Integration of Renewable Energy Sources
Targets and benefits of large-scale deployment of renewable energy sources

Background paper for "The Hague Conference on Environment, Security and Sustainable Development", 9-12 May 2004.

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1. Introduction

In the long term, renewable energies[1] will necessarily dominate the world's energy supply system. The reason is at the same time very simple and imperative: there is no alternative. Mankind cannot indefinitely continue to base its life on the consumption of finite energy resources.

Today, the world's energy supply is largely based on fossil fuels and nuclear power. These sources of energy will not last forever and have proven to be one of the main causes of our environmental problems. Environmental impacts of energy use are not new but they are increasingly well known, they range from deforestation to local and global pollution.
In less than three centuries since the industrial revolution, mankind has already burned roughly half of the fossil fuels accumulated under the earth's surface during hundreds of millions of years. Nuclear power is also based on a limited resource like uranium and the use of nuclear power creates such incalculable risks that nuclear power plants cannot be insured.

Renewable sources of energy are in line with an overall strategy of sustainable development. They help reduce the dependence of energy imports, or do not create a dependance of energy imports, thereby ensuring a sustainable security of supply. Furthermore renewable energy sources can help improve the competitivness of industries at least in the long run and have a positive impact on regional development and employment. Renewable energy technologies are suitable for off-grid services, serving those in remote areas of the world without having to build or extend expensive and complicated grid infrastructure !

The earth receives solar energy as radiation from the sun, in a quantity by far exceeding mankind's use. By heating the planet, the sun generates wind. Wind creates waves. The sun also powers the evapotranspiration cycle, which allows water to generate power in hydro schemes – currently the largest source of renewable electricity in use today. Plants photosynthesis, which is essentially a chemical storage of solar energy, creates a wide range of so-called biomass products ranging from wood fuel to rapeseed, which can be used for heat, electricity and liquid fuels. Inter-actions with the moon produce tidal flows, which can be intercepted and used to produce electricity**.** Renewable Energy Sources (RES) are based on the natural and interconnected flows of energy of our planet earth.

Though humans have been tapping into most renewable energy sources (wood, solar, wind, geothermal and water) for thousands of years, so far only a tiny fraction of the

[1] Any energy resource naturally regenerated over a short time scale which is derived directly from the sun (such as thermal, photochemical, and photoelectric), indirectly from the sun (such as wind, hydropower, and photosynthetic energy stored in biomass), or from other natural movements and mechanisms of the environment (such as geothermal and tidal energy).

technical[2] and economic potential of renewable energy has been captured and exploited. Yet, with existing and proven technologies, renewable energy offers safe, reliable, clean, local and increasingly cost-effective alternatives for all our energy needs.

Combined with the improvement of energy efficiency and the rational use of energy, renewable energy can provide everything fossil fuels currently offer in terms of energy services:

- **Heating and cooling** – solar domestic water heating, solar passive, biomass and solar space heating for buildings, geothermal heat and geothermal heat pumps are entering the market as mainstream technologies. Solar cooling for buildings and industry has been installed in a number of demonstration projects.
- **Electricity** – Electricity from wind power, small-scale hydro and biomass are market reality. Geothermal electricity has existed for decades and supplies electricity for 30 million people worldwide. Photovoltaics are already cost-effective in niche markets world-wide, while tidal and wave power as well as concentrated solar power will need further research and development before their full commercial potential can be realised.
- **Transport fuels** – liquid biofuels like bioethanol and biodiesel produced from agricultural crops, will require better recognition of their low-carbon benefits and their rate of progress will be influenced by decisions taken in other areas of policy such as taxation policy and agricultural policy
- **Chemicals** – biofuels can provide a wide range of products currently based on oil and gas.

2. Integration of Renewable Energy

The rapid deployment of renewable energy technologies and their larger deployment in the near future, raise challenges and opportunities regarding their integration into energy supply systems. Energy systems are needed to meet the demands for a broad range of services (household, commerce, industry, and transportation needs…).
Energy systems include an energy supply sector and the end-use technology to provide the aforementioned energy services. In the EU, the **electricity supply system** is mainly composed of large power units, mostly fossil fuelled and centrally controlled, with average capacities of hundreds of MW. Renewable energy sources are geographically widely distributed and if embedded in distribution networks are often closer to the customers. Locating renewable and other generators downstream in the distribution network is known as Distributed Generation.

Distributed generation involves the use of small, modular electricity generation units close to the point of consumption. In the power sector, utilities have limited experience of interconnecting numerous small scale generation units to their distribution networks, and the possible level of renewables penetration depends strongly on the existing electrical infrastructure. Bringing on land the power produced from a large offshore wind farm is (economically) only possible where sufficient electricity grid capacity is available. In some specific locations, a new electricity infrastructure has been set up with the specific purpose of providing very high penetration levels, up to 100% electricity from renewables.

Distributed electricity generation, close to the end customer, differs fundamentally from the

[2] A study (see section on wind) shows that the total available global wind resource technically recoverable is more than twice as large as the projection for the world's entire electricity demand in 2020. Similarly, theoretical solar energy potential (see section on solar thermal and solar PV) corresponds to almost 90,000,000 Mtoe per year, which is almost 10,000 times the World Total Primary Energy Supply (IEA 2003)

traditional model of an energy system consisting of large power stations generating centrally controlled power. The approach is completely new, replacing the concept of economy of scale using large units by economy of numbers using many small units)[3]. Far from being a threat, distributed generation based on renewable energy offers opportunities.

It can

- Reduce the transmission and distribution losses as well as transmission and distribution costs[4]
- Provide customers with continuity and reliability of supply[5]
- Stimulate competition in supply, adjusting prices via market forces
- Be implemented in a short time due to the modular nature of Renewable Energy Technologies

In the **transport sector**, the use of renewable energies in the form of biofuels is just starting to develop in Europe, whereas in some countries like Brazil it already plays an important role. Also in the transport sector, the integration of renewables requires the adaptation of an infrastructure which has grown over a century of development based exclusively on fossil fuels. Besides the gradual substitution of the vehicles in circulation, it is necessary to develop a new supply chain for the production and distribution of bio-fuels. This will require substantial investments. However, the development of the fossil fuel based transport system also required investments that were historically subsidised by the public sector in many countries.

Also in the **heating sector**, the full integration of renewable energies requires an adaptation of historically grown infrastructures. This process is particularly important because, in many parts of Europe, it is possible already today to have new buildings which are completely independent from fossil fuels or electricity for their heating needs. This can be achieved using state of the art renewable heating and cooling applications which are linked with energy efficiency measures and demand side management.

A substantial economic restriction to the integration of renewable heating (solar thermal, biomass, geothermal) is given by the long lifetime of buildings. The installation of renewable heating systems is much more cost effective during the construction of a building or when the overall heating system is being refurbished. This means that there is a short window of opportunity for cost effective integration of renewable heating. If this occasion is lost, for decades that building will remain dependent on fossil fuels or electricity to cover its heating demand.

For this reason, it is essential that all possible measures be taken to make sure that the available renewable heating sources are installed in all new buildings. It is also necessary to promote the use of renewable heating at the moment of the modernisation of the conventional heating system.

The existing infrastructure and market dominance of conventional heating represents a substantial barrier to growth for renewable heating. Biomass heating can be competitive in areas where the fuel supply chain is well developed, but this is not yet the case in many areas of Europe. A solar thermal system can be a good economic investment, but in many areas of Europe most users are not aware of this and most heating installers are trained only for conventional heating systems and therefore recommend their customers to stick to

[3] Weinberg 1995; Ianucci and others 1999, World Energy Council 2001

[4] The IEA alternative scenario (WEO, 2002; WEIO 2003) predicts savings of about 40% for the transmission grid and 36% for the distribution due in particular by the increased use of distributed generation energy.

[5] This argument is a major driver when you take into account the recent black out in the United States and Italy.

the conventional heating.

Renewable heating sources can be used also for **cooling purposes.** An increasing number of well working systems is being installed, mainly based on solar thermal and geothermal energy. The growing demand for cooling is having a dramatic impact on the electricity systems in Europe, with several countries reaching peak electricity demand in summer instead of winter. These problems can be mitigated by supporting the development and commercialisation of renewable cooling technologies .

The choices of millions of citizens in their homes and offices are crucial to the future integration of renewable energies in the heating sector. Raising awareness among the general public and specific training of the professional groups involved (heating installers, building engineers, architects, managers of heat intensive buildings or devices) are therefore very important.

Increasing the use of renewable energies must obviously be accompanied by **energy efficiency and demand side management** measures at the customers' end. Renewable Energy development and increase of energy efficiency are strongly interdependent. The European Union has always stressed the pressing need to renew commitment both at Community and Member State level to promote energy efficiency more actively. In the light of the Kyoto agreement to reduce CO_2 emissions, improved energy efficiency together with increased use of renewables will play a key role in meeting the EU Kyoto target economically. In addition to a significant positive environmental impact, improved energy efficiency will lead to a more sustainable development and enhanced security of supply, as well as to many other benefits.

An estimated economic potential for energy efficiency improvement of more than 18% of present energy consumption still exists today in the EU as a result of market barriers, which prevent the satisfactory diffusion of energy-efficient technology and the efficient use of energy. This potential is equivalent to over 160 Mtoe, or 1,900 TWh, roughly the total final energy demand of Austria, Belgium, Denmark, Finland, Greece and the Netherlands combined.

Special emphasis should be placed on **urban areas**, where a high proportion of all energy is consumed. Urban areas are characterised by a highly developed infrastructure, not always easily allowing a rapid increase of the level of renewable energy generation. The fact that electrical network infrastructures are generally over-dimensioned in urban areas, can in some cases allow a high degree of penetration of PV generators, without changing the existing cabling, transformer stations, etc. However, in general, the future energy infrastructure will have to be designed from the beginning to effectively accommodate RES to a very high level.

3. Market development of Renewable Energy

The European renewable energy industry has already reached an annual turnover of €10 billion and employs 200,000 people. Europe is the global leader and the front runner in renewable energy technologies. The use of renewables has a considerable impact on the investments made in the energy sector. Renewable energy replaces imported fuels, with beneficial effects on the balance of payments. Although per unit of installed capacity renewable energy technology is more capital intensive, taking in account the avoided external costs, investing in renewables turns out to be cheaper for society than business-as-usual investments in conventional energy. Renewable energy technologies are often of a smaller scale than big fossil fuel and nuclear projects, they can be brought on-line

quickly and with lower risks. And finally, deployment of renewables creates more employment, compared to other energy technologies[6].

The development of smarter and more efficient energy technology over the last decades has been spectacular. The technologies have improved and costs have fallen dramatically. The examples of wind and solar photovoltaic are striking. In terms of costs, investment costs for wind declined by around 3% per annum over the last 15 years. For solar photovoltaic (PV) cells, stimulated initially by the space programme, unit costs have fallen by a factor of 10 in the past 15 years.

In the European Union, renewables have already reached a significant share of the total energy production. Germany, for example, has doubled its renewable output in the past five years to 8% of total electricity production. Denmark now gets 18 % of its electricity from wind power alone, and has created an industry that has more jobs than the electricity sector itself. Spain has leapt from virtually nothing a few years ago to become the second biggest wind power country in Europe with 6,000 MW of capacity. Countries such as Finland, Sweden and Austria have supported the development of very successful modern biomass power and heating industries through fiscal policies, sustained R&D support and synergistic forestry and industrial policies. As well as saving significant CO_2 emissions, equipment from all three countries is now exported world-wide.

Generally speaking, renewable energy technologies are important for local employment and income generation which results from manufacturing, project development, servicing and in the case of biomass, rural jobs and income diversification for farmers.

4. *The benefits of Renewable Energy*

Renewables contribute to increasing the security of supply

The European Commission's Green Paper on Energy Security highlights the importance of both renewable energy and energy efficiency in reducing dependence on imported oil from areas such as the Middle East. According to the Green Paper , in two decades, Europe will be importing 70% of its energy (an increase from 50% today) unless we change direction. This import dependency is bringing economical, societal, ecological and safety policy problems. Energy supply is a vital service of public interest.

> *"Renewable sources of energy have a considerable potential for increasing security of supply in Europe. Developing their use, however, will depend on extremely substantial political and economic efforts. (...) In the medium term, renewables are the only source of energy in which the European Union has a certain amount of room for manoeuvre aimed at increasing supply in the current circumstances. We can not afford to neglect this form of energy."*
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> *Source: Green Paper on the security of energy supply - 2001*

All value-added processes are dependant on energy supply and thereby also on energy prices. Even if the energy demand were to stay at the same level as today, most of the fossil fuels would be exploited during the 21st century. Only coal supply will be guaranteed for more than 200 years. In the long term, it is absolutely sure that the prices for fossil fuel supply will increase steadily. But also in the short term, the volatile world market prices for conventional energy sources, in particular oil, pose great risks for large parts of the world's economic and political stability, with sometimes dramatic effects on energy-importing

[6] Mitre project (http://www.eufores.org/Summary.htm)

developing countries. In this context, renewable energies can help to diversify energy supply and to increase the security of energy supply. Additionally, in the mid-and long-term perspective, renewable energies prolong the availability of fossil fuels for the satisfaction of energy and non-energy needs that can at the moment only be covered by fossil fuels.

Renewables have the lowest Environmental Impact of all energy sources.

Renewable energy technologies do have an impact on the environment, as do all energy technologies. However, renewables have a far lower impact than fossil fuels and nuclear power. A major EU study[7] concluded that when climate change and the possible impact of catastrophic accidents of nuclear plants are accounted for, renewables generally have a significantly lower environmental impact.

Renewables are 'the' solution to climate change. Renewable energy should no longer have the 'alternative' tag – it is a mainstream set of energy options able to provide cost-effective and reliable low-carbon energy. After extensive RD&D and commercialisation over the past 20 years, wind power, biomass heating and power, solar heating and power and the other renewable energy options have emerged as important components of the modern energy mix. By reaching its target for 2010 of 12% share of renewables in the total energy consumption, the EU will fulfil 95% of the CO_2 savings necessary to meet the EU Kyoto commitment.

The global challenge of climate protection demands a reformed, environmentally sound energy system that will be viable for the future. If we want to avoid catastrophic consequences for our planet, we will have to slow down global warming. By the end of this century, the average temperature must not have risen by more than 2 degrees Celsius since the industrial revolution. In order to achieve this, we have to significantly reduce the emissions of greenhouse gases. An important core element in the efforts must be a massive expansion of renewable energies.

Renewables offer sustainable energy development world-wide.

Energy is central to concerns about sustainable development and poverty reduction. It affects practically all aspects of social and economic development, including livelihoods, water, agriculture, population, health, education, job creation, and gender-related issues

In developing countries, per capita energy consumption is one sixth of the energy consumption in the industrialized countries., The majority of citizens of the least developed countries (LDC) have no access to electricity at all. In total there are more than 2 billion people on earth living without electricity supply. At the same time, current patterns of energy production and consumption have direct negative impacts on the environment and natural resources at the local, regional and global levels.

Energy demand in developing countries is growing rapidly. In order to meet this demand and at the same time to achieve sustainable development objectives on a global scale, conventional approaches to energy must be reoriented toward energy systems based on renewable energy and energy efficiency, which will make it possible to address social, economic, and environmental concerns simultaneously. Due to their decentralized character, renewables offer quick solutions without investments in large scale energy supply structures and networks.

As part of the Kyoto protocol, the Clean Development Mechanism (CDM) aims to encourage sustainable development projects in developing countries funded by

[7] Extern-E (http://www.externe.info/)

industialised countries. In line with the European strategy for global sustainability, the European Union is committed to fostering the market growth of renewable energy sources in developing countries.

Europe is playing a leading role in the Johannesburg Renewable Energy Coalition (JREC), which is a major driving force for renewable energies at international level. More than 80 of the world's states – including all 25 Member States of the EU – have joined this coalition. By setting voluntary targets for the increased use of renewable energies, they are creating a secure basis for the investments that are needed.

5. Challenges of large-scale deployment of renewable energy

Public opinion continues to strongly support renewable energy, as proven by numerous surveys. A European Commission survey across the EU 15 countries in early 2003 showed that:

- 69 % of the European Union (EU) citizens support more renewable energy-related research compared to 13% for gas, 10% for nuclear fission, 6% for oil and 5% for coal.
- 88% of EU citizens stated that global warming and climate change are serious issues which need immediate action
- 75% answered that the use of fossil fuels (coal, oil, gas, etc.) contributes significantly to global warming and climate change

But public opinion alone cannot overcome barriers to growth for renewable energies.. Heavy admionistrative approvals procedures, , existing market structures with a dominant position of the incumbent industries, a widely diffused underestimation of the potential of renewables and a lack of incentives are some of the factors that slow down the growth of renewable energies. If reliable framework conditions and a favourable climate for investment are created, then renewables can quickly increase their contributions.

While most renewable fuels are free, renewable energy projects have high up-front costs, and a number of factors combine to make many renewable energies appear to be more expensive than conventional energy. Distortions resulting from unequal tax burdens and existing subsidies, and the failure to internalize all costs and benefits of conventional energy production and use, erect high barriers to renewable energy. Additional barriers include the cost of the renewable energy technologies themselves (and the need to achieve economies of scale in production), the lack of access to affordable credit, the costs of connecting with the grid, and transmission charges, which often penalize intermittent energy sources.

In many countries, electric utilities maintain monopoly rights to produce, transmit and distribute electricity. High costs or a lack of standards for connection and transmission discourage renewable energy projects. In addition, lack of information about available renewable energy resources and about the current state of renewable energy technologies, or negative past experiences with old technologies, and a lack of understanding about the benefits associated with renewable energy all act as barriers to their use. Each of these factors works to increase the perceived risks—technical and financial—of investing in renewable energy.

Research, technological development and innovation will remain major drivers for renewables deployment in the coming decades. Even technologies close to maturity, like

wind energy will see further improvements and completely new concepts enter the markets. Aspects related to the systems technology for integration of renewables into existing energy infrastructures will receive more emphasis.

The problems of the intermittent character of some renewables will be largely overcome through new storage technologies under development that can be expected to enter the market in the coming years. In the electricity sector, technologies such as pressurised air storage and electrochemical storage through fuel cells will make important contributions. In the heating sector, underground seasonal heat storage will allow to accumulate solar heat in summer and use it in winter.

The application of indirect storage options and energy carriers are expected to complement solutions provided by direct storage. Some indirect storage options are the storage of heat or cold, displacing the need for electrical power at peak moments. In countries where drinking water is produced through desalination, the storage of this water works indirectly as an energy storage. It is essential to adapt electricity grids using more intelligent management systems that can deal with a large variety of renewable energy generators. Protection systems must evolve according to these new network needs, allowing bi-directional electrical flows, at the same pace as the application level of distributed generation and renewables increases.

Rather than attempting to match power generation to consumer demand, the philosophy of load management takes action to vary the load (i.e. the demand) to match the power available (the supply). When assessing the possible use of load control, energy users' attitudes should be taken into consideration. Users will need to accept a tariff structure that distinguishes between periods of peak and off-peak and learn to control their use of electricity to avoid peak periods.

Better software should be developed to forecast both the load and the renewable power available. The development of an adaptable advanced control system is necessary to achieve optimal utilisation of different kinds of renewable energy sources and to maintain a high degree of reliability and security. The deployment of such an advanced control system would greatly mitigate any negative effects arising from the intermittence of renewable energy sources, and thus ensure the stability of the electrical system.

6. Political framework

Renewables need strong, continued and smart political commitment. Since 1993, the European Commission has deployed substantial efforts to build up a common, stable policy framework in Europe to foster the market penetration of Renewable Energy Sources. In the early nineties, it became clear that in addition to the efforts made for more than thirty years to develop Renewable Technologies through Community Research, Demonstration and Innovation programmes, a Policy framework which combines legislative and support measures was necessary to increase and foster Renewable market penetration.

The Community Policy framework establishes indicative mid-term targets for 2010 both at global and sectoral level. The first time that the European Community proposed a target for Renewable Energy was in the ALTENER programme in 1993: the objective was to double the part of Renewable Energy in the gross domestic consumption from 4% in 1991 to 8% by 2005. In the White Paper of 1997, the objective was to achieve a share of 12% of total EU energy consumption by 2010. This objective was confirmed in 2000 in the Green Paper on the security of energy supply. Community support programmes have been

oriented to help reaching this objective by promoting EU-wide measures and actions in favour of Renewable Energy at national, regional and local level.

A European legislative framework to promote renewable energies has been meanwhile established both in the electricity and in the transport sector, with two specific EC directives that establish growth targets for renewable energies in these sectors, both at Community and national level, as well as a series of specific measures and monitoring schemes that are described more in detail below. For the heating sector, however, there is not yet a specific EC legislation, though the recent EC Directives on the energy performance of buildings and on cogeneration indirectly contribute to the market penetration of heating based on renewable energies.

The enlarged Community is a reality since May 2004, and 25 countries will soon be implementing the same policies and pursuing common objectives in the field of renewable energy sources. The Community Policy Framework applies also to most of the EEA countries that committed themselves to it. As a result, more than 30 countries in Europe with more than 450 million people will have a common policy framework for renewables.

In parallel to the policy framework, in addition to significant research and development support for renewable energy technologies (even if still far less than for conventional and nuclear energy), the European renewable industry is leading world-wide for most of the renewable technologies. These favourable conditions lead to increases in production capacities, and thereby to significant cost reductions. For example, the production cost of a kilowatt-hour generated by wind power has decreased by 80% in the last 20 years. With this strong position on the home market, European companies also play an increasingly important role on the world market and dedicate more and more efforts to exports. For the year 2010, a 17 billion euros annual export business is projected for the EU.

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7. Targets for renewables – from 12% in 2010 to 20% in 2020

Worldwide, there are several scenarios with the common goal of sustainability – in general or in the energy field. Thus, ground-breaking targets along the way towards this goal are important both for renewable energy and end-use energy efficiency. Such targets can guide policy-makers during decision-making and send important signals to investors, entrepreneurs and the public.

There are several case studies that demonstrate how concrete targets lead to increased impacts in various fields. In the case of renewable energies, policy-makers formulate concrete policies and support measures that foster their development, and investors develop related strategies and renewable businesses as the targets convince them that their investment will yield the expected returns.

The targets set out in the EC White Paper of 1997 foresee a 12% share of renewables in total energy consumption by the year 2010 (a doubling of the 1997 share). Individual targets for each renewable energy technology are set out. Looking at the annual growth rates between 1995 and 2001, it is clear that one sector (wind) is far beyond the target and others are well in line with the expectations of the White Paper, i.e., hydro, geothermal and photovoltaic. To reach both the overall target and the sectorial targets, which is feasible, specific support actions for some technologies that lag behind, such as biomass and solar thermal have to be taken soon.

Given the present state of market progress and a strong political support, the current expectation is that the overall contribution of renewable energy to energy consumption in

2020 will be 20%, if strong and additional support measures are adopted. These estimates are based on a conservative annual growth scenario for the different technologies. In order to reach the target, strong energy efficiency measures have to be taken to stabilise the energy consumption between 2010 and 2020.

The estimation done by EREC looks like the following :

	2000		TARGETS 2010		TARGETS 2020	
TYPE OF ENERGY	**Eurostat Convention**	**% of total**	**Eurostat Convention**	**% of total**	**Eurostat Convention**	**% of total**
Total Gross Inland Consumption	**1,455**		**1,576 (trends to 2030)**		**1,576**	
1. Wind	**1.92**	**0.13**	**14.4**	**0.91**	**38**	**2.4**
2. Hydro	**27.6**	**1.9**	**30.6**	**1.94**	**33**	**2.1**
3. Photovoltaics	**0.01**		**0.3**	**0.02**	**3.6**	**0.2**
4. Biomass	**54.5**	**3.73**	**125.5**	**7.96**	**205**	**13.0**
5. Geothermal	**3.32**	**0.22**	**6.2**	**0.4**	**12.4**	**0.8**
6. STC	**0.38**	**0.02**	**3**	**0.2**	**24**	**1.5**
Total Renewable Energies	**87.8**	**6.0**	**180**	**11.43**	**316**	**20.0**

source : EREC

8 Benefits of using a bigger share of renewables

If the target of 20 % by 2020 will be met, renewables will deliver the following benefits:

Investments

The implementation of new policies to promote renewable energy sources will have a considerable impact on the amount of investments made in this sector. In order to reach the 20% target an investment of €443 billion in renewable energy is needed over the period 2001 – 2020.

Investments (in billion €)

	2001-2010	2011-2020	2001-2020
Wind	55	101	156
Photovoltaic	10	66	76
Biomass	44	45	89
Hydro	11	9	20
Geothermal	4	7	11
Solar Thermal	16	75	91
TOTAL RES	**140**	**303**	**443**

source : EREC

Avoided fuel costs and avoided external costs

Increasing prices in oil and gas supply due to limitation of the resources can, to a large extent, be covered through the avoided fuel costs by using cost free fuel and low cost renewable energy technologies. Wind, PV, Solar thermal and hydro power has zero fuel costs as the resource is free and supply is endless. Additional renewable energy eliminates direct fuel costs for the lifetime operating plant. Moreover, the external costs to society derived from burning fossil fuels or from nuclear generation are not fully included in energy prices. These costs have both a local and a global component, the latter mainly related to the consequences of climate change. There is a lot of uncertainty about the magnitude of such costs, and they are difficult to identify and quantify. The table shows a higher and a lower calculation of avoided external costs through the use of renewables together with the avoided fuel cost. [8]

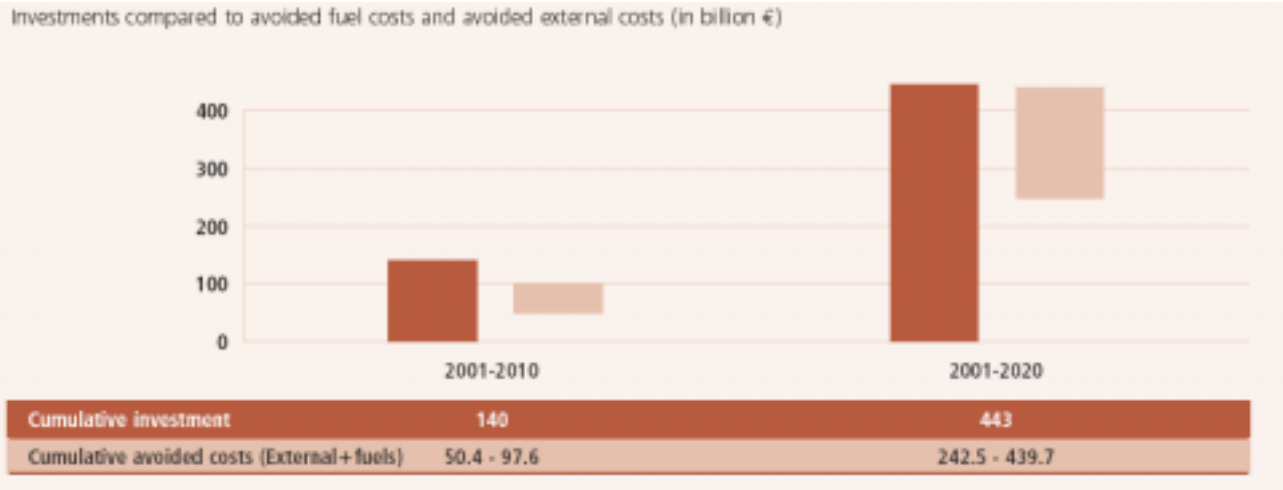
Avoided fuel costs and avoided external costs (in billion €)

	2001-2010		2001-2020	
	External	Fuel	External	Fuel
Wind	9,4 - 24	12,9	40,2 - 102,8	63
PV	0,2 - 0,5	0,2	2,7 - 6,8	4,3
Biomass	16,7 - 42,7		62,6 - 160,1	
Hydro	2,2 - 5,6	3,1	7,5 - 19,1	11,5
Geothermal	0,6 - 1,4	1,5	2,5 - 6,3	7,3
Solar Thermal	1,3 - 3,4	2,3	11,2 - 28,8	29,7
Total RES	**30,4 - 77,6**	**20**	**126,7 - 323,9**	**115,8**

source : EREC

Investments compared to avoided fuel costs and avoided external costs

Calculating with high external cost assumptions and average fuel costs, the saved amount is nearly as high as all the investments needed for fulfilling the 20 % target.



source : EREC

[8] The figures used for the calculation of the external costs are based on a European Commission project, the “Extern-E” project.

CO_2 emission savings.

Renewable Energy offers the leading solution to climate change. By providing carbon-neutral sources of power, heat, cooling and transport fuels, renewable energy options offer a safe transition to a low carbon economy. The table shows that the CO_2 savings due to RES development during the period 2001-2010, will be 320 Million tonnes per year in 2010. This amount represents 95% of the EU Kyoto commitment of reducing Green House Gas emissions (GHG) by 8% between 1990 and 2010. By 2020 the CO_2 reduction due to RES will be 728 Mt/year, representing a decrease of 17,3% of the total GHG emissions in 1990 in the EU-15.

	2010	2020
Wind	99	236
Photovoltaic	2.2	24
Biomass	176	326
Hydro	23	35
Geothermal	5.8	15
Solar Thermal	14	92
TOTAL RES	**320**	**728**
% of total EU 15 GHG (Greenhouse Gases) emissions in 1990	**7.6 %**	**17.3 %**

source : EREC

Employment

Using renewable energy technologies creates employment at much higher rates than many other energy technologies. There are economic opportunities for new industries and new industrial and craft jobs through production, installation and maintenance of renewable energy systems. The table shows the employment growth with respect to the year 2000 in the RES industry and includes both the direct and indirect employment. The job losses in the conventional energy sector have already been subtracted.

Employment

	2010 jobs FTE	2020 Jobs FTE *
Wind	184,000	318,000
Photovoltaic	30,000	245,000
Biomass	338,000	528,000
Biofuels	424,000	614,000
Small Hydro	15,000	28,000
Geothermal	6,000	10,000
Solar Thermal	70,000	280,000
TOTAL RES	**1,067,000**	**2,023,000**

** Full time employment*

source : EREC