806	102408	134637	145390	142400	125116	122606	120044	123468	125568	121715	124120	6,1	3,6	-1,5	-0,4	0,5	-0,1
Biomass & Waste	5724	10033	14960	25901	35356	52271	76372	82943	85031	85162	88407	91143	91361	10,1	9,0	8,0	1,1	0,4	0,3
Geothermal heat	2774	2992	2939	4645	5400	5963	6213	6664	7122	7406	7724	7800	7872	0,6	6,3	1,4	1,4	0,8	0,2
Hydrogen - Methanol	0	0	0	0	0	0	0	0	0	0	0	0	0						
Fuel Input in other transformation proc.	**839073**	**814654**	**827098**	**842975**	**793113**	**803071**	**776300**	**766396**	**746743**	**736376**	**724836**	**717189**	**711318**	**-0,1**	**-0,4**	**-0,2**	**-0,4**	**-0,3**	**-0,2**
Refineries	679426	705954	735244	758152	718218	720744	689515	679553	659477	649983	640382	632962	627528	0,8	-0,2	-0,4	-0,4	-0,3	-0,2
Biofuels and hydrogen production	2	202	610	3129	12209	19513	28618	30946	34309	34435	34686	35133	35769	79,6	34,9	8,9	1,8	0,1	0,3
District heating	32960	23240	19323	16212	15409	15322	13687	13190	13423	14265	13242	12207	11198	-5,2	-2,2	-1,2	-0,2	-0,1	-1,7
Others	126685	85258	71921	65482	47277	47493	44479	42707	39533	37694	36527	36887	36823	-5,5	-4,1	-0,6	-1,2	-0,8	0,1
Energy Branch Consumption	**82379**	**88696**	**88176**	**96033**	**91074**	**90307**	**85126**	**83086**	**77769**	**76037**	**75036**	**74997**	**74079**	**0,7**	**0,3**	**-0,7**	**-0,9**	**-0,4**	**-0,1**
Non-Energy Uses	**97931**	**110541**	**112495**	**117477**	**111510**	**115326**	**117845**	**118225**	**119183**	**120291**	**121266**	**122262**	**123092**	**1,4**	**-0,1**	**0,6**	**0,1**	**0,2**	**0,1**
Final Energy Demand	**1068710**	**1069989**	**1112989**	**1173676**	**1160910**	**1214761**	**1157872**	**1148252**	**1136214**	**1138392**	**1141619**	**1151330**	**1156559**	**0,4**	**0,4**	**0,0**	**-0,2**	**0,0**	**0,1**
by sector																			
Industry	365650	328513	326949	326308	310965	322828	318673	315968	314300	318427	327826	338492	350391	-1,1	-0,5	0,2	-0,1	0,4	0,7
- energy intensive industries	234722	214526	213112	210991	192086	196730	191465	187221	183614	182826	184911	187198	189754	-1,0	-1,0	0,0	-0,4	0,1	0,3
- other industrial sectors	130928	113987	113837	115317	118878	126099	127208	128747	130686	135602	142915	151294	160638	-1,4	0,4	0,7	0,3	0,9	1,2
Residential	264307	280418	286784	308104	306404	320964	289275	282307	281757	281704	280210	280297	277205	0,8	0,7	-0,6	-0,3	-0,1	-0,1
Tertiary	158484	160442	159866	176859	173576	183822	167174	165382	164934	166522	167126	168815	168144	0,1	0,8	-0,4	-0,1	0,1	0,1
Transport	280269	300617	339389	362405	369964	387147	382749	384595	375223	371739	366457	363726	360820	1,9	0,9	0,3	-0,2	-0,2	-0,2
by fuel																			
Solids	125031	84977	61454	54486	47496	47065	43019	40725	37186	34923	34368	34026	33887	-6,9	-2,5	-1,0	-1,4	-0,8	-0,1
Oil	444429	456959	478882	495857	477192	477043	445487	437131	418452	409529	399224	392154	383567	0,7	0,0	-0,7	-0,6	-0,5	-0,4
Gas	227902	245996	265552	283524	268367	273535	226044	214901	212684	205436	198786	196074	192096	1,5	0,1	-1,7	-0,6	-0,7	-0,3
Electricity	184145	193367	216403	237537	241828	264545	267064	275001	278517	294300	310981	327092	339827	1,6	1,1	1,0	0,4	1,1	0,9
Heat (from CHP and District Heating) [(A)]	48610	44616	40061	44441	57335	71257	77936	82605	85099	91632	93998	96950	98920	-1,9	3,7	3,1	0,9	1,0	0,5
Other	38592	44073	50640	57832	68692	81316	98321	97888	104276	102572	104261	105034	108261	2,8	3,1	3,7	0,6	0,0	0,4
CO_2 Emissions (Mt of CO_2 - sec approach)	**4030,6**	**3800,1**	**3810,6**	**3946,6**	**3686,1**	**3688,6**	**3211,3**	**3122,7**	**2904,1**	**2753,4**	**2536,8**	**2414,6**	**2367,4**	**-0,6**	**-0,3**	**-1,4**	**-1,0**	**-1,3**	**-0,7**
Power generation/District heating	1484,3	1321,2	1320,8	1381,1	1269,1	1273,8	1035,4	1017,4	886,4	803,7	647,7	564,8	553,3	-1,2	-0,4	-2,0	-1,5	-3,1	-1,6
Energy Branch	152,2	171,0	170,2	181,6	157,4	146,3	130,1	121,3	110,3	94,8	82,6	68,6	68,3	1,1	-0,8	-1,9	-1,6	-2,8	-1,9
Industry	781,4	678,1	623,0	581,9	497,8	483,8	442,1	419,0	399,4	383,3	382,1	391,4	399,3	-2,2	-2,2	-1,2	-1,0	-0,4	0,4
Residential	499,4	481,6	466,2	486,7	467,3	467,1	380,6	351,3	341,7	332,1	318,6	308,7	293,1	-0,7	0,0	-2,0	-1,1	-0,7	-0,8
Tertiary	300,5	275,3	242,0	262,2	246,3	240,1	187,0	180,9	178,7	173,8	166,7	162,6	156,8	-2,1	0,2	-2,7	-0,5	-0,7	-0,6
Transport	812,7	872,9	988,5	1053,1	1048,2	1077,6	1036,1	1032,8	987,7	965,8	939,1	918,6	896,6	2,0	0,6	-0,1	-0,5	-0,5	-0,5
CO_2 Emissions Index (1990=100)	**100,0**	**94,3**	**94,5**	**97,9**	**91,5**	**91,5**	**79,7**	**77,5**	**72,1**	**68,3**	**62,9**	**59,9**	**58,7**						
CO_2 Emissions (Mt of CO_2 - ref approach)	**4172,0**	**3950,7**	**3922,7**	**4087,6**	**3753,2**	**3756,3**	**3280,2**	**3189,8**	**2972,4**	**2819,5**	**2601,4**	**2477,3**	**2434,3**	**-0,6**	**-0,4**	**-1,3**	**-1,0**	**-1,3**	**-0,7**

EU27: Current Policy Initiatives scenario														SUMMARY ENERGY BALANCE AND INDICATORS (B)					
	1990	1995	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050	'90-'00	'00-'10	'10-'20	'20-'30	'30-'40	'40-'50
														Annual % Change					
Main Energy System Indicators																			
Population (Million)	470,388	477,010	481,072	489,211	499,389	507,727	513,838	517,811	519,942	520,654	520,103	518,362	515,303	0,2	0,4	0,3	0,1	0,0	-0,1
GDP (in 000 MEuro'05)	8142,7	8748,4	10107,2	11063,1	11385,6	12750,3	14164,0	15503,7	16824,7	18157,1	19527,9	21002,9	22560,0	2,2	1,2	2,2	1,7	1,5	1,5
Gross Inl. Cons./GDP (toe/MEuro'05)	203,9	190,0	170,5	165,1	153,9	141,4	120,0	108,0	96,8	89,6	82,9	77,3	71,6	-1,8	-1,0	-2,5	-2,1	-1,5	-1,5
Gross Inl. Cons./Capita (toe/inhabitant)	3,53	3,49	3,58	3,73	3,51	3,55	3,31	3,23	3,13	3,12	3,11	3,13	3,13	0,1	-0,2	-0,6	-0,5	-0,1	0,1
Electricity Generated/Capita (kWh gross/inhabitant)	5448	5686	6219	6693	6634	7117	7094	7265	7271	7664	8118	8580	8966	1,3	0,6	0,7	0,2	1,1	1,0
Carbon intensity (t of CO_2/toe of GIC)	2,43	2,29	2,21	2,16	2,10	2,05	1,89	1,86	1,78	1,69	1,57	1,49	1,47	-0,9	-0,5	-1,1	-0,6	-1,3	-0,7
CO_2 Emissions/Capita (t of CO_2/inhabitant)	8,57	7,97	7,92	8,07	7,38	7,26	6,25	6,03	5,59	5,29	4,88	4,66	4,59	-0,8	-0,7	-1,7	-1,1	-1,3	-0,6
CO2 Emissions to GDP (t of CO2/MEuro'05)	495,0	434,4	377,0	356,7	323,7	289,3	226,7	201,4	172,6	151,6	129,9	115,0	104,9	-2,7	-1,5	-3,5	-2,7	-2,8	-2,1
Import Dependency %	44,6	43,5	46,8	52,5	53,6	56,6	55,7	56,8	57,5	57,1	56,9	56,9	58,0						
Energy intensity indicators (2000=100)																			
Industry (Energy on Value added)	130,3	115,2	100,0	95,1	89,9	84,6	75,6	68,9	63,7	60,1	57,8	55,8	54,1	-2,6	-1,1	-1,7	-1,7	-1,0	-0,7
Residential (Energy on Private Income)	114,4	113,2	100,0	97,5	96,3	89,7	73,1	65,9	61,0	56,0	51,9	47,9	44,4	-1,3	-0,4	-2,7	-1,8	-1,6	-1,5
Tertiary (Energy on Value added)	126,5	117,0	100,0	99,4	93,9	88,0	71,7	64,5	59,1	55,1	51,2	47,9	44,3	-2,3	-0,6	-2,7	-1,9	-1,4	-1,5
Transport (Energy on GDP)	102,5	102,3	100,0	97,6	96,8	90,4	80,5	73,9	66,4	61,0	55,9	51,6	47,6	-0,2	-0,3	-1,8	-1,9	-1,7	-1,6
Carbon Intensity indicators																			
Electricity and Steam production (t of CO_2/MWh)	0,46	0,40	0,37	0,35	0,31	0,27	0,22	0,21	0,18	0,15	0,12	0,10	0,09	-2,1	-2,0	-3,4	-2,0	-4,1	-2,3
Final energy demand (t of CO_2/toe)	2,24	2,16	2,08	2,03	1,95	1,87	1,77	1,73	1,68	1,63	1,58	1,55	1,51	-0,7	-0,7	-1,0	-0,5	-0,6	-0,5
Industry	2,14	2,06	1,91	1,78	1,60	1,50	1,39	1,33	1,27	1,20	1,17	1,16	1,14	-1,1	-1,7	-1,4	-0,9	-0,9	-0,2
Residential	1,89	1,72	1,63	1,58	1,53	1,46	1,32	1,24	1,21	1,18	1,14	1,10	1,06	-1,5	-0,6	-1,5	-0,8	-0,6	-0,7
Tertiary	1,90	1,72	1,51	1,48	1,42	1,31	1,12	1,09	1,08	1,04	1,00	0,96	0,93	-2,2	-0,6	-2,3	-0,3	-0,8	-0,7
Transport	2,90	2,90	2,91	2,91	2,83	2,78	2,71	2,69	2,63	2,60	2,56	2,53	2,48	0,0	-0,3	-0,5	-0,3	-0,3	-0,3
Electricity and steam generation																			
Net Generation Capacity in MW_e			**654168**	**715466**	**821506**	**927968**	**1013372**	**1045670**	**1123061**	**1197316**	**1311405**	**1414578**	**1501619**		**2,3**	**2,1**	**1,0**	**1,6**	**1,4**
Nuclear energy			133966	134452	131393	125743	124707	105768	101557	106734	110775	116332	116922		-0,2	-0,5	-2,0	0,9	0,5
Renewable energy			112878	147262	206776	279103	393538	446051	534888	589105	671048	725267	783812		6,2	6,6	3,1	2,3	1,6
Hydro (pumping excluded)			99714	104505	107315	111368	114584	116108	117567	119359	120037	121142	122241		0,7	0,7	0,3	0,2	0,2
Wind			12793	40584	83905	139251	223516	257880	317537	345380	381920	406916	431501		20,7	10,3	3,6	1,9	1,2
Solar			371	2172	15307	27909	53760	69195	95654	120062	164310	191934	223547		45,1	13,4	5,9	5,6	3,1
Other renewables (tidal etc.)			0	1	249	575	1678	2868	4130	4304	4781	5276	6523			21,0	9,4	1,5	3,2
Thermal power			407324	433752	483337	523122	495127	493851	486617	501477	529582	572979	600885		1,7	0,2	-0,2	0,8	1,3
of which cogeneration units			76323	85573	98206	117216	121639	129744	136540	151746	168594	189716	200582		2,6	2,2	1,2	2,1	1,8
of which CCS units			0	0	0	0	2711	2711	2858	7130	21494	33685	38601				0,5	22,4	6,0
Solids fired			194165	186620	183632	182385	157369	141203	123174	109336	106993	107732	103963		-0,6	-1,5	-2,4	-1,4	-0,3
Gas fired			129444	166863	218425	248820	240901	246498	256144	286580	311450	340496	365540		5,4	1,0	0,6	2,0	1,6
Oil fired			71058	62082	55989	46686	35662	35490	32806	30468	31211	35959	37959		-2,4	-4,4	-0,8	-0,5	2,0
Biomass-waste fired			12051	17502	24564	44434	60366	69771	73543	74105	78898	87751	92374		7,4	9,4	2,0	0,7	1,6
Hydrogen plants			0	0	0	0	0	0	0	0	0	0	0						
Geothermal heat			605	686	727	796	829	889	950	987	1030	1040	1049		1,9	1,3	1,4	0,8	0,2
Load factor for net electric capacities (%)			49,1	49,1	43,8	42,4	39,3	39,3	36,9	36,5	35,2	34,3	33,6						
Indicators for gross electricity production																			
Efficiency for thermal electricity production (%)			37,6	38,5	39,5	40,1	39,9	40,3	40,0	41,2	43,1	44,7	45,4						
CHP indicator (% of electricity from CHP)			11,4	11,7	14,9	19,0	20,2	20,9	21,0	23,0	24,4	25,3	25,4						
CCS indicator (% of electricity from CCS)			0,0	0,0	0,0	0,0	0,7	0,7	0,8	1,8	4,9	7,2	7,6						
Non fossil fuels in electricity generation (%)			45,8	44,8	47,3	50,3	58,4	59,8	64,3	66,4	68,3	68,9	69,4						
- nuclear			31,6	30,5	27,5	25,5	23,9	22,2	20,7	21,7	21,3	21,2	20,6						
- renewable energy forms and industrial waste			14,2	14,3	19,8	24,9	34,5	37,7	43,7	44,8	47,0	47,7	48,8						
Indicators for renewables (excluding industrial waste) (%) (B)																			
RES in gross final energy demand (%)			7,6	8,6	11,4	14,7	20,6	22,1	24,7	25,5	27,0	27,9	29,0						
RES in transport (%)			0,5	1,4	4,3	6,6	10,0	10,9	13,1	14,6	16,3	18,1	19,9						
Transport sector																			
Passenger transport activity (Gpkm)	**4880,7**	**5307,7**	**5892,2**	**6240,3**	**6511,3**	**7131,9**	**7500,5**	**7937,8**	**8374,0**	**8704,3**	**8990,6**	**9239,0**	**9449,4**	**1,9**	**1,0**	**1,4**	**1,1**	**0,7**	**0,5**
Public road transport	544,0	504,0	517,6	526,0	545,0	573,7	622,1	629,4	642,5	655,1	667,8	677,9	685,0	-0,5	0,5	1,3	0,3	0,4	0,3
Private cars and motorcycles	3501,1	3986,3	4428,1	4686,5	4866,0	5288,2	5442,3	5707,8	5975,4	6199,1	6358,1	6487,7	6566,1	2,4	0,9	1,1	0,9	0,6	0,3
Rail	472,5	421,7	447,9	461,0	482,5	524,8	567,5	606,6	642,7	678,6	714,3	744,4	767,6	-0,5	0,7	1,6	1,3	1,1	0,7
Aviation	317,3	351,3	456,9	527,3	576,9	702,8	824,6	948,7	1066,9	1124,0	1202,0	1279,8	1380,8	3,7	2,4	3,6	2,6	1,2	1,4
Inland navigation	45,8	44,4	41,7	39,5	40,8	42,5	43,9	45,3	46,5	47,5	48,4	49,2	49,8	-0,9	-0,2	0,7	0,6	0,4	0,3
Travel per person (km per capita)	10376	11127	12248	12756	13038	14047	14597	15329	16106	16718	17286	17823	18337	1,7	0,6	1,1	1,0	0,7	0,6
Freight transport activity (Gtkm)	**1848,4**	**1942,4**	**2195,7**	**2494,6**	**2662,6**	**2952,2**	**3034,2**	**3216,0**	**3392,2**	**3540,0**	**3661,9**	**3765,9**	**3842,6**	**1,7**	**1,9**	**1,3**	**1,1**	**0,8**	**0,5**
Trucks	1060,4	1288,7	1518,7	1800,3	1940,3	2164,4	2188,8	2327,7	2468,1	2583,2	2675,6	2756,1	2814,6	3,7	2,5	1,2	1,2	0,8	0,5
Rail	526,3	386,1	403,7	414,1	440,5	488,9	528,8	556,7	580,4	602,6	623,7	641,0	655,9	-2,6	0,9	1,8	0,9	0,7	0,5
Inland navigation	261,6	267,6	273,3	280,2	281,9	299,0	316,6	331,7	343,8	354,2	362,6	368,7	372,1	0,4	0,3	1,2	0,8	0,5	0,3
Freight activity per unit of GDP (tkm/000 Euro'05)	227	222	217	225	234	232	214	207	202	195	188	179	170	-0,4	0,7	-0,9	-0,6	-0,7	-1,0
Energy demand in transport (ktoe)	**280269**	**300617**	**339389**	**362405**	**369964**	**387147**	**382749**	**384595**	**375223**	**371739**	**366457**	**363726**	**360820**	**1,9**	**0,9**	**0,3**	**-0,2**	**-0,2**	**-0,2**
Public road transport	5197	4732	4914	5039	5182	5315	5453	5220	5049	4935	4857	4717	4541	-0,6	0,5	0,5	-0,8	-0,4	-0,7
Private cars and motorcycles	154395	166321	182974	187736	186407	184711	175412	172112	164284	158346	151677	146045	141786	1,7	0,2	-0,6	-0,7	-0,8	-0,7
Trucks	74969	79037	90951	105104	111606	123125	121102	124119	124184	126725	127901	128575	129498	2,0	2,1	0,8	0,3	0,3	0,1
Rail	9560	9452	9600	9436	9594	10156	10082	9695	8533	8440	8568	8620	8605	0,0	0,0	0,5	-1,7	0,0	0,0
Aviation	29038	34112	45395	49703	51709	58141	64727	67225	66767	66741	66784	69024	69623	4,6	1,3	2,3	0,3	0,0	0,4
Inland navigation	7110	6963	5555	5386	5466	5699	5973	6224	6405	6552	6671	6744	6766	-2,4	-0,2	0,9	0,7	0,4	0,1
Efficiency indicator (activity related)																			
Passenger transport (toe/Mpkm)	39,6	39,5	40,3	39,5	38,0	35,4	33,3	31,3	28,7	26,9	25,3	24,3	23,3	0,2	-0,6	-1,3	-1,5	-1,2	-0,8
Freight transport (toe/Mtkm)	47,1	46,8	46,3	46,5	46,0	45,7	43,9	42,2	39,7	38,8	37,9	37,1	36,6	-0,2	-0,1	-0,5	-1,0	-0,5	-0,4

2. Energy Efficiency scenario

EU27: Energy efficiency														SUMMARY ENERGY BALANCE AND INDICATORS (A)					
ktoe	**1990**	**1995**	**2000**	**2005**	**2010**	**2015**	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**	**'90-'00**	**'00-'10**	**'10-'20**	**'20-'30**	**'30-'40**	**'40-'50**
														Annual % Change					
Production	**936047**	**950181**	**941860**	**900326**	**833839**	**803043**	**761596**	**694780**	**659682**	**659971**	**677363**	**685507**	**680022**	**0,1**	**-1,2**	**-0,9**	**-1,4**	**0,3**	**0,0**
Solids	366477	277810	213423	196277	177968	165896	132685	105933	84105	61497	48888	45343	41400	-5,3	-1,8	-2,9	-4,5	-5,3	-1,6
Oil	129551	171052	173006	134290	104398	73498	46081	34968	31144	22909	14606	6974	2193	2,9	-4,9	-7,9	-3,8	-7,3	-17,3
Natural gas	162447	188965	207559	188677	164866	129035	110135	89779	73329	60554	48415	33392	23763	2,5	-2,3	-4,0	-4,0	-4,1	-6,9
Nuclear	202589	223028	243761	257360	235016	237212	217631	187614	161520	165771	165576	157847	146133	1,9	-0,4	-0,8	-2,9	0,2	-1,2
Renewable energy sources	74984	89326	104111	123722	151591	197402	255065	276486	309583	349241	399878	441951	466532	3,3	3,8	5,3	2,0	2,6	1,6
Hydro	25101	28054	30374	26395	30008	30262	30768	31520	32079	32558	33059	33517	33906	1,9	-0,1	0,3	0,4	0,3	0,3
Biomass & Waste	46473	57201	67982	85129	98969	122484	146500	151294	154860	177498	203668	227210	235869	3,9	3,8	4,0	0,6	2,8	1,5
Wind	67	350	1913	6061	12781	27714	50673	61151	80495	90167	105631	115095	122373	39,8	20,9	14,8	4,7	2,8	1,5
Solar and others	153	274	421	807	3436	9426	18321	22558	29364	35042	42746	49933	57105	10,7	23,3	18,2	4,8	3,8	2,9
Geothermal	3190	3447	3421	5331	6398	7515	8803	9963	12785	13977	14775	16196	17279	0,7	6,5	3,2	3,8	1,5	1,6
Net Imports	**756079**	**738600**	**826299**	**986048**	**969505**	**1045609**	**935509**	**869497**	**843906**	**748776**	**638784**	**540949**	**447418**	**0,9**	**1,6**	**-0,4**	**-1,0**	**-2,7**	**-3,5**
Solids	81846	79338	98645	126639	103139	114716	90982	66752	47554	25532	10900	787	2967	1,9	0,4	-1,2	-6,3	-13,7	-12,2
Oil	535645	512185	533039	599851	580690	607132	577878	538823	515852	442342	350767	255642	190463	0,0	0,9	0,0	-1,1	-3,8	-5,9
- Crude oil and Feedstocks	508460	494000	513725	581995	578257	599933	574739	540765	519973	449730	362486	278648	213455	0,1	1,2	-0,1	-1,0	-3,5	-5,2
- Oil products	27185	18185	19314	17856	2433	7199	3139	-1942	-4121	-7388	-11719	-23005	-22993	-3,4	-18,7	2,6			
Natural gas	135121	145288	192531	257366	277990	316766	254933	258021	274177	272660	266365	268387	232950	3,6	3,7	-0,9	0,7	-0,3	-1,3
Electricity	3323	1508	1686	971	696	-620	-2172	-2767	-2085	-2423	-2391	-2221	-2631	-6,6	-8,5				
Renewable energy forms	144	279	397	1222	6989	7615	13889	8669	8409	10664	13142	18355	23669	10,7	33,2	7,1	-4,9	4,6	6,1
Gross Inland Consumption	**1660159**	**1662517**	**1723099**	**1825989**	**1753292**	**1796536**	**1644191**	**1511566**	**1451696**	**1359670**	**1269261**	**1181523**	**1084235**	**0,4**	**0,2**	**-0,6**	**-1,2**	**-1,3**	**-1,6**
Solids	452940	364248	321007	319922	281108	280612	223666	172685	131659	87029	59788	46130	44367	-3,4	-1,3	-2,3	-5,2	-7,6	-2,9
Oil	631058	650858	658727	676859	635036	628513	571044	521079	495657	419240	326444	232336	167513	0,4	-0,4	-1,1	-1,4	-4,1	-6,5
Natural gas	294905	333268	393417	445998	442856	445801	365068	347800	347506	333214	314780	301779	256714	2,9	1,2	-1,9	-0,5	-1,0	-2,0
Nuclear	202589	223028	243761	257360	235016	237212	217631	187614	161520	165771	165576	157847	146133	1,9	-0,4	-0,8	-2,9	0,2	-1,2
Electricity	3323	1508	1686	971	696	-620	-2172	-2767	-2085	-2423	-2391	-2221	-2631	-6,6	-8,5				
Renewable energy forms	75343	89606	104501	124880	158580	205017	268954	285155	317439	356839	405063	445653	472139	3,3	4,3	5,4	1,7	2,5	1,5
as % in Gross Inland Consumption																			
Solids	27,3	21,9	18,6	17,5	16,0	15,6	13,6	11,4	9,1	6,4	4,7	3,9	4,1						
Oil	38,0	39,1	38,2	37,1	36,2	35,0	34,7	34,5	34,1	30,8	25,7	19,7	15,4						
Natural gas	17,8	20,0	22,8	24,4	25,3	24,8	22,2	23,0	23,9	24,5	24,8	25,5	23,7						
Nuclear	12,2	13,4	14,1	14,1	13,4	13,2	13,2	12,4	11,1	12,2	13,0	13,4	13,5						
Renewable energy forms	4,5	5,4	6,1	6,8	9,0	11,4	16,4	18,9	21,9	26,2	31,9	37,7	43,5						
Gross Electricity Generation in GWh_e	**2562823**	**2712209**	**2991720**	**3274121**	**3319449**	**3587278**	**3554658**	**3441083**	**3444401**	**3644175**	**3966432**	**4189457**	**4280835**	**1,6**	**1,0**	**0,7**	**-0,3**	**1,4**	**0,8**
Nuclear	794718	881662	944823	997519	911418	920404	846514	734218	639274	659717	661427	634217	608141	1,7	-0,4	-0,7	-2,8	0,3	-0,8
Hydro & wind	292648	330306	375545	378836	514979	707557	1017720	1177498	1473125	1649559	1912200	2105358	2269402	2,5	3,2	7,0	3,8	2,6	1,7
Thermal (incl. biomass)	1475456	1500241	1671352	1897765	1893052	1959318	1690425	1529367	1332002	1334900	1392805	1449882	1403292	1,3	1,3	-1,1	-2,4	0,4	0,1
Fuel Inputs for Thermal Power Generation	**383492**	**362334**	**382613**	**424208**	**412218**	**422207**	**367293**	**329297**	**295031**	**283734**	**282175**	**281605**	**269007**	**0,0**	**0,7**	**-1,1**	**-2,2**	**-0,4**	**-0,5**
Solids	263837	230040	223012	229245	209766	210376	158208	111997	75238	45028	30014	32184	37868	-1,7	-0,6	-2,8	-7,2	-8,8	2,4
Oil (including refinery gas)	54404	51463	39294	29780	15651	13381	8038	7615	7868	8538	7631	5403	380	-3,2	-8,8	-6,4	-0,2	-0,3	-25,9
Gas	56754	67806	102408	134637	145862	139967	117729	117389	112273	122652	124658	118231	105581	6,1	3,6	-2,1	-0,5	1,1	-1,6
Biomass & Waste	5724	10033	14960	25901	35540	52481	76900	85207	89700	96904	108643	113964	113081	10,1	9,0	8,0	1,6	1,9	0,4
Geothermal heat	2774	2992	2939	4645	5400	6002	6418	7089	9951	10612	11229	11824	12096	0,6	6,3	1,7	4,5	1,2	0,7
Hydrogen - Methanol	0	0	0	0	0	0	0	0	0	0	0	0	0						
Fuel Input in other transformation proc.	**839073**	**814654**	**827098**	**842975**	**793734**	**792139**	**742125**	**692832**	**665908**	**588045**	**492738**	**389690**	**316019**	**-0,1**	**-0,4**	**-0,7**	**-1,1**	**-3,0**	**-4,3**
Refineries	679426	705954	735244	758152	718088	708691	655435	609166	583170	502456	402373	299193	221469	0,8	-0,2	-0,9	-1,2	-3,6	-5,8
Biofuels and hydrogen production	2	202	610	3129	12208	19510	26660	24758	24625	40526	57665	73263	85684	79,6	34,9	8,1	-0,8	8,9	4,0
District heating	32960	23240	19323	16212	15967	15982	13707	13042	12473	9350	7007	5001	3072	-5,2	-1,9	-1,5	-0,9	-5,6	-7,9
Others	126685	85258	71921	65482	47470	47956	46323	45867	45640	35714	25692	12234	5794	-5,5	-4,1	-0,2	-0,1	-5,6	-13,8
Energy Branch Consumption	**82379**	**88696**	**88176**	**96033**	**91099**	**89852**	**82278**	**75017**	**70319**	**64303**	**59086**	**59346**	**55593**	**0,7**	**0,3**	**-1,0**	**-1,6**	**-1,7**	**-0,6**
Non-Energy Uses	**97931**	**110541**	**112495**	**117477**	**111500**	**115323**	**118064**	**119577**	**121352**	**118886**	**116180**	**106083**	**98084**	**1,4**	**-0,1**	**0,6**	**0,3**	**-0,4**	**-1,7**
Final Energy Demand	**1068710**	**1069989**	**1112989**	**1173676**	**1160767**	**1212131**	**1120527**	**1044943**	**1024697**	**954176**	**877444**	**807998**	**738230**	**0,4**	**0,4**	**-0,4**	**-0,9**	**-1,5**	**-1,7**
by sector																			
Industry	365650	328513	326949	326308	310910	322853	317442	316773	317290	303896	294495	276110	259502	-1,1	-0,5	0,2	0,0	-0,7	-1,3
- energy intensive industries	234722	214526	213112	210991	192094	196880	191006	188606	186913	175155	165311	150100	136307	-1,0	-1,0	-0,1	-0,2	-1,2	-1,9
- other industrial sectors	130928	113987	113837	115317	118816	125973	126437	128167	130376	128742	129184	126010	123194	-1,4	0,4	0,6	0,3	-0,1	-0,5
Residential	264307	280418	286784	308104	306282	320006	275661	248067	240692	224271	205576	188243	165480	0,8	0,7	-1,0	-1,3	-1,6	-2,1
Tertiary	158484	160442	159866	176859	173610	182117	158198	133819	130461	116183	102818	93756	84424	0,1	0,8	-0,9	-1,9	-2,4	-2,0
Transport	280269	300617	339389	362405	369965	387155	369225	346283	336253	309827	274555	249888	228825	1,9	0,9	0,0	-0,9	-2,0	-1,8
by fuel																			
Solids	125031	84977	61454	54486	47354	44926	40766	35674	30340	20573	14313	6593	2733	-6,9	-2,6	-1,5	-2,9	-7,2	-15,3
Oil	444429	456959	478882	495857	476981	476342	428033	386634	363986	299457	222062	158764	115466	0,7	0,0	-1,1	-1,6	-4,8	-6,3
Gas	227902	245996	265552	283524	267988	275277	219884	200299	204484	178877	150969	127025	91728	1,5	0,1	-2,0	-0,7	-3,0	-4,9
Electricity	184145	193367	216403	237537	242288	262641	261006	255066	258178	268371	280557	280314	275498	1,6	1,1	0,7	-0,1	0,8	-0,2
Heat (from CHP and District Heating) [A]	48610	44616	40061	44441	57863	72183	77278	79968	80195	81302	80089	77103	74105	-1,9	3,7	2,9	0,4	0,0	-0,8
Other	38592	44073	50640	57832	68292	80762	93560	87302	87515	105596	129454	158199	178701	2,8	3,0	3,2	-0,7	4,0	3,3
CO_2 Emissions (Mt of CO_2 - sec approach)	**4030,6**	**3800,1**	**3810,6**	**3946,6**	**3690,0**	**3666,5**	**3062,8**	**2666,1**	**2419,0**	**1945,1**	**1429,3**	**967,6**	**628,5**	**-0,6**	**-0,3**	**-1,8**	**-2,3**	**-5,1**	**-7,9**
Power generation/District heating	1484,3	1321,2	1320,8	1381,1	1275,0	1258,0	963,2	772,0	609,0	456,6	283,6	118,6	26,9	-1,2	-0,4	-2,8	-4,5	-7,4	-21,0
Energy Branch	152,2	171,0	170,2	181,6	157,2	145,6	126,9	110,4	102,9	76,9	59,4	43,5	27,2	1,1	-0,8	-2,1	-2,1	-5,4	-7,5
Industry	781,4	678,1	623,0	581,9	497,7	480,4	441,8	428,5	426,1	360,9	304,4	233,9	167,5	-2,2	-2,2	-1,2	-0,4	-3,3	-5,8
Residential	499,4	481,6	466,2	486,7	466,4	465,5	360,8	298,8	285,1	230,4	165,8	114,5	62,7	-0,7	0,0	-2,5	-2,3	-5,3	-9,3
Tertiary	300,5	275,3	242,0	262,2	245,5	239,4	180,9	151,3	146,4	119,5	87,9	59,3	34,9	-2,1	0,1	-3,0	-2,1	-5,0	-8,8
Transport	812,7	872,9	988,5	1053,1	1048,2	1077,6	989,2	905,1	849,5	700,8	528,3	397,8	309,3	2,0	0,6	-0,6	-1,5	-4,6	-5,2
CO_2 Emissions Index (1990=100)	**100,0**	**94,3**	**94,5**	**97,9**	**91,5**	**91,0**	**76,0**	**66,1**	**60,0**	**48,3**	**35,5**	**24,0**	**15,6**						
CO_2 Emissions (Mt of CO_2 - ref approach)	**4172,0**	**3950,7**	**3922,7**	**4087,6**	**3757,3**	**3735,2**	**3129,3**	**2730,3**	**2485,1**	**2006,8**	**1494,1**	**1053,4**	**727,7**	**-0,6**	**-0,4**	**-1,8**	**-2,3**	**-5,0**	**-6,9**

EU27: Energy efficiency														SUMMARY ENERGY BALANCE AND INDICATORS (B)					
	1990	1995	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050	'90-'00	'00-'10	'10-'20	'20-'30	'30-'40	'40-'50
														Annual % Change					
Main Energy System Indicators																			
Population (Million)	470,388	477,010	481,072	489,211	499,389	507,727	513,838	517,811	519,942	520,654	520,103	518,362	515,303	0,2	0,4	0,3	0,1	0,0	-0,1
GDP (in 000 MEuro'05)	8142,7	8748,4	10107,2	11063,1	11385,6	12750,3	14164,0	15503,7	16824,7	18157,1	19527,9	21002,9	22560,0	2,2	1,2	2,2	1,7	1,5	1,5
Gross Inl. Cons./GDP (toe/MEuro'05)	203,9	190,0	170,5	165,1	154,0	140,9	116,1	97,5	86,3	74,9	65,0	56,3	48,1	-1,8	-1,0	-2,8	-2,9	-2,8	-3,0
Gross Inl. Cons./Capita (toe/inhabitant)	3,53	3,49	3,58	3,73	3,51	3,54	3,20	2,92	2,79	2,61	2,44	2,28	2,10	0,1	-0,2	-0,9	-1,4	-1,3	-1,5
Electricity Generated/Capita (kWh gross/inhabitant)	5448	5686	6219	6693	6647	7065	6918	6645	6625	6999	7626	8082	8307	1,3	0,7	0,4	-0,4	1,4	0,9
Carbon intensity (t of CO_2/toe of GIC)	2,43	2,29	2,21	2,16	2,10	2,04	1,86	1,76	1,67	1,43	1,13	0,82	0,58	-0,9	-0,5	-1,2	-1,1	-3,8	-6,4
CO_2 Emissions/Capita (t of CO_2/inhabitant)	8,57	7,97	7,92	8,07	7,39	7,22	5,96	5,15	4,65	3,74	2,75	1,87	1,22	-0,8	-0,7	-2,1	-2,4	-5,1	-7,8
CO2 Emissions to GDP (t of CO2/MEuro'05)	495,0	434,4	377,0	356,7	324,1	287,6	216,2	172,0	143,8	107,1	73,2	46,1	27,9	-2,7	-1,5	-4,0	-4,0	-6,5	-9,2
Import Dependency %	44,6	43,5	46,8	52,5	53,8	56,6	55,1	55,6	56,1	53,2	48,5	44,1	39,7						
Energy intensity indicators (2000=100)																			
Industry (Energy on Value added)	130,3	115,2	100,0	95,1	89,9	84,6	75,3	69,1	64,3	57,4	52,0	45,5	40,0	-2,6	-1,1	-1,8	-1,6	-2,1	-2,6
Residential (Energy on Private Income)	114,4	113,2	100,0	97,5	96,2	89,4	69,7	57,9	52,1	44,6	38,1	32,2	26,5	-1,3	-0,4	-3,2	-2,9	-3,1	-3,6
Tertiary (Energy on Value added)	126,5	117,0	100,0	99,4	93,9	87,1	67,9	52,2	46,7	38,5	31,5	26,6	22,2	-2,3	-0,6	-3,2	-3,7	-3,9	-3,4
Transport (Energy on GDP)	102,5	102,3	100,0	97,6	96,8	90,4	77,6	66,5	59,5	50,8	41,9	35,4	30,2	-0,2	-0,3	-2,2	-2,6	-3,5	-3,2
Carbon Intensity indicators																			
Electricity and Steam production (t of CO_2/MWh)	0,46	0,40	0,37	0,35	0,31	0,27	0,21	0,17	0,13	0,10	0,06	0,02	0,01	-2,1	-1,9	-3,9	-4,3	-8,3	
Final energy demand (t of CO_2/toe)	2,24	2,16	2,08	2,03	1,95	1,87	1,76	1,71	1,67	1,48	1,24	1,00	0,78	-0,7	-0,7	-1,0	-0,6	-2,9	-4,5
Industry	2,14	2,06	1,91	1,78	1,60	1,49	1,39	1,35	1,34	1,19	1,03	0,85	0,65	-1,1	-1,7	-1,4	-0,4	-2,6	-4,6
Residential	1,89	1,72	1,63	1,58	1,52	1,45	1,31	1,20	1,18	1,03	0,81	0,61	0,38	-1,5	-0,7	-1,5	-1,0	-3,8	-7,3
Tertiary	1,90	1,72	1,51	1,48	1,41	1,31	1,14	1,13	1,12	1,03	0,85	0,63	0,41	-2,2	-0,7	-2,1	-0,2	-2,7	-7,0
Transport	2,90	2,90	2,91	2,91	2,83	2,78	2,68	2,61	2,53	2,26	1,92	1,59	1,35	0,0	-0,3	-0,6	-0,6	-2,7	-3,5
Electricity and steam generation																			
Net Generation Capacity in MW_e			**654168**	**715466**	**821516**	**922175**	**1012749**	**1024363**	**1111329**	**1171937**	**1305302**	**1401647**	**1472585**		**2,3**	**2,1**	**0,9**	**1,6**	**1,2**
Nuclear energy			133966	134452	131393	125743	123107	100140	81678	83169	84304	83228	78908		-0,2	-0,6	-4,0	0,3	-0,7
Renewable energy			112878	147262	206776	281934	409965	475929	604380	689196	812765	912993	1011756		6,2	7,1	4,0	3,0	2,2
Hydro (pumping excluded)			99714	104505	107315	111511	114720	116661	118615	120810	121774	123301	125416		0,7	0,7	0,3	0,3	0,3
Wind			12793	40584	83905	141830	239169	283249	366453	408508	472133	513679	547588		20,7	11,0	4,4	2,6	1,5
Solar			371	2172	15307	28018	54353	73156	115047	155244	213167	269202	329948		45,1	13,5	7,8	6,4	4,5
Other renewables (tidal etc.)			0	1	249	575	1724	2863	4265	4635	5691	6811	8804			21,4	9,5	2,9	4,5
Thermal power			407324	433752	483347	514498	479676	448294	425271	399571	408232	405427	381921		1,7	-0,1	-1,2	-0,4	-0,7
of which cogeneration units			76247	85453	98320	120241	121929	125299	132343	142413	150906	151283	152391		2,6	2,2	0,8	1,3	0,1
of which CCS units			0	0	0	0	2711	2711	2711	17421	59014	110509	148782				0,0	36,1	9,7
Solids fired			194165	186620	183619	182252	153772	126961	106137	84672	74814	73155	70193		-0,6	-1,8	-3,6	-3,4	-0,6
Gas fired			129444	166863	218530	240906	229892	222902	218995	211695	220205	211816	187304		5,4	0,5	-0,5	0,1	-1,6
Oil fired			71058	62082	55901	46054	34548	27877	24196	20255	17577	15867	14705		-2,4	-4,7	-3,5	-3,1	-1,8
Biomass-waste fired			12051	17502	24569	44484	60608	69609	74617	81537	94142	103016	108110		7,4	9,4	2,1	2,4	1,4
Hydrogen plants			0	0	0	0	0	0	0	0	0	0	0						
Geothermal heat			605	686	727	801	856	945	1325	1413	1495	1574	1610		1,9	1,6	4,5	1,2	0,7
Load factor for net electric capacities (%)			49,1	49,1	43,9	42,4	38,4	36,9	34,2	34,3	33,3	32,5	31,5						
Indicators for gross electricity production																			
Efficiency for thermal electricity production (%)			37,6	38,5	39,5	39,9	39,6	39,9	38,8	40,5	42,4	44,3	44,9						
CHP indicator (% of electricity from CHP)			11,4	11,7	14,9	19,0	20,1	21,4	20,4	21,1	19,8	19,0	17,9						
CCS indicator (% of electricity from CCS)			0,0	0,0	0,0	0,0	0,5	0,6	0,7	3,3	10,0	17,2	20,5						
Non fossil fuels in electricity generation (%)			45,8	44,8	47,2	51,0	60,6	65,2	71,4	74,0	76,1	76,8	78,4						
- nuclear			31,6	30,5	27,5	25,7	23,8	21,3	18,6	18,1	16,7	15,1	14,2						
- renewable energy forms and industrial waste			14,2	14,3	19,7	25,3	36,8	43,8	52,9	55,9	59,5	61,7	64,2						
Indicators for renewables (excluding industrial waste) (%) [(B)]																			
RES in gross final energy demand (%)			7,6	8,6	11,4	14,7	21,3	24,3	27,6	33,3	41,3	49,5	57,3						
RES in transport (%)			0,5	1,4	4,3	6,6	10,9	14,1	19,1	31,0	44,7	55,6	63,7						
Transport sector																			
Passenger transport activity (Gpkm)	**4880,7**	**5307,7**	**5892,2**	**6240,3**	**6511,3**	**7132,8**	**7455,9**	**7747,0**	**8191,1**	**8478,2**	**8718,8**	**8969,1**	**9155,4**	**1,9**	**1,0**	**1,4**	**0,9**	**0,6**	**0,5**
Public road transport	544,0	504,0	517,6	526,0	545,0	573,7	643,5	703,6	750,2	796,5	837,2	876,4	915,3	-0,5	0,5	1,7	1,5	1,1	0,9
Private cars and motorcycles	3501,1	3986,3	4428,1	4686,5	4866,0	5288,2	5387,0	5471,6	5714,0	5823,0	5913,0	5993,6	6037,2	2,4	0,9	1,0	0,6	0,3	0,2
Rail	472,5	421,7	447,9	461,0	482,5	525,7	611,8	675,0	735,2	795,9	852,4	923,3	999,7	-0,5	0,7	2,4	1,9	1,5	1,6
Aviation	317,3	351,3	456,9	527,3	576,9	702,8	770,7	852,5	945,0	1014,0	1065,5	1123,4	1149,4	3,7	2,4	2,9	2,1	1,2	0,8
Inland navigation	45,8	44,4	41,7	39,5	40,8	42,5	43,0	44,3	46,7	48,8	50,7	52,4	53,8	-0,9	-0,2	0,5	0,8	0,8	0,6
Travel per person (km per capita)	10376	11127	12248	12756	13038	14048	14510	14961	15754	16284	16764	17303	17767	1,7	0,6	1,1	0,8	0,6	0,6
Freight transport activity (Gtkm)	**1848,4**	**1942,4**	**2195,7**	**2494,6**	**2662,6**	**2952,5**	**3044,6**	**3126,6**	**3290,4**	**3393,0**	**3492,5**	**3558,0**	**3575,6**	**1,7**	**1,9**	**1,3**	**0,8**	**0,6**	**0,2**
Trucks	1060,4	1288,7	1518,7	1800,3	1940,3	2164,3	2135,3	2124,4	2218,2	2246,4	2271,7	2269,4	2222,9	3,7	2,5	1,0	0,4	0,2	-0,2
Rail	526,3	386,1	403,7	414,1	440,5	489,2	580,8	647,8	698,7	753,4	811,6	864,6	916,6	-2,6	0,9	2,8	1,9	1,5	1,2
Inland navigation	261,6	267,6	273,3	280,2	281,9	299,0	328,5	354,5	373,6	393,2	409,2	424,1	436,0	0,4	0,3	1,5	1,3	0,9	0,6
Freight activity per unit of GDP (tkm/000 Euro'05)	227	222	217	225	234	232	215	202	196	187	179	169	158	-0,4	0,7	-0,8	-0,9	-0,9	-1,2
Energy demand in transport (ktoe)	**280269**	**300617**	**339389**	**362405**	**369965**	**387155**	**369225**	**346283**	**336253**	**309827**	**274555**	**249888**	**228825**	**1,9**	**0,9**	**0,0**	**-0,9**	**-2,0**	**-1,8**
Public road transport	5197	4732	4914	5039	5182	5315	5450	5424	5067	4778	4027	3552	3413	-0,6	0,5	0,5	-0,7	-2,3	-1,6
Private cars and motorcycles	154395	166321	182974	187736	186407	184712	166635	144181	134057	114545	92322	80824	71252	1,7	0,2	-1,1	-2,2	-3,7	-2,6
Trucks	74969	79037	90951	105104	111606	123126	118018	114862	115960	110166	101954	91543	82474	2,0	2,1	0,6	-0,2	-1,3	-2,1
Rail	9560	9452	9600	9436	9595	10163	11135	11258	10127	9926	9624	9080	8645	0,0	0,0	1,5	-0,9	-0,5	-1,1
Aviation	29038	34112	45395	49703	51709	58141	61911	64123	64281	63437	59545	57841	56124	4,6	1,3	1,8	0,4	-0,8	-0,6
Inland navigation	7110	6963	5555	5386	5466	5699	6076	6435	6761	6975	7083	7048	6917	-2,4	-0,2	1,1	1,1	0,5	-0,2
Efficiency indicator (activity related)																			
Passenger transport (toe/Mpkm)	39,6	39,5	40,3	39,5	38,0	35,4	31,9	28,1	25,4	22,1	18,4	16,3	14,7	0,2	-0,6	-1,7	-2,3	-3,2	-2,2
Freight transport (toe/Mtkm)	47,1	46,8	46,3	46,5	46,0	45,7	43,1	41,0	39,0	36,1	32,7	29,1	26,2	-0,2	-0,1	-0,7	-1,0	-1,7	-2,2

3. Diversified supply technologies scenario

EU27: Diversified supply technologies scenario														SUMMARY ENERGY BALANCE AND INDICATORS (A)					
ktoe	1990	1995	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050	'90-'00	'00-'10	'10-'20	'20-'30	'30-'40	'40-'50
														Annual % Change					
Production	**936047**	**950181**	**941860**	**900326**	**833819**	**806219**	**782568**	**741273**	**710247**	**736535**	**769462**	**779947**	**759856**	**0,1**	**-1,2**	**-0,6**	**-1,0**	**0,8**	**-0,1**
Solids	366477	277810	213423	196277	177950	167093	132831	105139	76032	67826	62855	58584	54278	-5,3	-1,8	-2,9	-5,4	-1,9	-1,5
Oil	129551	171052	173006	134290	104398	73577	46284	35883	31973	23886	14992	6914	2258	2,9	-4,9	-7,8	-3,6	-7,3	-17,2
Natural gas	162447	188965	207559	188677	164866	129039	110512	89498	72741	61103	48339	33115	23552	2,5	-2,3	-3,9	-4,1	-4,0	-6,9
Nuclear	202589	223028	243761	257360	235016	237362	230060	218921	200382	211834	218666	214369	186613	1,9	-0,4	-0,2	-1,4	0,9	-1,6
Renewable energy sources	74984	89326	104111	123722	151589	199149	262880	291833	329118	371886	424609	466965	493156	3,3	3,8	5,7	2,3	2,6	1,5
Hydro	25101	28054	30374	26395	30008	30276	30808	31576	32124	32602	33117	33578	33950	1,9	-0,1	0,3	0,4	0,3	0,2
Biomass & Waste	46473	57201	67982	85129	98966	122954	149764	158637	164137	186903	212324	236947	246870	3,9	3,8	4,2	0,9	2,6	1,5
Wind	67	350	1913	6061	12781	28237	52537	65980	85195	96030	113177	122694	133309	39,8	20,9	15,2	5,0	2,9	1,7
Solar and others	153	274	421	807	3436	9380	18828	23562	32182	39368	48097	54414	58226	10,7	23,3	18,5	5,5	4,1	1,9
Geothermal	3190	3447	3421	5331	6398	8301	10944	12077	15480	16983	17894	19331	20801	0,7	6,5	5,5	3,5	1,5	1,5
Net Imports	**756079**	**738600**	**826299**	**986048**	**969466**	**1048683**	**951682**	**911619**	**875818**	**799693**	**700305**	**591212**	**500125**	**0,9**	**1,6**	**-0,2**	**-0,8**	**-2,2**	**-3,3**
Solids	81846	79338	98645	126639	102995	116197	85995	68840	43409	34083	27730	17546	22441	1,9	0,4	-1,8	-6,6	-4,4	-2,1
Oil	535645	512185	533039	599851	580687	608084	582484	556160	531957	460462	365970	263491	197447	0,0	0,9	0,0	-0,9	-3,7	-6,0
- Crude oil and Feedstocks	508460	494000	513725	581995	578249	601419	578003	555498	534379	465684	375120	285786	219420	0,1	1,2	0,0	-0,8	-3,5	-5,2
- Oil products	27185	18185	19314	17856	2438	6665	4481	662	-2423	-5222	-9150	-22295	-21973	-3,4	-18,7	6,3			
Natural gas	135121	145288	192531	257366	278100	317390	271194	280220	293381	295569	294978	293594	258514	3,6	3,7	-0,3	0,8	0,1	-1,3
Electricity	3323	1508	1686	971	696	-620	-2139	-2574	-1489	-1854	-1898	-2254	-2610	-6,6	-8,5				
Renewable energy forms	144	279	397	1222	6988	7631	14148	8973	8561	11433	13525	18836	24334	10,7	33,2	7,3	-4,9	4,7	6,0
Gross Inland Consumption	**1660159**	**1662517**	**1723099**	**1825989**	**1753233**	**1802785**	**1681336**	**1600181**	**1534173**	**1487363**	**1423147**	**1326691**	**1217114**	**0,4**	**0,2**	**-0,4**	**-0,9**	**-0,7**	**-1,6**
Solids	452940	364248	321007	319922	280945	283290	218827	173979	119442	101910	90585	76130	76719	-3,4	-1,3	-2,5	-5,9	-2,7	-1,6
Oil	631058	650858	658727	676859	635033	629544	575853	539331	512591	438574	342295	240510	174832	0,4	-0,4	-1,0	-1,2	-4,0	-6,5
Natural gas	294905	333268	393417	445998	442965	446429	381707	369718	366122	356672	343318	326709	282066	2,9	1,2	-1,5	-0,4	-0,6	-1,9
Nuclear	202589	223028	243761	257360	235016	237362	230060	218921	200382	211834	218666	214369	186613	1,9	-0,4	-0,2	-1,4	0,9	-1,6
Electricity	3323	1508	1686	971	696	-620	-2139	-2574	-1489	-1854	-1898	-2254	-2610	-6,6	-8,5				
Renewable energy forms	75343	89606	104501	124880	158577	206780	277028	300806	337126	380226	430181	471227	499495	3,3	4,3	5,7	2,0	2,5	1,5
as % in Gross Inland Consumption																			
Solids	27,3	21,9	18,6	17,5	16,0	15,7	13,0	10,9	7,8	6,9	6,4	5,7	6,3						
Oil	38,0	39,1	38,2	37,1	36,2	34,9	34,2	33,7	33,4	29,5	24,1	18,1	14,4						
Natural gas	17,8	20,0	22,8	24,4	25,3	24,8	22,7	23,1	23,9	24,0	24,1	24,6	23,2						
Nuclear	12,2	13,4	14,1	14,1	13,4	13,2	13,7	13,7	13,1	14,2	15,4	16,2	15,3						
Renewable energy forms	4,5	5,4	6,1	6,8	9,0	11,5	16,5	18,8	22,0	25,6	30,2	35,5	41,0						
Gross Electricity Generation in GWh_e	**2562823**	**2712209**	**2991720**	**3274121**	**3319422**	**3623036**	**3677371**	**3767945**	**3758199**	**4096405**	**4594818**	**4816170**	**4912423**	**1,6**	**1,0**	**1,0**	**0,2**	**2,0**	**0,7**
Nuclear	794718	881662	944823	997519	911418	921025	896138	863846	794926	842821	872584	867140	793221	1,7	-0,4	-0,2	-1,2	0,9	-0,9
Hydro & wind	292648	330306	375545	378836	514979	713802	1042725	1246880	1552240	1744992	2045510	2241384	2429406	2,5	3,2	7,3	4,1	2,8	1,7
Thermal (incl. biomass)	1475456	1500241	1671352	1897765	1893025	1988209	1738508	1657219	1411033	1508593	1676725	1707645	1689795	1,3	1,3	-0,8	-2,1	1,7	0,1
Fuel Inputs for Thermal Power Generation	**383492**	**362334**	**382613**	**424208**	**412181**	**427685**	**374835**	**351638**	**306109**	**313991**	**330702**	**323691**	**317428**	**0,0**	**0,7**	**-0,9**	**-2,0**	**0,8**	**-0,4**
Solids	263837	230040	223012	229245	209629	213287	154828	115993	66591	60848	61708	63081	70510	-1,7	-0,6	-3,0	-8,1	-0,8	1,3
Oil (including refinery gas)	54404	51463	39294	29780	15656	14040	8336	9901	9869	10226	9542	4516	325	-3,2	-8,8	-6,1	1,7	-0,3	-28,7
Gas	56754	67806	102408	134637	145944	141085	125040	128464	123552	131159	136724	128716	120269	6,1	3,6	-1,5	-0,1	1,0	-1,3
Biomass & Waste	5724	10033	14960	25901	35552	52468	78092	88039	93583	98566	108908	112965	111576	10,1	9,0	8,2	1,8	1,5	0,2
Geothermal heat	2774	2992	2939	4645	5400	6804	8541	9240	12513	13192	13819	14414	14724	0,6	6,3	4,7	3,9	1,0	0,6
Hydrogen - Methanol	0	0	0	0	0	0	0	0	0	0	0	0	24						
Fuel Input in other transformation proc.	**839073**	**814654**	**827098**	**842975**	**793702**	**793187**	**744905**	**708154**	**678462**	**607383**	**509199**	**400936**	**328041**	**-0,1**	**-0,4**	**-0,6**	**-0,9**	**-2,8**	**-4,3**
Refineries	679426	705954	735244	758152	718083	710257	658909	624834	598425	519944	416361	307164	228035	0,8	-0,2	-0,9	-1,0	-3,6	-5,8
Biofuels and hydrogen production	2	202	610	3129	12208	19510	26830	25839	25763	43488	61535	78040	91677	79,6	34,9	8,2	-0,4	9,1	4,1
District heating	32960	23240	19323	16212	15971	15665	13851	13263	11109	9104	6816	4746	2992	-5,2	-1,9	-1,4	-2,2	-4,8	-7,9
Others	126685	85258	71921	65482	47441	47756	45315	44219	43165	34847	24487	10986	5338	-5,5	-4,1	-0,5	-0,5	-5,5	-14,1
Energy Branch Consumption	**82379**	**88696**	**88176**	**96033**	**91098**	**90066**	**83512**	**77683**	**72431**	**69908**	**70530**	**67360**	**63157**	**0,7**	**0,3**	**-0,9**	**-1,4**	**-0,3**	**-1,1**
Non-Energy Uses	**97931**	**110541**	**112495**	**117477**	**111507**	**115321**	**118126**	**119713**	**121498**	**121009**	**120142**	**112694**	**105832**	**1,4**	**-0,1**	**0,6**	**0,3**	**-0,1**	**-1,3**
Final Energy Demand	**1068710**	**1069989**	**1112989**	**1173676**	**1160735**	**1214824**	**1145596**	**1097606**	**1074761**	**1025779**	**953643**	**878642**	**803921**	**0,4**	**0,4**	**-0,1**	**-0,6**	**-1,2**	**-1,7**
by sector																			
Industry	365650	328513	326949	326308	310880	322813	317708	315743	316063	310591	306942	290646	274547	-1,1	-0,5	0,2	-0,1	-0,3	-1,1
- energy intensive industries	234722	214526	213112	210991	192062	196771	190586	187062	185196	177815	170666	156799	142350	-1,0	-1,0	-0,1	-0,3	-0,8	-1,8
- other industrial sectors	130928	113987	113837	115317	118818	126041	127123	128681	130867	132776	136275	133847	132197	-1,4	0,4	0,7	0,3	0,4	-0,3
Residential	264307	280418	286784	308104	306282	320909	290029	271190	264030	253170	234190	214118	188059	0,8	0,7	-0,5	-0,9	-1,2	-2,2
Tertiary	158484	160442	159866	176859	173607	183950	167348	153008	147122	139991	128571	117233	105749	0,1	0,8	-0,4	-1,3	-1,3	-1,9
Transport	280269	300617	339389	362405	369965	387152	370511	357665	347547	322028	283941	256645	235565	1,9	0,9	0,0	-0,6	-2,0	-1,9
by fuel																			
Solids	125031	84977	61454	54486	47328	44821	39468	33134	27358	19957	14093	6229	2505	-6,9	-2,6	-1,8	-3,6	-6,4	-15,9
Oil	444429	456959	478882	495857	476962	476697	433056	401972	378688	314889	232777	164528	119592	0,7	0,0	-1,0	-1,3	-4,7	-6,4
Gas	227902	245996	265552	283524	268020	274969	227765	210034	212569	192780	165157	137545	99173	1,5	0,1	-1,6	-0,7	-2,5	-5,0
Electricity	184145	193367	216403	237537	242290	265247	270039	277419	279654	296944	315278	316478	311115	1,6	1,1	1,1	0,4	1,2	-0,1
Heat (from CHP and District Heating) [(A)]	48610	44616	40061	44441	57860	71946	79127	83114	83271	84600	84302	81349	79040	-1,9	3,7	3,2	0,5	0,1	-0,6
Other	38592	44073	50640	57832	68275	81145	96140	91933	93222	116609	142036	172513	192494	2,8	3,0	3,5	-0,3	4,3	3,1
CO_2 Emissions (Mt of CO_2 - sec approach)	**4030,6**	**3800,1**	**3810,6**	**3946,6**	**3689,6**	**3682,0**	**3093,4**	**2773,2**	**2456,8**	**2024,6**	**1481,8**	**979,3**	**648,2**	**-0,6**	**-0,3**	**-1,7**	**-2,3**	**-4,9**	**-7,9**
Power generation/District heating	1484,3	1321,2	1320,8	1381,1	1274,7	1273,7	965,3	818,5	597,7	458,1	270,2	89,7	18,9	-1,2	-0,4	-2,7	-4,7	-7,6	-23,3
Energy Branch	152,2	171,0	170,2	181,6	157,2	145,6	127,6	113,4	102,9	79,2	61,3	44,6	26,2	1,1	-0,8	-2,1	-2,1	-5,1	-8,1
Industry	781,4	678,1	623,0	581,9	497,5	479,6	435,0	414,2	408,2	359,8	309,5	233,2	170,4	-2,2	-2,2	-1,3	-0,6	-2,7	-5,8
Residential	499,4	481,6	466,2	486,7	466,4	466,2	383,9	326,4	311,5	262,3	194,0	135,2	74,6	-0,7	0,0	-1,9	-2,1	-4,6	-9,1
Tertiary	300,5	275,3	242,0	262,2	245,6	239,3	188,8	164,1	156,5	135,6	99,9	67,8	39,4	-2,1	0,1	-2,6	-1,9	-4,4	-8,9
Transport	812,7	872,9	988,5	1053,1	1048,2	1077,6	992,8	936,7	880,0	729,6	546,9	408,9	318,6	2,0	0,6	-0,5	-1,2	-4,6	-5,3
CO_2 Emissions Index (1990=100)	**100,0**	**94,3**	**94,5**	**97,9**	**91,5**	**91,3**	**76,7**	**68,8**	**61,0**	**50,2**	**36,8**	**24,3**	**16,1**						
CO_2 Emissions (Mt of CO_2 - ref approach)	**4172,0**	**3950,7**	**3922,7**	**4087,6**	**3756,9**	**3749,7**	**3161,4**	**2840,1**	**2525,4**	**2087,6**	**1547,5**	**1068,6**	**753,3**	**-0,6**	**-0,4**	**-1,7**	**-2,2**	**-4,8**	**-6,9**

EU27: Diversified supply technologies scenario														SUMMARY ENERGY BALANCE AND INDICATORS (B)					
	1990	1995	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050	'90-'00	'00-'10	'10-'20	'20-'30	'30-'40	'40-'50
														Annual % Change					
Main Energy System Indicators																			
Population (Million)	470,388	477,010	481,072	489,211	499,389	507,727	513,838	517,811	519,942	520,654	520,103	518,362	515,303	0,2	0,4	0,3	0,1	0,0	-0,1
GDP (in 000 MEuro'05)	8142,7	8748,4	10107,2	11063,1	11385,6	12750,3	14164,0	15503,7	16824,7	18157,1	19527,9	21002,9	22560,0	2,2	1,2	2,2	1,7	1,5	1,5
Gross Inl. Cons./GDP (toe/MEuro'05)	203,9	190,0	170,5	165,1	154,0	141,4	118,7	103,2	91,2	81,9	72,9	63,2	54,0	-1,8	-1,0	-2,6	-2,6	-2,2	-3,0
Gross Inl. Cons./Capita (toe/inhabitant)	3,53	3,49	3,58	3,73	3,51	3,55	3,27	3,09	2,95	2,86	2,74	2,56	2,36	0,1	-0,2	-0,7	-1,0	-0,8	-1,5
Electricity Generated/Capita (kWh gross/inhabitant)	5448	5686	6219	6693	6647	7136	7157	7277	7228	7868	8834	9291	9533	1,3	0,7	0,7	0,1	2,0	0,8
Carbon intensity (t of CO_2/toe of GIC)	2,43	2,29	2,21	2,16	2,10	2,04	1,84	1,73	1,60	1,36	1,04	0,74	0,53	-0,9	-0,5	-1,3	-1,4	-4,2	-6,5
CO_2 Emissions/Capita (t of CO_2/inhabitant)	8,57	7,97	7,92	8,07	7,39	7,25	6,02	5,36	4,73	3,89	2,85	1,89	1,26	-0,8	-0,7	-2,0	-2,4	-4,9	-7,9
CO2 Emissions to GDP (t of CO2/MEuro'05)	495,0	434,4	377,0	356,7	324,1	288,8	218,4	178,9	146,0	111,5	75,9	46,6	28,7	-2,7	-1,5	-3,9	-3,9	-6,3	-9,3
Import Dependency %	44,6	43,5	46,8	52,5	53,8	56,5	54,9	55,2	55,2	52,1	47,6	43,1	39,7						
Energy intensity indicators (2000=100)																			
Industry (Energy on Value added)	130,3	115,2	100,0	95,1	89,9	84,5	75,4	68,9	64,1	58,6	54,1	47,9	42,4	-2,6	-1,1	-1,7	-1,6	-1,7	-2,4
Residential (Energy on Private Income)	114,4	113,2	100,0	97,5	96,2	89,6	73,3	63,3	57,2	50,3	43,4	36,6	30,1	-1,3	-0,4	-2,7	-2,4	-2,7	-3,6
Tertiary (Energy on Value added)	126,5	117,0	100,0	99,4	93,9	88,0	71,8	59,7	52,7	46,3	39,4	33,3	27,8	-2,3	-0,6	-2,6	-3,1	-2,9	-3,4
Transport (Energy on GDP)	102,5	102,3	100,0	97,6	96,8	90,4	77,9	68,7	61,5	52,8	43,3	36,4	31,1	-0,2	-0,3	-2,1	-2,3	-3,5	-3,3
Carbon Intensity indicators																			
Electricity and Steam production (t of CO_2/MWh)	0,46	0,40	0,37	0,35	0,31	0,27	0,20	0,17	0,12	0,09	0,05	0,02	0,00	-2,1	-1,9	-4,1	-4,9	-9,0	
Final energy demand (t of CO_2/toe)	2,24	2,16	2,08	2,03	1,95	1,86	1,75	1,68	1,63	1,45	1,21	0,96	0,75	-0,7	-0,7	-1,1	-0,7	-3,0	-4,6
Industry	2,14	2,06	1,91	1,78	1,60	1,49	1,37	1,31	1,29	1,16	1,01	0,80	0,62	-1,1	-1,7	-1,5	-0,6	-2,4	-4,7
Residential	1,89	1,72	1,63	1,58	1,52	1,45	1,32	1,20	1,18	1,04	0,83	0,63	0,40	-1,5	-0,7	-1,4	-1,1	-3,5	-7,1
Tertiary	1,90	1,72	1,51	1,48	1,41	1,30	1,13	1,07	1,06	0,97	0,78	0,58	0,37	-2,2	-0,7	-2,2	-0,6	-3,1	-7,1
Transport	2,90	2,90	2,91	2,91	2,83	2,78	2,68	2,62	2,53	2,27	1,93	1,59	1,35	0,0	-0,3	-0,6	-0,6	-2,7	-3,5
Electricity and steam generation																			
Net Generation Capacity in MW_e			**654168**	**715466**	**821492**	**926838**	**1030076**	**1077932**	**1192511**	**1274724**	**1452239**	**1565336**	**1620951**		**2,3**	**2,3**	**1,5**	**2,0**	**1,1**
Nuclear energy			133966	134452	131393	125743	124707	106684	104841	106207	109310	114100	101712		-0,2	-0,5	-1,7	0,4	-0,7
Renewable energy			112878	147262	206776	283873	420168	503915	642175	733432	878759	980140	1080701		6,2	7,3	4,3	3,2	2,1
Hydro (pumping excluded)			99714	104505	107315	111550	114915	116945	118918	121015	122055	123611	125633		0,7	0,7	0,3	0,3	0,3
Wind			12793	40584	83905	143729	247338	302919	386165	433350	505776	546147	594652		20,7	11,4	4,6	2,7	1,6
Solar			371	2172	15307	28018	56183	81070	132827	173250	244150	302357	350540		45,1	13,9	9,0	6,3	3,7
Other renewables (tidal etc.)			0	1	249	575	1732	2981	4265	5818	6778	8026	9876			21,4	9,4	4,7	3,8
Thermal power			407324	433752	483323	517222	485201	467333	445495	435085	464169	471095	438539		1,7	0,0	-0,9	0,4	-0,6
of which cogeneration units			76247	85453	98242	119491	124538	132761	141487	153435	157838	162549	161436		2,6	2,4	1,3	1,1	0,2
of which CCS units			0	0	0	0	2711	2711	3436	31909	94816	160119	192600				2,4	39,3	7,3
Solids fired			194165	186620	183617	182688	154351	128492	107941	96189	95149	94999	93591		-0,6	-1,7	-3,5	-1,3	-0,2
Gas fired			129444	166863	218508	242854	232921	233881	229826	226031	246728	249817	218321		5,4	0,6	-0,1	0,7	-1,2
Oil fired			71058	62082	55901	46070	34961	32427	29356	27364	24397	19764	18894		-2,4	-4,6	-1,7	-1,8	-2,5
Biomass-waste fired			12051	17502	24570	44703	61830	71302	76706	83745	96056	104597	105774		7,4	9,7	2,2	2,3	1,0
Hydrogen plants			0	0	0	0	0	0	0	0	0	0	0						
Geothermal heat			605	686	727	908	1138	1231	1665	1755	1839	1918	1959		1,9	4,6	3,9	1,0	0,6
Load factor for net electric capacities (%)			49,1	49,1	43,9	42,6	39,0	38,4	34,8	35,2	34,3	33,1	32,5						
Indicators for gross electricity production																			
Efficiency for thermal electricity production (%)			37,6	38,5	39,5	40,0	39,9	40,5	39,6	41,3	43,6	45,4	45,8						
CHP indicator (% of electricity from CHP)			11,4	11,7	14,9	19,0	20,3	21,1	20,7	20,2	18,4	18,2	16,9						
CCS indicator (% of electricity from CCS)			0,0	0,0	0,0	0,0	0,6	0,6	0,8	6,1	14,9	21,8	24,2						
Non fossil fuels in electricity generation (%)			45,8	44,8	47,2	50,7	60,9	65,3	72,4	73,0	73,4	74,5	75,2						
- nuclear			31,6	30,5	27,5	25,4	24,4	22,9	21,2	20,6	19,0	18,0	16,1						
- renewable energy forms and industrial waste			14,2	14,3	19,7	25,3	36,6	42,4	51,2	52,4	54,4	56,5	59,1						
Indicators for renewables (excluding industrial waste) (%) (B)																			
RES in gross final energy demand (%)			7,6	8,6	11,4	14,8	21,3	24,2	27,7	32,6	39,8	47,4	54,6						
RES in transport (%)			0,5	1,4	4,3	6,6	10,9	13,8	18,6	29,8	43,0	53,7	61,9						
Transport sector																			
Passenger transport activity (Gpkm)	**4880,7**	**5307,7**	**5892,2**	**6240,3**	**6511,3**	**7132,6**	**7479,8**	**7914,0**	**8358,8**	**8672,0**	**8919,9**	**9164,8**	**9355,2**	**1,9**	**1,0**	**1,4**	**1,1**	**0,7**	**0,5**
Public road transport	544,0	504,0	517,6	526,0	545,0	573,7	639,6	675,1	721,4	766,9	807,1	846,7	886,3	-0,5	0,5	1,6	1,2	1,1	0,9
Private cars and motorcycles	3501,1	3986,3	4428,1	4686,5	4866,0	5288,2	5414,1	5648,7	5889,0	6019,0	6113,2	6186,1	6231,5	2,4	0,9	1,1	0,8	0,4	0,2
Rail	472,5	421,7	447,9	461,0	482,5	525,5	607,2	645,5	704,3	764,1	819,8	890,5	966,4	-0,5	0,7	2,3	1,5	1,5	1,7
Aviation	317,3	351,3	456,9	527,3	576,9	702,8	775,7	899,7	996,7	1072,4	1128,5	1188,4	1216,3	3,7	2,4	3,0	2,5	1,2	0,8
Inland navigation	45,8	44,4	41,7	39,5	40,8	42,5	43,1	45,0	47,4	49,6	51,5	53,1	54,6	-0,9	-0,2	0,6	1,0	0,8	0,6
Travel per person (km per capita)	10376	11127	12248	12756	13038	14048	14557	15283	16076	16656	17150	17680	18155	1,7	0,6	1,1	1,0	0,6	0,6
Freight transport activity (Gtkm)	**1848,4**	**1942,4**	**2195,7**	**2494,6**	**2662,6**	**2952,5**	**3058,1**	**3212,4**	**3375,0**	**3493,1**	**3597,3**	**3655,5**	**3666,4**	**1,7**	**1,9**	**1,4**	**1,0**	**0,6**	**0,2**
Trucks	1060,4	1288,7	1518,7	1800,3	1940,3	2164,3	2155,1	2255,0	2349,0	2393,5	2424,7	2414,9	2362,3	3,7	2,5	1,1	0,9	0,3	-0,3
Rail	526,3	386,1	403,7	414,1	440,5	489,1	575,1	608,3	658,0	711,9	769,0	822,1	874,1	-2,6	0,9	2,7	1,4	1,6	1,3
Inland navigation	261,6	267,6	273,3	280,2	281,9	299,0	327,8	349,1	368,0	387,8	403,6	418,4	430,0	0,4	0,3	1,5	1,2	0,9	0,6
Freight activity per unit of GDP (tkm/000 Euro'05)	227	222	217	225	234	232	216	207	201	192	184	174	163	-0,4	0,7	-0,8	-0,7	-0,8	-1,2
Energy demand in transport (ktoe)	**280269**	**300617**	**339389**	**362405**	**369965**	**387152**	**370511**	**357665**	**347547**	**322028**	**283941**	**256645**	**235565**	**1,9**	**0,9**	**0,0**	**-0,6**	**-2,0**	**-1,9**
Public road transport	5197	4732	4914	5039	5182	5315	5423	5237	4922	4644	3847	3429	3315	-0,6	0,5	0,5	-1,0	-2,4	-1,5
Private cars and motorcycles	154395	166321	182974	187736	186407	184711	167399	148661	139252	120689	95654	83490	73071	1,7	0,2	-1,1	-1,8	-3,7	-2,7
Trucks	74969	79037	90951	105104	111606	123126	119059	121497	122053	116030	107072	95127	86415	2,0	2,1	0,6	0,2	-1,3	-2,1
Rail	9560	9452	9600	9436	9595	10161	11030	10601	9637	9494	9225	8719	8326	0,0	0,0	1,4	-1,3	-0,4	-1,0
Aviation	29038	34112	45395	49703	51709	58141	61530	65280	64973	64251	61125	58944	57623	4,6	1,3	1,8	0,5	-0,6	-0,6
Inland navigation	7110	6963	5555	5386	5466	5699	6070	6387	6710	6919	7018	6936	6816	-2,4	-0,2	1,1	1,0	0,5	-0,3
Efficiency indicator (activity related)																			
Passenger transport (toe/Mpkm)	39,6	39,5	40,3	39,5	38,0	35,4	31,9	28,2	25,5	22,4	18,5	16,4	14,8	0,2	-0,6	-1,7	-2,2	-3,2	-2,2
Freight transport (toe/Mtkm)	47,1	46,8	46,3	46,5	46,0	45,7	43,2	41,8	39,7	36,6	33,1	29,1	26,6	-0,2	-0,1	-0,6	-0,8	-1,8	-2,2

4. High RES scenario

EU27: High RES scenario														SUMMARY ENERGY BALANCE AND INDICATORS (A)					
ktoe	**1990**	**1995**	**2000**	**2005**	**2010**	**2015**	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**	**'90-'00**	**'00-'10**	**'10-'20**	**'20-'30**	**'30-'40**	**'40-'50**
														Annual % Change					
Production	**936047**	**950181**	**941860**	**900326**	**833310**	**806698**	**779610**	**742056**	**698518**	**699081**	**731599**	**752101**	**764124**	**0,1**	**-1,2**	**-0,7**	**-1,1**	**0,5**	**0,4**
Solids	366477	277810	213423	196277	177924	167143	130847	105741	70120	50626	42866	34971	29452	-5,3	-1,8	-3,0	-6,0	-4,8	-3,7
Oil	129551	171052	173006	134290	104398	73819	46224	35904	31670	23560	14980	7066	2278	2,9	-4,9	-7,8	-3,7	-7,2	-17,2
Natural gas	162447	188965	207559	188677	164866	129037	110518	89489	71627	58053	44334	29044	19735	2,5	-2,3	-3,9	-4,2	-4,7	-7,8
Nuclear	202589	223028	243761	257360	235016	237344	229652	213206	145795	112636	85647	64628	43640	1,9	-0,4	-0,2	-4,4	-5,2	-6,5
Renewable energy sources	74984	89326	104111	123722	151107	199354	262370	297715	379306	454205	543773	616393	669019	3,3	3,8	5,7	3,8	3,7	2,1
Hydro	25101	28054	30374	26395	30008	30294	30817	31604	32220	32722	33245	33693	34059	1,9	-0,1	0,3	0,4	0,3	0,2
Biomass & Waste	46473	57201	67982	85129	98472	122897	149005	159999	180886	218149	253415	282753	294621	3,9	3,8	4,2	2,0	3,4	1,5
Wind	67	350	1913	6061	12781	28465	52714	67465	103030	125049	161406	189752	215507	39,8	20,9	15,2	6,9	4,6	2,9
Solar and others	153	274	421	807	3446	9395	19017	26413	40371	52058	67572	79864	90649	10,7	23,4	18,6	7,8	5,3	3,0
Geothermal	3190	3447	3421	5331	6400	8305	10817	12234	22800	26227	28134	30331	34182	0,7	6,5	5,4	7,7	2,1	2,0
Net Imports	**756079**	**738600**	**826299**	**986048**	**969129**	**1046554**	**952439**	**911227**	**863234**	**767139**	**631727**	**510481**	**413127**	**0,9**	**1,6**	**-0,2**	**-1,0**	**-3,1**	**-4,2**
Solids	81846	79338	98645	126639	102268	112548	86128	69892	38524	19365	7407	-6329	-6046	1,9	0,4	-1,7	-7,7	-15,2	
Oil	535645	512185	533039	599851	580795	609089	582627	557236	533764	460454	364573	263832	198402	0,0	0,9	0,0	-0,9	-3,7	-5,9
- Crude oil and Feedstocks	508460	494000	513725	581995	578276	603822	577997	556269	534989	464675	373779	285995	221344	0,1	1,2	0,0	-0,8	-3,5	-5,1
- Oil products	27185	18185	19314	17856	2519	5267	4630	967	-1225	-4221	-9206	-22163	-22942	-3,4	-18,4	6,3			
Natural gas	135121	145288	192531	257366	278450	317916	271631	276670	282045	273453	241524	227188	190699	3,6	3,8	-0,2	0,4	-1,5	-2,3
Electricity	3323	1508	1686	971	696	-634	-2118	-1959	558	1723	3146	4397	4829	-6,6	-8,5			18,9	4,4
Renewable energy forms	144	279	397	1222	6921	7636	14171	9388	8342	12143	15077	21393	25243	10,7	33,1	7,4	-5,2	6,1	5,3
Gross Inland Consumption	**1660159**	**1662517**	**1723099**	**1825989**	**1752388**	**1801136**	**1679135**	**1600572**	**1509860**	**1417185**	**1316560**	**1217955**	**1134336**	**0,4**	**0,2**	**-0,4**	**-1,1**	**-1,4**	**-1,5**
Solids	452940	364248	321007	319922	280191	279691	216975	175633	108644	69991	50272	28642	23406	-3,4	-1,4	-2,5	-6,7	-7,4	-7,4
Oil	631058	650858	658727	676859	635141	630791	575936	540429	514095	438052	340749	240880	175825	0,4	-0,4	-1,0	-1,1	-4,0	-6,4
Natural gas	294905	333268	393417	445998	443315	446953	382149	366159	353672	331506	285858	256232	210434	2,9	1,2	-1,5	-0,8	-2,1	-3,0
Nuclear	202589	223028	243761	257360	235016	237344	229652	213206	145795	112636	85647	64628	43640	1,9	-0,4	-0,2	-4,4	-5,2	-6,5
Electricity	3323	1508	1686	971	696	-634	-2118	-1959	558	1723	3146	4397	4829	-6,6	-8,5			18,9	4,4
Renewable energy forms	75343	89606	104501	124880	158028	206990	276541	307103	387095	463277	550887	623177	676202	3,3	4,2	5,8	3,4	3,6	2,1
as % in Gross Inland Consumption																			
Solids	27,3	21,9	18,6	17,5	16,0	15,5	12,9	11,0	7,2	4,9	3,8	2,4	2,1						
Oil	38,0	39,1	38,2	37,1	36,2	35,0	34,3	33,8	34,0	30,9	25,9	19,8	15,5						
Natural gas	17,8	20,0	22,8	24,4	25,3	24,8	22,8	22,9	23,4	23,4	21,7	21,0	18,6						
Nuclear	12,2	13,4	14,1	14,1	13,4	13,2	13,7	13,3	9,7	7,9	6,5	5,3	3,8						
Renewable energy forms	4,5	5,4	6,1	6,8	9,0	11,5	16,5	19,2	25,6	32,7	41,8	51,2	59,6						
Gross Electricity Generation in GWh_e	**2562823**	**2712209**	**2991720**	**3274121**	**3310017**	**3609375**	**3665380**	**3751472**	**3666305**	**3879733**	**4357597**	**4726244**	**5140565**	**1,6**	**1,0**	**1,0**	**0,0**	**1,7**	**1,7**
Nuclear	794718	881662	944823	997519	911418	920951	894470	840519	578404	449157	344218	260161	179105	1,7	-0,4	-0,2	-4,3	-5,1	-6,3
Hydro & wind	292648	330306	375545	378836	514979	716559	1046829	1280628	1838420	2222236	2819421	3298070	3744893	2,5	3,2	7,4	5,8	4,4	2,9
Thermal (incl. biomass)	1475456	1500241	1671352	1897765	1883620	1971864	1724081	1630325	1249481	1208340	1193958	1168013	1216567	1,3	1,2	-0,9	-3,2	-0,5	0,2
Fuel Inputs for Thermal Power Generation	**383492**	**362334**	**382613**	**424208**	**410954**	**424609**	**371495**	**346950**	**280705**	**264227**	**256594**	**249960**	**264725**	**0,0**	**0,7**	**-1,0**	**-2,8**	**-0,9**	**0,3**
Solids	263837	230040	223012	229245	208905	209783	153229	116717	53950	29831	22172	15880	17556	-1,7	-0,7	-3,1	-9,9	-8,5	-2,3
Oil (including refinery gas)	54404	51463	39294	29780	15595	14589	8560	10199	9028	8466	6629	2096	246	-3,2	-8,8	-5,8	0,5	-3,0	-28,0
Gas	56754	67806	102408	134637	145869	141081	124787	126024	110577	110044	85265	66166	55752	6,1	3,6	-1,5	-1,2	-2,6	-4,2
Biomass & Waste	5724	10033	14960	25901	35185	52352	76511	84921	88926	94230	107154	111032	109233	10,1	8,9	8,1	1,5	1,9	0,2
Geothermal heat	2774	2992	2939	4645	5400	6804	8409	9089	18156	20713	22294	23895	26799	0,6	6,3	4,5	8,0	2,1	1,9
Hydrogen - Methanol	0	0	0	0	0	0	0	0	69	942	13079	30891	55138					69,0	15,5
Fuel Input in other transformation proc.	**839073**	**814654**	**827098**	**842975**	**793843**	**795868**	**744588**	**709740**	**683212**	**609457**	**525856**	**442356**	**399684**	**-0,1**	**-0,4**	**-0,6**	**-0,9**	**-2,6**	**-2,7**
Refineries	679426	705954	735244	758152	718104	712903	658842	625630	598726	518600	415000	307676	230223	0,8	-0,2	-0,9	-1,0	-3,6	-5,7
Biofuels and hydrogen production	2	202	610	3129	12208	19510	26833	25850	25967	44429	77991	116325	158393	79,6	34,9	8,2	-0,3	11,6	7,3
District heating	32960	23240	19323	16212	15983	15699	13874	13522	13912	11437	8920	6722	5813	-5,2	-1,9	-1,4	0,0	-4,3	-4,2
Others	126685	85258	71921	65482	47547	47757	45039	44738	44607	34990	23945	11634	5255	-5,5	-4,1	-0,5	-0,1	-6,0	-14,1
Energy Branch Consumption	**82379**	**88696**	**88176**	**96033**	**90926**	**90041**	**83106**	**77580**	**70485**	**63523**	**56656**	**52976**	**48370**	**0,7**	**0,3**	**-0,9**	**-1,6**	**-2,2**	**-1,6**
Non-Energy Uses	**97931**	**110541**	**112495**	**117477**	**111488**	**115324**	**118124**	**119728**	**121483**	**120976**	**120110**	**112142**	**105116**	**1,4**	**-0,1**	**0,6**	**0,3**	**-0,1**	**-1,3**
Final Energy Demand	**1068710**	**1069989**	**1112989**	**1173676**	**1160711**	**1214573**	**1145345**	**1103544**	**1093422**	**1039229**	**965315**	**885616**	**804231**	**0,4**	**0,4**	**-0,1**	**-0,5**	**-1,2**	**-1,8**
by sector																			
Industry	365650	328513	326949	326308	310794	322842	317478	316730	319583	314659	311272	291614	275822	-1,1	-0,5	0,2	0,1	-0,3	-1,2
- energy intensive industries	234722	214526	213112	210991	192050	196819	190503	188016	187697	180244	173169	157044	142999	-1,0	-1,0	-0,1	-0,1	-0,8	-1,9
- other industrial sectors	130928	113987	113837	115317	118743	126023	126975	128714	131887	134414	138104	134570	132823	-1,4	0,4	0,7	0,4	0,5	-0,4
Residential	264307	280418	286784	308104	306349	320875	289859	273993	273054	260550	240796	220031	190190	0,8	0,7	-0,6	-0,6	-1,2	-2,3
Tertiary	158484	160442	159866	176859	173601	183698	167475	154457	151363	140799	126815	114332	100614	0,1	0,8	-0,4	-1,0	-1,8	-2,3
Transport	280269	300617	339389	362405	369967	387158	370533	358363	349421	323222	286432	259639	237605	1,9	0,9	0,0	-0,6	-2,0	-1,9
by fuel																			
Solids	125031	84977	61454	54486	47220	44757	39481	33969	29050	19765	14092	5914	2458	-6,9	-2,6	-1,8	-3,0	-7,0	-16,0
Oil	444429	456959	478882	495857	477402	476889	433240	403337	382481	317430	235116	166879	120383	0,7	0,0	-1,0	-1,2	-4,7	-6,5
Gas	227902	245996	265552	283524	268457	275889	227971	209061	212137	193706	165069	137402	95510	1,5	0,1	-1,6	-0,7	-2,5	-5,3
Electricity	184145	193367	216403	237537	241593	264268	269375	277243	277332	290261	301824	296091	290419	1,6	1,1	1,1	0,3	0,8	-0,4
Heat (from CHP and District Heating) [A]	48610	44616	40061	44441	57920	71519	78393	82568	78039	71951	69538	61492	53924	-1,9	3,8	3,1	0,0	-1,1	-2,5
Other	38592	44073	50640	57832	68119	81250	96886	97365	114383	146118	179676	217838	241538	2,8	3,0	3,6	1,7	4,6	3,0
CO_2 Emissions (Mt of CO_2 - sec approach)	**4030,6**	**3800,1**	**3810,6**	**3946,6**	**3687,8**	**3672,9**	**3087,1**	**2776,2**	**2394,9**	**1964,4**	**1454,9**	**986,9**	**670,0**	**-0,6**	**-0,3**	**-1,8**	**-2,5**	**-4,9**	**-7,5**
Power generation/District heating	1484,3	1321,2	1320,8	1381,1	1271,6	1261,5	957,9	817,6	523,3	403,4	250,3	103,5	52,5	-1,2	-0,4	-2,8	-5,9	-7,1	-14,5
Energy Branch	152,2	171,0	170,2	181,6	156,5	146,2	127,7	112,0	97,6	65,1	48,0	33,0	21,1	1,1	-0,8	-2,0	-2,7	-6,8	-7,9
Industry	781,4	678,1	623,0	581,9	498,3	480,6	434,7	412,7	407,6	363,6	314,0	238,3	165,7	-2,2	-2,2	-1,4	-0,6	-2,6	-6,2
Residential	499,4	481,6	466,2	486,7	466,9	466,9	384,3	329,2	318,5	260,1	186,8	125,4	66,6	-0,7	0,0	-1,9	-1,9	-5,2	-9,8
Tertiary	300,5	275,3	242,0	262,2	246,3	240,1	189,7	166,1	162,3	138,4	102,2	70,7	41,0	-2,1	0,2	-2,6	-1,5	-4,5	-8,7
Transport	812,7	872,9	988,5	1053,1	1048,2	1077,6	992,9	938,6	885,6	733,8	553,5	416,0	323,1	2,0	0,6	-0,5	-1,1	-4,6	-5,2
CO_2 Emissions Index (1990=100)	**100,0**	**94,3**	**94,5**	**97,9**	**91,5**	**91,1**	**76,6**	**68,9**	**59,4**	**48,7**	**36,1**	**24,5**	**16,6**						
CO_2 Emissions (Mt of CO_2 - ref approach)	**4172,0**	**3950,7**	**3922,7**	**4087,6**	**3755,2**	**3740,5**	**3154,9**	**2843,0**	**2463,7**	**2028,4**	**1522,0**	**1075,6**	**775,5**	**-0,6**	**-0,4**	**-1,7**	**-2,4**	**-4,7**	**-6,5**

EU27: High RES scenario														SUMMARY ENERGY BALANCE AND INDICATORS (B)					
	1990	1995	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050	'90-'00	'00-'10	'10-'20	'20-'30	'30-'40	'40-'50
														Annual % Change					
Main Energy System Indicators																			
Population (Million)	470,388	477,010	481,072	489,211	499,389	507,727	513,838	517,811	519,942	520,654	520,103	518,362	515,303	0,2	0,4	0,3	0,1	0,0	-0,1
GDP (in 000 MEuro'05)	8142,7	8748,4	10107,2	11063,1	11385,6	12750,3	14164,0	15503,7	16824,7	18157,1	19527,9	21002,9	22560,0	2,2	1,2	2,2	1,7	1,5	1,5
Gross Inl. Cons./GDP (toe/MEuro'05)	203,9	190,0	170,5	165,1	153,9	141,3	118,5	103,2	89,7	78,1	67,4	58,0	50,3	-1,8	-1,0	-2,6	-2,7	-2,8	-2,9
Gross Inl. Cons./Capita (toe/inhabitant)	3,53	3,49	3,58	3,73	3,51	3,55	3,27	3,09	2,90	2,72	2,53	2,35	2,20	0,1	-0,2	-0,7	-1,2	-1,4	-1,4
Electricity Generated/Capita (kWh gross/inhabitant)	5448	5686	6219	6693	6628	7109	7133	7245	7051	7452	8378	9118	9976	1,3	0,6	0,7	-0,1	1,7	1,8
Carbon intensity (t of CO_2/toe of GIC)	2,43	2,29	2,21	2,16	2,10	2,04	1,84	1,73	1,59	1,39	1,11	0,81	0,59	-0,9	-0,5	-1,3	-1,5	-3,5	-6,1
CO_2 Emissions/Capita (t of CO_2/inhabitant)	8,57	7,97	7,92	8,07	7,38	7,23	6,01	5,36	4,61	3,77	2,80	1,90	1,30	-0,8	-0,7	-2,0	-2,6	-4,9	-7,4
CO2 Emissions to GDP (t of CO2/MEuro'05)	495,0	434,4	377,0	356,7	323,9	288,1	218,0	179,1	142,3	108,2	74,5	47,0	29,7	-2,7	-1,5	-3,9	-4,2	-6,3	-8,8
Import Dependency %	44,6	43,5	46,8	52,5	53,8	56,5	55,0	55,1	55,3	52,3	46,3	40,4	35,1						
Energy intensity indicators (2000=100)																			
Industry (Energy on Value added)	130,3	115,2	100,0	95,1	89,8	84,6	75,3	69,1	64,8	59,4	54,9	48,1	42,6	-2,6	-1,1	-1,7	-1,5	-1,6	-2,5
Residential (Energy on Private Income)	114,4	113,2	100,0	97,5	96,3	89,6	73,3	63,9	59,1	51,8	44,6	37,6	30,5	-1,3	-0,4	-2,7	-2,1	-2,8	-3,7
Tertiary (Energy on Value added)	126,5	117,0	100,0	99,4	93,9	87,9	71,9	60,3	54,2	46,6	38,9	32,5	26,5	-2,3	-0,6	-2,6	-2,8	-3,3	-3,8
Transport (Energy on GDP)	102,5	102,3	100,0	97,6	96,8	90,4	77,9	68,8	61,8	53,0	43,7	36,8	31,4	-0,2	-0,3	-2,1	-2,3	-3,4	-3,3
Carbon Intensity indicators																			
Electricity and Steam production (t of CO_2/MWh)	0,46	0,40	0,37	0,35	0,31	0,27	0,20	0,17	0,11	0,08	0,05	0,02	0,01	-2,1	-2,0	-4,2	-5,8	-8,1	
Final energy demand (t of CO_2/toe)	2,24	2,16	2,08	2,03	1,95	1,87	1,75	1,67	1,62	1,44	1,20	0,96	0,74	-0,7	-0,7	-1,1	-0,7	-3,0	-4,7
Industry	2,14	2,06	1,91	1,78	1,60	1,49	1,37	1,30	1,28	1,16	1,01	0,82	0,60	-1,1	-1,7	-1,6	-0,7	-2,3	-5,0
Residential	1,89	1,72	1,63	1,58	1,52	1,45	1,33	1,20	1,17	1,00	0,78	0,57	0,35	-1,5	-0,6	-1,4	-1,3	-4,0	-7,6
Tertiary	1,90	1,72	1,51	1,48	1,42	1,31	1,13	1,08	1,07	0,98	0,81	0,62	0,41	-2,2	-0,6	-2,2	-0,5	-2,8	-6,6
Transport	2,90	2,90	2,91	2,91	2,83	2,78	2,68	2,62	2,53	2,27	1,93	1,60	1,36	0,0	-0,3	-0,6	-0,6	-2,7	-3,5
Electricity and steam generation																			
Net Generation Capacity in MW_e			**654168**	**715466**	**821393**	**925364**	**1028870**	**1093152**	**1323971**	**1473174**	**1763357**	**2002770**	**2219028**		**2,3**	**2,3**	**2,6**	**2,9**	**2,3**
Nuclear energy			133966	134452	131393	125743	124752	106542	89509	74531	70208	59974	40649		-0,2	-0,5	-3,3	-2,4	-5,3
Renewable energy			112878	147262	206776	284863	421571	520864	790367	975140	1266151	1510674	1748963		6,2	7,4	6,5	4,8	3,3
Hydro (pumping excluded)			99714	104505	107315	111624	114963	117041	120084	124646	127086	129206	131439		0,7	0,7	0,4	0,6	0,3
Wind			12793	40584	83905	144765	247477	308743	469770	567394	734513	865683	984455		20,7	11,4	6,6	4,6	3,0
Solar			371	2172	15307	27898	57398	92099	195255	272546	385411	491250	602883		45,1	14,1	13,0	7,0	4,6
Other renewables (tidal etc.)			0	1	249	575	1732	2981	5259	10554	19140	24534	30187			21,4	11,7	13,8	4,7
Thermal power			407324	433752	483224	514758	482548	465746	444095	423503	426999	432122	429416		1,7	0,0	-0,8	-0,4	0,1
of which cogeneration units			76247	85453	97871	118960	124171	132317	135857	154830	170519	176464	178477		2,5	2,4	0,9	2,3	0,5
of which CCS units			0	0	0	0	2711	2711	2711	6268	22077	42460	52528				0,0	23,3	9,1
Solids fired			194165	186620	183457	182723	154491	129046	107532	83960	73806	67977	62189		-0,6	-1,7	-3,6	-3,7	-1,7
Gas fired			129444	166863	218569	241148	231203	231452	227152	215553	204223	193967	181585		5,4	0,6	-0,2	-1,1	-1,2
Oil fired			71058	62082	55901	45785	34998	33937	29321	24824	20949	20026	18956		-2,4	-4,6	-1,8	-3,3	-1,0
Biomass-waste fired			12051	17502	24569	44194	60735	70101	77673	96413	125058	146976	163125		7,4	9,5	2,5	4,9	2,7
Hydrogen plants			0	0	0	0	0	0	0	0	0	0	0						
Geothermal heat			605	686	727	908	1121	1211	2418	2754	2964	3176	3562		1,9	4,4	8,0	2,1	1,9
Load factor for net electric capacities (%)			49,1	49,1	43,8	42,5	39,0	37,7	30,7	29,3	27,0	25,5	24,8						
Indicators for gross electricity production																			
Efficiency for thermal electricity production (%)			37,6	38,5	39,4	39,9	39,9	40,4	38,3	39,3	40,0	40,2	39,5						
CHP indicator (% of electricity from CHP)			11,4	11,7	14,8	18,8	20,2	21,1	18,5	17,5	15,2	13,0	10,5						
CCS indicator (% of electricity from CCS)			0,0	0,0	0,0	0,0	0,6	0,6	0,6	0,9	3,3	6,0	6,9						
Non fossil fuels in electricity generation (%)			45,8	44,8	47,3	50,9	61,0	65,6	75,6	79,2	84,8	88,5	90,0						
- nuclear			31,6	30,5	27,5	25,5	24,4	22,4	15,8	11,6	8,0	5,7	3,6						
- renewable energy forms and industrial waste			14,2	14,3	19,8	25,4	36,6	43,2	59,8	67,6	76,8	82,9	86,4						
Indicators for renewables (excluding industrial waste) (%) [(B)]																			
RES in gross final energy demand (%)			7,6	8,6	11,4	14,8	21,3	24,6	31,2	39,1	50,6	63,0	75,2						
RES in transport (%)			0,5	1,4	4,3	6,6	10,9	13,9	20,0	33,3	50,2	63,2	73,5						
Transport sector																			
Passenger transport activity (Gpkm)	**4880,7**	**5307,7**	**5892,2**	**6240,3**	**6511,3**	**7133,0**	**7480,3**	**7921,8**	**8379,5**	**8681,7**	**8912,2**	**9140,9**	**9287,2**	**1,9**	**1,0**	**1,4**	**1,1**	**0,6**	**0,4**
Public road transport	544,0	504,0	517,6	526,0	545,0	573,7	639,6	675,1	721,1	766,5	806,9	846,2	887,8	-0,5	0,5	1,6	1,2	1,1	1,0
Private cars and motorcycles	3501,1	3986,3	4428,1	4686,5	4866,0	5288,2	5414,1	5655,3	5908,7	6030,5	6111,5	6174,0	6179,1	2,4	0,9	1,1	0,9	0,3	0,1
Rail	472,5	421,7	447,9	461,0	482,5	525,9	607,7	646,0	703,3	761,5	813,5	878,4	953,4	-0,5	0,7	2,3	1,5	1,5	1,6
Aviation	317,3	351,3	456,9	527,3	576,9	702,8	775,7	900,3	999,1	1073,6	1128,9	1189,1	1212,4	3,7	2,4	3,0	2,6	1,2	0,7
Inland navigation	45,8	44,4	41,7	39,5	40,8	42,5	43,1	45,0	47,4	49,6	51,5	53,2	54,5	-0,9	-0,2	0,6	1,0	0,8	0,6
Travel per person (km per capita)	10376	11127	12248	12756	13038	14049	14558	15299	16116	16675	17135	17634	18023	1,7	0,6	1,1	1,0	0,6	0,5
Freight transport activity (Gtkm)	**1848,4**	**1942,4**	**2195,7**	**2494,6**	**2662,6**	**2952,6**	**3058,2**	**3216,8**	**3387,8**	**3499,1**	**3597,1**	**3654,0**	**3646,6**	**1,7**	**1,9**	**1,4**	**1,0**	**0,6**	**0,1**
Trucks	1060,4	1288,7	1518,7	1800,3	1940,3	2164,3	2155,1	2259,0	2362,1	2400,8	2427,4	2419,1	2347,9	3,7	2,5	1,1	0,9	0,3	-0,3
Rail	526,3	386,1	403,7	414,1	440,5	489,3	575,3	608,5	657,5	710,6	766,1	816,4	868,7	-2,6	0,9	2,7	1,3	1,5	1,3
Inland navigation	261,6	267,6	273,3	280,2	281,9	299,0	327,8	349,2	368,2	387,8	403,6	418,4	430,0	0,4	0,3	1,5	1,2	0,9	0,6
Freight activity per unit of GDP (tkm/000 Euro'05)	227	222	217	225	234	232	216	207	201	193	184	174	162	-0,4	0,7	-0,8	-0,7	-0,9	-1,3
Energy demand in transport (ktoe)	**280269**	**300617**	**339389**	**362405**	**369967**	**387158**	**370533**	**358363**	**349421**	**323222**	**286432**	**259639**	**237605**	**1,9**	**0,9**	**0,0**	**-0,6**	**-2,0**	**-1,9**
Public road transport	5197	4732	4914	5039	5182	5315	5423	5239	4928	4673	3910	3474	3317	-0,6	0,5	0,5	-1,0	-2,3	-1,6
Private cars and motorcycles	154395	166321	182974	187736	186407	184712	167417	148591	139470	120494	97075	85366	75653	1,7	0,2	-1,1	-1,8	-3,6	-2,5
Trucks	74969	79037	90951	105104	111606	123126	119059	121710	122731	116740	107691	95806	86075	2,0	2,1	0,6	0,3	-1,3	-2,2
Rail	9560	9452	9600	9436	9597	10166	11035	10609	9631	9491	9275	8779	8356	0,0	0,0	1,4	-1,4	-0,4	-1,0
Aviation	29038	34112	45395	49703	51709	58141	61530	65826	65945	64896	61450	59255	57377	4,6	1,3	1,8	0,7	-0,7	-0,7
Inland navigation	7110	6963	5555	5386	5466	5699	6070	6389	6715	6929	7030	6958	6827	-2,4	-0,2	1,1	1,0	0,5	-0,3
Efficiency indicator (activity related)																			
Passenger transport (toe/Mpkm)	39,6	39,5	40,3	39,5	38,0	35,4	31,9	28,3	25,6	22,4	18,7	16,7	15,1	0,2	-0,6	-1,7	-2,2	-3,1	-2,1
Freight transport (toe/Mtkm)	47,1	46,8	46,3	46,5	46,1	45,7	43,2	41,8	39,8	36,8	33,3	29,4	26,6	-0,2	-0,1	-0,6	-0,8	-1,8	-2,2

5. Delayed CCS scenario

EU27: Delayed CCS scenario — **SUMMARY ENERGY BALANCE AND INDICATORS (A)**

ktoe	1990	1995	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050	'90-'00	'00-'10	'10-'20	'20-'30	'30-'40	'40-'50
														Annual % Change					
Production	**936047**	**950181**	**941860**	**900326**	**833867**	**806385**	**782247**	**742604**	**714997**	**744879**	**778988**	**793313**	**782885**	**0,1**	**-1,2**	**-0,6**	**-0,9**	**0,9**	**0,0**
Solids	366477	277810	213423	196277	177999	167124	133606	105175	74570	49694	40615	42623	41972	-5,3	-1,8	-2,8	-5,7	-5,9	0,3
Oil	129551	171052	173006	134290	104398	73701	46270	35888	31924	22671	14122	6825	2229	2,9	-4,9	-7,8	-3,6	-7,8	-16,9
Natural gas	162447	188965	207559	188677	164866	129039	110511	89429	72639	58928	47180	33038	23566	2,5	-2,3	-3,9	-4,1	-4,2	-6,7
Nuclear	202589	223028	243761	257360	235016	237360	229121	218234	202468	231475	244015	237692	216897	1,9	-0,4	-0,3	-1,2	1,9	-1,2
Renewable energy sources	74984	89326	104111	123722	151588	199161	262739	293879	333395	382111	433056	473134	498221	3,3	3,8	5,7	2,4	2,6	1,4
Hydro	25101	28054	30374	26395	30008	30276	30808	31569	32129	32612	33132	33587	33949	1,9	-0,1	0,3	0,4	0,3	0,2
Biomass & Waste	46473	57201	67982	85129	98965	122967	149650	159101	164958	193397	216805	238746	246615	3,9	3,8	4,2	1,0	2,8	1,3
Wind	67	350	1913	6061	12781	28237	52499	65906	86270	98019	115112	124712	135662	39,8	20,9	15,2	5,1	2,9	1,7
Solar and others	153	274	421	807	3436	9380	18834	24906	32945	38957	47498	53628	58134	10,7	23,3	18,5	5,8	3,7	2,0
Geothermal	3190	3447	3421	5331	6398	8301	10949	12396	17094	19125	20509	22461	23861	0,7	6,5	5,5	4,6	1,8	1,5
Net Imports	**756079**	**738600**	**826299**	**986048**	**969437**	**1048749**	**952256**	**910645**	**868793**	**732708**	**629866**	**552711**	**496822**	**0,9**	**1,6**	**-0,2**	**-0,9**	**-3,2**	**-2,3**
Solids	81846	79338	98645	126639	103003	116164	86465	68874	39638	13851	1793	-3503	14624	1,9	0,4	-1,7	-7,5	-26,6	23,4
Oil	535645	512185	533039	599851	580674	608334	582557	556019	530722	440649	345390	255622	196721	0,0	0,9	0,0	-0,9	-4,2	-5,5
- Crude oil and Feedstocks	508460	494000	513725	581995	578242	602274	577961	555450	533431	449575	355767	277010	218651	0,1	1,2	0,0	-0,8	-4,0	-4,8
- Oil products	27185	18185	19314	17856	2432	6060	4596	569	-2710	-8927	-10377	-21388	-21930	-3,4	-18,7	6,6			
Natural gas	135121	145288	192531	257366	278078	317239	271247	279361	291381	268296	271060	284030	264006	3,6	3,7	-0,2	0,7	-0,7	-0,3
Electricity	3323	1508	1686	971	696	-620	-2172	-2596	-1495	-1775	-1859	-1911	-2329	-6,6	-8,5				
Renewable energy forms	144	279	397	1222	6987	7633	14159	8987	8547	11689	13483	18473	23800	10,7	33,2	7,3	-4,9	4,7	5,8
Gross Inland Consumption	**1660159**	**1662517**	**1723099**	**1825989**	**1753252**	**1803017**	**1681588**	**1600538**	**1531898**	**1430568**	**1364649**	**1303197**	**1237672**	**0,4**	**0,2**	**-0,4**	**-0,9**	**-1,1**	**-1,0**
Solids	452940	364248	321007	319922	281002	283287	220071	174049	114209	63545	42408	39120	56596	-3,4	-1,3	-2,4	-6,3	-9,4	2,9
Oil	631058	650858	658727	676859	635020	629918	575912	539195	511306	419492	323152	233738	174438	0,4	-0,4	-1,0	-1,2	-4,5	-6,0
Natural gas	294905	333268	393417	445998	442944	446277	381758	368790	364020	327224	318239	317068	287572	2,9	1,2	-1,5	-0,5	-1,3	-1,0
Nuclear	202589	223028	243761	257360	235016	237360	229121	218234	202468	231475	244015	237692	216897	1,9	-0,4	-0,3	-1,2	1,9	-1,2
Electricity	3323	1508	1686	971	696	-620	-2172	-2596	-1495	-1775	-1859	-1911	-2329	-6,6	-8,5				
Renewable energy forms	75343	89606	104501	124880	158574	206794	276898	302865	341391	390608	438694	477489	504498	3,3	4,3	5,7	2,1	2,5	1,4
as % in Gross Inland Consumption																			
Solids	27,3	21,9	18,6	17,5	16,0	15,7	13,1	10,9	7,5	4,4	3,1	3,0	4,6						
Oil	38,0	39,1	38,2	37,1	36,2	34,9	34,2	33,7	33,4	29,3	23,7	17,9	14,1						
Natural gas	17,8	20,0	22,8	24,4	25,3	24,8	22,7	23,0	23,8	22,9	23,3	24,3	23,2						
Nuclear	12,2	13,4	14,1	14,1	13,4	13,2	13,6	13,6	13,2	16,2	17,9	18,2	17,5						
Renewable energy forms	4,5	5,4	6,1	6,8	9,0	11,5	16,5	18,9	22,3	27,3	32,1	36,6	40,8						
Gross Electricity Generation in GWh_e	**2562823**	**2712209**	**2991720**	**3274121**	**3320232**	**3622963**	**3676708**	**3761247**	**3747228**	**3940991**	**4353762**	**4593478**	**4872341**	**1,6**	**1,0**	**1,0**	**0,2**	**1,5**	**1,1**
Nuclear	794718	881662	944823	997519	911418	921018	892305	861315	803812	932416	987532	970241	935346	1,7	-0,4	-0,2	-1,0	2,1	-0,5
Hydro & wind	292648	330306	375545	378836	514979	713811	1042328	1245697	1564951	1770491	2068888	2259430	2454950	2,5	3,2	7,3	4,1	2,8	1,7
Thermal (incl. biomass)	1475456	1500241	1671352	1897765	1893835	1988135	1742075	1654234	1378465	1238085	1297342	1363807	1482045	1,3	1,3	-0,8	-2,3	-0,6	1,3
Fuel Inputs for Thermal Power Generation	**383492**	**362334**	**382613**	**424208**	**412247**	**427642**	**375988**	**351192**	**301418**	**271283**	**279041**	**289489**	**306228**	**0,0**	**0,7**	**-0,9**	**-2,2**	**-0,8**	**0,9**
Solids	263837	230040	223012	229245	209696	213286	156039	116096	61973	32175	22100	28286	50501	-1,7	-0,6	-2,9	-8,8	-9,8	8,6
Oil (including refinery gas)	54404	51463	39294	29780	15655	14092	8297	9759	9226	8443	7380	4179	384	-3,2	-8,8	-6,2	1,1	-2,2	-25,6
Gas	56754	67806	102408	134637	145953	140938	125048	128301	122409	113218	120162	120907	119922	6,1	3,6	-1,5	-0,2	-0,2	0,0
Biomass & Waste	5724	10033	14960	25901	35542	52522	78058	87794	93906	102341	113230	118669	117637	10,1	9,0	8,2	1,9	1,9	0,4
Geothermal heat	2774	2992	2939	4645	5400	6804	8546	9240	13904	15106	16169	17448	17743	0,6	6,3	4,7	5,0	1,5	0,9
Hydrogen - Methanol	0	0	0	0	0	0	0	0	0	0	0	0	41						
Fuel Input in other transformation proc.	**839073**	**814654**	**827098**	**842975**	**793682**	**794123**	**744759**	**707996**	**677216**	**584335**	**477770**	**387931**	**326515**	**-0,1**	**-0,4**	**-0,6**	**-0,9**	**-3,4**	**-3,7**
Refineries	679426	705954	735244	758152	718075	711235	658854	624792	597431	502676	396234	298395	227316	0,8	-0,2	-0,9	-1,0	-4,0	-5,4
Biofuels and hydrogen production	2	202	610	3129	12206	19490	26745	25790	25703	44990	59174	75061	90453	79,6	34,9	8,2	-0,4	8,7	4,3
District heating	32960	23240	19323	16212	15970	15644	13844	13201	11307	10760	7205	4860	3443	-5,2	-1,9	-1,4	-2,0	-4,4	-7,1
Others	126685	85258	71921	65482	47431	47753	45316	44213	42775	25908	15158	9616	5304	-5,5	-4,1	-0,5	-0,6	-9,9	-10,0
Energy Branch Consumption	**82379**	**88696**	**88176**	**96033**	**91103**	**90108**	**83563**	**77664**	**72262**	**64800**	**59023**	**56033**	**62866**	**0,7**	**0,3**	**-0,9**	**-1,4**	**-2,0**	**0,6**
Non-Energy Uses	**97931**	**110541**	**112495**	**117477**	**111508**	**115320**	**118130**	**119715**	**121502**	**121019**	**120132**	**112308**	**105651**	**1,4**	**-0,1**	**0,6**	**0,3**	**-0,1**	**-1,3**
Final Energy Demand	**1068710**	**1069989**	**1112989**	**1173676**	**1160719**	**1214911**	**1145539**	**1098479**	**1073123**	**979418**	**906948**	**853415**	**796953**	**0,4**	**0,4**	**-0,1**	**-0,7**	**-1,7**	**-1,3**
by sector																			
Industry	365650	328513	326949	326308	310867	322893	317727	315774	315746	304794	301680	286024	273050	-1,1	-0,5	0,2	-0,1	-0,5	-1,0
- energy intensive industries	234722	214526	213112	210991	192045	196810	190595	187117	184911	172601	165966	153150	141629	-1,0	-1,0	-0,1	-0,3	-1,1	-1,6
- other industrial sectors	130928	113987	113837	115317	118822	126082	127133	128658	130835	132193	135714	132874	131421	-1,4	0,4	0,7	0,3	0,4	-0,3
Residential	264307	280418	286784	308104	306277	320909	289992	272097	263833	237654	220271	208125	186747	0,8	0,7	-0,5	-0,9	-1,8	-1,6
Tertiary	158484	160442	159866	176859	173611	183954	167277	152932	146319	127074	116899	112028	104394	0,1	0,8	-0,4	-1,3	-2,2	-1,1
Transport	280269	300617	339389	362405	369965	387156	370542	357676	347225	309896	268098	247238	232762	1,9	0,9	0,0	-0,6	-2,6	-1,4
by fuel																			
Solids	125031	84977	61454	54486	47313	44817	39498	33100	26905	15091	10585	4716	2465	-6,9	-2,6	-1,8	-3,8	-8,9	-13,6
Oil	444429	456959	478882	495857	476944	476736	433195	401949	377958	298182	216449	157751	119008	0,7	0,0	-1,0	-1,4	-5,4	-5,8
Gas	227902	245996	265552	283524	268007	275220	227782	209417	211385	176861	152774	135736	101462	1,5	0,1	-1,6	-0,7	-3,2	-4,0
Electricity	184145	193367	216403	237537	242353	265245	269920	276873	278937	288677	307654	310406	308281	1,6	1,1	1,1	0,3	1,0	0,0
Heat (from CHP and District Heating) [(A)]	48610	44616	40061	44441	57826	71764	79088	82821	83257	82387	80019	77480	76437	-1,9	3,7	3,2	0,5	-0,4	-0,5
Other	38592	44073	50640	57832	68276	81129	96056	94319	94681	118220	139467	167325	189301	2,8	3,0	3,5	-0,1	3,9	3,1
CO_2 Emissions (Mt of CO_2 - sec approach)	**4030,6**	**3800,1**	**3810,6**	**3946,6**	**3689,7**	**3682,8**	**3098,2**	**2771,6**	**2430,3**	**1831,0**	**1374,9**	**993,4**	**668,6**	**-0,6**	**-0,3**	**-1,7**	**-2,4**	**-5,5**	**-7,0**
Power generation/District heating	1484,3	1321,2	1320,8	1381,1	1274,9	1273,5	969,6	818,5	578,3	379,7	263,1	136,0	30,3	-1,2	-0,4	-2,7	-5,0	-7,6	-19,4
Energy Branch	152,2	171,0	170,2	181,6	157,2	145,9	127,6	113,4	102,9	74,6	57,5	44,2	32,0	1,1	-0,8	-2,1	-2,1	-5,7	-5,7
Industry	781,4	678,1	623,0	581,9	497,5	480,1	435,1	414,5	405,9	332,9	290,8	234,3	176,2	-2,2	-2,2	-1,3	-0,7	-3,3	-4,9
Residential	499,4	481,6	466,2	486,7	466,4	466,2	383,9	325,0	308,6	229,5	167,8	125,0	74,1	-0,7	0,0	-1,9	-2,2	-5,9	-7,8
Tertiary	300,5	275,3	242,0	262,2	245,5	239,3	188,8	163,4	155,3	118,6	85,7	62,1	39,3	-2,1	0,1	-2,6	-1,9	-5,8	-7,5
Transport	812,7	872,9	988,5	1053,1	1048,2	1077,7	993,1	936,9	879,3	695,8	510,0	391,7	316,7	2,0	0,6	-0,5	-1,2	-5,3	-4,7
CO_2 Emissions Index (1990=100)	**100,0**	**94,3**	**94,5**	**97,9**	**91,5**	**91,4**	**76,9**	**68,8**	**60,3**	**45,4**	**34,1**	**24,6**	**16,6**						
CO_2 Emissions (Mt of CO_2 - ref approach)	**4172,0**	**3950,7**	**3922,7**	**4087,6**	**3757,0**	**3750,6**	**3166,2**	**2838,5**	**2498,9**	**1893,9**	**1440,7**	**1082,8**	**774,3**	**-0,6**	**-0,4**	**-1,7**	**-2,3**	**-5,4**	**-6,0**

EU27: Delayed CCS scenario														SUMMARY ENERGY BALANCE AND INDICATORS (B)					
	1990	1995	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050	'90-'00	'00-'10	'10-'20	'20-'30	'30-'40	'40-'50
														Annual % Change					
Main Energy System Indicators																			
Population (Million)	470,388	477,010	481,072	489,211	499,389	507,727	513,838	517,811	519,942	520,654	520,103	518,362	515,303	0,2	0,4	0,3	0,1	0,0	-0,1
GDP (in 000 MEuro'05)	8142,7	8748,4	10107,2	11063,1	11385,6	12750,3	14164,0	15503,7	16824,7	18157,1	19527,9	21002,9	22560,0	2,2	1,2	2,2	1,7	1,5	1,5
Gross Inl. Cons./GDP (toe/MEuro'05)	203,9	190,0	170,5	165,1	154,0	141,4	118,7	103,2	91,1	78,8	69,9	62,0	54,9	-1,8	-1,0	-2,6	-2,6	-2,6	-2,4
Gross Inl. Cons./Capita (toe/inhabitant)	3,53	3,49	3,58	3,73	3,51	3,55	3,27	3,09	2,95	2,75	2,62	2,51	2,40	0,1	-0,2	-0,7	-1,0	-1,2	-0,9
Electricity Generated/Capita (kWh gross/inhabitant)	5448	5686	6219	6693	6649	7136	7155	7264	7207	7569	8371	8862	9455	1,3	0,7	0,7	0,1	1,5	1,2
Carbon intensity (t of CO_2/toe of GIC)	2,43	2,29	2,21	2,16	2,10	2,04	1,84	1,73	1,59	1,28	1,01	0,76	0,54	-0,9	-0,5	-1,3	-1,5	-4,4	-6,0
CO_2 Emissions/Capita (t of CO_2/inhabitant)	8,57	7,97	7,92	8,07	7,39	7,25	6,03	5,35	4,67	3,52	2,64	1,92	1,30	-0,8	-0,7	-2,0	-2,5	-5,5	-6,9
CO2 Emissions to GDP (t of CO2/MEuro'05)	495,0	434,4	377,0	356,7	324,1	288,8	218,7	178,8	144,4	100,8	70,4	47,3	29,6	-2,7	-1,5	-3,9	-4,1	-6,9	-8,3
Import Dependency %	44,6	43,5	46,8	52,5	53,8	56,5	54,9	55,1	54,9	49,6	44,7	41,1	38,8						
Energy intensity indicators (2000=100)																			
Industry (Energy on Value added)	130,3	115,2	100,0	95,1	89,8	84,6	75,4	68,9	64,0	57,5	53,2	47,2	42,1	-2,6	-1,1	-1,7	-1,6	-1,8	-2,3
Residential (Energy on Private Income)	114,4	113,2	100,0	97,5	96,2	89,6	73,3	63,5	57,2	47,2	40,8	35,6	29,9	-1,3	-0,4	-2,7	-2,5	-3,3	-3,1
Tertiary (Energy on Value added)	126,5	117,0	100,0	99,4	93,9	88,0	71,8	59,7	52,4	42,1	35,8	31,8	27,5	-2,3	-0,6	-2,7	-3,1	-3,7	-2,6
Transport (Energy on GDP)	102,5	102,3	100,0	97,6	96,8	90,4	77,9	68,7	61,5	50,8	40,9	35,1	30,7	-0,2	-0,3	-2,1	-2,3	-4,0	-2,8
Carbon Intensity indicators																			
Electricity and Steam production (t of CO_2/MWh)	0,46	0,40	0,37	0,35	0,31	0,27	0,20	0,17	0,12	0,07	0,05	0,02	0,01	-2,1	-1,9	-4,1	-5,2	-8,5	
Final energy demand (t of CO_2/toe)	2,24	2,16	2,08	2,03	1,94	1,86	1,75	1,67	1,63	1,41	1,16	0,95	0,76	-0,7	-0,7	-1,1	-0,7	-3,3	-4,2
Industry	2,14	2,06	1,91	1,78	1,60	1,49	1,37	1,31	1,29	1,09	0,96	0,82	0,65	-1,1	-1,7	-1,5	-0,6	-2,8	-3,9
Residential	1,89	1,72	1,63	1,58	1,52	1,45	1,32	1,19	1,17	0,97	0,76	0,60	0,40	-1,5	-0,7	-1,4	-1,2	-4,2	-6,3
Tertiary	1,90	1,72	1,51	1,48	1,41	1,30	1,13	1,07	1,06	0,93	0,73	0,55	0,38	-2,2	-0,7	-2,2	-0,6	-3,6	-6,5
Transport	2,90	2,90	2,91	2,91	2,83	2,78	2,68	2,62	2,53	2,25	1,90	1,58	1,36	0,0	-0,3	-0,6	-0,6	-2,8	-3,3
Electricity and steam generation																			
Net Generation Capacity in MW_e			**654168**	**715466**	**821505**	**926251**	**1029593**	**1076048**	**1199296**	**1286867**	**1445606**	**1536466**	**1638739**		**2,3**	**2,3**	**1,5**	**1,9**	**1,3**
Nuclear energy			133966	134452	131393	125743	124707	106393	106421	122512	130739	131701	126606		-0,2	-0,5	-1,6	2,1	-0,3
Renewable energy			112878	147262	206776	283876	420035	503365	648548	744990	891318	989081	1093433		6,2	7,3	4,4	3,2	2,1
Hydro (pumping excluded)			99714	104505	107315	111550	114915	116917	118978	121120	122702	124346	126055		0,7	0,7	0,3	0,3	0,3
Wind			12793	40584	83905	143733	247153	302574	391801	442429	515971	557736	608692		20,7	11,4	4,7	2,8	1,7
Solar			371	2172	15307	28018	56235	80894	133467	175455	245538	298509	348458		45,1	13,9	9,0	6,3	3,6
Other renewables (tidal etc.)			0	1	249	575	1732	2981	4302	5986	7108	8491	10228			21,4	9,5	5,1	3,7
Thermal power			407324	433752	483337	516631	484851	466290	444327	419365	423549	415684	418700		1,7	0,0	-0,9	-0,5	-0,1
of which cogeneration units			76247	85453	98258	119251	124528	132706	141144	158032	163436	153848	150789		2,6	2,4	1,3	1,5	-0,8
of which CCS units			0	0	0	0	2657	2657	2862	8816	37677	81789	147663				0,7	29,4	14,6
Solids fired			194165	186620	183624	182691	154302	128370	107078	84751	70835	67409	73335		-0,6	-1,7	-3,6	-4,0	0,3
Gas fired			129444	166863	218517	242663	232712	232853	230370	220033	222262	212082	209830		5,4	0,6	-0,1	-0,4	-0,6
Oil fired			71058	62082	55901	46066	34927	32601	28143	24422	21533	19758	18477		-2,4	-4,6	-2,1	-2,6	-1,5
Biomass-waste fired			12051	17502	24567	44304	61771	71235	76886	88149	106768	114115	114699		7,4	9,7	2,2	3,3	0,7
Hydrogen plants			0	0	0	0	0	0	0	0	0	0	0						
Geothermal heat			605	686	727	908	1139	1231	1850	2010	2151	2320	2360		1,9	4,6	5,0	1,5	0,9
Load factor for net electric capacities (%)			49,1	49,1	43,9	42,6	39,0	38,4	34,5	33,8	33,1	32,5	32,0						
Indicators for gross electricity production																			
Efficiency for thermal electricity production (%)			37,6	38,5	39,5	40,0	39,8	40,5	39,3	39,2	40,0	40,5	41,6						
CHP indicator (% of electricity from CHP)			11,4	11,7	14,9	19,0	20,3	21,0	20,6	19,4	17,1	15,4	14,2						
CCS indicator (% of electricity from CCS)			0,0	0,0	0,0	0,0	0,6	0,6	0,7	2,2	6,3	12,0	19,0						
Non fossil fuels in electricity generation (%)			45,8	44,8	47,2	50,7	60,8	65,3	73,2	79,1	81,0	81,2	79,9						
- nuclear			31,6	30,5	27,5	25,4	24,3	22,9	21,5	23,7	22,7	21,1	19,2						
- renewable energy forms and industrial waste			14,2	14,3	19,7	25,3	36,5	42,4	51,7	55,4	58,3	60,0	60,7						
Indicators for renewables (excluding industrial waste) (%) [B]																			
RES in gross final energy demand (%)			7,6	8,6	11,4	14,8	21,3	24,4	28,0	35,0	42,6	49,3	55,7						
RES in transport (%)			0,5	1,4	4,3	6,6	10,8	13,8	18,7	30,7	44,8	55,1	62,2						
Transport sector																			
Passenger transport activity (Gpkm)	**4880,7**	**5307,7**	**5892,2**	**6240,3**	**6511,3**	**7132,6**	**7480,0**	**7913,9**	**8355,1**	**8560,1**	**8778,9**	**9046,4**	**9246,8**	**1,9**	**1,0**	**1,4**	**1,1**	**0,5**	**0,5**
Public road transport	544,0	504,0	517,6	526,0	545,0	573,7	639,6	675,1	721,5	770,2	812,8	850,1	885,5	-0,5	0,5	1,6	1,2	1,2	0,9
Private cars and motorcycles	3501,1	3986,3	4428,1	4686,5	4866,0	5288,3	5414,7	5648,9	5886,0	5915,0	5980,5	6072,8	6126,7	2,4	0,9	1,1	0,8	0,2	0,2
Rail	472,5	421,7	447,9	461,0	482,5	525,5	607,0	645,1	704,0	765,4	821,9	891,8	964,6	-0,5	0,7	2,3	1,5	1,6	1,6
Aviation	317,3	351,3	456,9	527,3	576,9	702,8	775,7	899,7	996,3	1060,1	1112,4	1178,5	1215,4	3,7	2,4	3,0	2,5	1,1	0,9
Inland navigation	45,8	44,4	41,7	39,5	40,8	42,5	43,1	45,0	47,4	49,4	51,3	53,1	54,6	-0,9	-0,2	0,6	0,9	0,8	0,6
Travel per person (km per capita)	10376	11127	12248	12756	13038	14048	14557	15283	16069	16441	16879	17452	17944	1,7	0,6	1,1	1,0	0,5	0,6
Freight transport activity (Gtkm)	**1848,4**	**1942,4**	**2195,7**	**2494,6**	**2662,6**	**2952,5**	**3058,3**	**3212,4**	**3372,9**	**3425,4**	**3520,0**	**3610,5**	**3657,4**	**1,7**	**1,9**	**1,4**	**1,0**	**0,4**	**0,4**
Trucks	1060,4	1288,7	1518,7	1800,3	1940,3	2164,4	2155,4	2255,1	2346,9	2323,1	2341,6	2366,1	2353,6	3,7	2,5	1,1	0,9	0,0	0,1
Rail	526,3	386,1	403,7	414,1	440,5	489,1	575,1	608,2	658,0	715,2	775,1	826,0	873,5	-2,6	0,9	2,7	1,4	1,7	1,2
Inland navigation	261,6	267,6	273,3	280,2	281,9	299,0	327,8	349,1	368,0	387,2	403,3	418,4	430,3	0,4	0,3	1,5	1,2	0,9	0,6
Freight activity per unit of GDP (tkm/000 Euro'05)	227	222	217	225	234	232	216	207	200	189	180	172	162	-0,4	0,7	-0,8	-0,7	-1,1	-1,1
Energy demand in transport (ktoe)	**280269**	**300617**	**339389**	**362405**	**369965**	**387156**	**370542**	**357676**	**347225**	**309896**	**268098**	**247238**	**232762**	**1,9**	**0,9**	**0,0**	**-0,6**	**-2,6**	**-1,4**
Public road transport	5197	4732	4914	5039	5182	5315	5423	5238	4922	4142	3401	3287	3262	-0,6	0,5	0,5	-1,0	-3,6	-0,4
Private cars and motorcycles	154395	166321	182974	187736	186407	184714	167418	148669	139189	123023	96945	85240	74097	1,7	0,2	-1,1	-1,8	-3,6	-2,7
Trucks	74969	79037	90951	105104	111606	123128	119072	121502	121946	109612	96681	88458	84019	2,0	2,1	0,6	0,2	-2,3	-1,4
Rail	9560	9452	9600	9436	9594	10160	11029	10599	9635	9281	8671	8127	7909	0,0	0,0	1,4	-1,3	-1,0	-0,9
Aviation	29038	34112	45395	49703	51709	58141	61531	65280	64824	57081	55657	55427	56812	4,6	1,3	1,8	0,5	-1,5	0,2
Inland navigation	7110	6963	5555	5386	5466	5699	6071	6387	6709	6758	6743	6699	6663	-2,4	-0,2	1,1	1,0	0,1	-0,1
Efficiency indicator (activity related)																			
Passenger transport (toe/Mpkm)	39,6	39,5	40,3	39,5	38,0	35,4	31,9	28,2	25,5	22,0	18,2	16,4	15,0	0,2	-0,6	-1,7	-2,2	-3,3	-2,0
Freight transport (toe/Mtkm)	47,1	46,8	46,3	46,5	46,0	45,7	43,2	41,8	39,7	35,4	30,7	27,5	25,8	-0,2	-0,1	-0,6	-0,8	-2,5	-1,7

6. Low nuclear scenario

EU27: Low nuclear scenario														SUMMARY ENERGY BALANCE AND INDICATORS (A)					
ktoe	**1990**	**1995**	**2000**	**2005**	**2010**	**2015**	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**	**'90-'00**	**'00-'10**	**'10-'20**	**'20-'30**	**'30-'40**	**'40-'50**
														Annual % Change					
Production	**936047**	**950181**	**941860**	**900326**	**833880**	**806302**	**783208**	**729856**	**655412**	**634719**	**652843**	**647364**	**647871**	**0,1**	**-1,2**	**-0,6**	**-1,8**	**0,0**	**-0,1**
Solids	366477	277810	213423	196277	177975	167224	136642	110080	83810	81928	83306	78964	73504	-5,3	-1,8	-2,6	-4,8	-0,1	-1,2
Oil	129551	171052	173006	134290	104398	73687	46256	35838	31856	23740	14974	7052	2225	2,9	-4,9	-7,8	-3,7	-7,3	-17,4
Natural gas	162447	188965	207559	188677	164866	129038	110475	89793	73132	61058	48751	33622	22827	2,5	-2,3	-3,9	-4,0	-4,0	-7,3
Nuclear	202589	223028	243761	257360	235016	237465	227497	199311	125368	79056	62962	37271	29326	1,9	-0,4	-0,3	-5,8	-6,7	-7,4
Renewable energy sources	74984	89326	104111	123722	151625	198889	262338	294836	341246	388937	442850	490455	519989	3,3	3,8	5,6	2,7	2,6	1,6
Hydro	25101	28054	30374	26395	30008	30274	30795	31570	32111	32594	33116	33579	33949	1,9	-0,1	0,3	0,4	0,3	0,2
Biomass & Waste	46473	57201	67982	85129	99000	122712	149289	159128	167569	191670	215871	241554	251459	3,9	3,8	4,2	1,2	2,6	1,5
Wind	67	350	1913	6061	12781	28217	52300	66202	89644	103804	122309	135561	148699	39,8	20,9	15,1	5,5	3,2	2,0
Solar and others	153	274	421	807	3438	9384	18817	24998	33382	40619	50366	56988	61610	10,7	23,4	18,5	5,9	4,2	2,0
Geothermal	3190	3447	3421	5331	6399	8302	11137	12937	18541	20250	21188	22774	24271	0,7	6,5	5,7	5,2	1,3	1,4
Net Imports	**756079**	**738600**	**826299**	**986048**	**969296**	**1048783**	**956523**	**912998**	**884995**	**824651**	**740294**	**632191**	**531930**	**0,9**	**1,6**	**-0,1**	**-0,8**	**-1,8**	**-3,3**
Solids	81846	79338	98645	126639	102765	116218	91199	70928	45170	48601	51530	40660	42204	1,9	0,4	-1,2	-6,8	1,3	-2,0
Oil	535645	512185	533039	599851	580732	608318	582774	555199	530926	459431	365668	263723	195890	0,0	0,9	0,0	-0,9	-3,7	-6,1
- Crude oil and Feedstocks	508460	494000	513725	581995	578269	602162	578385	555029	534076	465431	374988	285683	218147	0,1	1,2	0,0	-0,8	-3,5	-5,3
- Oil products	27185	18185	19314	17856	2463	6155	4390	171	-3150	-6000	-9320	-21960	-22257	-3,4	-18,6	6,0			
Natural gas	135121	145288	192531	257366	278116	317218	270529	280183	301835	306217	311090	310690	271546	3,6	3,7	-0,3	1,1	0,3	-1,4
Electricity	3323	1508	1686	971	696	-620	-2153	-2586	-1280	-839	-1192	-1292	-1457	-6,6	-8,5				
Renewable energy forms	144	279	397	1222	6987	7649	14174	9273	8344	11241	13199	18409	23747	10,7	33,2	7,3	-5,2	4,7	6,0
Gross Inland Consumption	**1660159**	**1662517**	**1723099**	**1825989**	**1753125**	**1802969**	**1686817**	**1590142**	**1488516**	**1410951**	**1346846**	**1235421**	**1137200**	**0,4**	**0,2**	**-0,4**	**-1,2**	**-1,0**	**-1,7**
Solids	452940	364248	321007	319922	280741	283442	227841	181007	128981	130529	134836	119624	115708	-3,4	-1,3	-2,1	-5,5	0,4	-1,5
Oil	631058	650858	658727	676859	635078	629888	576116	538325	511443	437880	342273	241138	173496	0,4	-0,4	-1,0	-1,2	-3,9	-6,6
Natural gas	294905	333268	393417	445998	442981	446256	381003	369976	374967	367275	359841	344312	294373	2,9	1,2	-1,5	-0,2	-0,4	-2,0
Nuclear	202589	223028	243761	257360	235016	237465	227497	199311	125368	79056	62962	37271	29326	1,9	-0,4	-0,3	-5,8	-6,7	-7,4
Electricity	3323	1508	1686	971	696	-620	-2153	-2586	-1280	-839	-1192	-1292	-1457	-6,6	-8,5				
Renewable energy forms	75343	89606	104501	124880	158613	206538	276512	304109	349038	397050	448127	494367	525755	3,3	4,3	5,7	2,4	2,5	1,6
as % in Gross Inland Consumption																			
Solids	27,3	21,9	18,6	17,5	16,0	15,7	13,5	11,4	8,7	9,3	10,0	9,7	10,2						
Oil	38,0	39,1	38,2	37,1	36,2	34,9	34,2	33,9	34,4	31,0	25,4	19,5	15,3						
Natural gas	17,8	20,0	22,8	24,4	25,3	24,8	22,6	23,3	25,2	26,0	26,7	27,9	25,9						
Nuclear	12,2	13,4	14,1	14,1	13,4	13,2	13,5	12,5	8,4	5,6	4,7	3,0	2,6						
Renewable energy forms	4,5	5,4	6,1	6,8	9,0	11,5	16,4	19,1	23,4	28,1	33,3	40,0	46,2						
Gross Electricity Generation in GWh_e	**2562823**	**2712209**	**2991720**	**3274121**	**3319118**	**3622155**	**3692684**	**3749635**	**3684346**	**4003032**	**4530075**	**4732533**	**4852610**	**1,6**	**1,0**	**1,1**	**0,0**	**2,1**	**0,7**
Nuclear	794718	881662	944823	997519	911418	921451	885417	779772	492435	313482	251187	151146	120339	1,7	-0,4	-0,3	-5,7	-6,5	-7,1
Hydro & wind	292648	330306	375545	378836	514979	713551	1039903	1250333	1608849	1848852	2175334	2418050	2646680	2,5	3,2	7,3	4,5	3,1	2,0
Thermal (incl. biomass)	1475456	1500241	1671352	1897765	1892721	1987153	1767363	1719529	1583062	1840698	2103554	2163336	2085591	1,3	1,3	-0,7	-1,1	2,9	-0,1
Fuel Inputs for Thermal Power Generation	**383492**	**362334**	**382613**	**424208**	**412058**	**427495**	**382177**	**362656**	**335562**	**367803**	**399473**	**395402**	**379404**	**0,0**	**0,7**	**-0,7**	**-1,3**	**1,8**	**-0,5**
Solids	263837	230040	223012	229245	209496	213465	162971	123186	76816	91592	105773	106405	109961	-1,7	-0,6	-2,5	-7,2	3,3	0,4
Oil (including refinery gas)	54404	51463	39294	29780	15656	14147	8067	10169	10353	10963	10330	5005	485	-3,2	-8,8	-6,4	2,5	0,0	-26,4
Gas	56754	67806	102408	134637	145959	140766	124249	130766	134700	145212	152853	147900	137605	6,1	3,6	-1,6	0,8	1,3	-1,0
Biomass & Waste	5724	10033	14960	25901	35546	52312	78156	88761	98393	103707	113533	118393	113326	10,1	9,0	8,2	2,3	1,4	0,0
Geothermal heat	2774	2992	2939	4645	5400	6804	8733	9773	15299	16328	16985	17700	18008	0,6	6,3	4,9	5,8	1,1	0,6
Hydrogen - Methanol	0	0	0	0	0	0	0	0	0	0	0	0	19						
Fuel Input in other transformation proc.	**839073**	**814654**	**827098**	**842975**	**793665**	**794095**	**745841**	**707244**	**678415**	**607425**	**509797**	**401404**	**325061**	**-0,1**	**-0,4**	**-0,6**	**-0,9**	**-2,8**	**-4,4**
Refineries	679426	705954	735244	758152	718103	711109	659266	624319	598003	519578	416258	307345	226788	0,8	-0,2	-0,9	-1,0	-3,6	-5,9
Biofuels and hydrogen production	2	202	610	3129	12208	19510	26828	25818	25726	44241	61725	77999	90412	79,6	34,9	8,2	-0,4	9,1	3,9
District heating	32960	23240	19323	16212	15962	15725	13843	13081	11533	9119	6389	4527	3004	-5,2	-1,9	-1,4	-1,8	-5,7	-7,3
Others	126685	85258	71921	65482	47391	47751	45903	44025	43154	34487	25425	11533	4857	-5,5	-4,1	-0,3	-0,6	-5,2	-15,3
Energy Branch Consumption	**82379**	**88696**	**88176**	**96033**	**91094**	**90076**	**83701**	**77476**	**72395**	**73565**	**74797**	**71351**	**66487**	**0,7**	**0,3**	**-0,8**	**-1,4**	**0,3**	**-1,2**
Non-Energy Uses	**97931**	**110541**	**112495**	**117477**	**111511**	**115318**	**118137**	**119710**	**121465**	**120967**	**120103**	**112174**	**105679**	**1,4**	**-0,1**	**0,6**	**0,3**	**-0,1**	**-1,3**
Final Energy Demand	**1068710**	**1069989**	**1112989**	**1173676**	**1160743**	**1214869**	**1147435**	**1095212**	**1065310**	**1011338**	**946291**	**868740**	**793419**	**0,4**	**0,4**	**-0,1**	**-0,7**	**-1,2**	**-1,7**
by sector																			
Industry	365650	328513	326949	326308	310858	322787	318753	315293	313987	307432	305065	286550	271549	-1,1	-0,5	0,3	-0,2	-0,3	-1,2
- energy intensive industries	234722	214526	213112	210991	192040	196748	191503	186743	183733	175684	169784	154005	140471	-1,0	-1,0	0,0	-0,4	-0,8	-1,9
- other industrial sectors	130928	113987	113837	115317	118818	126039	127250	128550	130254	131748	135281	132545	131078	-1,4	0,4	0,7	0,2	0,4	-0,3
Residential	264307	280418	286784	308104	306318	320952	290108	270925	261270	248474	232717	212334	185477	0,8	0,7	-0,5	-1,0	-1,2	-2,2
Tertiary	158484	160442	159866	176859	173603	183981	167740	152016	143445	134612	125926	114755	102850	0,1	0,8	-0,3	-1,6	-1,3	-2,0
Transport	280269	300617	339389	362405	369964	387148	370834	356978	346607	320820	282583	255101	233542	1,9	0,9	0,0	-0,7	-2,0	-1,9
by fuel																			
Solids	125031	84977	61454	54486	47270	44790	40209	32886	26273	17616	13511	5906	2239	-6,9	-2,6	-1,6	-4,2	-6,4	-16,5
Oil	444429	456959	478882	495857	476999	476739	433211	400710	377138	313365	232377	164064	117903	0,7	0,0	-1,0	-1,4	-4,7	-6,6
Gas	227902	245996	265552	283524	268025	275255	228194	208413	210001	189505	166301	137513	95784	1,5	0,1	-1,6	-0,8	-2,3	-5,4
Electricity	184145	193367	216403	237537	242283	265184	271120	276033	274027	287361	307103	307121	305497	1,6	1,1	1,1	0,1	1,1	-0,1
Heat (from CHP and District Heating) [A]	48610	44616	40061	44441	57849	71838	79028	83235	84786	87142	86190	82369	79380	-1,9	3,7	3,2	0,7	0,2	-0,8
Other	38592	44073	50640	57832	68316	81063	95672	93936	93084	116348	140809	171767	192616	2,8	3,0	3,4	-0,3	4,2	3,2
CO_2 Emissions (Mt of CO_2 - sec approach)	**4030,6**	**3800,1**	**3810,6**	**3946,6**	**3688,9**	**3683,2**	**3131,7**	**2796,9**	**2481,5**	**1993,9**	**1495,0**	**986,5**	**634,3**	**-0,6**	**-0,3**	**-1,6**	**-2,3**	**-4,9**	**-8,2**
Power generation/District heating	1484,3	1321,2	1320,8	1381,1	1274,2	1273,9	998,2	851,2	637,7	449,5	284,9	98,8	21,2	-1,2	-0,4	-2,4	-4,4	-7,7	-22,9
Energy Branch	152,2	171,0	170,2	181,6	157,2	145,9	128,4	113,0	103,1	79,7	61,0	45,6	24,4	1,1	-0,8	-2,0	-2,2	-5,1	-8,7
Industry	781,4	678,1	623,0	581,9	497,0	480,0	439,5	412,8	404,1	349,1	308,2	234,9	165,5	-2,2	-2,2	-1,2	-0,8	-2,7	-6,0
Residential	499,4	481,6	466,2	486,7	466,7	466,4	383,8	322,8	304,8	255,7	194,5	132,9	70,8	-0,7	0,0	-1,9	-2,3	-4,4	-9,6
Tertiary	300,5	275,3	242,0	262,2	245,7	239,4	188,2	162,4	154,1	133,5	102,0	68,3	38,2	-2,1	0,2	-2,6	-2,0	-4,0	-9,4
Transport	812,7	872,9	988,5	1053,1	1048,2	1077,6	993,7	934,7	877,7	726,3	544,5	406,0	314,2	2,0	0,6	-0,5	-1,2	-4,7	-5,3
CO_2 Emissions Index (1990=100)	**100,0**	**94,3**	**94,5**	**97,9**	**91,5**	**91,4**	**77,7**	**69,4**	**61,6**	**49,5**	**37,1**	**24,5**	**15,7**						
CO_2 Emissions (Mt of CO_2 - ref approach)	**4172,0**	**3950,7**	**3922,7**	**4087,6**	**3756,3**	**3751,1**	**3199,3**	**2863,6**	**2550,6**	**2056,8**	**1560,2**	**1073,7**	**737,6**	**-0,6**	**-0,4**	**-1,6**	**-2,2**	**-4,8**	**-7,2**

EU27: Low nuclear scenario — SUMMARY ENERGY BALANCE AND INDICATORS (B)

	1990	1995	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050	'90-'00	'00-'10	'10-'20	'20-'30	'30-'40	'40-'50
														Annual % Change					
Main Energy System Indicators																			
Population (Million)	470,388	477,010	481,072	489,211	499,389	507,727	513,838	517,811	519,942	520,654	520,103	518,362	515,303	0,2	0,4	0,3	0,1	0,0	-0,1
GDP (in 000 MEuro'05)	8142,7	8748,4	10107,2	11063,1	11385,6	12750,3	14164,0	15503,7	16824,7	18157,1	19527,9	21002,9	22560,0	2,2	1,2	2,2	1,7	1,5	1,5
Gross Inl. Cons./GDP (toe/MEuro'05)	203,9	190,0	170,5	165,1	154,0	141,4	119,1	102,6	88,5	77,7	69,0	58,8	50,4	-1,8	-1,0	-2,5	-2,9	-2,5	-3,1
Gross Inl. Cons./Capita (toe/inhabitant)	3,53	3,49	3,58	3,73	3,51	3,55	3,28	3,07	2,86	2,71	2,59	2,38	2,21	0,1	-0,2	-0,7	-1,4	-1,0	-1,6
Electricity Generated/Capita (kWh gross/inhabitant)	5448	5686	6219	6693	6646	7134	7186	7241	7086	7688	8710	9130	9417	1,3	0,7	0,8	-0,1	2,1	0,8
Carbon intensity (t of CO_2/toe of GIC)	2,43	2,29	2,21	2,16	2,10	2,04	1,86	1,76	1,67	1,41	1,11	0,80	0,56	-0,9	-0,5	-1,2	-1,1	-4,0	-6,7
CO_2 Emissions/Capita (t of CO_2/inhabitant)	8,57	7,97	7,92	8,07	7,39	7,25	6,09	5,40	4,77	3,83	2,87	1,90	1,23	-0,8	-0,7	-1,9	-2,4	-4,9	-8,1
CO2 Emissions to GDP (t of CO2/MEuro'05)	495,0	434,4	377,0	356,7	324,0	288,9	221,1	180,4	147,5	109,8	76,6	47,0	28,1	-2,7	-1,5	-3,7	-4,0	-6,3	-9,5
Import Dependency %	44,6	43,5	46,8	52,5	53,8	56,5	55,0	55,6	57,5	56,5	53,1	49,4	45,1						
Energy intensity indicators (2000=100)																			
Industry (Energy on Value added)	130,3	115,2	100,0	95,1	89,8	84,5	75,6	68,8	63,7	58,0	53,8	47,2	41,9	-2,6	-1,1	-1,7	-1,7	-1,7	-2,5
Residential (Energy on Private Income)	114,4	113,2	100,0	97,5	96,3	89,7	73,3	63,2	56,6	49,4	43,1	36,3	29,7	-1,3	-0,4	-2,7	-2,6	-2,7	-3,7
Tertiary (Energy on Value added)	126,5	117,0	100,0	99,4	93,9	88,0	72,0	59,3	51,4	44,6	38,6	32,6	27,1	-2,3	-0,6	-2,6	-3,3	-2,8	-3,5
Transport (Energy on GDP)	102,5	102,3	100,0	97,6	96,8	90,4	78,0	68,6	61,4	52,6	43,1	36,2	30,8	-0,2	-0,3	-2,1	-2,4	-3,5	-3,3
Carbon Intensity indicators																			
Electricity and Steam production (t of CO_2/MWh)	0,46	0,40	0,37	0,35	0,31	0,27	0,21	0,17	0,13	0,09	0,05	0,02	0,00	-2,1	-2,0	-3,8	-4,5	-9,2	
Final energy demand (t of CO_2/toe)	2,24	2,16	2,08	2,03	1,94	1,86	1,75	1,67	1,63	1,45	1,21	0,97	0,74	-0,7	-0,7	-1,1	-0,7	-2,9	-4,8
Industry	2,14	2,06	1,91	1,78	1,60	1,49	1,38	1,31	1,29	1,14	1,01	0,82	0,61	-1,1	-1,7	-1,5	-0,7	-2,4	-4,9
Residential	1,89	1,72	1,63	1,58	1,52	1,45	1,32	1,19	1,17	1,03	0,84	0,63	0,38	-1,5	-0,6	-1,4	-1,2	-3,3	-7,5
Tertiary	1,90	1,72	1,51	1,48	1,42	1,30	1,12	1,07	1,07	0,99	0,81	0,60	0,37	-2,2	-0,7	-2,3	-0,4	-2,8	-7,5
Transport	2,90	2,90	2,91	2,91	2,83	2,78	2,68	2,62	2,53	2,26	1,93	1,59	1,35	0,0	-0,3	-0,6	-0,6	-2,7	-3,5
Electricity and steam generation																			
Net Generation Capacity in MW_e			**654168**	**715466**	**821498**	**926071**	**1028502**	**1075129**	**1198871**	**1305721**	**1493474**	**1630142**	**1721011**		**2,3**	**2,3**	**1,5**	**2,2**	**1,4**
Nuclear energy			133966	134452	131393	125743	123641	96195	62110	38502	30675	19846	15501		-0,2	-0,6	-6,7	-6,8	-6,6
Renewable energy			112878	147262	206776	283787	419250	505806	672162	784712	945955	1069262	1192680		6,2	7,3	4,8	3,5	2,3
Hydro (pumping excluded)			99714	104505	107315	111540	114859	116960	119176	121256	122464	124554	126859		0,7	0,7	0,4	0,3	0,4
Wind			12793	40584	83905	143654	246396	303989	411622	473458	554340	612137	674115		20,7	11,4	5,3	3,0	2,0
Solar			371	2172	15307	28018	56262	81851	137038	183893	261900	323804	380723		45,1	13,9	9,3	6,7	3,8
Other renewables (tidal etc.)			0	1	249	575	1732	3005	4327	6105	7252	8767	10982			21,4	9,6	5,3	4,2
Thermal power			407324	433752	483329	516541	485612	473129	464599	482506	516844	541034	512830		1,7	0,0	-0,4	1,1	-0,1
of which cogeneration units			76247	85453	98311	119406	125133	135436	149703	163897	164135	169283	170040		2,6	2,4	1,8	0,9	0,4
of which CCS units			0	0	0	0	2711	2711	8209	61535	129400	213141	247835				11,7	31,8	6,7
Solids fired			194165	186620	183620	182825	154527	131745	115037	122760	128280	125565	124868		-0,6	-1,7	-2,9	1,1	-0,3
Gas fired			129444	166863	218514	242623	233617	236189	236679	240491	261180	285925	255451		5,4	0,7	0,1	1,0	-0,2
Oil fired			71058	62082	55901	46087	34821	32248	29516	28203	24752	18766	17720		-2,4	-4,6	-1,6	-1,7	-3,3
Biomass-waste fired			12051	17502	24567	44098	61483	71646	81332	88881	100373	108425	112395		7,4	9,6	2,8	2,1	1,1
Hydrogen plants			0	0	0	0	0	0	0	0	0	0	0						
Geothermal heat			605	686	727	908	1164	1302	2035	2172	2259	2354	2395		1,9	4,8	5,8	1,0	0,6
Load factor for net electric capacities (%)			49,1	49,1	43,9	42,6	39,3	38,3	33,9	33,2	32,5	30,9	30,0						
Indicators for gross electricity production																			
Efficiency for thermal electricity production (%)			37,6	38,5	39,5	40,0	39,8	40,8	40,6	43,0	45,3	47,1	47,3						
CHP indicator (% of electricity from CHP)			11,4	11,7	14,9	19,0	20,3	21,7	22,4	22,2	20,3	19,9	18,1						
CCS indicator (% of electricity from CCS)			0,0	0,0	0,0	0,0	0,5	0,7	2,1	12,8	22,2	30,4	31,9						
Non fossil fuels in electricity generation (%)			45,8	44,8	47,2	50,7	60,3	63,6	68,0	64,9	64,4	65,3	67,3						
- nuclear			31,6	30,5	27,5	25,4	24,0	20,8	13,4	7,8	5,5	3,2	2,5						
- renewable energy forms and industrial waste			14,2	14,3	19,7	25,3	36,4	42,8	54,6	57,1	58,8	62,1	64,8						
Indicators for renewables (excluding industrial waste) (%) [(B)]																			
RES in gross final energy demand (%)			7,6	8,6	11,4	14,8	21,2	24,5	28,8	34,3	41,3	49,7	57,5						
RES in transport (%)			0,5	1,4	4,3	6,6	10,9	13,9	19,1	30,9	44,6	55,8	64,2						
Transport sector																			
Passenger transport activity (Gpkm)	**4880,7**	**5307,7**	**5892,2**	**6240,3**	**6511,3**	**7132,2**	**7480,2**	**7908,5**	**8340,8**	**8638,2**	**8897,8**	**9145,0**	**9321,6**	**1,9**	**1,0**	**1,4**	**1,1**	**0,6**	**0,5**
Public road transport	544,0	504,0	517,6	526,0	545,0	573,7	639,6	675,1	721,6	767,7	807,3	847,3	890,0	-0,5	0,5	1,6	1,2	1,1	1,0
Private cars and motorcycles	3501,1	3986,3	4428,1	4686,5	4866,0	5288,2	5414,2	5644,5	5875,4	5992,2	6097,9	6172,9	6203,9	2,4	0,9	1,1	0,8	0,4	0,2
Rail	472,5	421,7	447,9	461,0	482,5	525,1	607,1	644,5	701,2	759,1	813,6	885,0	964,8	-0,5	0,7	2,3	1,5	1,5	1,7
Aviation	317,3	351,3	456,9	527,3	576,9	702,8	776,2	899,4	995,2	1069,7	1127,6	1186,6	1208,4	3,7	2,4	3,0	2,5	1,3	0,7
Inland navigation	45,8	44,4	41,7	39,5	40,8	42,5	43,1	45,0	47,4	49,5	51,5	53,1	54,5	-0,9	-0,2	0,6	0,9	0,8	0,6
Travel per person (km per capita)	10376	11127	12248	12756	13038	14047	14557	15273	16042	16591	17108	17642	18090	1,7	0,6	1,1	1,0	0,6	0,6
Freight transport activity (Gtkm)	**1848,4**	**1942,4**	**2195,7**	**2494,6**	**2662,6**	**2952,3**	**3058,2**	**3209,7**	**3365,7**	**3475,9**	**3590,6**	**3645,4**	**3636,4**	**1,7**	**1,9**	**1,4**	**1,0**	**0,6**	**0,1**
Trucks	1060,4	1288,7	1518,7	1800,3	1940,3	2164,3	2155,1	2252,5	2340,6	2377,1	2419,5	2405,9	2330,1	3,7	2,5	1,1	0,8	0,3	-0,4
Rail	526,3	386,1	403,7	414,1	440,5	489,0	575,3	608,0	657,2	711,2	767,4	821,0	876,3	-2,6	0,9	2,7	1,3	1,6	1,3
Inland navigation	261,6	267,6	273,3	280,2	281,9	299,0	327,8	349,1	367,9	387,7	403,7	418,5	430,0	0,4	0,3	1,5	1,2	0,9	0,6
Freight activity per unit of GDP (tkm/000 Euro'05)	227	222	217	225	234	232	216	207	200	191	184	174	161	-0,4	0,7	-0,8	-0,8	-0,8	-1,3
Energy demand in transport (ktoe)	**280269**	**300617**	**339389**	**362405**	**369964**	**387148**	**370834**	**356978**	**346607**	**320820**	**282583**	**255101**	**233542**	**1,9**	**0,9**	**0,0**	**-0,7**	**-2,0**	**-1,9**
Public road transport	5197	4732	4914	5039	5182	5315	5422	5236	4925	4637	3789	3404	3320	-0,6	0,5	0,5	-1,0	-2,6	-1,3
Private cars and motorcycles	154395	166321	182974	187736	186407	184711	167383	148571	139304	122019	96088	83957	73503	1,7	0,2	-1,1	-1,8	-3,6	-2,6
Trucks	74969	79037	90951	105104	111606	123126	119058	121370	121625	114475	105852	93858	84726	2,0	2,1	0,6	0,2	-1,4	-2,2
Rail	9560	9452	9600	9436	9594	10157	11032	10594	9617	9386	9087	8656	8299	0,0	0,0	1,4	-1,4	-0,6	-0,9
Aviation	29038	34112	45395	49703	51709	58141	61868	64820	64430	63407	60777	58327	56916	4,6	1,3	1,8	0,4	-0,6	-0,7
Inland navigation	7110	6963	5555	5386	5466	5699	6070	6386	6706	6895	6990	6899	6778	-2,4	-0,2	1,1	1,0	0,4	-0,3
Efficiency indicator (activity related)																			
Passenger transport (toe/Mpkm)	39,6	39,5	40,3	39,5	38,0	35,4	31,9	28,2	25,5	22,5	18,5	16,4	14,8	0,2	-0,6	-1,7	-2,2	-3,2	-2,2
Freight transport (toe/Mtkm)	47,1	46,8	46,3	46,5	46,0	45,7	43,2	41,8	39,7	36,4	32,8	28,9	26,3	-0,2	-0,1	-0,6	-0,8	-1,9	-2,2

ATTACHMENT 2: ASSUMPTIONS ABOUT INTERCONNECTIONS AND MODELLING OF ELECTRICITY TRADE

Short description of the model

The electricity trade model of PRIMES covers all countries in the European continent except countries of the CIS and Turkey. Interconnector capacities at the various country borders are determined exogenously.

The model performs unit commitment, endogenous use of interconnectors (with given capacities and Net Transfer Capacities (NTC)) and also optimal power generation capacity expansion planning in a perfect foresight manner until 2050. Simulations of different electricity demand levels with the model allow identification of bottlenecks and of the amount of investment in interconnectors necessary to remove such bottlenecks.

The model covers demand both for electricity and CHP steam/heat, as given from results of the entire PRIMES model. Demand for electricity and for steam/heat is supposed to be given and is represented through two typical days (for winter and summer).

Investment in new power plants is endogenous. The rate of use of power capacities and interconnectors is endogenous. Regarding the use of interconnectors the model performs a linear Direct Current optimal power flow under oriented NTC constraints defined per each couple of countries. The model makes distinction between AC lines and DC lines, the use of the latter being controlled by operators. All interconnectors existing today or planned to be constructed in the future are represented (one by one) in the model.

Among the inputs, the model considers non linear cost-supply curves for fuels used in power generation and non linear investment cost curves for nuclear and renewable energy power plants, which are a function of total installed capacity (unit investment costs increase as approaching the potential).

The electricity model, used in stage 1, is identical to the model used in the entire PRIMES model, but could be used with endogenous electricity trade only for the work during stage 1 because of very long computing times for each model run when iterations are performed between demand and supply and for meeting carbon targets.

Assumptions for the modelling exercise

All data about NTCs and interconnection capacities were taken from ENTSOe databases. Information on new constructions was taken from the latest “Ten-year network development plan 2010-2020”, complemented, where necessary, with information from the Nordic Pool TSOs and the Energy Community (for South East Europe). Some of the planned new constructions would justify increase of NTCs values until 2020, as mentioned in the ENTSOe’s TYNDP document. Other mentioned new constructions regard directly the building of new interconnection lines which are introduced as such in the model database.
According to assumptions agreed with the Energy DG of the European Commission, the following three cases were formulated regarding the NTC values:

a) NTC-0: keeping the NTC values of 2020, which are much higher than today, unchanged until 2050; the projection of NTC values to the year 2020 from today levels follows a study by KEMA, except few cases either because the links were not included in that study or because ENTSOe's NTC values announced for 2010-2011 were exceeding the KEMA's values. This assumption does not use the TYNDP information about new constructions aiming at increasing the NTC values in the future, except indirectly if in some cases the KEMA values for 2020 increase from today's levels.

b) NTC-2: apply a doubling of 2020 NTC values between 2020 and 2050 and interpolate linearly between 2020 and 2050; increase capacities of interconnectors where necessary so as to keep NTC values lower than total interconnection capacity by individual couples of countries. Some additional DC lines were added (linking Italy with western Balkans).
c) NTC-4: apply a quadrupling of 2020 NTC values by 2050 and interpolate with extension of interconnection capacities where needed.

Two energy demand and pricing contexts were considered to analyze the implications from the above mentioned NTC assumptions, which are as follows:

1. Reference scenario: demand, prices, taxes and ETS carbon prices are taken as identical to the DG ENER Reference scenario. Some adjustments on electricity demand figures were made only for year 2010, based on monthly statistics for 2010, in order to be able to simulate the true NTC values for this year.
2. Decarbonisation scenario: demand, prices and ETS carbon prices, as well as the parameters mirroring RES facilitation and other policies, are taken from the DG CLIMA "Decarbonisation scenario under effective technologies and global climate action" scenario.

Discussion of model results for the Reference scenario with three NTC value cases

The model results show that the NTC values retained for the year 2020 do not lead to substantial changes compared to results for the standard Reference scenario, i.e. the Reference scenario referred to in the Low Carbon Economy Roadmap). The countries projected to be net exporters in the standard reference scenario remain so in the model results presented here; the same applies to countries projected to be net importers in the standard reference scenario. There are differences in the magnitude of exports or imports for the year 2020, as for example for Belgium, Portugal, Lithuania and Latvia (higher net imports), for Hungary and Denmark (lower net imports) and for Slovenia, Slovakia, Sweden and Bulgaria (more net exports). It is reminded that for the standard Reference scenario import-exports of electricity were derived following a different methodology, which applied common balancing by region, contrasting the pan-European balancing applied for the model runs presented here.
NTC-0 case.

Regarding the scenario with NTC values remaining unchanged at the year 2020, the model results provide information about congestion by considering whether the NTC constraints are binding or close to be binding for couples of countries. The findings from this analysis regarding the projected NTC values for 2020 are summarized below

- Link Switzerland-Germany: appears congested and NTC is 32% of capacity
- Link Germany-Poland: appears congested and NTC is 17% of capacity
- Link Denmark-Sweden: appears congested and NTC is 54% of capacity
- Link Austria-Italy: appears very congested and NTC is 16% of capacity
- Link Italy-Slovenia: appears congested and NTC is 15% of capacity

- Link Austria-Hungary: appears congested and NTC is 31% of capacity
- Link Slovenia-Croatia: appears congested and NTC is 18% of capacity
- Links in the Balkans (FYROM-Greece, Albania-Greece, Bulgaria-Greece, Serbia-FYROM, Romania-Serbia, Serbia-Albania, Bulgaria-FYROM) appear very congested and NTC are below 30% of capacity, except Greece-Bulgaria NTC which is 68% of capacity

Congestion is detected in the model runs due to NTCs that are only a small part of existing capacities. One option for dealing with congestion would be to increase NTC without necessarily construct new lines. From the above overview it can be seen that the congestions after 2020 remain between Germany and neighbours to the east and south, between Austria, Italy, Slovenia, and Hungary, and finally in the Balkans, both within the Balkans and the linkages with northern neighbours.

NTC-2 and NTC-4 cases

The NTC-2 and NTC-4 cases assume doubling and quadrupling of NTC values, respectively from 2020 to2050, with linear interpolation applied between 2020 and 2050. The model results show that this way of uniformly increasing the NTC values does not really solve the problem of systematic congestions mentioned above for the case NTC-0. These congestions are removed only in the case NTC-4 and after 2030, with the exception of the Austria-Italy and Germany-Poland links, which remain congested until 2050 despite the quadrupled NTCs. The congestion problems in the Balkans are removed only in the NTC-4 case after 2030, but the area remains strongly congested under the NTC-2 assumptions. The congestions in links with Germany (Switzerland, Poland, Czech Rep. and Austria) are not removed in the NTC-2 case.

The doubling and quadrupling of NTCs values do not provide any advantages concerning the large list of links, which are not found congested under the NTC-0 assumptions.

The doubling of NTCs under the assumptions of NTC-2 case lead to lower rates of use of interconnection capacities (reported as percentage of NTCs), compared with NTC-0 results in the following cases:

- UK-Ireland: 17 percentage points less use
- France, Belgium, Netherlands, Luxembourg, Germany: between 15 and 30 percentage points less use
- Nordic area: around 15 percentage points less use
- Czech Rep., Slovakia, Poland, Hungary, Romania, Croatia: between 20 and 30 percentage points less use
- Latvia-Estonia: 20 percentage points less use

Passing from the doubling to the quadrupling implies even lower rates of use of interconnection possibilities.

Both cases NTC-2 and NTC-4 have adverse implications on the rate of use of DC lines leading to lower rates of use compared to case NTC-0, which under NTC-4 are close to zero in some cases. The NTC constraints help using the DC links for which the NTC values are usually equal to the interconnection capacities. Excessively high NTC constraints, which also mean more AC links, imply much less use of DC lines, which of course is unrealistic, as the DC lines correspond to today known constructions and are furthermore expensive. So the companies would not build so many new AC lines as the ones corresponding to NTC-4 on economic grounds including the adverse effects on DC lines.

A major issue with NTC-2 and NTC-4 cases regards the investment cost implicitly associated with the increase of interconnection capacities stemming from the doubling and quadrupling of NTC values. Total interconnection capacity is projected to increase by 43% in 2020 compared to 2010 levels, as a result of implementing the construction program of the TYNDP. In NTC-0 the capacity remains roughly unchanged until 2050. But in NTC-2 the capacity has to increase by 95% in 2050 compared to 2020 levels and in NTC-4 this increase is 277%. Such a construction program exceeds by far capacity requirements and would unnecessarily penalize costs and electricity prices in the scenarios.

According to the model results, we obtain the following changes in energy terms from NTC-2 and NTC-4 assumptions compared to NTC-0 results:

- Total volume of electricity traded increases by 5% in NTC-2 and by 8% in NTC-4 compared to NTC-0 in cumulative terms for the period 2015-2050. It is evident that the additional cost of interconnectors cannot be justified by such small increases in total traded volumes (i.e. adding absolute values of flows between countries).
- Total electricity production costs decrease by 0.13% in NTC-2 and by 0.23% in NTC-4 compared to NTC-0 in cumulative terms 2015-2050
- CO_2 emissions from electricity production decrease by 0.8% in NTC-2 and by 0.9% in NTC-4 compared to NTC-0 in cumulative terms 2015-2050
- Nuclear and RES cumulative production are found slightly higher in NTC-2 and NTC-4 compared to NTC-0, but the changes are less than 1% in cumulative terms.

It can therefore be concluded that the NTC expansion according to the NTC-2 and NTC-4 assumptions are not needed for the functioning of the electricity system and would entail high unnecessary cost without providing any noticeable benefit. These assumptions do not solve the serious congestion issues, do not provide gains for the non congested areas and have adverse effects on the economics of DC lines.

The conclusion for a Reference or Current Policy Initiatives framework is therefore to follow an approach that focuses on identified bottlenecks. For stage 2 of the modelling it is appropriate to increase NTC values and interconnection capacities after 2020 in a selective way, with priority to areas that would be congested in the future according to the reference scenario results. Such areas are the southern and eastern connections of Germany, the area linking Italy, Austria and Slovenia, the linkages of Balkans with northern neighbours and the linkages within Balkans. Some NTC additions should be also made for the linkages Denmark-Sweden and Latvia-Estonia.

With lower electricity demand due to the assumed strong energy efficiency policies, these results also hold for the Current Policy Initiatives scenario.

Discussion of model results for a Decarbonisation scenario with three NTC value cases

Under the assumptions of the decarbonisation scenario, total demand for electricity (in the 32 countries included in the model) increases by 15% in 2050 compared to the Reference scenario for year 2050. ,
It is assumed that the renewable facilitation policies develop in all countries in favour of domestic renewable potential. The scenario does not assume inflows of RES electricity from outside EU countries (e.g. North Africa) and does not include the possibility of exploitation of offshore wind located at long distance from the coasts.

The results from the model show that the NTC values retained for the period until 2020 do not alter the electricity trade pattern projected in previous decarbonisation exercises and compared to the Reference scenario.

The congestions identified in the context of the decarbonisation scenario for the year 2020 are the same as in the context of the reference scenario (see previous section).

Under the assumptions of the NTC-0 case the results show congestions similar to those found for the reference scenario, i.e. in south and east of Germany, in the Balkans, in the northern connections of the Balkans, in the linkages between Italy, Austria and Slovenia. Some additional congestion cases, found in the context of decarbonisation, relate to the link Germany-Sweden, Norway-UK and Germany-UK which are based on DC-links and do not concern the NTC values.

The doubling of NTC values under the assumptions of the NTC-2 case does not help removing the congestions. The quadrupling of NTC values (NTC-4 case) helps removing the congestions only in the long term, after 2040. So the linear interpolation method seems not to be useful as it brings little benefits and entails high costs for building new interconnectors. Increase of NTC values in a selective way and at an early stage after 2020 seems more suitable.

In the context of the decarbonisation scenario, the NTC-2 case allows increase of total volumes traded by 12% when compared to NTC-0. The increase obtained for the NTC-4 case is 14% (up from NTC-0). NTC-2 reduces total power generation costs roughly by 0.85% in cumulative terms compared to NTC-0. In NTC-4, the additional effect on power generation costs is smaller, NTC-4 power generation costs are 0.2%) lower compared with NTC-2. It is important to note that these statements related to power generation costs, and that the move from NTC-0 to NTC-2 and even more NTC-4 involves large costs for grid investment. NTC-2 has small impacts favouring slightly more nuclear and RES generation, whereas NTC-4 add very little to NTC-2 effects.

Overall conclusions on decarbonisation scenarios (except for those with very strong reliance on RES)

Following these economic modelling results, the approach for further modelling was chosen to start fromNTC-0 assumptions and to increase in selective way NTC values immediately after 2020 for the linkages found to be congested. This concerns interconnections around Germany, in Austria-Italy-Slovenia, Balkans and Denmark-Sweden.

For very high RES penetration, such linkages may not be sufficient. Therefore, this case has been examined separately. The results of this analysis are reported in the following chapter.

Assumptions about interconnections in the Decarbonisation scenario with High RES deployment both domestically and in the North Sea

Under the assumptions of this decarbonisation scenario, full exploitation of off-shore wind potential at North Sea is foreseen. In this modelling, exploiting the highest possible offshore wind potential is envisaged for Denmark, the UK, France, Germany, Netherlands, Sweden, Norway, Belgium and Ireland, according to the division of the sea in economic zones. Data on potentials come from published reports (e.g. EEA); the additional potentials, compared to standard RES scenario, are remarkably high for Norway, UK and Netherlands. It is assumed that a dense DC interconnection system will develop mainly offshore but also partly onshore, to facilitate power flows from the North Sea offshore wind parks.

After several model runs with different DC topology configurations and after considering elimination of congestions arising from wind offshore power flows, we have concluded to the following assumptions about the additional DC interconnections:

In MW — Investment in additional new interconnectors in the 4.1 scenario – North Sea

		2030	2035	2040	2045	2050	Total
Ireland	UK	0	0	1000	0	0	1000
Spain	France	1000	0	1000	0	0	2000
France	Germany	0	0	1000	1000	0	2000
France	Belgium	0	0	1000	0	0	1000
Belgium	Netherlands	0	0	1000	1000	0	2000
Netherlands	Germany	0	500	1000	1000	0	2500
UK	France	1000	0	1000	500	0	2500
UK	Belgium	1000	0	500	0	0	1500
UK	Netherlands	0	0	1000	0	0	1000
UK	Germany	1000	0	1000	1000	0	3000
Norway	Belgium	1000	1000	1000	1000	1000	5000
Norway	Netherlands	1000	1000	500	500	0	3000
Norway	Germany	1000	1000	1000	1000	1000	5000
Germany	Denmark	0	1000	2000	1000	500	4500
Norway	Denmark	1000	0	0	0	0	1000
UK	Norway	0	1000	0	1000	0	2000
Norway	Sweden	1000	0	0	0	0	1000
Sweden	Poland	1000	2000	2000	2000	3000	10000
Netherlands	Denmark	500	500	1000	500	0	2500
Denmark	Sweden	500	500	1000	1000	1000	4000
Germany	Poland	0	1000	1000	1500	1500	5000
Denmark	Poland	0	1000	2000	2500	500	6000
	Total	11000	10500	21000	16500	8500	67500

The NTC values are identical to the DC capacities, as assumed for all DC lines.

The congestions in this scenario are related to the wheeling of electricity from the North Sea region to consumption centres. The links of Sweden with Poland, Sweden with Lithuania, Austria with Italy, France with Italy and links in the Balkan region appear to be congested.
In this scenario, the electricity trade changes drastically. The United Kingdom, Netherlands, Denmark, Sweden, Norway export large amount of electricity while France, Belgium Germany, Italy, Czech Republic, Slovakia, Poland become or remain importing countries. This changes the results for the decarbonisation scenario as regards several countries.

ATTACHMENT 3: SHORT DESCRIPTION OF THE MODELS USED

The scenarios were derived with the PRIMES model by a consortium led by the National Technical University of Athens (E3MLab), supported by some more specialised models (e.g. GEM-E3 model that has been used for projections for the value added by branch of activity and PROMETHEUS model that has been deployed for projections of world energy prices).

GEM-E3

The GEM-E3 (World and Europe) model is an applied general equilibrium model, simultaneously representing World regions and European countries, linked through endogenous bilateral trade flows and environmental flows. The European model is including the EU countries, the Accession Countries and Switzerland. The world model version includes 18 regions among which a grouping of European Union states. GEM-E3 aims at covering the interactions between the economy, the energy system and the environment. It is a comprehensive model of the economy, the productive sectors, consumption, price formation of commodities, labour and capital, investment and dynamic growth. The model is dynamic, recursive over time, driven by accumulation of capital and equipment. Technology progress is explicitly represented in the production function, either exogenous or endogenous, depending on R&D expenditure by private and public sector and taking into account spillovers effects. The current GEM-E3 version has been updated to the GTAP7 database (base year 2004) and has been updated with the latest Eurostat statistics for the EU Member States.

PRIMES model

The PRIMES model simulates the response of energy consumers and the energy supply systems to different pathways of economic development and exogenous constraints and drivers. It is a modelling system that simulates a market equilibrium solution in the European Union and its member states. The model determines the equilibrium by finding the prices of each energy form such that the quantity producers find best to supply match the quantity consumers wish to use. The equilibrium is forwarding looking and includes dynamic relationships for capital accumulation and technology vintages. The model is behavioural formulating agents' decisions according to microeconomic theory, but it also represents in an explicit and detailed way the available energy demand and supply technologies and pollution abatement technologies. The system reflects considerations about market competition economics, industry structure, energy /environmental policies and regulation. These are conceived so as to influence market behaviour of energy system agents. The modular structure of PRIMES reflects a distribution of decision making among agents that decide individually about their supply, demand, combined supply and demand, and prices. Then the market integrating part of PRIMES simulates market clearing.

PRIMES is a partial equilibrium model simulating the entire energy system both in demand and in supply; it contains a mixed representations of bottom-up and top-down elements. The PRIMES model covers the 27 EU Member States as well as candidate and neighbour states (Norway, Switzerland, Turkey, South East Europe). The timeframe of the model is 2000 to 2050 by five-year periods; the years up to 2005 are calibrated to Eurostat data. The level of detail of the model is large as it contains:

- 12 industrial sectors, subdivided into 26 sub-sectors using energy in 12 generic processes (e.g. air compression, furnaces)
- 5 tertiary sectors, using energy in 6 processes (e.g. air conditioning, office equipment)
- 4 dwelling types using energy in 5 processes (e.g. water heating, cooking) and 12 types of electrical durable goods (e.g. refrigerator, washing machine, television)
- 4 transport modes, 10 transport means (e.g. cars, buses, motorcycles, trucks, airplanes) and 10 vehicle technologies (e.g. internal combustion engine, hybrid cars)
- 14 fossil fuel types, new fuel carriers (hydrogen, biofuels) 10 renewable energy types
- Main Supply System: power and steam generation with 150 power and steam technologies and 240 grid interconnections
- Other sub-systems: refineries, gas supply, biomass supply, hydrogen supply, primary energy production
- 7 types of emissions from energy processing (e.g. SO2, NOx, PM)
- CO2 emissions from industrial processes
- GHG emissions and abatement (using IIASA's marginal abatement cost curves for non CO2 GHGs).

For further information see
http://www.e3mlab.ntua.gr/e3mlab/index.php?option=com_content&view=article&id=58%3Amanual-for-primes-model&catid=35%3Aprimes&Itemid=80&lang=en

Prometheus model

A fully stochastic World energy model used for assessing uncertainties and risks associated with the main energy aggregates including uncertainties associated with economic growth and resource endowment as well as the impact of policy actions (R&D on specific technologies, taxes, standards, subsidies and other supports). The model projects endogenously to the future the world energy prices, supply, demand and emissions for 10 World regions. World fossil fuel price trajectories are used for the EU modelling as import price assumptions for PRIMES.

Annex 2 - Energy Roadmap 2050 – Selected Stakeholders' Scenarios

1. INTRODUCTION

Stakeholders are continuing their work on scenarios for long term transformation of energy systems. These analyses, using a variety of models and assumptions and exploring a variety of constraints, all help in assessing the **robustness of conclusions** on policy actions needed in the coming years.

The bulk of this report, chapters 2-4, is a systematic presentation of a representative sample of European long term energy scenarios. Their policy targets, assumptions on various economic, social and technological factors, and resulting outcomes of model-based analyses are compared. The purpose is not to judge the outcomes of the scenarios but to try to understand and clearly describe the similarities and differences in the scenarios[20]. This work was completed in April 2011.

Since then, several scenarios this year explore consequences of the Fukushima accident and unconventional gas. In the **IEA**[21]'s global scenario to 2035 entitled The Golden Age of Gas, ample availability of gas, much of it unconventional, keeps average gas prices well below levels assumed in WEO-2010. Especially in growing economies in China and other non-OECD countries, gas consumption increases throughout the energy system, driven by price, improved access to supplies, efficiency improvements in technologies, also emissions benefits. Its flexibility is a distinct benefit in a perspective of much change in energy systems and much uncertainty about how drivers will play out. In Europe, scenario analyses by the **European Gas Advocacy Forum**[22] and **Eurogas**[23] underline this flexibility and how it can be used. EGAF argues that with greater use of gas in the short to medium term, to 2030 or so, implementation risks in the early years of a long-term strategy focused on renewables[24] can be reduced as well as overall costs. Eurogas similarly argues that the balance which will emerge between renewables and CCS/fossil fuels cannot be known today and that investing in gas keeps these long-term options open. The importance of **CCS** in these strategies in the long term is evident in the IEA scenario which does not assume availability of CCS by 2035. In this scenario, the long-term trajectory for CO2 emissions is towards 650ppm, thus a probable temperature rise well above the 2 degrees C target.

The European Climate Foundation in this year's phase of its Roadmap 2050 work, concentrates on trade-offs in the **period till 2030**, exploring coherent policy actions needed to keep the European energy system on track to 2050. With further analyses of its 60% renewables and high renewables scenarios for the power sector[25], trade-offs among additional grid infrastructures, generation capacities and their location, storage and demand side management are examined. Additional grid investments beyond 2020, although substantial, are low compared to generation investments. If these grid investments are not made, the result

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[20] Key references for this work are: (1) "Analysis and Comparison of Relevant Mid- and Long-term Energy Scenarios for EU and their Key Underlying Assumptions" (PROGNOS, 2011) [8], and (2) "Key Factors Affecting the Deployment of Electricity Generation Technologies in Energy Technology Scenarios" (Paul Scherrer Institut, 2009) [9].

[21] World Energy Outlook 2011 - special early insights: "Are We Entering A Golden Age Of Gas?" International Energy Agency, June 2011 (complete WEO 2011 due 9 November)

[22] "Making the Green Journey Work", European Gas Advocacy Forum, February 2011

[23] Eurogas Roadmap 2050, 13 October 2011

[24] EGAF refers to European Climate Foundation's 60% RES scenario for the power sector (Roadmap 2050, 2010)

[25] "Power Perspectives 2030", European Climate Foundation, 7 November 2011; scenarios from Roadmap 2050, ECF, 2010.

is an increase in back-up and operational costs amounting to far more than the grid investments saved. Demand response, within day, reduces the need for additional transmission infrastructure. The deployment of renewables in order of productiveness across Europe reduces cumulative generation capital costs by over a fifth by 2030 compared to a Member State by Member State approach. ECF also examines price setting in regional markets and utilisation rates of additional back-up plant, crucial for understanding market design issues.

Greenpeace concentrated on grids in its 2011 scenario analyses[26], building on its earlier Renewables 24/7 study. Looking beyond 2030, a High Grid scenario encompassing much trade and North African solar resources and a Low Grid scenario with more local solutions within Europe are explored. With adequate transmission, both would imply shrinking utilisation rates for coal and nuclear plants and later for gas fired plants, which could then be converted to biogas.

Scenarios for sustained transformation of the energy system are now being developed by a **whole range of organisations**, at local, Member State and European level[27]. Many look explicitly at the European market and policy context[28].

The conclusions of these scenario analyses and the **analyses by the Commission** are consistent on many but not all issues. All agree on the importance of **energy efficiency** in any strategy. The increased reliance on **capital investments** in the transformation of the energy system and in energy efficiency improvements is evident in all scenarios, raising financing, risk management and cost of capital issues to the top of the agenda. All see a much stronger reliance on **renewables** than currently, which raises issues notably for the power system. **Flexibility** from all sources is increasingly important. **Grid investments** and the market developments that go with them look like a no-regrets policy, at least in the period to 2030. Areas of difference among scenarios often concern **timing**. They include the degree of **early reliance on electrification** as opposed to direct use of, notably, gas, in heating, transport and industry. Estimates of **total system costs** in scenarios are still very different. They are not easy to compare.

2. SCANNING OF STAKEHOLDER SCENARIOS

A variety of international organisations, industry associations, individual companies, NGOs and research/academic institutions have put forward mid- and long-term energy scenarios. In order to make a representative sample, 28 studies were identified by screening contributions and publications from stakeholders.

A representative set of 7 studies was selected (see Table 1). The criteria used were time horizon until at least 2030, geographical coverage of EU-27 (or Europe[29]), public availability of main results in a quantitative form, coverage of at least the electricity sector, level of detail, and the scenarios being well known and discussed internationally. For example, studies covering only the world as a whole without defining Europe as a region were not selected. The time horizon, geographical and sectorial coverages, as well as the level of detail, vary greatly among the scanned studies.

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26 "Battle of the Grids", Greenpeace supported by Energynautics, 2011

27 For example, members of European Environment and Sustainable Development Advisory Councils

28 Eg. DIW work for review of German energy concept

29 "Europe" is sometimes defined as OECD-Europe, EU-25 (for older scenario studies) or EU-27.

Table 1: Scanning of Energy Scenario Studies

Nr.		Year of publication	Time horizon	Amount of scenarios (sensitivities)	Geographical coverage: World	Geographical coverage: Europe	Geographical coverage: EU-27	Quantifiability	Coverage of the sectors: Residential	Coverage of the sectors: Commercial / Services	Coverage of the sectors: Industrial	Coverage of the sectors: Transportation	Coverage of the sectors: Power	Coverage of the sectors: Other conversion sectors	Amount of sectors covered	Level of detail (our subjective estimate)	Type of model: Bottom-up	Type of model: Top-down	Type of model: None	Short list for selection
	Governmental institutions:																			
1	US-DOE EIA (2010). International Energy Outlook 2010	2010	2035	1 (+4)	x	*(OECD)*	*(EU-19)*	x	x	x	x	x	x	x	6	+++	x			
2	European Parliament (2009). Future Energy Systems in Europe	2009	2030	3			x	x		x		x	x		3	+	x			
3	EU DG TREN/ENER (2008, 2010, 2011) - "EC Reference Scenario to 2050"	2008 / 2010	2030	1 resp. 2			x	x	x	x	x	x	x	x	6	+++	x			x
4	EU DG Research (2006). World Energy Technology Outlook. WETO - H2	2006	2050	3	x	x		x	x		x	x	x		4	++	x			
5	EU DG TREN (2006). Scenarios on energy efficiency and renewables	2006	2030	3 (+2)			*(EU-25)*	x	x	x	x	x	x	x	6	++	x			
	Inter-governmental institutions and Non-governmental organisations:																			
6	ECF (2010). Roadmap 2050	2010	2050	3 (+1)			x		x	x	x	x	x	?	6	+++	x			x
7	EREC (2010). RE-Thinking 2050	2010	2050	1 (+1)			x	x	x (Renewable heat) x (RES-E)						2	+	x			(x)
8	Greenpeace/EREC (2010). Energy [r]evolution	2010	2050	3	x	*(OECD)*	x	x	x		x	x	x		4	+++	x			x
9	IEA (2010). Energy Technology Perspectives	2010	2050	2 (+4)	x	x	x	x	x		x	x	x	x	5	+++	x			x
10	IEA/NEA (2010). Technology Roadmap; Nuclear Energy	2010	2050	3	Based on IEA (2010)				Based on IEA (2010)						0	+				
11	IAEA (2009). Energy, Electricity and Nuclear Power Estimates for Period up to 2030	2009	2030	2	x	x		x					*(Nuclear)*		0	+				
12	IEA (2009). World Energy Outlook 2009	2009	2030	2	x	*(OECD)*	x	x	x		x	x	x	x	5	+++	x			x
13	NEA (2008). Nuclear Energy Outlook 2008	2008	2050	2	x	*(OECD)*							*(Nuclear)*		0	+			x	
14	WEC (2007). Deciding the Future: Energy Policy Scenarios to 2050	2007	2050	4	x			*(x)*							0	+				
15	EEA (2005). European Environment Outlook	2005	2030	2		x	x		x	x	x	x	x		5	+	x			
	Industry:																			
16	ExxonMobil (2009). Outlook for Energy; A View to 2030	2009	2030	1	x			x	x		x	x	x		4	+	x (?)			
17	IHS Global Insight (2008). European Energy and Environmental Outlook	2008	2030	1		x	x	x	x	x	x	x	x	x	6	++	x (?)			
18	Shell (2008). Shell energy scenarios to 2050	2008	2050	2	x			x	x	x	x	x			4	+	x (?)			
19	PWC (2006). The World in 2050	2006	2050	6	x			x							0	+	x (?)			
	Industry associations:																			
20	Eurelectric (2009). Power Choices	2009	2050	1 (+ base)			x	x	x	x	x	x	x		5	++	x			x
21	Euracoal (2007). The future role of coal in Europe	2007	2030	5			x	x					x		1	++	x			
22	Eurelectric (2007). The Role of Electricity	2007	2030/2050	4			*(EU-25)*	x	x	x	x	x	x		5	+	x			
	Research / academic consortia:																			
23	FEEM et al.(2010). Probabilistic long-term assessm.of new energy technol.scenarios	2010	2050	10	x	x	x	x	x	x	x	x	x	x	6	+++	x	x		x
24	Capros et al. (2008). Model-based Analysis of the 2008 EU Policy Package	2008	2030	9			x	x	x	x	x	x	x	x	6	++	x			
25	Energy Watch Group (2008). Renewable Energy Outlook 2030	2008	2030	2	x	*(OECD)*		x		x		x	x	x	4	++	x			
26	Öko-Institut (2006, update 2011). The Vision Scenario for the European Union	2006	2030	2			*(EU-25)*	x	x	x	x	x	x	x	6	+	x			
27	ECN (2005). The next 50 years: Four European energy futures	2005	2050	4		x									0	+			x	
28	ISIS et al. (2005-9). NEEDS - New Energy Externalities Development for Sustainability	2009	2050	7		x		x								+				

The **7 studies selected to be compared in detail** are, as follows (see full references at the end of this report):

- ***European Commission Reference Scenario to 2050***, published in 2011, [1]:
    - *"The 2050 Reference scenario depicts energy and greenhouse gas (GHG) emission developments on the basis of policies implemented up to March 2010, mirroring as well the achievement of the legally binding 2020 targets on renewables (RES) and GHG and the implementation of the ETS Directive. It shows the magnitude of the additional effort needed for EU policies to achieve the European Council's GHG mitigation objective."*

- ***European Climate Foundation (ECF) – Roadmap 2050***, 2010, [2]:
    - *"The objectives of the Roadmap 2050 are: a) to investigate the technical and economic feasibility of achieving at least an 80% reduction in greenhouse gas emissions below 1990 levels by 2050, while maintaining or improving today's levels of electricity supply reliability, energy security, economic growth and prosperity; and b) to derive the implications for the European energy system over the next 5 to 10 years."*

- ***Greenpeace/EREC – Energy [R]evolution (+EREC (2010), Re-thinking 2050)***, 2010, [3]:
    - *"The report demonstrates how the world can get from where we are now, to where we need to be in terms of phasing out fossil fuels, cutting CO2 while ensuring energy security. This includes illustrating how the world's carbon emissions from the energy and transport sectors alone can peak by 2015 and be cut by over 80% by 2050."*

- ***International Energy Agency (IEA) – Energy Technologies Perspectives (ETP)***, 2010, [4]:
    - *"The goal of the analysis in this book is to provide an IEA perspective on the potential for energy technologies to contribute to deep emission reduction targets and the associated costs and benefits. It uses a techno-economic approach to identify the role of both current and new technologies in reducing CO2 emissions and improving energy security."*

- ***IEA – World Energy Outlook (WEO)***, 2009, [5]:
    - *"The results of the analysis presented here aim to provide policy makers, investors and energy consumers alike with a rigorous, quantitative framework for assessing likely future trends in energy markets and the cost-effectiveness of new policies to tackle climate change, energy insecurity and other pressing energy-related policy challenges."* (Reference scenario);
    - *"More specifically, this report is intended to inform the climate negotiations by providing an analytical basis for the adoption and implementation of commitments and plans to reduce greenhouse-gas emissions."* (450 Scenario).

- ***Eurelectric – Power Choices***, 2009, [6]:
    - *"The Eurelectric Power Choices study was set up to examine how the vision, of cutting Greenhouse Gas (GHG) emissions by 75% in 2050, can be made reality. Power Choices looks into the technological developments that will be needed in the coming decades and examines some of the policy options that will have to be put in place within the EU to attain a deep cut in carbon emissions by mid-century."*

- ***FEEM[30] et al., EU-RTD Project PLANETS: Probabilistic Long-term Assessment of New Energy Technology Scenarios***, 2010, [7]:
    - *"PLANETS is a research project funded by the EC under the 7th Framework Programme with the scope of devising robust scenarios for the evolution of energy technologies in the next 50 years. The project aims to assess the impact of technology development and deployment at world and European levels, by means of an ensemble of analytical tools designed to foresee the best technological hedging policy in response to future environmental and energy policies."*

[30] Fondazione Eni Enrico Mattei (FEEM).

3. COMPARATIVE ANALYSIS OF SCENARIO STUDIES

3.1 Policy Assumptions and Targets

All scenario studies analysed use a *"baseline scenario"* to show the impact of presently implemented policies (e.g. until 2009). These baseline scenarios are used as a basis for assessing impacts of alternative scenarios.

The *"alternative scenarios"* all aim at reducing GHG or CO_2 emissions (and are generally in line with the EU 2020 target of -20% and to the long term target of -80% to -95% by 2050).

Most models concentrate on the electricity sector and are much less detailed (or provide no details) on developments in the heating and transport sectors (except insofar as they may assume major electrification in these sectors).

Table 2 gives an overview of main pre-defined policy assumptions and targets across the scenarios (for EU-27 or OECD-Europe, depending on study) for:

- GHG or CO_2 emissions reduction (economy-wide),
- Share of renewables (RES),
- Role of nuclear,
- Efficiency,
- Emission Trading System (ETS) and remarks on status of policies taken into account.

Table 2: Overview of Main Policy Assumptions and Pre-Defined Targets in the Scenarios

Short name scenario	**GHG or CO_2-emissions reduction, economy-wide**	**Share of renewables in gross final energy consumption**	**Share of nuclear in power generation**	**Reduction in primary energy by improved energy efficiency**	**Carbon policy**
WEO Ref	▪ GHG: -20% below 1990 levels by 2020 for EU	▪ 20% by 2020 for EU	▪	▪ 20% by 2020 for EU	▪ Policies until mid 2009 ▪ ETS
WEO 450 ppm	▪ GHG: -20% below 1990 levels by 2020 and -80% by 2050	▪ 20% by 2020	▪	▪ 20% by 2020	▪ Policies until mid-2009 ▪ ETS (OECD+, OME)
ETP BL OECD Europe	▪ GHG: -20% below 1990 levels by 2020 for EU	▪ 20% by 2020 for EU	▪	▪ 20% by 2020 for EU	▪ Policies until mid-2009 ▪ ETS
ETP Blue Map OECD Europe	▪ CO2eq: -74% below 2007 levels by 2050 ▪ GHG: -20% below 1990 levels by 2020 for EU	▪ 20% by 2020 for EU	▪	▪ 20% by 2020 for EU	▪ Policies until mid-2009 ▪ ETS (OECD+, OME)
EC Reference Scenario to 2050	▪ GHG: -20% below 1990 levels by 2020 (in Reference scenario)	▪ 20% by 2020 (in the Reference scenario)	▪ Economic modelling with currently non nuclear MS remaining non nuclear except Poland and Italy;	▪	▪ Implemented Policies until March 2010 & achievement of legally binding

			phase-out in 2 MS		targets ■ Revised ETS Directive applied until 2050
ECF BL	■ GHG: -20% below 1990 levels by 2020 for EU	■ 20% by 2020 for EU	■	■ 20% by 2020 for EU	■ Policies until mid-2009 ■ ETS
ECF 80% RES	■ GHG: -80% below 1990 levels by 2050	■ 80% RES of power generation by 2050	■ 10% nuclear of power generation by 2050	■ 20% by 2020 for EU	■ ETS (OECD+OME)
ECF 60% RES	■ GHG: -80% below 1990 levels by 2050	■ 60% RES of power generation by 2050	■ 20% nuclear of power generation by 2050	■ 20% by 2020 for EU	■ ETS (OECD+OME)
ECF 40% RES	■ GHG: -80% below 1990 levels by 2050	■ 40% RES of power generation by 2050	■ 30% nuclear of power generation by 2050	■ 20% by 2020 for EU	■ ETS (OECD+OME)
E[R] Ref	■	■	■	■	■ No specific targets or policies mentioned
E[R]	■ CO_2: -80% below 1990 levels by 2050	■	■ Phasing out	■	■ No specific targets or policies mentioned
E[R] Adv	■ CO_2: -95% below 1990 levels by 2050	■ High RES share: "Close to fully renewable energy system" by 2050	■ Phasing out	■	■ No specific targets or policies mentioned
Eurelectric BL	■	■	■ Germany and Belgium phased out	■	■ Policies until mid-2009 ■ ETS
Eurelectric Power Choices	■ GHG: -40% below 1990 levels by 2030 and -75% by 2050	■ 20% by 2020	■ Germany and Belgium phased out	■ 20% by 2020 for EU	■ Policies until mid-2009 ■ ETS (all sectors)
FEEM-WITCH	■	■	■ No exogenous constraint	■	■

Abbreviations used: ETS: Emissions Trading System, GHG: Greenhouse Gas, OME: Other Major Economies (Brazil, Russia, South Africa and the countries of the Middle East), MS: EU Member States.

From Table 2 it can be seen that:

In relation to reduction of GHG emissions,

- Most of the studies do not take into account negative or positive effects of climate change on the economy in the models used. One exception found are the FEEM-scenarios where the WITCH-model incorporates an integrated assessment module which is able to take into account a dynamic linkage of climate change and economic activity.

- In general, some form of European Emissions Trading (ETS) is considered in most studies (exceptions are Greenpeace/EREC and FEEM), some models used for scenarios development even have specific modules which simulate a market for emission allowances[31] (e.g. PRIMES used by both Commission services and Eurelectric).

- The scenarios differ in their assumptions about future emissions trading markets. There is a large consensus about the sectors included, but not about the geographical coverage. Some studies assume no extension of the current EU emissions trading, others assume an expansion of the market from OECD+ up to a global dimension. With the Clean Development Mechanism (CDM), another possibility to enlarge the geographic coverage of the allowances market exists. The EU DG ENER scenarios focus on this issue, other scenarios give little information. Finally, some scenarios envisage small deviations from the current status of the allocation process, assuming full auctioning in the power sector and grandfathering in the other sectors. Other scenarios tend towards a general full auctioning of allowances.

Carbon pricing in the different scenarios is shown in Table 3:

Table 3: Comparison of Carbon Pricing in the Scenarios

Scenario	**Sectoral coverage**	**Geographical coverage**	**Auctioning or grandfathering**	**CDM**
IEA – WEO	Existing EU-ETS, including aviation	n/a	n/a	CDM taken into account
IEA – WEO 450 ppm	n/a	OECD+ in 2013, major economies as of 2021	n/a	CDM taken into account
IEA – ETP Reference	n/a	n/a	n/a	n/a
IEA – ETP Blueline	n/a	n/a	n/a	n/a
EU DG ENER Reference	Existing EU-ETS including aviation	n/a	Auctioning in power sector, grandfathering for other-sectors	CDM taken into account
EU DG ENER Baseline	n/a	n/a	Auctioning in power sector, grandfathering for other-sectors	Limited use of CDM-credits
ECF Roadmap Reference	Industry, power sector, aviation	n/a	n/a	n/a
ECF Roadmap Pathways	Industry, power sector, aviation	Until 2020 OECD-countries, from 2020 including developing countries	n/a	n/a

[31] ETS is explicitly modelled by the Commission services' scenarios that derive ETS prices endogenously.

Energy [R]evolution	n/a	Global CO_2 trading system in the long term	n/a	n/a
Energy [R]evolution Advanced	n/a	Global CO_2 trading system in the long term	All allowances should be auctioned	n/a
Eurelectric Baseline	n/a	n/a	Full auctioning as of 2015 (except some new Member States)	n/a
Eurelectric Power Choices	ETS extended to all major economic sectors after 2020	International carbon market after 2020	Full auctioning as of 2015 (except some new Member States)	n/a
FEEM et al. - Planets	n/a	n/a	n/a	n/a

In relation to future energy mixes,

- A few studies use pre-defined future energy mix targets, by preferring or excluding certain technologies from the beginning (in a "back-casting approach"):
- Predetermined Role of Renewables (RES): Only Greenpeace/EREC and ECF make specifications on the desired shares of RES energies in 2050:
  - Greenpeace/EREC sets in its advanced Energy [R]evolution scenario the 2050 RES target share at 100% (all sectors).
  - ECF sets in its alternative scenarios the 2050 power sector RES target share at 40%, 60% and 80%, respectively.
- Predetermined Role of Nuclear Energy (NUC) and Carbon Capture & Storage (CCS): Greenpeace/EREC and ECF specify pre-defined shares of NUC and CCS in 2050:
  - Greenpeace/EREC sets in its advanced Energy [R]evolution scenario the 2050 NUC as well as CCS target shares to 0%.
  - ECF focuses on the RES share. For the purposes of the analysis, particularly of infrastructure needs, it divides the remaining share equally between NUC and CCS, thus 30%, 20% and 10% for each, in the three alternative scenarios[32].

The other scenarios determine the contribution of NUC and CCS on the basis of cost assumptions and optimisation rather than pre-defined policy targets.

In relation to sustainability aspects other than GHG reduction,

Economic constraints or the issue of maintaining high levels of grid stability and overall system reliability are in most cases either not considered or at least not fully quantified:

- Economic constraints, e.g.:
  - Minimisation of private financial costs (investment in new generation capacities and infrastructure (an exception is e.g. ECF)),
  - Minimisation of social costs, such as environmental externalities (costs of GHG avoided, other environmental pollution, land use, etc.)[33].

Maintaining high levels of grid stability and overall system reliability[34], e.g.:

[32] and 20% Demand-Side Management (DSM) by 2050 in the ECF study.

[33] In scenarios mirroring cost-effective achievement of GHG reduction, PRIMES scenarios make sure that marginal costs are equal across sectors and MS.

[34] In a study published by KEMA and Imperial College London in 2010 and performed for ECF, these issues went at least partly into the modelling.

The high relevance of this issue is due to the fact that scenarios with high shares of RES energy sources, particularly wind and solar energy, increase the need for backup capacity or other means of ensuring grid stability. Substitution of electricity for FOS fuels in buildings and transportation, results in higher electricity demand but also expanded possibilities for demand management. These challenges are addressed by all of the studies in one way or another. Several approaches can be identified in the scenarios:

- Flexible thermal power plants (NUC, FOS) for load-following operation and back-up capacity,
- Greater use of non variable RES energy (biomass, solar with storage, geothermal, hydro with pumped storage facilities),
- Transmission expansion. This approach is constrained in some of the scenarios by model limitations. In PRIMES, interconnections are exogenous. The model used in ECF's scenarios derives transmission needs,
- Large-scale storage
- Smart grids and demand side management developments.

Maintaining high levels of system reliability and thus high levels of power supply security is qualitatively mentioned across most studies as a key objective and in some studies also as a key challenge.

Regarding realisation, particularly studies with ambitious GHG reduction targets implicitly assume significant progress in grid technology (ECF maintains that they use existing technologies) and social acceptance related to transmission expansion to be able to achieve their targets. However, analysis is typically not taken further[35] from such largely qualitative statements and it is usually concluded that financing needs to be found for the large increases in pan-European transmission and storage capacities to be able to cope with the expected large future shares of intermittent generation.

Implications for distribution networks are not addressed by most of the studies. This is particularly concerning as almost all studies emphasize at the same time the relevance of technologically advanced smart grids and smart metering, especially those confronted with ambitious emission reductions (Energy [R]evolution, ECF Pathways, ETP Blueline, Eurelectric Power Choices).

In relation to security of supply of energy resources,

- All scenarios expect reserves of natural gas to be sufficient to meet future demands. Unconventional oil reserves are expected to be deployed in some scenarios without ambitious emission reductions (e.g. ETP Reference). No indictors of security of supply are developed. Possible indicators (diversity of imports, stability of exports, reliability of supply, diversity of supply, etc.) are not developed.

3.2 Economic Assumptions

Regarding general economic assumptions,

- The scenarios assume a steady increase of GDP of ~1-2% per year until 2030/2050. The recent financial crisis is taken into account in the projections of GDP.

[35] Only one study was identified containing specific data in this field (ECF/KEMA).

Regarding fossil fuel prices,

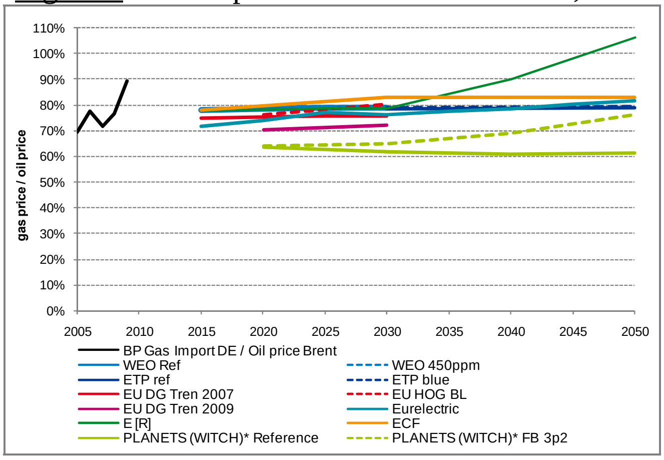
- Fossil fuel prices are often exogenously determined (in PRIMES scenarios by using a separate modelling framework). ECF and Greenpeace/EREC use price developments from WEO 2009. In WEO 2009, international fossil fuel prices are based on a top-down assessment of prices which would create enough investment to meet energy demand over the projection period (global balance of supply and demand). Therefore, fossil fuel prices in WEO are endogenously determined and sensitive to scenario assumptions. ETP takes prices up to 2030 from WEO 2009 and calculates prices for the period beyond 2030 by taking into account the long-term oil supply cost curve.

- Recent studies suggest a range of ~90-120 USD/barrel until 2030 and 2050 for the oil price. Only Greenpeace/EREC considers an oil price that increases to 150 USD/barrel in 2030. Oil prices in Greenpeace/EREC and ECF are assumed to stay constant after 2030.

- Until 2030 most scenarios presume an increasing gas price. In the IEA alternative scenarios the prices of gas, as for oil, stabilise or decrease after 2030 due to weaker energy demand, while in the reference case gas prices increase in respond to increasing demand (e.g. from additional gas-fired power plants).

- Most studies agree on the idea that gas prices will keep their linkage with oil prices, i.e. the ratio of gas and oil prices remains quite constant[36]. Main exceptions are the Greenpeace/EREC Energy [R]evolution and – to some extent – the alternative scenario of the PLANETS-WITCH project (see Figure 1). The PLANETS alternative scenario assumes a higher increase of gas prices than oil prices, motivated by the high gas demand and relatively low oil demand.

Figure 1: Development of Gas to Oil Prices, in %



[36] WEO expects US gas prices to be partly disconnected from oil prices, due to large indigenous gas reserves.

- A moderate increase of <u>coal prices</u> is assumed in most of the scenarios. Some differences exist in expectations of future gas-to-coal price ratios. Most of the studies (e.g. Eurelectric) expect coal prices to increase at far lower rates than gas prices. A slight decoupling can be observed in most of the scenario studies. In contrast to the other studies, the Energy [R]evolution of Greenpeace/EREC and the alternative scenario of the PLANETS-WITCH project show a stronger increase of coal than oil prices in the long run.

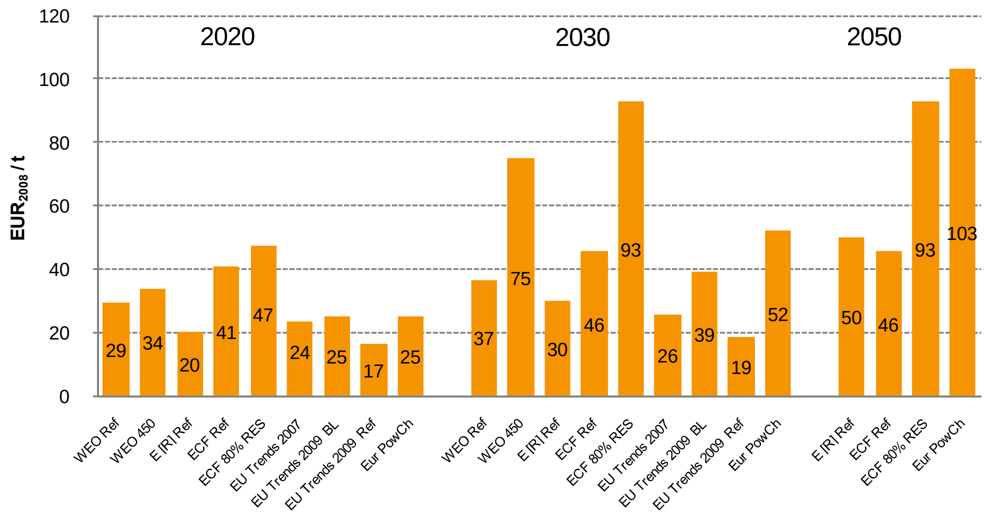
Regarding <u>incentives for RES</u>,

- Some studies (e.g. Eurelectric Power Choices) explicitly assume decreasing direct incentives for RES in the future due to assumed increasing cost-competitiveness.

Regarding <u>CO2-certificate prices</u>,

- Different developments for the (typically assumed) <u>CO2-certificate prices</u> are to some part also determined by targets set and the resulting CO2-emissions development. As shown in <u>Figure 2</u>, emissions in the ECF Pathways and the WEO 450 ppm show a faster decline than emissions in the Eurelectric Power Choices scenario, which seems to allow a higher degree of flexibility to reach the targets set for 2050. Furthermore, the sharp increase of CO2-certificate prices in the Eurelectric Power Choices scenario from 2030 onwards partly results from the assumed removal of mandatory RES-targets after 2020. Therefore, carbon prices gain high importance to deliver required emission reductions by 2050.

<u>Figure 2</u>: Development of CO2-certificate prices, in EUR_{2008}/t CO2



On the other hand, assumed geographical extension of emission trading systems (e.g. in the ECF Pathways, WEO 450 ppm and the Power Choices scenario international carbon markets are assumed not later than 2020) can be interpreted to prevent carbon prices from rising unlimited. This effect is due to more abundant and cheap opportunities for emission reduction outside the EU/OECD.

Relatively <u>low prices for emission certificates in the Greenpeace/EREC study may be partly determined by the idea that the process of emission trading remains unclear and is not able to help RES energy expansion</u> (and is thus not considered adequate to become an important parameter for Greenpeace/EREC in their model).

In summary, the pre-defined importance of carbon prices as an instrument in different scenario studies may also explain their different resulting price levels (e.g. in the Power Choices scenario, carbon prices are assumed to be important to reach emission targets).

Regarding investment costs,

- All scenarios confronted with high emission reduction requirements estimate a considerable increase in capital expenditure. Even baseline scenarios suggest an increase in capital expenditure in the coming years. The somewhat higher estimation in the emissions reduction scenarios is generally based on several effects: higher capital intensity of RES technologies in terms of costs per power produced and the need for higher power transmission capacity due to intermittency of most of the expected new RES (investment in power transmission capacity is roughly estimated to be 20-50 % higher in most of the alternative scenarios, compared to Baseline or Reference scenarios); higher capital intensity of new NUC and CCS investments. The scenarios also agree in the estimation of lower expenses for FOS fuels in due course due to large substitutions of RES for FOS fuels and energy efficiency improvements.

- Overall, these effects lead to somewhat different total cost results across scenarios with large methodological uncertainties, strongly influenced by different modelling mechanisms (e.g. cost-optimization vs. accounting frameworks), framework parameters (e.g. price developments; see above) and conventions for cost-estimations. Furthermore, results are often not available for the same timeframes and geographical boundaries.

- Results on future investment costs are also strongly influenced by the chosen assumptions on technological developments in energy transformation and end-user applications. A lot depends on learning rates For example, in ECF, learning rates are 5% for wind offshore/onshore, 15% for solar PV and 12% for CCS and yearly reductions in investments costs per capacity are estimated at 1% for biomass and geothermal plants, compared to 0,5% for FOS-fired plants.

- Table 4 shows compliance costs available in alternative scenarios, differentiated into total costs and grid costs or investment:

Table 4: Comparison of Compliance and Grid Costs/Investment in Alternative Scenarios

Scenario	Estimated compliance costs/investment	Estimated grid costs/investment	Comments
IEA – WEO 450 ppm	▪ EU-27: +1600 bn USD (vs. Ref.) cumulative investment in the energy sector (incl. grid costs) till 2035	▪ Global: 5100 bn USD (20% lower vs. Ref.) cumulative investment till 2035	▪ External costs not included (except GHG) ▪ Grid investment (Ref.): 25% transmission, 75% distribution
IEA – ETP Blue Map	▪ EU-27: additional cumulative investment (energy sector) compensated by cumulative fuel savings: 7100 bn USD vs. 13100 bn USD till 2050 (vs. Bas.)	▪ Global: 12300 bn USD (incl. smart grids) cumulative grid-investment till 2050 (+50% vs. Bas.)	▪ Grid investment (Ref.): 30% transmission, 70% distribution ▪ Back-up costs may be considered implicitly
EU DG ENER Ref.	▪ ~175 bn € p.a. (2030) capital and O&M costs in power generation (i.e. 51,0 €/MWh)	▪ EU-27: grid costs of 10,8 €/MWh (2030) vs. 7,4 (2010), i.e. ~165 bn € cumulative grid costs	▪ Distribution grid not included ▪ Back-up costs

			considered implicitly
▪ ECF Roadmap 80% RES	▪ Lower fuel costs dominate capital cost expenses: overall -80 bn € in 2020 (-205 bn € in 2030) vs. Ref.	▪ Cumulative additional transmission capex: 95-129 bn €, additional back-up capex: 63-99 bn € (vs. Ref.) ▪ Cumulative additional distribution capex: 200-300 bn €	▪ Amount by which distribution costs are incremental to the Ref. is unclear
Energy [R]evolution Advanced	▪ Global: 292 bn USD add. investment p.a. 2007-2030 (vs. Ref.) ▪ 42 bn € additional investment p.a., fuel savings of 62 bn € p.a. (2007-2050, vs. Ref.)	▪ Costs of 209 bn € p.a. for the assumed new European "Supergrid"	▪ Grid costs estimated externally, cost structure of grid costs not further specified
Eurelectric Power Choices	▪ Capital and O&M costs of 53,3 €/MWh in 2030	▪ Grid-costs rise from 7,3 to 12,6 €/MWh (2050) ▪ Cumulative grid investment: 1.500 bn € (+35% vs. Baseline)	▪ No external costs besides CO2-costs ▪ Not clear if back-up costs are considered implicitly
FEEM et al. - Planets	▪ Global: ~800 (2030) and 2500 (2050) bn € yearly costs (i.e. 1-2,5 % of GDP)	▪ n/a	▪ Costs are measured as consumption losses vs. the Reference scenario

- Table 4 shows that:

    - A comparison of total cost results from the different scenario studies is hardly possible as the underlying assumptions on methods and data used are in most cases not presented sufficiently transparently to give a clear picture on the dependability of figures presented (see also above discussion about grid costs).

    - Macroeconomic costs or benefits are not provided, so the net economic cost or benefit (e.g. including the gains or losses from competitiveness factors) are not available.

    - Distribution costs are hardly ever estimated although they seem to represent the majority of necessary grid investments. This makes it doubtful that costs for infrastructure changes are realistically included in most scenarios.

Regarding electricity prices,

- Electricity prices increase in most of the studies at least in the medium term (up to 2030). Some studies with high emission reduction targets expect a decrease of electricity prices in the long term (up to 2050), mainly driven by lower consumption of FOS fuels in the power sector in combination with assumed technological improvements for RES power plants. Not all studies actually calculate electricity prices for a market environment with supply of and demand for electricity. Therefore Table 5, providing an overview on electricity prices and their main drivers, displays electricity generation costs as a proxy for electricity prices in these cases.

Table 5: Comparison of Properties of Electricity Prices in the Different Scenarios

Study and scenario	Electricity price/cost developments	Main drivers
IEA – WEO Ref and 450 ppm	▪ No data for Europe	▪ No data for Europe
IEA – ETP Ref and Blue Map	▪ No data for Europe	▪ No data for Europe
EU DG ENER Reference	▪ 1.4% average annual rise 2000-2030, declining after 2025	▪ Increasing fuel prices, higher capital costs of RES, NUC and CCS, auctioning of CO2-allowances
EU DG ENER Baseline	▪ 1.5% average annual rise 2000-2030, declining after 2025	▪ Increasing fuel prices, higher capital costs of RES, NUC and CCS, auctioning of CO2-allowances
ECF Roadmap Reference	▪ n/a	▪ Carbon prices, fossil-fuel prices, technology learning rates
ECF Roadmap Pathways	▪ Higher levelised costs of electricity (LCOE) than in the Ref. (short term), slightly higher LCOE by 2050	▪ Carbon prices, fossil-fuel prices, technology learning rates
Energy [R]evolution	▪ Generation costs increase up to 2020, upward tendency until 2050	▪ Fossil fuel prices, technology improvements of RES-technologies, costs for CO2-allowances
Energy [R]evolution Advanced	▪ Generation costs increase up to 2030 and decrease afterwards (-34-43 % 2050 compared to the Baseline)	▪ Fossil fuel prices, technology improvements of RES-technologies, costs for CO2-allowances
Eurelectric Baseline	▪ Strong increase up to 2025, stabili-zation afterwards	▪ Fossil fuel prices, restructuring of the power plant fleet
Eurelectric Power Choices	▪ Strong increase up to 2025, slight decrease afterwards	▪ Fossil fuel prices, restructuring of the power plant fleet, lower fossil fuel consumption and lower demand for CO2-allowances)
FEEM et al. – Planets	▪ Electricity prices stay almost constant	▪ Restructuring of power generation
FEEM et al. – Planets Fb 3.2	▪ Increase until 2015, stagnation 2015 to 2035, sharp increase after 2035	▪ Restructuring of power generation, increasing electricity demand

Key points:

- The economic performances of all energy technologies – FOS, NUC and RES – are reflected by their specific generation costs which are heavily influenced by assumed future fuel and carbon prices, and assumed technology learning rates.
- Technology-neutral studies, such as from IEA, DG ENER or Eurelectric, give high importance to the carbon price as a key driver to deploy the most competitive low-carbon technologies and leave it then to the market to develop the future energy mix.
- Comparison of total costs for developing a more sustainable EU energy system by 2050 is hardly possible due to lack of transparency in most scenarios on methodological and data assumptions.
- Most scenarios seem to lack a realistic consideration of the costs for necessary infrastructure changes. For example, although investments in the distribution grid represents the majority of necessary grid investments, in almost all scenarios only transmission costs (if at all) are considered.
- Electricity prices increase in most of the studies at least in the medium term (2030).

3.3 Assumptions on Social Issues

The most important effect in the EU social structure considered in the scenarios is change in size of population. Throughout the studies, a slight increase of the EU population is expected in the medium term (immigration), with the tendency to a stabilised population in the long term. Some studies also assume a significant decrease in the size of households.

However, in none of the scenarios analyzed evidence on fundamental changes in the behavioural patterns of the economic agents was found.

Some studies (e.g. PRIMES-based Eurelectric, DG TREN, FEEM) apply fixed microeconomic decisions of economic agents concerning demand for energy related products and investment in energy supply equipment. These scenarios partly take into account different levels of risk-awareness of agents (higher levels for individuals than for enterprises, reflected by high discount rates for individuals), lack of information, market barriers for new technologies and rebound-effects in energy-efficiency investments. Investment decisions are modelled under full information and perfect foresight assumptions.

Only very little information concerning trends and effects on the labour market was found in the studies. However, in some scenarios (ECF pathways, Energy [R]evolution) sectorial shifts on the labour market from traditional energy sectors (e.g. FOS fuels) to sectors linked to RES installations are expected. Magnitudes of these effects are very differently estimated, usually ignoring the related loss of employment and market leadership in more traditional sectors.

The risk of loss of global competitiveness of energy intensive industries and related deindustrialisation in Europe is usually not considered explicitly.

Issues of public acceptance regarding deployment of new power plants (large-scale RES, new NUC, low-carbon FOS), new RES-support infrastructure (pan-European grid, large storage) or new enforced consumer behaviour (smart metering) are nowhere explicitly modelled (implicitly only for NUC by assuming e.g. growth rates being much more limited than economic optimisation would suggest).

Key points:

- Only few studies explicitly model changes in the behaviour of economic agents with regard to changes in consumer behaviour or public acceptance of deployment of new power generation plants and RES-support infrastructures,
- Effects on the EU labour market and the economy as a whole (e.g. risk of deindustrialisation) as a consequence of visions of a future EU energy mix are not consistently modelled in any scenario study and are usually limited to presenting short-term positive effects of preferred technological solutions.

3.4 Further Technology Assumptions

The following conclusions on technology assumptions in the different scenarios are in addition to the technology-related assumptions already evaluated and compared under *Sections 3.1 (Policy Assumptions and Targets)* and *3.2 (Economic Assumptions)*:

- In all of the studies, a Baseline or Reference scenario is compared with scenarios which are more ambitious in reducing GHG-emissions. These "GHG-ambitious scenarios" mostly assume significant growth rates in RES energy sources for power generation (up to shares of e.g. 50% in the ETP Blueline and 97% in the Energy [R]evolution scenario by 2050) and agree on the main RES electricity generation technologies: onshore/offshore wind, biomass and solar-PV.

- The studies are more diverse regarding the estimations for the shares of thermal and hydro-RES: Of course, higher shares of FOS fuels are estimated in the absence of additional policies promoting RES-deployment. In the scenarios with more ambitious emission-reduction policies, gas-fired power plants often have a high relevance in serving peak-loads and load-following, due to the high shares of variable RES sources. Nuclear power plants, without t restrictions on development, are often considered as a vital option to help significantly reducing GHG-emissions from power generation in a cost-effective way (e.g. ETP Blueline).

- Innovative solutions for road transport (electric vehicles, biofuels) and other new power and energy technologies are identified as crucial for future energy systems throughout the studies. Most of the studies focus on electric vehicles and biofuels besides power sector restructuring.

- The scope for biomass technology improvements to 2050 is not explored in most cases, nor is the prospect of productivity increases driven by rising demand for biomass.

- Most of the studies emphasize the importance of policies concerning end-user efficiency (residential and industrial energy demand) and some studies describe measures in this field as crucial factors in the short run (2010 to 2030) to reach the emission targets set for the long run (e.g. ETP Blueline). The proposed measures comprise the thermal integrity of buildings, heat pumps, technological development in the processes of energy-intensive industries and more energy-efficient vehicles.

- Efficiency considerations on the one hand affect end-user efficiency and on the other hand the energy transformation sector (mainly power generation). There is little information on the latter and if, the studies estimate improvements in the efficiency of traditional power generation technologies, but only small ones compared to current state of the art (e.g. in the ECF Reference efficiencies of 60 % are assumed for CCGT-plants and 50 % for coal-fired plants in 2050).

- In most scenarios except those of ECF, grid development is not modelled or optimised for the given energy mix; it is pre-determined. Given the expected burst in electrification, the role of "smart grid" technology developments, increased balancing needs and distributed generation, the assumptions about grid development equate to assumptions regarding costs and energy mixes.

Key points:

In addition to the technology-related "Key points" already presented at the end of Sections 3.1 (Policy Assumptions and Targets) and 3.2 (Economic Assumptions), the following key conclusions on technology assumptions in the different scenarios can be made:

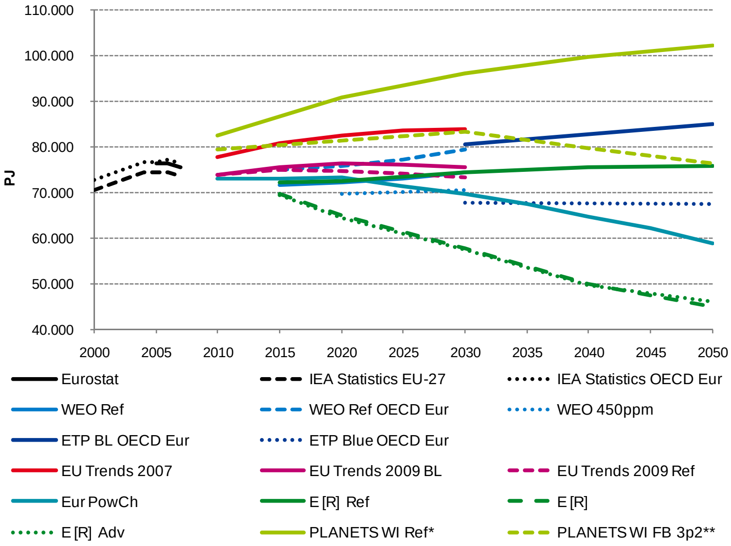
- Most scenarios assume significant growth rates in the use of RES energy sources for power generation.
- NUC, without restrictions on development, is often considered as a vital option to help significantly reducing GHG-emissions from power generation in a cost-effective way.
- Competitiveness of CCS depends strongly on the carbon price.
- Problems in extended use of biomass needed to counter-balance future shares of intermittent wind and solar are nowhere analysed in detail.
- Estimated future investment costs are strongly influenced by chosen assumptions on technological developments in energy technologies..
- Innovative solutions for road transport (electric vehicles, biofuels) are identified as crucial for future energy systems throughout the studies.
- Most studies emphasize the importance of policies concerning end-user efficiency (residential and industrial energy demand) and some studies describe measures in this field as crucial factors in the short run to reach emission targets set for the long run.

3.5 Key Results of Scenarios

From the above modelling assumptions taken by different stakeholders, scenario models result in often different, sometimes similar projections regarding specific future trends:

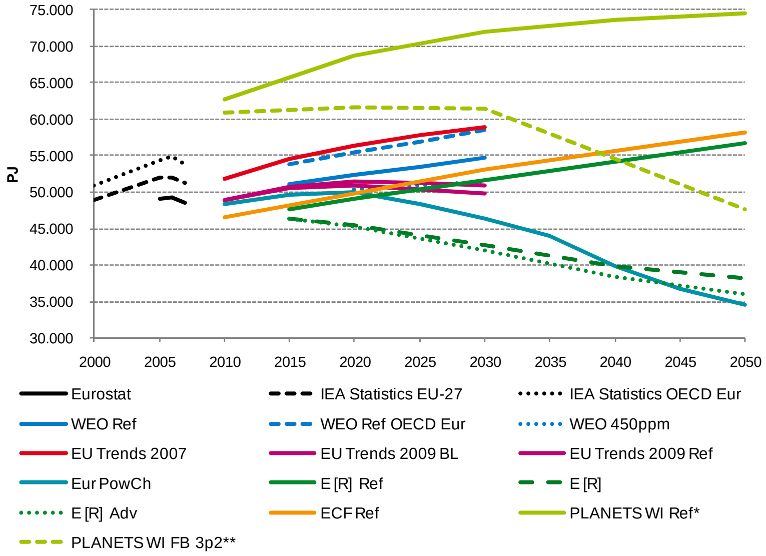
- **Future primary energy demand** has to be seen in relation with the final energy demand and the technologies used. As shown in Figure 3, whereas the baseline scenarios show generally slightly increasing primary energy demands, the alternative scenarios aiming at reducing GHG-emissions show generally declining demands:

Figure 3: Development of Economy-Wide Primary Energy Demand, in PJ



- As can be seen from Figure 4, without new energy policies to reduce energy demand or GHG-emissions, **final energy demand** will increase, similar to GDP-development. With new stringent policy measures, final energy demand can be reduced by 20-25% until 2050.

Figure 4: Development of Economy-Wide Final Energy Demand, in PJ

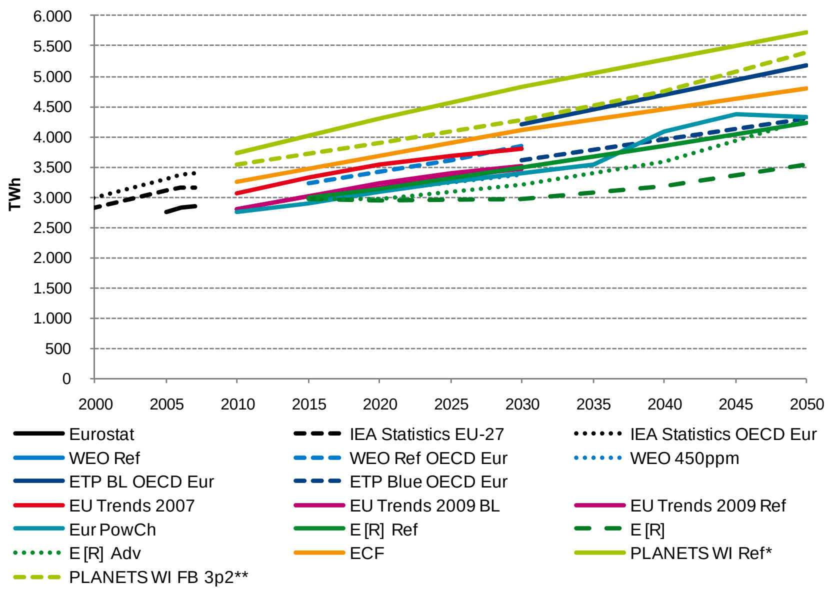


- Compared to primary energy demand, long term developments in final energy demand are also influenced by the structure of the power generation sector (see Figure 4).

- It has to be noted, that in some cases, differences in **efficiency targets** may lead to major differences in projected energy demand. For example, ambitious energy efficiency measures are implemented in the Greenpeace/EREC Energy [R]evolution scenarios and in the Eurelectric Power Choices scenario, even in the medium term up to 2020. This results in significant declines of final energy demand and also primary energy demand, if measures aim at reducing energy demand of end-consumers.

- Looking at **future electricity demand**, a steady increase can be seen in all scenarios. Compared to the picture of the final energy demand, in general a substitution towards electricity can be observed. This tendency is especially relevant for scenarios with high GHG-reduction targets as these scenarios focus on decarbonisation of power generation and substitution for FOS fuels in transportation (e.g. electric vehicles) and buildings (e.g. heat pumps). Generally, this substitution process is induced through cost-optimization, either for individuals (DG ENER, Eurelectric), or for the whole region (e.g. ECF, FEEM), with the exception of the Greenpeace/EREC Energy [R]evolution scenarios. Beneath this substitution effect, electricity demand also increases due to higher income and economic activity. Figure 5 clearly shows that reductions in electricity demand due to energy-efficiency policies are outweighed by additional demand caused by the mentioned factors.

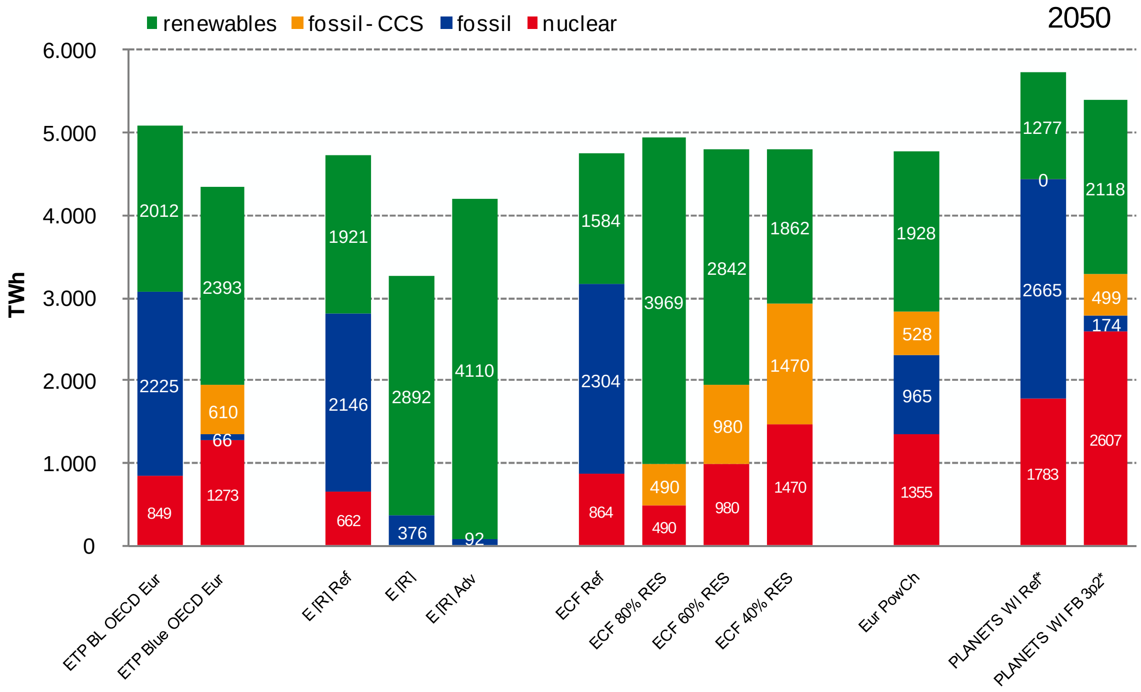
Figure 5: Development of Economy-Wide Electricity Demand, in TWh



- The **changes in electricity generation** (development as well as structure), which are shown in Figure 6 for 2050 depend on:

  - GHG and RES targets set in the scenarios,
  - competitiveness of power plants assumed differently in different scenarios (capital costs, fixed and variable O&M costs, fuel and CO2-prices),
  - pre-defined RES-targets set in "back-casting" scenarios (Greenpeace/EREC, ECF),
  - bounds set for deployment of NUC/CCS in some scenarios (Greenpeace/EREC, ECF).

Figure 6: Electricity Generation in 2050, in TWh



In the medium term, up to 2030 and especially up to 2020, differences between the alternative scenarios are relatively small. Of course, even in the medium term, differences between scenarios with emission reduction targets and reference scenarios are considerable: Ambitious scenarios generally show higher shares for RES and NUC, with diverse views on CCS, except when NUC and CCS are excluded from the beginning.

In the long term, even differences between alternative scenarios are considerable. In the Eurelectric Power Choices and the ETP Blueline scenarios, nuclear power plants are estimated to obtain a high relevance in reaching the emission reduction targets. Nuclear power plants are assumed to be the most economic option to serve baseload in these scenarios, whereas FOS-fuelled plants are mainly used for load following (gas-fired plants), with the exemption of coal-fired plants with CCS. Differences between the two scenarios could be due to slightly different geographical coverage (ETP focusing on OECD-Europe, including Norway and Switzerland, both with high RES-shares) and differences in the estimated competitiveness of CCS / FOS fuels vis-à-vis NUC and RES power generation.

Deployment of CCS is of importance for all alternative scenarios (except Energy [R]evolution where it is excluded), but significantly higher in the Power Choices scenario and the ECF-pathways. Deployment for this form of emission abatement starts typically in the period from 2020 to 2030, but is assumed to gain importance only after 2030 (ETP, ECF, Eurelectric, PLANETS). The outcomes in the basic and advanced Greenpeace/EREC Energy [R]evolution scenarios are significantly different, due to exclusion of NUC and CCS in these scenarios.

In the low carbon scenarios examined, the quantity of electricity from RES produced by 2050 ranges from 1862 TWh to 4110 TWh. Fossil fuel generated electricity deploying CCS ranges from 490 TWh to 1470. Nuclear powered electricity production ranges from 490 TWh to 2607 TWh.

Key points:

- Without new energy policies to reduce energy demand or GHG-emissions, final energy demand will increase, similar to GDP-development.
- The significant differences across scenarios on assumptions on feasibility of efficiency improvements lead to major differences in projected energy demand.
- Compared to primary energy demand, long term developments in final energy demand are also influenced by the structure of the power generation sector. Higher decreases of final energy demand in relation to primary energy demand can be achieved by a technology-neutral approach in developing future power generation mixes (i.e. resulting in higher shares for CCS and NUC).
- Electricity demand increases across all scenarios due to higher income and economic activity. Reductions due to energy-efficiency policies are outweighed by additional demand.
- If a technology-neutral approach is chosen, high prices of CO2-certificates are the main driver for deployment of both RES and NUC, but also for development of CCS. Therefore, GHG-ambitious technology-neutral scenarios generally show higher shares for RES and NUC, except when NUC and CCS are excluded from the beginning.

3.6 Models Used and Interdependencies Between Studies

In all scenario studies analysed bottom-up models are used, some of them in combination with top-down models, as summarised (for the main models) in Table 6:

Table 6: Characteristics of Models Used

Study	**Models used**	**Type of model**	**Characteristic**
IEA - WEO	▪ World Energy Model	▪ Bottom-up-model (with additive top-down model)	▪ Simulation
IEA - ETP	▪ ETP MARKAL/TIMES	▪ Bottom-up-model	▪ Optimization (lead costs)
EU DG TREN	▪ PRIMES	▪ Mixed representation: Bottom-up and top-down model	▪ Partial market equilibrium
ECF Roadmap	▪ a.o. McKinsey Power Generation Model	▪ Bottom-Up-Model (with additive top-down model)	▪ Simulation
Greenpeace/EREC Energy [R]evolution	▪ MESAP/PlaNet	▪ Bottom-up model	▪ Simulation
Eurelectric Power Choices	▪ PRIMES	▪ Mixed representation: Bottom-up and top-down model	▪ Partial market equilibrium

Not least because of the use of the same models by different scenario studies, a variety of studies uses the input and output of other studies.

Two main studies can be indentified: IEA World Energy Outlook and DG ENER / PRIMES.

- The IEA Energy Technology Perspectives, the ECF Roadmap 2050, Eurelectric's Power Choices and Greenpeace/EREC's Energy [R]evolution use the WEO baseline.
- Input and output of the DG ENER PRIMES study are used for the Eurelectric study.

4. SUMMARY OF COMPARISON

From the comparison of stakeholder scenarios presented in this report, the following conclusions can be drawn:

- **Overall Goal:**
  - Scenarios are marked by GHG and/or RES targets and development of future energy mixes is primarily based on optimising this parameter.
  - Security of supply indicators are not created (or optimised), except for the grid-oriented modelling of ECF.
  - Competitiveness indicators are limited, partial and not optimised.
- **Basic Modelling Approaches used by Stakeholders:**
  - Models used for scenario studies can broadly be grouped into market-based optimisation models ("fore-casts") and models which use exogenously defined market shares ("back-casts").
  - If market-based optimisation is applied (i.e. a technology-neutral approach chosen), deployment of the different energy technologies (FOS, NUC, RES) mainly depends on their relative total costs.
  - Grid modelling (and its major implications) are modelled by ECF; in most other scenario analyses, they are pre-determined.
- **Energy/Electricity Demand:**
  - Without new policy measures demand will increase due to GDP growth. Final energy consumption in 2030 in low carbon scenarios range from 41000 PJ to 61000 PJ; in 2050 from 34000 PJ to 49000 PJ.
  - Electrification is assumed in (almost) all scenarios. Electricity is estimated to gain higher shares in final energy demand, especially in scenarios confronted with ambitious GHG-targets (mainly as a substitute for fossil fuels).
- **Development of More Sustainable Future Energy Systems:**
  - Most scenarios, such as those generated by the PRIMES model, optimise to determine the final energy mix ("technology neutrality"), based on cost input and technology learning assumptions. Greenpeace/EREC and the ECF scenarios backcast from several targeted generation shares, the former excluding NUC and CCS...
  - Estimated future investment costs are also strongly influenced by chosen assumptions on technological developments in energy technologies whose dependability is often difficult or impossible to verify.
  - Most scenarios seem to lack a clear consideration of the costs for necessary infrastructure changes to enable further deployment of variable RES. For example, although investments in the distribution grid seem to represent the majority of necessary grid investments and although all studies stress the

importance of smart grids, in almost all scenarios merely transmission (if at all) is considered.

- Few studies explicitly model changes in the behaviour of economic agents with regard to changes in consumer behaviour.
- Effects on the EU labour market and the economy as a whole (e.g. risk of deindustrialisation) are not consistently modelled in any scenario study.
- Electricity prices increase in most studies at least in the medium term (2030). Some studies with high emission reduction targets expect a decrease of electricity prices in the long term (up to 2050), due to lower fossil-fuel consumption.

- **Renewables:**
  - Absolute and relative increases of RES in the power sector across all scenarios.
  - Investment costs for RES decrease across all scenarios, especially in a long term perspective.

- **Nuclear Power:**
  - When optimised purely on costs, nuclear power tends to expand and gain increasing shares.

- **Fossil fuel plants:**
  - CCS plays an increasing role in scenarios with a focus on a strong future role of the carbon price.

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