Background information about renewable energy, climate change and the electricity market

Compiled by the EKOenergy Secretariat, 2014

This text doesn't have the ambition to be complete. It wants to give an easy to understand overview, meant for people who aren't experts.

We welcome updates, corrections, additions, translations...
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Introduction

EKOenergy is an organization which promotes the use of sustainable electricity in Europe. EKOenergy fully agrees with the conclusions of the IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation (SRREN) published in 2011:

"As well as having a large potential to mitigate climate change, RE [Renewable Energy] can provide wider benefits. RE may, if implemented properly, contribute to social and economic development, energy access, a secure energy supply, and reducing negative impacts on the environment and health. RE can contribute to social and economic development."

Nonetheless, we are aware that promoting renewable energy is not an easy task, and brings up a lot of questions and doubts. Lots of consumers feel confused by the lack of clear information, and fail to see the significance of their own purchase of electricity. Why buy renewable? Where is my electricity really coming from? What about the negative impacts of renewables? What is a Guarantee of Origin? Those are some of the topics discussed in the present document.

The following pages do not have the ambition to give a complete overview of the most recent developments and publications on all the topics linked to the renewable electricity sector. They do attempt to give a compass for consumers wanting to move into the field of renewables. A list of references is recommended for further reading.

The electricity market is constantly evolving and we cannot be sure that information relevant today will be so tomorrow. For this reason, we welcome all your inputs to help us improve these pages and make them a source of shared knowledge for the common good.

These pages are organized around several topics, and it is possible to navigate freely among them, without following the page order. You can refer to the table of contents to go directly to the specific points you might be interested in.

I - WHAT IS RENEWABLE ELECTRICITY?

Renewable electricity is electricity produced from sources which are naturally replenished on a human timescale.

EKOenergy currently accepts the following types of renewable sources:

1°) Wind

Wind turbines work by pooling the mechanical energy of wind and transforming it into electricity. Wind turns the blades, which spin a shaft, which then connects to a generator and produces electricity. Wind turbines can be built on land or offshore in large bodies of water like oceans and lakes.

Based on data from EWEA (European Wind Energy Association), in 2010 there were 70,488 onshore wind turbines and 1,132 offshore turbines across the EU. With technological progress turbines are becoming bigger and more efficient: the same amount of energy can be generated with fewer turbines.

An average size onshore turbine manufactured in 2014 can power annually more than 1,500 average EU households. An average offshore wind turbine of 3.6 MW can power more than 3,312 average EU households.

At present (2014), the development of onshore windmills is more economical than that of offshore ones. However, in the coming years, as offshore turbines are manufactured on a larger scale, prices will go down, thus making offshore wind energy increasingly competitive.

In 2014, according to EWEA, there is 19.5 MW of wind power capacity installed per 1,000 km of land area in the EU, with the highest densities in Denmark and Germany. Although 25 of the 27 EU Member States now utilise wind power, there is still a substantial amount of wind power capacity available in countries like France, the UK and Italy.

The total wind power capacity installed in Europe at the end of 2012 covers 7% of the EU-27’s annual electricity demand.

Wind provides 26% of electricity produced in Denmark, while Portugal and Spain produce around 16% of their electricity from wind power, followed by Ireland (12%) and Germany (11%).

Advantages:

- Producing electricity from wind energy causes **no greenhouse gas emissions**. A turbine will yield up to 80 times more energy than the energy used to build, install, operate, maintain and decommission it (EWEA's numbers). EWEA estimates that, in 2011, wind energy saved the emission of 140 million tonnes of CO_2 in the EU, equivalent of taking 33% of EU cars – 71 million vehicles – off the road.

- As opposed to fossil fuels, wind as a '**raw material' has no cost and will always be available**.

- Wind power plants take up limited space on the ground, allowing for extended land use in their surroundings (e.g. agriculture).

- The **construction time is usually very short** – a 10 MW wind farm can easily be built in two months. A larger 50 MW wind farm can be built in six months.

- Unlike fossil fuel and nuclear power plants, wind technology uses very little water to produce electricity. **Given the fact that water scarcity is already a pressing issue and will be gravely exacerbated by climate change and population growth, wind energy is a key to preserving water resources.**

Disadvantages:

- Wind is not constant: it is possible to have storms as well as a total absence of wind. If there is no wind, a wind power plant does not produce electricity at all. This is why wind power plants need to be coupled with *load following power plants* (such as hydropower or bioenergy) and smart grid solutions.

- Wind power stations have also received criticism because of noise pollution. The problem of noise pollution is easy to solve by choosing a suitable location for plant construction and by favouring modern wind power technology. You can consult the review conducted in 2009 by the American and Canadian Wind Energy Association for further information.

- Wind power is also criticized for ruining landscapes (as a matter of taste, this remains debatable). Choosing the appropriate location resolves this issue as well. Most EU countries have identified important landscapes, protected areas and cultural heritage sites, which help power producers finding unobtrusive locations for power plants.

- Wind turbines may affect birds and bats. If a wind power plant is built in a carelessly chosen spot it can disturb the nesting and feeding of birds. They can also interfere with migration and even cause mortality. However, deaths from birds colliding into wind turbines represent only a tiny fraction of those caused by other human-related causes such as collision with vehicles and buildings. Again, these problems can be avoided by choosing the right locations for wind power production. It is worth noting that wind farms are often subject to an Environmental Impact Assessment. This ensures that their effect on the immediate surroundings, including fauna and flora, is carefully considered before construction starts.

- Despite its impacts on birds even bird protection NGOs favour wind power. For instance, many agree that climate change is the single largest threat to birds and wind and renewables were a clear solution to climate change.

You can read more about the environmental impact of wind power in this very detailed article of Wikipedia.

EKOenergy sets criteria to wind power and all other renewables. EKOenergy-labelled wind power comes always from outside of threatened habitats, migratory routes, protected areas and cultural heritage sites.

2°) Solar

There are two main ways to transform solar energy to electricity:

- Solar photovoltaic (PV) converts light (photons) into electricity (voltage).

- Concentrating solar power (CSP), also known as Concentrating Solar Thermal (CST) technologies: the sun's light energy is converted into heat through the use of mirrors. The heat creates steam, which drives a turbine that generates electrical power – solar thermal electricity (STE).


© SunEdison

Over the period 2000-11, solar PV was the fastest-growing renewable power technology worldwide. Cumulative installed capacity of solar PV reached roughly 65 gigawatts at the end of 2011, up from only 1.5 GW in 2000. In 2011, Germany and Italy accounted for over half of the global cumulative capacity.

Concentrated solar power is a re-emerging market. Roughly 350 megawatts (MW) of commercial plants were built in California in the 1980s; activity started again in 2006 in the United States and in Spain. At present, these two countries are the only ones with significant CSP capacity, with respectively about 1 GW and 500 MW installed, and more under construction or commissioned. (source: International Energy Agency)

Advantages:

- Solar cells **do not produce any greenhouse gas emission**. Nor do they create any other pollution.

- Solar energy is (and will remain) **free to use**, drastically limiting costs linked to electricity production. These costs are expected to keep decreasing in the coming years. Also the cost of maintaining solar PV panels is considered negligible compared to most other renewable energy systems.

- Solar energy **can be made available almost everywhere** where there is daylight. It represents a huge advantage for local economy as it means you do not rely on other countries for raw material.

- Solar panels **do not make any noise**, which makes them suitable for urban areas.

Disadvantages:

- Solar power is not accessible at night, which means that you have to either have another source of electricity or a good storage system (i.e. a battery). Nonetheless, with CSP the heat can still be stored and produce electricity for six hours; we can expect this potential to grow in the future.

- Also, in big solar power plants, toxic chemicals are often used to keep plants away from shadowing the power plants. These chemicals are sometimes released and pollute the environment.

- To have large capacity you need large areas of land which equal the size of forests or farms. Luckily industrial and residential areas and roofs are perfectly suitable for solar power production.

The criteria of EKOenergy for solar, wind, geothermal and marine energy share a main principle: they have been set up with environmental concern about the location of the plants, trying to avoid protected areas, with particular regard to birds.

3°) Hydroelectric power

Hydropower plants function by converting the kinetic energy of flowing water into electricity. The water runs through a dam, turns a turbine which then activates a generator. The volume of water as well as the height difference between the dam and the turbine determine the quantity of electricity production.

According to IHA (International Hydropower Association) Hydro-power report 2013, hydropower currently accounts for around 60% of all renewable electricity generation in Europe (including ocean and marine energy). In total it reaches 227GW of capacity in the whole of Europe. Norway has the biggest capacity of hydropower (30.3 GW), followed by France (25.4 GW), Italy (19.5 GW), Spain (16.1 GW) and Sweden (16 GW).

In Europe, most of the environmental organizations see few opportunities for new facilities, but there is still great potential in improving the already existing facilities: Albania, for instance, is planning the rehabilitation and modernisation of up to 14 dams.

Advantages:

- Contrary to wind and solar, hydroelectricity has the great advantage of not depending on the weather, although exceptionally dry periods decrease hydro power production in the long run. In general, **production is predictable** and can be adapted to the needs of end-consumers.

- Hydropower can be also easily and promptly regulated to follow electricity consumption peaks or sudden production outages in other power stations.

- Like the two other sources discussed previously, water is a renewable that **does not have any transportation costs**. Hydropower plants do not release greenhouse gases during their operations (we are going to discuss this last point later).

Disadvantages:

- Building a conventional dam implies the creation of a reservoir lake right behind it, which has its drawbacks. Flooding of large areas causes damages to the ecosystem. It can also destroy farming lands, or force people to move. In the meantime, in these stagnant waters the decomposition of flooded plants and trees leads to emissions of carbon dioxide and methane (which are greenhouse gases).

- The damages done to river ecosystem, in particular to fish, are of highest concern. Migratory fish species like salmon, trout or eel, are dependent on unblocked waterways. A hydropower station transforms rivers into artificial lakes, which are not suitable ecosystems for these species. By hindering migration, such artificial dams often prevent access to spawning areas. Click here to read more about the risks linked to hydropower.

- The regulation of water levels also has a negative effect on the environment. The most damaging hydropower stations can even dry rivers out completely.

Given the characteristics of hydropower and the risks it represents for biodiversity, EKOenergy has decided to set up specific criteria and to set strict requirements for hydropower plants that enter its database. EKOenergy does not diminish the advantages of hydropower for energy and climate concerns, but it believes this source has to be managed with the greatest caution. Get more information on our criteria here.

4°) Ocean and Marine Energy

This is the energy created by the movement of waves. There are different existing technologies:

- Tidal power: tidal streams and currents offer a consistent source of kinetic energy caused by regular tidal cycles, influenced by the phases of the moon. Tidal barrages exploit the rise and fall of tides in estuaries and bays to produce electricity.

- Wave power: devices are located at different distances from the shoreline, either on the sea-bed or surface-floating. All derive energy from the movement and power of ocean waves.

- Ocean thermal energy conversion – OTEC: devices exploit the temperature difference between deep cold ocean water and warm tropical surface waters. OTEC plants pump large quantities of deep cold seawater and surface seawater to run a power cycle and produce electricity.

- Salinity Gradient: power generation from salinity gradients utilizes the difference in salt content between fresh water and seawater to provide a steady base load of electricity from plants located close to the end-consumer.

Over 10MW of ocean-going devices are currently deployed in European waters, including several devices of 1MW and more.

Advantages:

- Waves are an abundant and often reliable source of electricity. The predictability of this source can range to up to several years ahead. For this reason, tidal energy could be a master asset for an energy system based only on renewables in the future.

- Due to its location, it has no impact on the land, avoiding many of the disadvantages of the other sources.

- It also does not create any greenhouse gas emissions nor does it release any waste in the ocean.

Disadvantages:

- The implemented projects have proven to be very expensive, as they are pilot cases.

- They may enter into conflict with other activities around the coast such as tourism and navigation.

- They also have an effect on the marine ecosystem by disturbing the seafloor.

- In addition, some of the toxic chemicals used in those power plants are responsible for pollution when released into the ocean.

- Finally, sites have to be chosen with care as, according to the area of implementation, waves have a varying degree of reliability.

The criteria of EKOenergy for wind, geothermal and marine energy share a main principle: they have been set up with environmental concern about the location of the plants, trying to avoid protected areas, protected or important habitats, with special regard to birds.

5°) Geothermal Energy

Nesjavellir geothermal power plant. CC BY 2.0. Lydur Skulason.

Geothermal electricity stems from a geological process. In Earth's crust water is heated until it turns into steam. By drilling in these areas it is possible to create high pressure (due to the steam); the pressure is used to run a turbine which creates electricity.

In Europe, geothermal energy is not a main source of electricity. Two countries stood out in terms of production in 2013: Italy (875.5 MW) and Iceland (664.4 MW). Minor capacity is also used in France (17.0MW, mainly in overseas territories) and Germany (11.9MW).

Advantages:

- Geothermal, although using expensive installations, has all in all a relatively low cost.

- It is **less polluting than nuclear and fossil fuelled power plants**.

- Geothermal power does not consume any imported raw materials, which makes it economically viable in places like Iceland.

Disadvantages:

- During the drilling phase, the operations will modify the landscape of the area and could damage local plants and wildlife. Blow-outs can pollute surface water. During drilling or flow-tests toxic gases may be discharged into the atmosphere.

- The next stage, the installation of the pipelines that will transport the geothermal fluids, and construction of the utilization plants, will also affect animal and plant life and the surface morphology.

- During the plant operation: Geothermal fluids (steam or hot water) usually contain gases (including carbon dioxide and methane) as well as dissolved chemicals, whose concentration usually increase with temperature. Some toxic gases released during the plant operation have proven to be responsible to respiratory diseases such as asthma. Some geothermal fluids, such as those utilised for district-heating in Iceland, are freshwaters, but this is very rare. The waste waters from geothermal plants also have a higher temperature than the environment and therefore constitute a potential thermal pollutant. This toxic water is sometimes pumped back into the ground producing tremors and quakes.

- The extraction of large quantities of fluids from geothermal reservoirs may give rise to subsidence phenomena, i.e. a gradual sinking of the land surface.
- The withdrawal and/or re-injection of geothermal fluids may trigger or increase the frequency of seismic events in certain areas.
- The sustainability of geothermal is quite debatable, as after some time the capacity starts to fall slowly, due to the fact that the amount of steam in the ground is exhaustible.

The criteria of EKOenergy for wind, geothermal and marine energy share a main principle: they have been set up with environmental concern about the location of the plants, trying to avoid protected areas, protected or important habitats, with special regard to birds.

6°) Bioenergy (solid, gas and liquid)

Bioenergy is derived from biomass, that is to say from organic material. It embraces a lot of different types of sources such as wood, organic waste, agricultural products or manure.

Biomass is turned into either a solid, a gaseous or a liquid form and later burned. The use of bioenergy raises different kind of questions, depending on the source and technique of production.

Biomass accounted for 8.4 % of the total final energy consumption in Europe in 2011. In some countries, such as Estonia, Latvia, Finland and Sweden, this is above 25%. This biomass was mainly used for heat (72% of the total final energy consumption of biomass), followed by biofuels for transport (16%) and bioelectricity (12%).

Advantages:

- Biomass for energy production has the advantage that **it can be stored and used fairly flexibly** when needed for energy consumption. Other forms of renewable energy, like wind and solar, usually require additional storage capacity (or a better control of electricity demand) to ensure that they can meet demand.

- Although the burning of biomass is releasing greenhouse gases, they are still generally considered as **a way to reduce the intensive carbon emissions of our energy system**. Indeed, even though burning wood causes carbon emissions, the same amount of carbon would have been released at the natural death of the trees and will be recaptured by the newly growing trees which replace them.

- Biomass **can also be used for the production of heat**, e.g. in a 'Combined Heat and Power installation', in other words, an installation producing electricity and heat at the same time. The efficiency of electricity production is about 30 % when producing electricity, whereas in producing both electricity and heat combined, it is about 90 %. Biomass is currently the best alternative to replace fossil fuels in such a system. Future changes in energy efficiency of buildings and heating systems may provide possibilities for a wider range of renewable energies to contribute to heating (e.g. heat pumps working with electricity).

- When biomass is a local source of energy, using it **is good for the local**

economy and the energy security.

Disadvantages:

Bioenergy is at the centre of several debates:

- The first question being: 'Is biomass as carbon neutral as it looks?'- The answer is not so clear for two reasons:

- The fact that carbon dioxide is released when burning biomass makes the emission savings from biomass use more questionable than from other non-fuel based renewable energies. The carbon emitted when burning might only be recaptured after a long time or might not be fully recaptured at all. The management of the harvested lands (e.g. forests) is therefore crucial and has to follow strict regulations.

- Also, unfortunately, some of the carbon emissions taken into account in other sectors are not considered in the calculation of CO_2 released in biomass-related processes. Examples of such sectors are agriculture (for instance: use of pesticide and fertilizers, animal farming) and transport (especially in case of imported biomass).

- Some of the sources (like energy crops) are grown in lands that could be used for farming, creating therefore a competition with food growth (especially in the poorest countries). The crops are pushing up the demand for food worldwide and so lead both to a general increase of food prices and to the conversion of natural areas into new agricultural land.

- This brings us to another problem: the impact on nature and biodiversity. Conversion of grasslands to biomass production is already taking place at the expense of biodiversity.

Increasing bioenergy demand can also lead to changes in the management regimes of different ecosystems (for example of forests), with potential negative impacts on the environment, water resources and biodiversity. This is particularly a problem when biomass is imported from tropical areas.

Given the numerous disadvantages of bioenergy, EKOenergy has set up stricter criteria than for the other sources. EKOenergy only accepts landfill gases and electricity from biomass power plants producing both heat and electricity. To know more about what kind of bioenergy we accept look at our criteria here.

As this short presentation shows, every source of renewable electricity has drawbacks. It is unlikely that the human being will ever find a source of electricity without any economical, social or ecological impact. Nonetheless, if they are used with caution, after consultation between businesses, ecological organizations and experts, their drawbacks can be minimized and they become a very useful tool. Renewable energy implementation has to be thoroughly planned and supervised, using local resources. Renewable sources also must be used to complement each other. It is often preferable to choose a source of electricity which is close to the area of consumption, to have a better understanding of the environmental impact.

II - CLIMATE CHANGE - GLOBAL WARMING

Climate change is a significant and lasting change in the statistical distribution of weather patterns over periods ranging from decades to millions of years. It may be a change in average weather conditions, or in the distribution of weather around the average conditions (i.e., more or fewer extreme weather events).[1]

Global warming refers to an unequivocal and continuing rise in the average temperature of the climate system of the Earth.[2]

1°) For a few decades, the climate has been warming on a global scale

Climate is a measure of the average pattern of variation in temperature, humidity, atmospheric pressure, wind, precipitation, atmospheric particle count and other meteorological variables in a given region over long periods of time. Climate is naturally variable, as shown by the lack of regularity of the seasons from one year to another.[3]

This variability is normal. It is due to the variation of ocean streams, volcanic activity, solar radiation and other components of the climatic system that we don't fully understand yet. What is more our climate also has its extremes (such as floods, drought, hail, tornados, hurricanes, etc.), which can become devastating.

Nonetheless, in the last decades, a certain amount of indicators and studies

[1] Source : http://en.wikipedia.org/wiki/Climate_change
[2] Source : http://en.wikipedia.org/wiki/Global_warming
[3] Source : http://en.wikipedia.org/wiki/Climate

has been showing that the climate is warming at a global scale.
The Summary for Policymakers of the 5th report of the IPCC (Intergovernmental Panel on Climate Change) published in October 2013 states: *"Warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia. The atmosphere and oceans have warmed, the amounts of snow and ice have diminished, sea level has risen, and the concentrations of greenhouse gases have increased."*

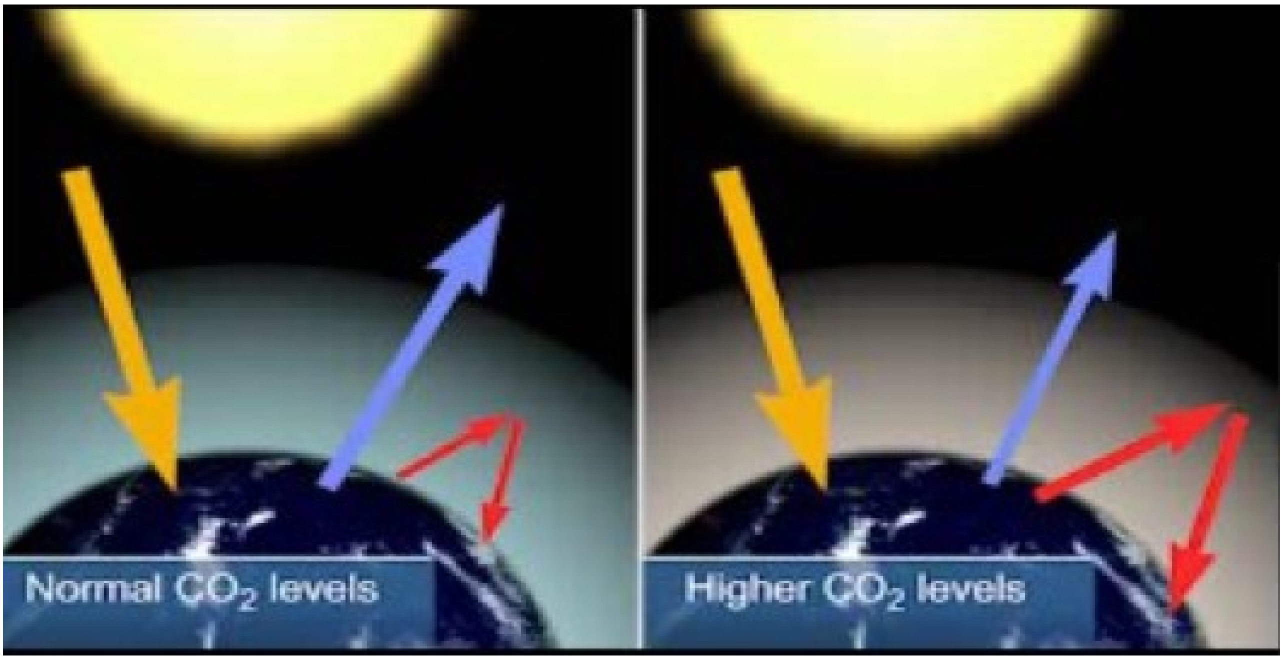
You can appreciate the changes of temperature through NASA images .

2°) What causes global warming

Temperatures on Earth are liveable because of a natural process called the greenhouse effect. When the sun's radiation reaches our atmosphere, some is reflected back into space, and some passes through and is absorbed by the Earth. This causes the surface of the Earth to warm up. Heat from the Earth is radiated outward and absorbed by gases present in the Earth's atmosphere, the so-called "greenhouse gases". This process prevents heat from disappearing, providing an average temperature of around +15°C instead of -19°C.

There are several greenhouse gases responsible for an additional warming of the atmosphere, which are produced by humans in a variety of ways. Most of them come from the combustion of fossil fuels in cars, factories and electricity production. The gas responsible for most of the warming is carbon dioxide, also called CO_2. Other contributors include methane released from landfills and agriculture (especially from the digestive systems of grazing animals), nitrous oxide from fertilizers, gases used for refrigeration and industrial processes, and the loss of forests that would otherwise store CO_2.

Green house effects with normal and higher CO2 levels(source: Encyclopedia Britannica)



IPCC Summary for Policy Makers of 2013 states: *"Human influence on the climate system is clear. This is evident from the increasing greenhouse gas concentrations in the atmosphere, positive radiative forcing, observed warming, and understanding of the climate system.(...)It is extremely likely that human influence has been the dominant cause of the observed warming since the mid-20th century.(...)Continued emissions of greenhouse gases will cause further warming and changes in all components of the climate system. Limiting climate change will require substantial and sustained reductions of greenhouse gas emissions."*

* In this Summary for Policy-makers, the term "extremely likely" refers to a probability of 95–100%

3°) Consequences

Climate change is changing our economy, health and communities in diverse ways. Scientists warn that if we do not substantially curb climate change now, the results will likely be disastrous.

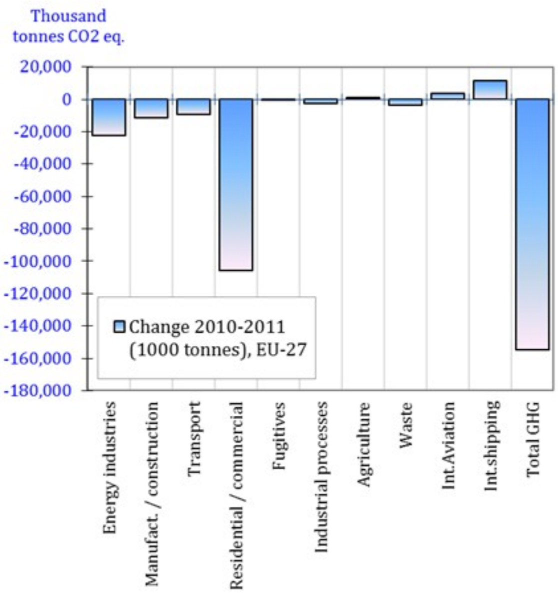
If Earth gets hotter, some of these important changes could happen:
- Water expands when it's heated and oceans absorb more heat than land, so sea levels would rise.
- Sea levels would also rise due to the melting of the glaciers and sea ice.
- Cities on coasts would flood.
- Places that usually get lots of rain and snowfall might get hotter and drier.
- Lakes and rivers could dry up.
- There would be more droughts making it hard to grow crops.

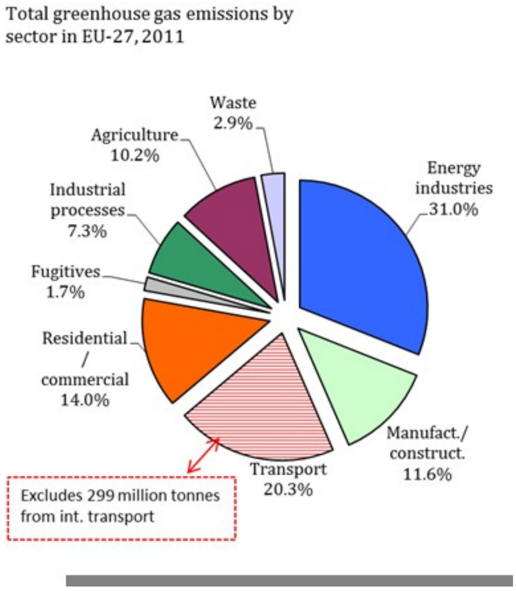
- Less water would be available for drinking, shower, agriculture and food production.
- Some plants and animals might become extinct because of the heat.
- Hurricanes, tornadoes and other storms caused by changes of heat and water evaporation may get more common.

4°) What are the possible solutions?

A) The use of renewables in the energy sector

We can observe on the graphics below the emissions linked to several sectors:





Scheme 1

The graph on the right makes clear that energy is a big part of our global greenhouse gas emissions. We have to acknowledge nowadays that by consuming energy, we participate actively in emitting carbons. Each year we release millions of tonnes of carbon dioxide by burning fossil fuels (oil, coal and gas) contributing to climate change. Renewables are in this respect a very good asset. As they don't produce greenhouse gases, they indeed seem to offer a good alternative to the burning of fossil fuels.

If all our energy was based on renewable sources, this graphic shows us that almost a third of our greenhouse gas emission would be cut back - a huge change in the balance.

Nuclear is often presented as another asset with great potential, linked to renewables in creating an energy industry with no emission. To see the debate on this aspect you can go directly to the nuclear discussion later in the document.

B) Other options to reduce the greenhouse gas emissions

EKOenergy is a network of organizations which focuses on promoting renewable energy. Nonetheless, EKOenergy does not think that renewables have to be seen as the only existing solution. All options have to be explored to allow us to react to the emergency of the current climate situation. Here is a list of some alternatives. Do not hesitate to contact us to add other proposals.

a. Energy efficiency and energy conservation

The term 'Energy Efficiency' refers to the possibility of reducing the quantity of electricity used without compromising the final result. It can be obtained for instance by insulating a home or by installing fluorescent light in the case of a household. Alternatively, it can be achieved through the design of buildings (see for instance the concept of passive house) or through the improvement of technology, for instance electric appliances.

Energy conservation, on the other hand, is obtained by the conscious decision to change a habit in order to save energy. For instance by heating the house less, or by turning off electric devices when they are unused.

Both methods combined can save significant amounts of energy.

If you want to know more about how to make energy savings: see e.g. the website of the Energy Saving Trust:
http://www.energysavingtrust.org.uk/
Most suppliers of electricity give their consumers suggestions about how to save energy. If your electricity seller doesn't provide you with good suggestions to reduce your energy consumption, it may be a good idea to switch your electricity contract to another electricity seller.

According to the European Council for an Energy Efficient Economy "*Energy efficiency provides us with the time needed to replace fossil fuels and other non-sustainable energy sources with renewables in an ecological, economic and socially responsible manner.*"

b. Negative emissions

The idea of negative emissions is to use technology to remove greenhouse gas emissions from the atmosphere. At the moment, research mostly focuses on Carbon Dioxide Removal (CDR), also called Carbon Geoengineering. Among the proposals, you can find for instance tree planting, carbon capture or fertilization of the oceans (read more here). The IPCC presents in its fourth assessment negative emissions as a necessary step in several of its long-term climate scenario models (read about it here).

Carbon Geoengineering is the object of diverse criticisms: too high economical investment required, technologies have many side effects, lack of efficiency, risk of diverting attention from more important cutting emissions policies. You can read here a very well documented report written in 2011 by Duncan Mac Larren of *Friends of the Earth UK*.

c. Carbon emission trading

Carbon emission trading is often considered in the negative emissions policy.

The system works with an allowance of a fixed amount of carbon emission per person/company. If a company is emitting less than what is allowed, it can sell the unused capacity to another company which needs it. By putting a price on the emission of carbon, this policy can be an effective incentive to reduce emissions.

A drawback of such a system is that it gives the wealthy a licence to emit, as long as they find people who need their money. It also focuses people on their individual emissions, creating the risk of missing the overall picture and limiting global responses to climate change issues.

d. Improvement of storage capacity of electricity

"Energy storage became a dominant factor in economic development with the widespread introduction of electricity. Unlike other common energy storage in prior use such as wood or coal, electricity must be used as it is being generated, or converted immediately into another form of energy such as potential, kinetic or chemical. Until recently electrical energy has not been converted and stored on a major scale, however new efforts to that effect began in the 21st century.

An early solution to the problem of storing energy for electrical purposes was the development of the battery as an electrochemical storage device. Batteries have previously been of limited use in electric power systems due to their relatively small capacity and high cost. However, since about the middle of the first decade of the 21st century newer battery technologies have been developed, that can now provide significant utility scale load-leveling capabilities; some of which, as of 2013, showed promise of being competitive with alternative methods. A similar possible solution to deal with the intermittency issue of solar and wind energy is found in the capacitor."[4]

Currently electricity storage is not highly efficient. Improvements however could make it a game-changer in the field of renewable energy. It would allow us to use electricity not when it is produced, but when it is needed, limiting our dependence on the weather.

e. Reduction of emissions in other areas

- Transportation

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4 Source ? http://en.wikipedia.org/wiki/Energy_storage#Economic_and_technical_evaluations

As shown by scheme 1, transportation is the second largest source of greenhouse gas emissions. It is therefore necessary to think about how to reduce emissions also in this sector.

At an individual level, people are encouraged to limit the use of personal vehicles. Alternative options include public transportation, car sharing, cycling, walking. Communities can help by improving the safety and comfort of pedestrians and bikers (e.g. bike lanes, bike parking, sidewalks), and the access to public transportation (e.g. reducing prices, proposing free parking next to bus/metro stations).

As for flying, a return flight from Europe to New York produces more or less the same level of emissions than the heating of a house of an average EU citizen in one year. A flight from Paris to Toulouse produces 90kg of CO_2, whereas the same journey in train only produces 5kg (-18 times less).

Buying local products can also limit the costs of transportation emissions from the industry sector. Buying seasonal is a further way of reducing emissions, by reducing the use of cooling systems. Avoiding processed products also reduces emissions.

- Agriculture and livestock farming

There are several ways to account for emissions in agriculture. On graph 1, the numbers used only refer to the emissions of farming itself, not counting the emissions released by burning fuel and using electricity.
In this sector several studies have shown that an important way to reduce greenhouse gas emissions would be to change the way we eat. Limiting our consumption of meat (especially red meat) and dairy products is one of the main factors that could influence GHG emissions (see for example this excellent study published in 2008 in the US). One major cause is that cattle, cows in particular, emit methane through exhalations and belches (especially if the food they are given is poor quality), they also produce manure that is often stocked and releases methane - more dominantly in large-scale livestock confinement systems.

Other sources of greenhouse gas emissions are:
- the use of nitrogen fertilizer;
- the use of fossil fuel in agricultural production;
- deforestation for the extension of the farming lands.

These practices have to be checked and supervised if we want to limit their impact.

III – RENEWABLES- OTHER ADVANTAGES

1°) When fossil fuels run low

It is hardly news, fossil fuels are fated to run out sooner or later. The main question, on which experts seem to have difficulties to agree, is when. Straightforward predictions are hard as there are a lot of unknown factors. One is future consumption, which will depend on elements such as population growth, the evolution of energy efficiency and the use of other energy sources. Secondly, there is uncertainty over the amount of reserves still available. According to some, what seemed off-limits a few years ago, may nowadays, be totally affordable, thanks to technological progress. How much will new technology facilitate extraction is still vague.

To read more about the evolution of fossil fuels resources, you can consult this article on the eco-info website.
Most experts agree however, that within a century fossil fuels will stop being an option. By that time extracting them will probably cost more energy than it could produce. One thing is for certain: the day will come and the less we prepare the harsher consequences we will have to face.

Deciding to use renewable energy nowadays is the way forward, because it gives technology time to evolve while fossil fuels are still available. This way, we can find new ways to produce energy and will get rid of our dependence on fossil fuels little by little, until there is no need for them any longer.

2°) Fossil fuels have a high cost for Europe

In 2012, the EU oil import bill was nearly EUR 1 billion per day. The increase in the oil price over the past few years from USD 20 to over USD 100 has added USD 45 billion to the EU's annual gas import bill. According to the European Council in 2011, the EU imports 54% of its energy. Europe is dependent on countries such as Russia, Algeria and Colombia for oil, gas and coal. For this reason prices are subject to the political situation in those countries. To brake it down to an individual level, in 2010 each person in the EU paid EUR 706 to countries like Russia, Algeria and Colombia to import oil, gas and coal.

Using a local source of energy, such as wind, helps the EU to be more self-reliant through producing its own power. By investing in renewables, Europe could commit to self-sufficiency. Wind and sun, for instance, will never be owned by any country, and can be used for free. This would be a clear limitation of our expenses and in the meantime safeguard the future of our energy. Already in 2012, wind power production in Europe avoided fuel costs of EUR 9.6 billion.

3°) Limit the risks of nuclear

Twenty five years after the Chernobyl disaster, the catastrophe of Fukushima has reminded us of the inherent risks of nuclear power. Japan is a highly developed country with a nuclear fleet that was generally considered safe. It was not only the natural disaster but also the nuclear industry's efforts to cut costs that created the ground for one of the most serious nuclear accidents ever.

Apart from human error, climate change poses a further threat for nuclear reactors. Most reactors are placed in coastal areas for easy access to cooling water. These locations are sensitive to sea level rise and to extreme weather events, such as intense storms and heavy rains while the cooling functions are under increased threat from warmer ocean temperatures. There is no way to ensure that events like the explosions at Fukushima will not happen again.

While uranium can be bought from global resources exchange like a number of other raw materials, nuclear reactors usually don't use natural uranium as their fuel. Instead, they use fuel that has to be made for each reactor type and model separately. Because of this, almost all nuclear power plants are bound to buy their fuel from the original supplier for their whole life-span. This can create a major import dependency in a quickly changing world.

Finally, no country in the world has managed to come up with a good solution for disposal of nuclear waste. Nuclear waste remains dangerous for 100,000 years; for this reason, we cannot be sure that total isolation from environment and reprocessing technologies available today can prevent the environment from contamination. The only working solution we have now is to reduce the production of more nuclear waste.

IV - GOALS FOR RENEWABLES

In 2009, the share of renewable energy in final energy consumption of the EU was 11%. The share of renewable electricity in the final electricity consumption was 19.9%.

The Renewable Energy Directive adopted in April 2009 sets binding targets for renewable energy for the EU member states of a share of 20% renewable energy consumption by 2020. This target is pooled amongst members.
In January 2014, a second target has been set up for 2030 of a share of renewable energy consumption of 27%.

IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation (SRREN) published in 2011 states that:

"The global technical potential of RE [RE stands for Renewable Energy] sources will not limit continued growth in the use of RE. A wide range of estimates is provided in the literature, but studies have consistently found that the total

global technical potential for RE is substantially higher than global energy demand. The technical potential for solar energy is the highest among the RE sources, but substantial technical potential exists for all six RE sources. Even in regions with relatively low levels of technical potential for any individual RE source, there are typically significant opportunities for increased deployment compared to current levels."

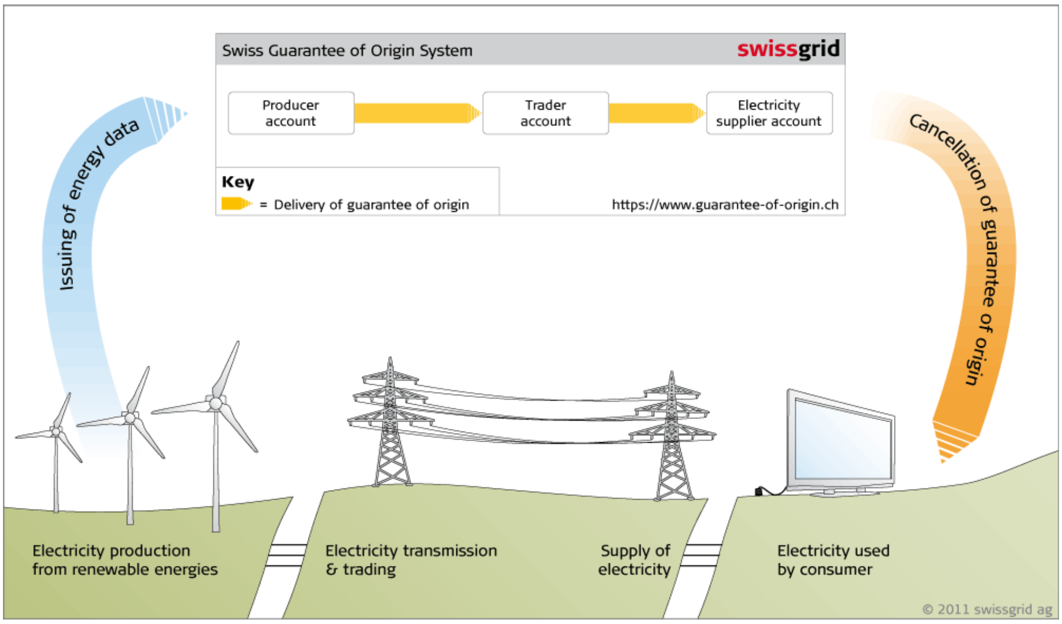
In short, IPCC supports the idea that there is a lot of potential for the growth of renewable in energy share for all types of sources, even enough to support all our energy needs. This would surpass goals required merely to tackle climate change.

Several studies have shown that the whole of global electricity consumption could be met by the exclusive use of renewable energy sources. Among the supporters of this idea you can find Herman Scheer, author of the book "*The Energy Imperative: 100 Percent Renewable Now" (2011),* and Mark Z. Jacobson and Mark Delucchi, authors of the article *"A plan to power 100 Percent of the Planet with Renewables" (2009).*

V - MARKET OF ELECTRICITY IN EUROPE

In Europe, the market of electricity has many aspects. One of these is the market of physical electrons. Physical electrons are put on the grid by a producer and bought by a supplier through stock options. The final supplier sells it to the end-consumer. After the purchase, the supplier ensures that the company in charge of the distribution of electricity delivers the necessary amounts of electricity to its customers. Physical electricity cannot be tracked, but most probably the electricity you get is coming from the closest power plant. This does not mean that your money is going to the owner of that power plant.

With the rise of renewable energy production, consumers feel the need to influence the market. As a result, a parallel market was set up besides the one of physical electrons. This market deals with the production and sales of green certificates, which are used to track the production and selling of renewable electricity. In Europe, a directive currently in effect which makes the use of GOs (Guarantee of Origin) mandatory for renewable electricity sales. The GO system is designed to track green certificates, which provide information about the production of electricity to the end-consumer.



1°) Liberalization of the European Market

The first step in understanding the European electricity market is to understand the liberalization process.

In 1996, *Directive 96/92/EC* of the European Parliament and of the Council of 19 December 1996 concerning common rules for the internal market in electricity, started the liberalization of the European electricity market. This Directive basically grants consumers the right to choose the electricity they want. However, there are critical voices about the differences in the implementation of the directive in different countries and the fact that it has not proved to work properly in some countries.

The liberalization of the market triggered a process within some of the companies. They tried to compete through the price of the product. However, it soon became clear that competition based only on prices wasn't enough. This is why some of the companies started to produce "special products" to offer to their consumers: thus began the "green" electricity market. It should be emphasized here, that the market has been mostly developed for the electricity sector. A few years ago, the rules of the liberalized "green" electricity market were taken into account by the European Union, which decided that it could be a good tool for consumers. The whole of Europe switched to a liberalized electricity market, even though not all member states have fully developed a suitable framework. Initially the green-energy market was mainly localized, so each country started promoting "green electricity" in their own way.

See the following categories to better understand how it works and where:

- European players on the liberalized market: Austria, Germany, the Netherlands, Belgium, Sweden, Finland and Norway. This category is defined by internationalization and green market volume. The "Guarantee of Origin systems" (see further) of these countries are linked to each other via the "hub" of the AIB[1].

- Countries that have a local “green” market: Italy, Portugal, Spain, France and UK. This group is characterized by having a small “green” market or/and a comparably small amount of exports/imports. These are also the countries with great potential for renewable energy production.

- Countries that have not developed a liberalized electricity market yet: Poland, Czech Republic, Hungary, Greece, Estonia, Lithuania, etc. These countries are undergoing the liberalization process gradually.

The role of environmental NGOs in this process has been very different in each of the countries. For instance in Germany NGOs have been really active and launched their own labels. In some other countries however, NGOs did not get involved in the market.

2°) Book and claim systems

Nowadays, most of the European countries realize the importance of the liberalization of the market; at the same time, consumers are willing to pay more to be sure what kind of electricity they get (for instance, to avoid particular forms of electricity). Here is where the notion of the “book and claim system” comes in.

In the book and claim system, the producer of the electricity has to ask for a 'certificate' each time he produces a certain amount of electricity. That certificate tells where and how the electricity has been produced. In technical terms, we say that 'a certificate is issued'.

At the other end of the supply chain, a consumer needs such a certificate to claim that these electrons have been put on the net 'on behalf of him'.

3°) Implementation of “Guarantees of Origin” Certificates

In Europe, such a system was created about 10 years ago on a voluntary basis (RECS certificates). Now, it has been officially adopted as a part of the EU Renewable Energy Policy: the art. 15 of Directive 2009/28 requires Member States to set up a system of 'Guarantees of Origin':

1. For the purposes of proving to final customers the share or quantity of energy from renewable sources in an energy supplier’s energy mix in accordance with Article 3(6) of Directive 2003/54/EC, Member States shall ensure that the origin of electricity produced from renewable energy sources can be guaranteed as such within the meaning of this Directive, in accordance with objective, transparent and non-discriminatory criteria.
2. To that end, Member States shall ensure that a guarantee of origin is issued

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[1] AIB : Association of Issuing Bodies

in response to a request from a producer of electricity from renewable energy sources. (...) A guarantee of origin shall be of the standard size of 1 MWh. No more than one Guarantee of Origin shall be issued in respect of each unit of energy produced. Member States shall ensure that the same unit of energy from renewable sources is taken into account only once.

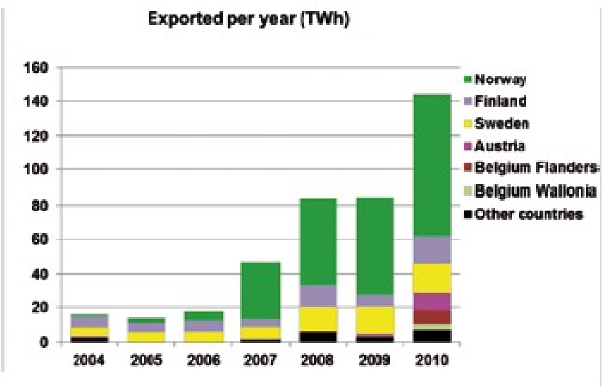
Consumer information and avoidance of double counting are the main objectives of this system.
Note that the system of Guarantees of Origin has no (direct) effect on the Member-States 2020 targets.

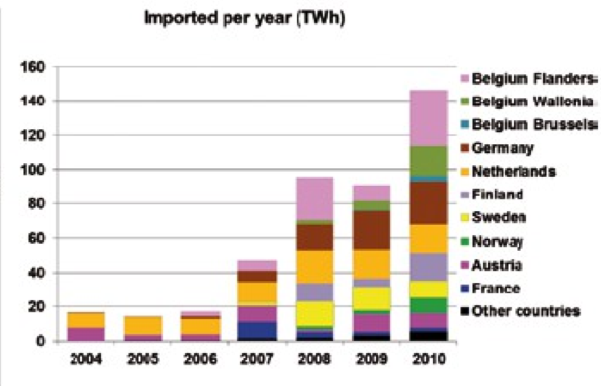
4°) AIB

We have mentioned above the GO Certification System, which was brought forward in the European directive 2001/28/EC (later in 2009/28/EC). The main target of the RECS Market is the provision of GO certificates to end-users who are using the tracking mechanism so that they can claim to consume green electricity.

The organization, which provides the framework and regulations of the European Energy Certificate Systems (EECS), is called Association of Issuing Bodies. The AIB runs the EECS, whose rules define that a certificate "*is an electronic document which identifies the source and method of production of a unit of energy, and relates to a specific purpose – such as energy source disclosure or compliance with an obligation"*.

See the graphs for implementation in different countries:





Source: Association of Issuing Bodies, Annual report 2012 (www.aib-net.org)

This evolution has happened largely without NGOs being aware of this, or without them having any substantial impact on the system. Also note that some countries are dominating the system. Demand for 'green electricity' is highest in Germany, Belgium and the Netherlands, however, more countries are likely to follow soon. These countries mainly buy from Nordic countries.

5°) Residual mix

To put it simply, the residual mix is the electricity delivered to the customers who do not have a contract to receive a particular form of electricity (such as green electricity, or a specific contract for nuclear electricity). A more complex definition is: consumers who purchase tracked electricity are investing in their choice of electricity production-technology. Those that do not make a specified electricity purchase via Guarantees of Origin (GOs) are receiving the electricity attributes ‘left-over’ as a public good. This 'left-over' power is known as the residual mix (the grid mix minus the traced and claimed electricity product).

The residual mix led many countries to regulate 'bundled' green products.
When the electricity suppliers sell renewable electricity, they must cancel the appropriate amount of GOs; in this way, the purchase of green electricity is tracked, double counting is avoided, and the consumer can 'claim' that the production of electricity was to serve his demand.
Large companies can also buy these GO certificates separately, or unbundled, from their electricity purchase to claim the ‘green’/carbon emission attributes attached to them. While these ‘personal’ disclosure statements (also known as carbon footprint) reported by large companies are not yet obligatory, it has become a practice to inform the public about the sustainability and energy usage of private/public organizations.

Note that such GO-like tracking systems can also exist for non-renewables. Some countries have introduced them already.

6°) Electricity disclosure

Electricity disclosure is one of the requirements of the Electricity Market Directive (2003/54/EC). The directive sets out that all electricity suppliers should give their customers information on how different energy sources contributed to overall electricity production the preceding year. Also, suppliers should provide information on CO_2 emissions and nuclear waste, as a minimum requirement. Member states have implemented measures to meet the requirements of electricity disclosure in their own ways.