

THE EFFECTS OF THE CLIMATE AND
ENERGY POLICY OF THE EU ON FINLAND
AND CATALONIA

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OKSANEN, ELISA: The effects of the climate and energy policy of the EU
on Finland and Catalonia

Ympäristöbiotekniikan opinnäytetyö, 45 sivua

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TIIVISTELMÄ

Tässä työssä keskitytään selvittämään energiatuotannon tilannetta Suomessa ja Kataloniassa ja etenkin mikä on uusiutuvan energian tila energiantuotannossa. Lisäksi tarkoituksena oli selvittää miten EUn uusi ilmasto- ja energiapaketti tulee vaikuttamaan molempiin.

Työ tehtiin vaihtoaikana Terrassassa yhteistyössä Universitat Politècnica de Catalunya kanssa. Ohjaajina UPC:n puolelta toimivat Dolors Alvarez ja Nuria Garrido sekä Lahden ammattikorkeakoulun puolelta Silja Kostia. Pääasiassa työssä keskityttiin tutkimaan internet-lähteitä, sillä niistä löytyy kaikkein ajantasaisinta tietoa.

Sekä Suomen että Katalonian täytyy tehdä mittavia muutoksia energian tuotannossa ja kulutuksessa saavuttaakseen Euroopan Unionin asettamat tavoitteet. Suomessa energiankulutuksen kasvun pysäyttäminen on avainasemassa, jotta uusiutuvan energian osuus saadaan nostettua 38 % ja jotta kasvihuonekaasupäästöt saadaan vaaditulle tasolle vuoteen 2020 mennessä. Myös Kataloniassa energiankulutuksen kasvu on saatava vähenemään, jotta kasvihuonekaasupäästöt ja uusiutuva energia saadaan vaaditulle tasolle. Muuttamalla lainsäädäntöä entistä ympäristökeskeisemmäksi ja kansalaisten asenteisiin vaikuttamalla, tavoitteet pyritään saavuttamaan.

Avainsanat: energian tuotanto, energian kulutus, uusiutuva energia

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ABSTRACT

The aim of this study was to find out what the situation in energy production in Finland and in Catalonia is and especially what the situation of renewable energy in energy production is. In addition, another target was to find out how EU's new climate and energy package will affect to both of them.

The study was done during exchange time in Terrassa in co-operation with the Universitat Politecnica de Catalunya. The study was instructed by professors from UPC, Dolors Alvarez and Nuria Garrido, and from Lahti University of Applied Sciences, Silja Kostia. The work was done mainly by using Internet sources because there one can find the most updated data.

Both Finland and Catalonia have to make major changes to their energy production and consumption in order to meet the obligations set by the European Commission. In Finland, the main objective is to stop the growth of energy consumption and to increase the amount of renewable energy to 38 % as well as to decrease the amount of greenhouse gas emissions to the demanded level by 2020. In Catalonia, the main objective is also to stop the growth of energy consumption so that greenhouse gas emissions and renewable energy will be on the required level. By changing the legislation into a more and more environmentally friendly direction and by affecting to the citizens' behavior, these aims will hopefully be achieved.

Key words: energy production, energy consumption, renewable energy

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Explanation of terms used in this thesis

CCS Carbon Capture and Storage

EAA European Environment Agency

ETS Emission Trading System

EU-15 Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden and the United Kingdom

Final energy consumption measures the consumption of finished energy products, that is, electricity and heat, and fuels used for heating the space in buildings, transport and industrial processes. In addition, it does not include energy transmission and distribution losses. (Statistics Finland h)

GDP gross domestic product at market prices is the final result of the production activity of resident producer units. It can be defined in three ways: as the sum of gross value added of the various institutional sectors or the various industries plus taxes and less subsidies on products; as the sum of final uses of goods and services by resident institutional units (final consumption, gross capital formation, exports minus imports); as the sum of uses in the total economy generation of income account (compensation of employees, taxes on production and imports less subsidies, gross operating surplus and gross mixed income) (Statistics Finland i)

GAV gross added value measures the contribution to the economy of each individual producer, industry or sector

IER Intensive Energy Efficiency and Renewable Energy Scenario

IPPC Intergovernmental Panel on Climate Change

KTEP 1 ktep equals 41.86 TJ

PJ petajoule 10^{15} joules

Primary energy consumption refers to the direct use at the source, or supply to user without transformation, of crude energy, that is, energy that has not been subjected to any conversion or transformation process

REE Red Eléctrica Española

REF recycled fuel

RES renewable energy source

TJ terajoule, 10^{12} joules

Total energy consumption describes the total use of domestic energy sources and imported energy. It includes fuels used in energy production and processing, as well as fuels used directly at the final consumption e.g. transportation fuels and fuels used for heating buildings

UNFCCC United Nations Framework Convention on Climate Change

1 INTRODUCTION

At present, issues related to energy production, consumption and price are discussed a lot. The growing standard of living in the developing countries increases energy consumption. At the same time, in the post industrialized countries more energy is needed every year. Most of the energy is still produced using fossil fuels which cause emissions that have negative environmental impacts. One of the most important ones is global warming. The Intergovernmental Panel on Climate Change (IPCC) has proved that human activity has a strong influence on global warming. Fortunately, awareness among citizens, decision-makers and business people has awakened and interest towards preventing climate change and its impacts has increased.

Renewable energy sources have been offered as a part of the solution. Bio-energy, wind power and solar power, for example, are already used but they are not economically competitive to fossil fuels. Despite the challenges related to renewable energy sources, the interest towards them is enormous at the moment. For example, European Union has made a commitment to increase the share of renewable energy up to 20 % of its total energy production. As a member of EU, Finland and Catalonia have to make changes to their energy production in the near future to achieve these requirements.

This Bachelor's thesis project was made during the student exchange time in Catalonia in spring 2009 and therefore the focus is in Catalonia, Spain and in Finland. The aim of this study was to examine how EU's new climate and energy policy will affect Finland and Catalonia. The objects were to find out what the situation of renewable energy sources in energy production in Finland and in Catalonia is at present, and to list and discuss the obligations that both areas have to meet.

2 ENERGY PRODUCTION AND CONSUMPTION

It is interesting to compare the energy consumption of Finland and Catalonia.

Population and the economical structure are quite the same in both areas but those are basically the only consistencies. Table 1 and Figure 1 present the similarities and differences of Finland and Catalonia.

TABLE 1. Information boxes of Finland and Catalonia (Government of Catalonia 2008a; Valtiokonttori 2009; Elinkeinoelämän keskusliitto 2008).

	Finland	Catalonia
Location	Scandinavia	South-Europe
Surface area (km²)	338 000	32 000
Coast line (km)	1 100	580
Population (millions)	5,3	7,2
Inhabitants /km²	17	224
Land use (%)		
-forests	69	59
-agricultural use	8	32,5
-waters	10	0,5
-swamp areas	5	-
-built land	3	4,7
-sand and beaches	-	2,9
Climate	cold winters, mild summers, raining moderately during all seasons	mild winters, warm and dry summers
Economy	GDP, %	GAV, %
-service sector	65	66
-industry	26	22
-agriculture	3	1
-construction	6	11
GDP / inhabitant, €	25 500	29 000



FIGURE 1. Finland's and Catalonia's locations on map. (Europa).

2.1 Energy production and consumption in Finland

Energy maintenance in Finland is quite distributed. The range of the energy sources is wide, and energy is purchased between in the international markets. Energy purchase has to be distributed since Finland is much dependent on imported energy. This is the only way to ensure that energy purchase is secured and balanced. In 2007, approximately 32% of energy was produced by domestic energy sources (mainly wood, peat and hydro power) and 68% was produced by foreign energy sources (Tilastokeskus 2008a). In Finland, the responsibility of energy production is mainly on state owned energy companies (e.g. Fortum plc), on municipal energy companies and on private, mostly on energy companies owned by the industry (e.g. Pohjolan Voima, Teollisuuden Voima). The production of energy is based on so-called standard power thought. In addition to the standard power, a so-called adjustment power compensates seasonal, weekly and diary changes (Hellgrén, Heikkinen, Suomalainen & Kala 1999, 57-58).

Electricity maintenance is divided into the production of electricity, the transmission of electricity and the distribution to the consumers. Organizations in electricity maintenance are divided into power companies owned by the state, to private power companies and to the industry's own electricity production as well as to a so-called electricity plant of distribution. The power companies sell the produced energy directly to the industry or to the electricity plant of distribution. Municipalities' energy plants produce heat either as a combined heat and power production or as a separate heat production. Normally there is a combined heat and power production plant in the biggest cities. In the small cities and in the country side the production and distribution of heat is taken care of by regional heat plants. Industry, however, produces its required energy mostly by itself. In Finland, the electricity markets are free, people can buy their electricity from any supplier of electricity they want. (Hellgrén, Heikkiläinen, Suomalainen & Kala 1999, 58-59.)

The trend in the consumption of energy has been increasing in Finland for a long time. From 1970 to 2007 the consumption of energy has grown approximately 700 petajoules, PJ (Figure 2). This is because of the level of the standard of living has grown after industrialization and urbanization. The increase has been rapid but there are also some years when the consumption has not grown. For example, in 2005, the industry needed less energy than in 2004. This was partially because of the forest industry's strike (Statistics Finland 2006b). Furthermore, winter 2005 was exceptionally warm which reduced the need of heating, and therefore the consumption of energy was lower. The same kind of warm winter was also in 2007. However, in the long run it is obvious that more and more energy has been consumed. (Statistics Finland 2008c.)

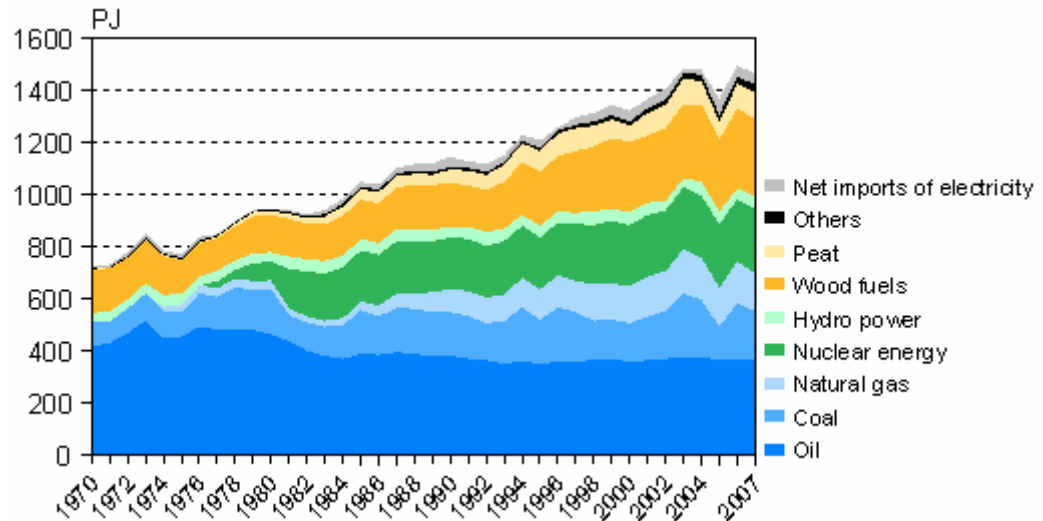


FIGURE 2. Total energy consumption in Finland in 1970 – 2007 (Statistics Finland 2008d).

Statistics Finland (2008c) has reported that in 2007 the total energy consumption in Finland was 1 470 petajoules. In 2007, most of Finland's energy was produced by fossil fuels. In total, approximately 75% of energy was produced by fossil fuels and 25% using renewable energy (Figure 3). In addition, Figure 3 includes recycled fuels (REF) and waste fuels, hydrogen used as fuel, biogas, solar energy, energy produced by heat-pumps, other bioenergy, and the reaction heat from the industry. The amount of energy produced by non-fossil fuels versus fossil fuels has been quite the same in the 2000's. From 1990, the share of renewable energy has, however, increased from 18% to the present 25% (Statistics Finland 2008e). The final energy consumption between the different sectors was the following; industry 51%, traffic 16% and others (e.g. space heating) 33% of all the produced energy in 2006. The high share of industry's consumption of energy is explained by the texture of the Finnish industry. There is plenty of forest and paper industry which consumes a lot of energy. Also the heating of buildings, especially in winter, requires a lot of energy.

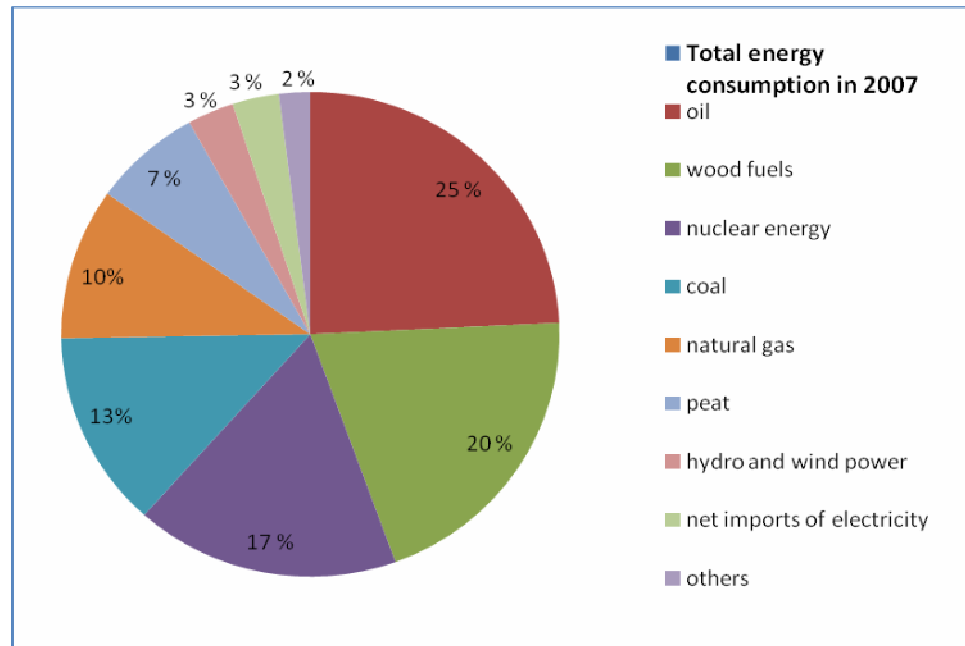


FIGURE 3. Total Energy Consumption by Sources in 2007 (Statistics Finland 2008f).

2.2 Energy production and consumption in Catalonia

Catalonia's energy maintenance is not as distributed as Finland's. The range of energy sources is narrower, but as in Finland, a lot of energy is produced by foreign energy sources or imported from other autonomous communities of Spain or from abroad. Energy is imported to Catalonia because it can produce less energy than it consumes. According to the Insitut Català d'Energia (2008a) primary energy production was 451 petajoules, whereas the final energy consumption was 677 petajoules in 2007. The most important sources of imported energy are France and Aragon (one of the autonomous communities of Spain). 3 620 GWh of energy was imported from France and 7 270 GWh from Aragonia. However, energy was also exported to Valencia and Andorra, 3 080 GWh and 260 GWh, respectively. (Red Eléctrica de España 2007.)

In Catalonia, electricity is largely produced in the conventional ways by nuclear energy, hydro power and thermal power (fossil fuels or waste). There are also combined cycle power plants, which combine gas turbine and steam turbine in order to produce electricity. The produced electricity is sold to the market under

the control of the operator of the market. However, it can be also sold directly to large consumers or to selected consumers through a contract between the two parties. In addition to conventional ways to produce electricity, the amount of renewable energy and cogeneration has increased. For example, the combined heat and power plants have been one of the most developed in Catalonia in the recent years, mainly to generate electricity for the industry with high requirements such as cost-effective production in the place of consumption. (Institut Català d'Energia 2008b.)

The transport and distribution of electricity and its economic system are regulated by the State Government. The high voltage lines are managed by Red Eléctrica Española (REE), constituted by the Government and the companies producing electricity. The lines in medium and low voltage are, however, property of each electric distribution company whose main activities include the construction of the distribution facilities to provide electricity at the peak of consumption, to ensure maintenance and to manage the operations. To ensure the principle of the free market, the law ensures that all consumers and marketers have a right to the access all of these distribution networks. The distribution networks are designed so that, when a sudden interruption of power supply at any point in the network happens, it is possible to receive electricity from another production center. Since the demand of electricity is not always uniform, as in certain moments there is bigger demand than normally, these centers are ready to respond to the increases in the consumption level. (Institut Català d'Energia 2008c.)

As in Finland, also in Catalonia energy consumption has increased during the years (Figure 4). In 2007, Catalonia's share was 19.7% of the total energy consumption of Spain (Instituto Nacional de Estadística 2009, 6). That is explained by the high rate of industrialization. According to the Institut Català d'Energia (2008a), the final energy consumption was 677 petajoules (16 173ktep) in 2007. In Figure 6, the shares of energy sources and their percentages are shown. Among the oil products, automotive fuel (gas-oil and gasoline) had the largest representation, followed by kerosene and petroleum coke. Electricity was mostly produced by nuclear power, combined cycle and cogeneration which formed more than 80% of the production. Furthermore, renewable energy biomass (including

forestal biomass, agricultural and livestock, biofuels and biogas) had the greatest share with 0.9% of 1% in the final energy consumption in Catalonia. In total the share of fossil fuels was approximately 99% and the share of renewable energy was around 1%. The amount of energy produced by non-fossil fuels versus fossil fuels has been quite the same from 1990 to 2007. The trend has been, however, decreasing but has now turned to rise. The final energy consumption between the different sectors was divided as follows in 2007; transport 40%, industry 31.5% and others 28.5% (domestic 14%, services 11%, primary 3.5%). (Instituto Nacional de Estadística 2007; Institut Català d'Energia 2008a.)

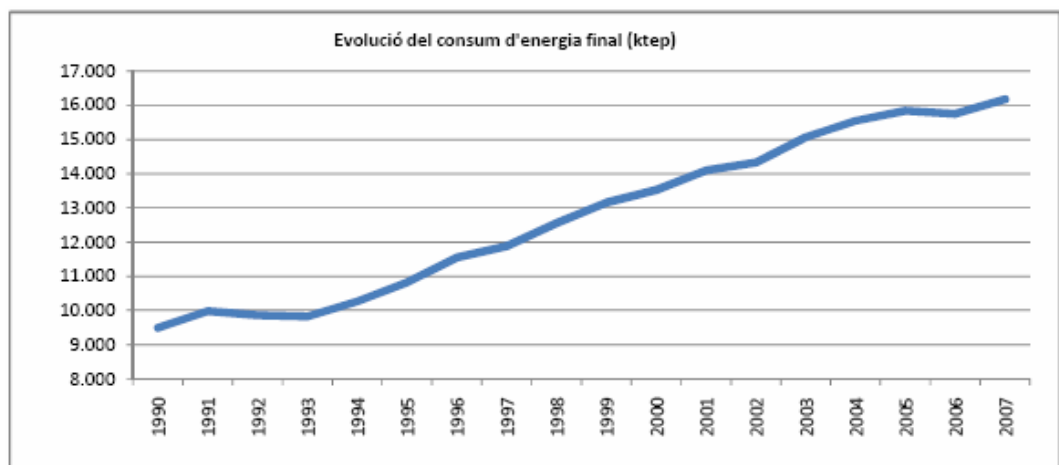


FIGURE 4. Final energy consumption in Catalonia in 1990 – 2007 (Institut Català d'Energia 2008d).

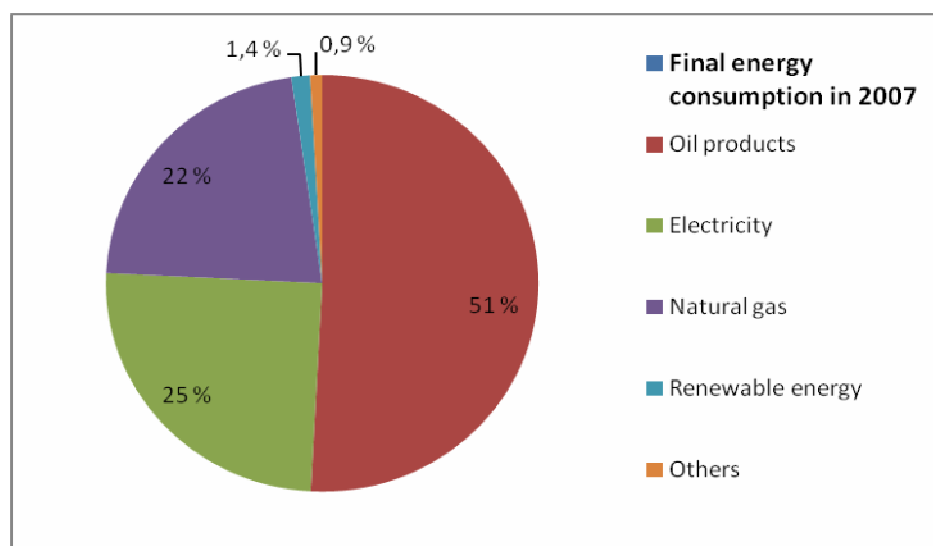


FIGURE 5. Final energy consumption in Catalonia in 2007 (Institut Català d'Energia 2008a).

3 RENEWABLE ENERGY

3.1 Renewable energy in Finland

Finland is one of the top countries with Sweden and Latvia to produce and consume the most renewable energy. One of the advantages of Finland is that we have possibilities to use different kinds of renewable energy sources. These sources can be, for example, bioenergy, hydro power and wind power. In 2005, Sweden was the first, Latvia, the second and Finland the third in the share of renewable energy in energy consumption. According to EU's calculations, Sweden's renewable energy use was 39.8%, Latvia's 34.9% and Finland's 28.5%. From Figure 6, it can be seen how the shares of renewable energy sources have been growing in Finland from the 1970's. (Motiva 2008a; EUbusiness.com 2008.)

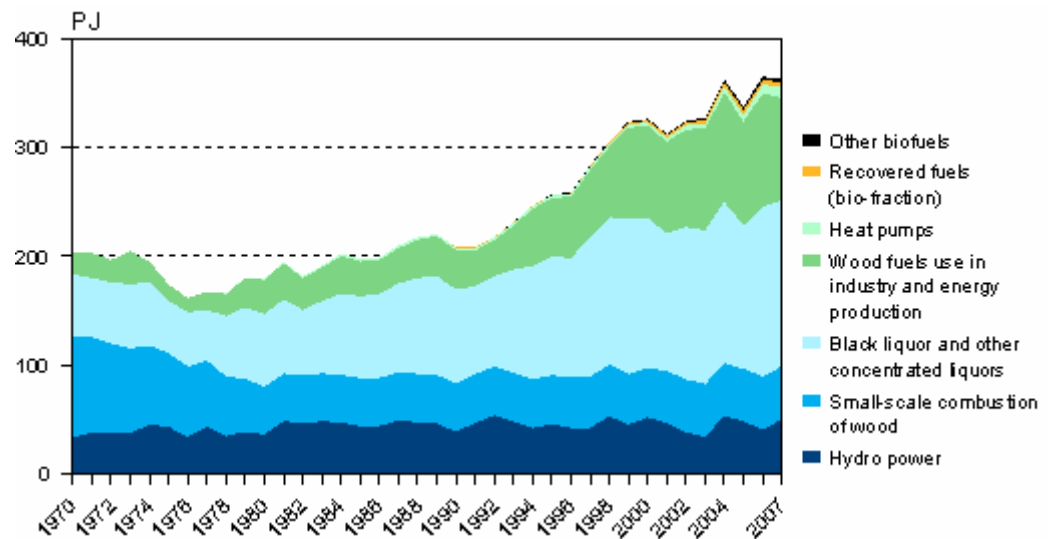


FIGURE 6. The share of renewable energy sources in 1970-2007 (Statistics Finland 2008g).

The most important renewable energy sources in Finland are bioenergy and hydro power. Together they form 97% of Finland's renewable energy sources (bioenergy 83% and hydro power 14% in 2007). The rest of the renewable energy (others) as presented in Figure 8, come from heat-pumps (2.8%), recycled fuels

(REF) bio-fraction (1.3 %), biogas (0.5 %), wind power (0.2%) and other biofuels (0.2 %).

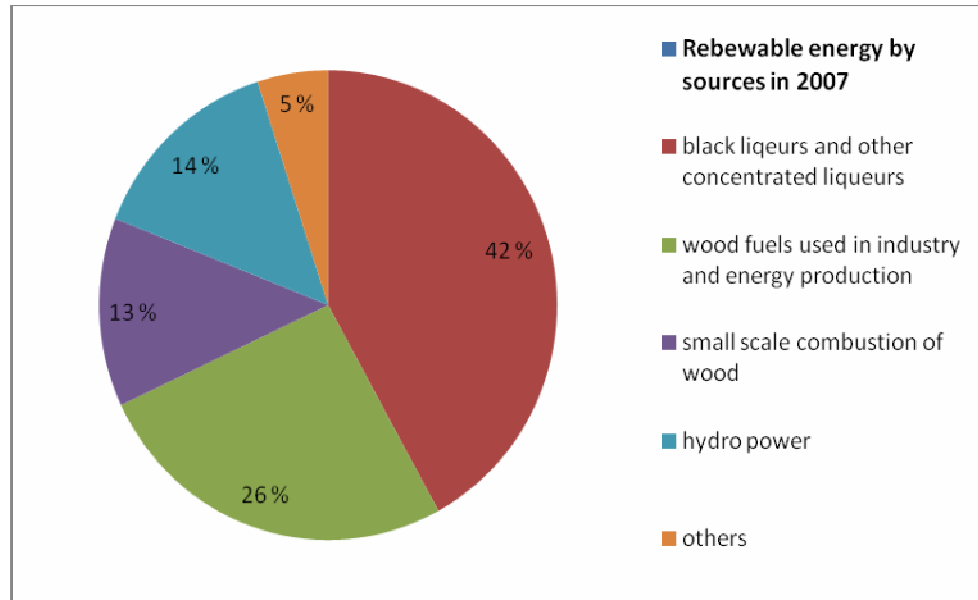


FIGURE 7. Renewable energy sources in 2007 (Motiva 2009a).

Bioenergy includes wood based fuels, biomass from forests and fields, biogas, biofuels and the bio-fraction of recycled fuels (REF). The use of bioenergy can be basically divided into two parts; bioenergy used in small scale combustion (private houses etc.) and bioenergy used in heat and power plants and industry's own energy production. It is natural that bioenergy has such a major part among the renewables because there are a lot of forests and forest industry in Finland and, therefore, a lot of wood-based fuels. About 97.5% of bioenergy is wood and wood based waste broth from the wood refining industry. The rest, 2.5%, come from bio-fraction of recycled waste, biogas, biomass from forests and fields and from biofuels. The biggest user of the wood energy is wood refining industry, which exploits wood fuels and wood-based waste broth from its own processes in energy production. Also the by-products that can be manufactured to traffic fuels come from forest industry. This technique is developed very intensively at the moment. Small scale combustion is also important in Finland since there is a

fireside place in many private houses which is used to heat the houses. (Motiva 2008b.)

Besides wood fuels, hydro power is one of the oldest ways to produce energy. In 2008, 4% of Finland's energy production was produced by hydro power. Finland's first hydro power plant was taken into use in 1929 in Imatrankoski, and it is still the biggest hydro power source. Almost all the main rivers in Finland have been harnessed. There are over 200 hydro power plants in Finland. The biggest plants are in the north, where over a half of the electricity is produced in the hydro power plants in Kemijoki, Oulujoki and Iijoki. In the south of Finland the main hydro power plants are located in Vuoksi, Kymijoki and Kokemäenjoki. The hydro resources in Finland are estimated at 19.1 TWh/a. 12.6 TWh/a are built and 6.5 TWh/a are protected or not built. Yet, it is unlikely that a lot more hydro power would be taken into use because of environmental reasons. Unharnessed rivers are protected by laws and, thus, the amount of energy produced in hydro power plants cannot be increased significantly in Finland. Old plants are, however, renovated and made more efficient (Lehto, Luoma, Virolainen 2006, 15, 24-25; Motiva 2008b.)

The share of wind power in energy production is very small, but it has grown very fast during the last years. According to VTT Technical Research Institute of Finland (2008), in 2008 electricity produced by wind power was almost 300 GWh, which is approximately 0.3% of the annual consumption of energy. Even though the amount of energy produced by wind power is small, wind energy is one of the most promising renewable energy technologies.

3.2 Renewable energy in Catalonia

The share of renewable energy in energy production and consumption is remarkably smaller in Catalonia than in Finland. In 2007, the share of renewable energy in the final energy consumption was only 1.4%. In the final energy consumption, the most important renewable energy source was biomass (agricultural, forestal and biodiesel). Also solar thermal energy had a small role as

RES. Within biomass biofuels have undergone the biggest change. In 2001, there were no biofuels consumed, but in 2007, its share had grown from 0 PJ to 4.2 PJ. In energy production the range of renewable energy sources is, however, wider than it seems according to the final energy consumption statistics. In addition, also hydro power, wind power and solar photovoltaic energy were produced. Their shares were, nevertheless, so small that in the final energy consumption they cannot be notified. Even though renewable energy is produced now (2000's) more than in 1990's, its share in the final energy consumption has decreased from 2.2% to 1.4%. This is because energy consumption has increased during the years and this demand has had to be satisfied with fossil fuels. There has simply not been enough capacity and money to answer the demand with renewable energy. (Institut Català d'Energia 2008a; Institut Català d'Energia 2008d, 6.)

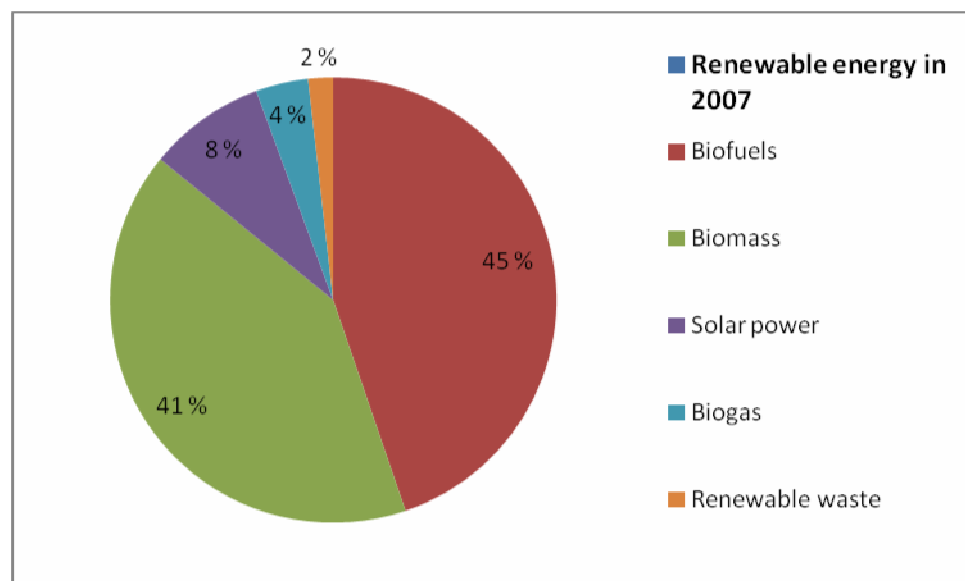


FIGURE 8. Renewable energy in Catalonia in 2007 (Institut Català d'Energia 2008d, 6).

3.3 Potential renewable energy sources in Europe

3.3.1 Hydro power

In Finland and in Catalonia, hydro power has an important role in renewable energy production. As mentioned earlier, the main hydro power plants in Finland are located in the north, in the waters of Kemijoki, Oulujoki and Iijoki. In the south of Finland, the main hydro power plants are in Vuoksi, Kymijoki and Kokemäenjoki. In Catalonia, the main hydro power plants are in the north, in Moralets, Tabescán and Estany Gento. In central Catalonia there is a hydro power plant in Canellas and in the south, in Mequinzenza and in Ribarroja. Hydro power is based on the movement of water between two different water levels. Water is running down through a turbine which rotates a generator, which in turn, transforms the energy of the water into electricity. (Lehto, Luoma, Virolainen 2006, 15, 24-25; Red Eléctrica de España 2007; Motiva 2008c; Energiategollisuus 2009a.)



FIGURE 9. Hydro power plant in Iijoki in the north of Finland (Pohjolan Voima Oy).

Hydro power is divided into three sizes, micro hydraulic (<1MW), mini hydraulic (1-10 MW) and great hydraulic (>10 MW). All hydro power is considered as renewable energy in the EU Directive on the Promotion of Electricity from

Renewable Sources. However, in Spain, from the point of view of support for renewable energy, embodied in the special regime, only those power plants that are less than 50 MW, for example mini hydraulic plants, are considered eligible. (Energias renovables para todos, 6.)

The advantages of hydro power are that water can be stored to reservoirs and then used during the demand peaks. The technology itself is long known and used, and, therefore, reliable with high efficiency. In some areas it may also work as a flood controller. In addition, hydro power does not produce waste products which would affect to air quality, or cause acid rains, such as sulfur dioxide (SO₂) or nitrogenous oxides (NO_x). In addition greenhouse gases are not formed during the production. It also reduces the use of other fuels (fossil fuels). Emissions are formed mainly during the construction phase. It is also a local energy source and, therefore, there is no need to transport fuel to the plant by cars. However, the production of hydro electricity is dependent on weather conditions. If there is no rain, or runoff from a snow pack, there may be a lack of water reservoir later on. Environmental effects reach from nature and animals to humans. For example, the creation of a reservoir affects to wildlife habitat (e.g. fish streams) but also humans may have to move elsewhere. Landscape changes a lot after building a hydro power plant and the beauty of the nature disappears. (U.S. Department of Energy 2005, Energias renovables para todos, 12,13.)

The main financial costs of hydro power come from building up a plant. However, after the plant is built, the operating and maintenance costs are low because of the long period of the using time. (IEAHydro 2005.)

3.3.2 Bioenergy

Bioenergy has a major role in the Finnish energy production. In 2006, it formed 84% of the total renewable energy consumption, and it represented also one fourth of the total energy consumption. In Catalonia, bioenergy is also an important source of renewable energy, and in 2006, it represented approximately 90% of the total renewable energy consumption. In the European Union area, the share of

biomass in the total energy consumption is around 2% (European Commission 2009a). On a global aspect, it forms about 14% of the produced energy. In the developing countries, the use of biomass (wood and manure), forms about one third of the energy production. (Institut Català d'Energia 2008a; Motiva 2008b; Tekes Bioteknologia Info.)

Bioenergy includes the biomass from forests and agriculture, biogas, biofuels and the municipal solid waste. In Finland, the most important source of bioenergy is wood fuels and wood-based waste products from the industry. In Catalonia, renewable municipal solid waste formed the biggest share of biomass, approximately half of it. The energy from the biomass is mainly received by burning, by digestion in an anoxic space with the result of biogas, or preparing ethanol which can substitute the use of gasoline. Furthermore, products such as bio-degradable plastic, perfumes, chemicals and glue can be made from biomass, and new products are developed all the time. The problem with biomass is that even though it is a renewable energy source and therefore diminishes the use of fossil fuels and carbon dioxide emissions, the production of certain biomass, for example sugar cane, requires large land areas which could be used for growing food. (Tekes Bioteknologia Info.)



FIGURE 10. Biogas plant in the province of Lleida, Catalonia (Ministry of the Environment, Conservation, Agriculture and Consumer Protection of the State of North Rhine Westphalia Germany).

3.3.3 Wind power

Wind is available everywhere in the world. The most suitable places for wind power are inland's open places, coasts and seas. In Europe, there is a lot of wind power in Denmark, Spain, Portugal and in Germany. For example, in 2007, 21% of Denmark's electricity was produced by wind power, whereas in Finland only 0.2% of electricity was produced by wind power in 2007 (Motiva 2008d). In Catalonia, the amount of electricity produced by wind energy was also very small, only 0.36% in 2003 (Institut Català d'Energia 2008e). The most suitable conditions for wind energy in Finland are on the south and east coast. At the end of 2007, there were 119 operating turbines with the capacity of 144 MW (VTT Technical Research Centre of Finland 2009). In Catalonia, the best places are in the north east and in the south of Catalonia (Figure 12). (Generalitat de Catalunya 2006a; EWEA 2008a.)

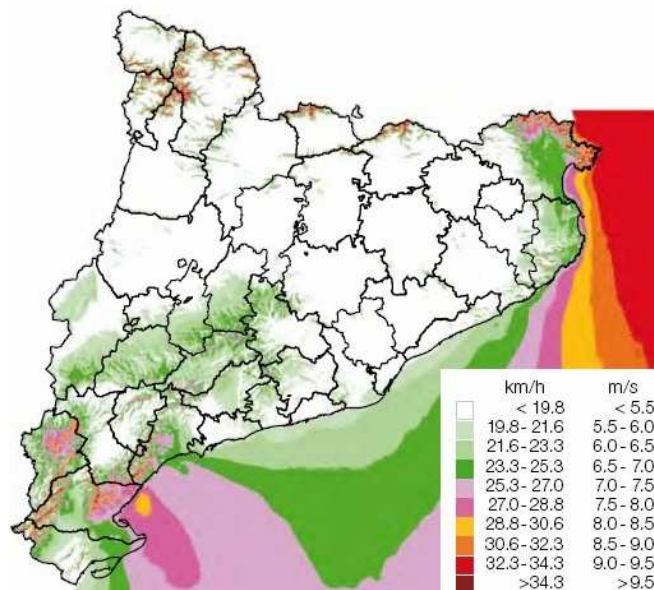


FIGURE 11. Wind resource map. (Generalitat de Catalunya 2006b, 49).

The first wind farm in Catalonia was installed in 1984 in Garriguella. It was actually the first wind farm in Spain. The farm was however closed in 1988. In Table 2 all the wind farms in Catalonia are presented. At the beginning of 2009,

the wind farms in Catalonia represented 2.5% of all installed wind power in Spain. (Asociación Empresarial Eólica 2007).

TABLE 2. Wind farms in Catalonia (Asociación Empresarial Eólica 2007).

Wind park	Province	Power, MW	Number of turbines
Serra del Talla	Tarragona	49,5	33
El Motarro	Tarragona	2,64	2
Les Forques	Tarragona	4	2
Serra de Vilobí	Lleida	40,5	27
Serra de Rubió II	Barcelona	25,5	17
Serra de Rubió I	Barcelona	49,5	33
Les Calobres	Tarragona	12,75	17
Les Colladetes	Tarragona	36,63	18 + 36
Mas de la Potra	Tarragona	2,6	2
Trucafort	Tarragona	30,85	66 + 25
Collet deis Feixos	Tarragona	7,92	6
Pebesa (Baix Ebre)	Tarragona	4,05	27
Tortosa (Coll d'Alba)	Tarragona	29,9	23
Les Comes	Tarragona	3	2
Ecovent CAT II y III	Tarragona	48,1	37
TOTAL		347,44	

The function of a wind turbine is simple; the wind blows and sets the blades of a turbine in motion generating power that can be converted into electricity. To start the production, a wind turbine needs at least 3 m/s wind speed. Between 4 – 13 m/s wind speed, the power of the power plant is directly depended on the wind speed. From 14 m/s to 25 m/s wind power, the plant produces constant power. If the wind speed is more than 25 m/s, there is a risk of strain and breaking down. The problem with wind power is that wind is not available all the time, or wind speed might be too weak or too strong. Since it is hard to storage electricity, the produced electricity has to be consumed simultaneously. So, if there is no wind, the required electricity has to be produced by another energy source. In addition, in the northern cold circumstances during the winter, problems which require technical resolves may occur. However, wind energy as a part of, for example, a

heating or cooling system is a good solution. (Suomen Tuulivoimayhdistys ry; Ympäristöenergia; Energiateollisuus 2009b.)



FIGURE 12. Wind park Serra de Rubió (Generalitat de Catalunya e).

The biggest financial costs are related to the manufacturing and installing a wind power plant. The wind turbine itself, the grid connection and the foundation form about 90% of the financial costs. The rest comes from, for example, land rent, electric installations, consultancy and control systems. When comparing the costs of wind energy onshore and offshore, it is about 50% more expensive offshore. However, since the wind speed is higher offshore, the electricity production there is also better and a part of the financial costs are offset. At the moment, wind energy capacity in offshore accounts only 1% of the total installed capacity in the world. (EWEA 2009b, 9-11.)

3.3.4 Solar power

Sun radiates light to the Earth all the time. During one hour, the surface of the Earth receives more solar radiation than what the whole mankind consumes in one year. The most suitable circumstances to utilize solar energy are at the equator because the amount of radiation is biggest there. For example, in the Sahara

Desert the yearly solar radiation is 2 500 kWh/m² and in Israel it is 2 000 kWh/m²/year (Apricus Solar Co. Ltd 2008). In Finland, the amount of radiation, 1 000 kWh/m²/year, is approximately the same than in Central Europe, but changes during the seasons are bigger. In the south of Finland, 90% of solar radiation is received between March and September. In addition, when moving to the north, the chances in radiation grow. In Catalonia, the average radiation, 1 450 kWh/m²/year, is a little bit bigger than in Finland (Generalitat de Catalunya 2006a). As in Finland, also in Catalonia the share of solar power (thermal or photovoltaic) is very small. (Apricus Solar Co. Ltd 2008; Energiategollisuus 2009c.)



FIGURE 13. Solar panels in Barcelona in Plaza Fotovoltaica (Elisa Oksanen 2009).



FIGURE 14. Solar panels in Barcelona in Plaza Fotovoltaica (Elisa Oksanen 2009).

Solar power can be utilized in two ways, with passive or active techniques. Ilmasto.org (2009a) determines that using the passive technique, houses are located and built so that they collect as much as possible solar radiation inside, and keep it there for as long as possible. For example, windows are located facing south, and insulation of heat in walls and windows is good enough. Normally these techniques are included in the energy saving techniques, and their potential in Finland is approximately half of the heat consumption of the houses. That means about 10% of the total energy consumption in Finland. On contrary to the passive techniques, active techniques require energy. Solar radiation can be converted into electricity by solar panels or into heat by solar captures. Heat-pumps and solar captures are the most used to convert solar energy to heat houses and tap water. At the moment, solar power is mostly used in small units, such as in private houses as a part of the heating system because solar technology is not developed enough to use in large applications or production. Only about 15% of solar radiation can be converted into electricity with solar panels and about 25-35% to heat with solar captures (Motiva 2008e).

For consumers the biggest financial costs naturally come from buying a solar energy system or solar panels. For example, companies in Finland announced that solar panels can cost hundreds of euros and the whole system can cost more than a thousand euros depending on the capacity. In Catalonia, the prices of solar systems and panels are approximately the same. At the moment, solar power production to grid is expensive since the efficiency is not good enough, but in small applications, such as in summer cottages, it can be a good choice. (SolarShop Bergman Oy 2007; Ilmasto.org 2008a; Motiva 2008e; St1verkkokauppa 2008; Sunwind 2009; ClimaCity S.L.).

3.3.5 Hydrogen power

Hydrogen is one of the most promising fuels for the future. Biological hydrogen production, for example the production of hydrogen from biomass by microorganisms, is a common phenomenon. In swamps and in biogas installations, hydrogen is produced from biomass under anoxic circumstances. However, this hydrogen is consumed as soon as it is produced by methanogenic bacteria, and methane is the end-product which becomes available. Therefore, hydrogen is currently produced using non-renewable technologies, such as steam reformation of natural gas, petroleum refining, or the gasification of coal. These techniques produce emission. A cleaner way to produce hydrogen is electrolysis. In this method, water is separated into hydrogen and oxygen. However, it consumes a lot of energy so if required the energy is produced by non-renewable fuels, it is not environmentally friendly. If the required energy is produced, for example, by solar power or wind power, H₂ production is sustainable. (The Solar Biofuels Consortium 2008; Biohydrogen Biological hydrogen production (BWP) II.)

At the moment hydrogen is mostly used in gas turbines and in gas engines to produce energy. The technique is nothing new, but it is an emissionfree way to produce energy. In the future, the most promising way to use hydrogen are fuel cells. A fuel cell is an electrochemical device that transforms a fuel's chemical energy straight into electricity and heat, so it is possible to use it both for electricity and heat production. Also in the future, it might be possible to use fuel

cells instead of a combustion engine. Then cars would produce water instead of harmful emissions. (Mikkola 2002, 3-4; Hydrogen Energy Center 2009.)

The problem with hydrogen power is transfer. Because hydrogen is a gas it is harder to transfer than liquid fuels. The most used way to transfer hydrogen is in pressured pipes or tanks. Hydrogen can be transformed into a liquid in very low temperature (-253°C). However, this requires a lot of energy, and the tanks must be very well isolated so that the hydrogen will not transform back into gas. Hydrogen can also be bound to a liquid compound, for example to methanol (CH₃OH), from which it can be separated just before use. In this way, the transfer and storage would be much easier. The problem is, however, that this way hydrogen energy amount per one kilogram decreases a lot. In addition, there is no available infrastructure for hydrogen distribution to consumers, so it would require changes to the whole energy system. (Mikkola 2002, 3.)

4 THE CLIMATE AND ENERGY PACKAGE OF THE EU

The Kyoto protocol (1997) was the first international agreement which was legally binding and set quantitative targets to emissions. It supplemented the United Nations Framework Convention on Climate Change (1992) whose target was to stabilize greenhouse gases to the level where they cannot negatively affect the climate system. The Kyoto protocol obligates European Union (EU-15) to reduce its greenhouse gas emissions by 8% of the 1990 emission level in 2008-2012. This reduction obligation is divided between every member state in the EU. Finland has agreed to stabilize its emissions to the 1990 level in 2008-2012. Contrary to Finland, Spain can increase its emissions by 15%. (Valtion ympäristöhallinto 2008a; Ilmasto.org 2009b.)

The United Nation's Framework Convention on Climate Change obligates the participants to report the steps they have taken to execute the contract regularly. In addition, the Kyoto protocol obligates the participants to report their annual greenhouse gas emissions and the progress to meet the objectives of the protocol. The European Commission and the European Environment Agency (EEA) gather

a report of the member states' information and send it to the Secretariat of United Nations Framework Convention on Climate Change, (UNFCCC). The first season of the Kyoto protocol ends in 2012. Negotiations to reach a new international agreement to stop the climate change and reduce greenhouse gas emissions are going on. The negotiations started in Bali in December 2007 and they will hopefully end in Copenhagen in December 2009. (Valtion ympäristöhallinto 2008a.)

Meanwhile EU is taking the leader's role in the fight against global warming. It has set to itself ambitious targets in this struggle. European Commission approved the so-called "20-20-20" deal in December 2008. That deal sets the following targets for 2020:

- cutting greenhouse gases by at least 20% of the 1990 levels (30% if other developed countries commit to comparable cuts after the Kyoto protocol ends).
- increasing the share of renewable energy (wind, solar, biomass, etc) to 20% of the total energy consumption (currently 8.5%) and to increase the amount of biofuels in traffic to 10%.
- cutting energy consumption by 20% of the projected 2020 levels by improving energy efficiency.

(European Commission 2008b.)

The Climate and Energy Package of the EU is a large legislation package. It includes four legislation proposals: the renewal of emission trading system (ETS), the agreement of burden sharing between the members, the directive on carbon capture and storage (CCS) and the directive on renewable energy sources (RES). The obligations and the objectives to every member state should be equal. The package is likely to come into effect by 2011 at the latest. (Valtion ympäristöhallinto 2009b.)

The Renewal of the EU ETS starts in 2013 when the third period of emission trading starts. EU ETS covers about 10 000 industrial factories in the EU. These industrial activities are included in Annex I of the Directive IPPC. They are, for example, power plants and other energy intensive industries which produce almost

half of the CO₂ emissions in the EU area. The emission trading system is divided into two parts, which both have their own targets to decrease the emissions. In the emission trading sector the aim is to decrease the right of emit year by year so that power plants' and energy-intensive industries' emissions would be 21% below 2005 levels by 2020. For sectors not covered by the ETS (e.g. farming, wastes, households and transport, excluding aviation, which will join the ETS in 2012), emissions have to be cut to 10% below the 2005 levels by 2020 through binding national targets (with higher reductions for richer countries and limited increases for the poorest ones). Every member state has a right to decide how they decrease emissions by themselves. However, the European Commission guards strictly that the member states progress to meet the 2020 obligations. (European Commission 2008b; Valtion ympäristöhallinto 2008b.)

Carbon capture and storage (CCS) is seen as an important technology since fossile fuels have an important role in energy production for a long time. The European Council has lined that there will be new regulations to the CCS technology. The promotion of the safe use of the CCS technologies could eventually remove most carbon emissions from fossil fuels used in power generation and industry. (European Commission 2008b; Valtion ympäristöhallinto 2008b.)

Renewable energy should produce 20% of all the energy of the EU by 2020. The targets are nationally varying from 10% for Malta to 49 % for Sweden. Furthermore, at least 10% of transport fuel in each country must be renewable (biofuels, hydrogen, electricity produced by renewable energy sources, etc.) and biofuels must meet the criteria. The reductions do not have to be done in the member states' own area because the emissions can be reduced by supporting renewable energy production and use everywhere in Europe. By investing there where renewable energy sources can be used the most effectively, the total costs can be decreased. (European Commission 2008b; Valtion ympäristöhallinto 2008b.)

National targets are calculated from the 2005 statistics. Finland's renewable energy target is 38% (28.5% in 2005) and Spain's target is 20% (8.7% in 2005) for renewable energy. Catalonia's targets are calculated based on Spain's targets.

Targets for the share of renewable energy are calculated from final energy consumption. This share is 4-5 percentage units higher compared to the share in the total energy consumption, which causes a little difference between the different statistics (e.g. Eurostat and Statistics Finland). Renewable energy consumption includes the direct use of the renewables (e.g. biofuels) plus the part of electricity and heat that is produced from the renewables (e.g. wind, hydro). The renewable energy sources' share includes also distribution losses for electricity and heat and the consumption of these fuels in the process of producing electricity and heat. (European Commission 2008c.)

4.1 Obligations to Finland

EU's new climate and energy package sets ambitious targets to Finland. The share of renewable energy has to be increased to 38% (10% higher than in 2005) of the total energy consumption by 2020. Even though this target looks high, the obligation is actually a little bit smaller than the average aim of the member states (11.5% higher than in 2005). Finland's target is a little bit smaller than the average target because Finland already has a high share of renewable energy in the energy consumption (28.5% in 2005 according to Eurostat). National targets to decrease CO₂ emissions are only in non-ETS emissions. Finland's part is to decrease its non-ETS CO₂ emissions 16% by 2020. The amount of the emissions in a sector outside the emission trading system would therefore be maximum 29.7 Mt CO₂-eqv. in 2020. There are also aims to increase the use of biofuels in traffic and to improve energy efficiency. The target with biofuels is, however, the same to every member state and the plan to improve energy efficiency is only objective. (Government of Finland 2008, 16, 26-27.)

The Government's Long-term Climate and Energy Strategy report to the Parliament (6th November 2008) describes, based on the European Commission's obligations to Finland, two scenarios (baseline and objective) and what actions these scenarios require to meet the obligations by 2020. The targets in the baseline scenario and in the objective scenario are presented in T 3. The baseline scenario is based on the thought that Finland's greenhouse gas emissions will grow in the

future since no big changes to Finland's climate and energy policy have been made. Because the targets will not be accomplished this way in the baseline scenario, the objective scenario of the Long-term Climate and Energy Strategy sets targets to fulfil Finland's obligations. It is clear that the climate and the energy policy actions will be needed to meet the obligations mentioned in the objective scenario in order to meet the targets set by the EU. (Government of Finland 2008, 36.)

TABLE 3. Finland's targets for energy consumption, greenhouse gas emissions and renewable energy for 2020 and the current situation. (Government of Finland 2008).

Finland	Situation in 2006	Baseline	Objective
Primary energy consumption, TWh	421	479	430
Final energy consumption, TWh	313	347	310
Electricity consumption, TWh	89,8	103	89
Greenhouse gas emissions, Mt CO ₂ eqv.	80,9	88	-
-emissions in ETS, Mt CO ₂ eqv.	45,7	53	-
-emissions in non-ETS, Mt CO ₂ eqv.	35,2	35	29,7
Renewable energy			
-final consumption, TWh	93	109	118
-share, %	28	30,5	38

4.1.1 Aims to different renewable energy sources

To meet the 38% share of renewable energy in energy consumption, Finland has to increase the use of renewable energy sources (RES), and to emphasize energy efficiency and energy saving. The targets with wood-based energy, heat pumps, biobased oil, bricets, solar power in heating, bioenergy from agriculture, biofuels in traffic, wind power, hydro power and wastes are presented in the Strategy. Also peat could be used to prepare biofuels if the European Commission approves it. Tariff systems can also be used to increase the use of renewable energy. Increasing the use of renewable energy is not, however, cheap. Different sources need different level of support (political and financial) and this need of support is also estimated in the Strategy. Some targets, for example in solar and wind power,

are ambitious and need high level of support to be comparable with other (mainly fossil) fuels and in order to be taken into larger use. On the contrary, other sources, for example hydro power, do not need support at all. However, the increase potential of these sources is not nearly close to those which are on high level of support sources. Table 4 shows the current situation, the targets and the level of support that the Government of Finland has found the best to accomplish Finland's obligations. (Government of Finland 2008, 16, 36-41, 43.)

TABLE 4. Targets to renewable energy sources (Government of Finland 2008).

Renewable energy source	Situation in 2006, TWh	Targets, TWh	Level of support
By-products from forest industry	70	60	Medium
Forest chips	7,2	21	Medium
Heat pumps	2,4	5	Medium
Small scale use of wood	13,6	13	Medium
Solar power and wind power	0,1	6	Strong
Bioenergy from agriculture and bricets	0,1	3	Medium
Biofuels in traffic	0	6	Strong
Hydro power	11,3	14	No need
Wastes	1,9	3	No need

Solar power, wind power and biofuels are classified to need strong level of support because the technology is expensive, and the mechanism of producing the energy is complicated. In addition, for example with solar power, the efficiency of the technology is too low to produce energy in large applications. Furthermore, the aim to increase the use of solar power, wind power and biofuels is big. Bioenergy is, on the other hand, classified in the category of medium level of support. That is because the target to increase the use of bioenergy is not big, excluding forest chips. In addition, the technology is well known and widely used already. Even though the target to increase the use of forest chips is greatest, it demands only medium level of support since there is capacity to increase its use,

and the technology is also familiar. The use of by-products from the industry and the small scale use of wood, the targets decrease since other renewable energy sources are aimed to increase a lot. On the other hand, hydro power and wastes are classified to the category no need of support because of their functioning mechanism while producing energy is well known, and the aim to increase their use is low. (Government of Finland 2008, 36-41.)

4.1.2 The main directive methods to meet the obligation of CO₂ reductions

The Government of Finland has planned different measures with which Finland is supposed to achieve EU's obligations. The aim is to

“meet the objectives set for renewable energy through its own measures, without the flexibility mechanisms between member states as planned for in the Directive. If necessary, Finland can utilize flexibility mechanisms either as a buyer or seller, depending on the costs of increasing renewable energy in Finland and in other member countries.” (Government of Finland 2008, 37.)

Research, new innovations and developments are an important role but they themselves cannot bring fast enough solutions to the energy problem (decreasing consumption and emissions). Furthermore, education and counseling have their roles also but it is very hard to affect people's behavior quickly. (Government of Finland 2008, 53.)

One of the planned methods is energy taxations. By taxing the more not environmentally friendly energy sources, the consumption can be channeled to a more environmentally friendly source. It is not, however, simple task to do. If energy taxation is raised on fossil fuels, it causes problems, such as increased costs to many energy companies and this affects the consumers eventually. It could be more reasonable to decrease the taxation of the environmentally friendly energy sources (renewable energy sources). By doing this, the government, however, loses tax money. The question of energy taxation is not easy to solve. It

is good for everybody if legislators have enough courage to make even dramatic changes. Together with energy taxation also different kinds of tariff systems have been planned for increasing the share of renewable energy in energy production and consumption. Many member states of the EU have already their own tariff systems, but Finland does not yet have one. It is likely that it will come later on. Tariff system will probably be a cost-effective feed-in tariff system, operating on market terms as far as possible. (Government of Finland 2008, 55-57.)

The government of Finland also plans to improve energy efficiency largely. This goal comes from the EU's level since it has set a wide range of directives in order to decrease energy consumption. Making power generation and distribution and electronical devices more energy efficient, and cars more fuel efficient, helps to decrease energy consumption and therefore also CO₂ emissions. Sticker norms to the energy efficiency of buildings', emission based vehicle taxation and improvements to public transport systems are also seen important factors in the battle of decreasing energy consumption. (Government of Finland 2008, 58-63, 66-70.)

4.2 Obligations to Catalonia

EU's target to the share of renewable energy in Spain is 20% of the total energy consumption by 2020. Catalonia's objectives are calculated based on Spain's obligations. Catalonia has its own energy plan, The Catalan Energy Plan, with which plans to achieve the targets. The Plan contains four different sections; energetic efficiency, infrastructure, R+D+I and renewable energy. (Government of Catalonia, 2007b.)

As mentioned earlier, Catalonia's emission reduction objectives are calculated on the basis of Spain's Kyoto Protocol target (+15% under EU's burden sharing), as well as the commitments under the EU Emission Trading System (ETS) for the sectors concerned. Since -20% greenhouse gas emissions target to the sectors covered by the emission trading system is shared with the whole European Union, there is a specific national target only to non-ETS sector. This target is

represented in Table 5 together with the renewable energy target. (Generalitat de Catalunya 2008c, 29.)

TABLE 5. Catalonia's greenhouse gas emissions and targets for the future (Generalitat de Catalunya 2008c).

Catalonia	
Greenhouse gas emissions in 2005, Mt CO ₂ eqv.	59,2
-emissions in ETS, Mt CO ₂ eqv.	20
-emissions in non-ETS, Mt CO ₂ eqv.	39,2
Target for non-ETS emissions by 2012, Mt CO ₂ eqv.	36,5
Renewable energy in 2005	0,9
Target for renewable energy by 2015, %	11
-increase, %	10,1

The emissions from non-ETS form approximately 66% of Catalonia's greenhouse gas emissions. The rest, 34%, come from emission trading system sector. This sector includes about 186 plants in Catalonia. The plants are related to the following industrial sectors: power generation, fuel combustion, ceramics, cement, steel, lime and gypsum, paper, glass, gas and oil refining. These plants have to declare and verify their emissions each year. (Generalitat de Catalunya 2008c, 27, 28, 66.)

The Plan for renewable energy sets two different scenarios with their own objectives. The Base scenario includes that the situation remains on the current trends of economic growth, energy and technological development. The Intensive energy efficiency and renewable energy (IER) scenario sets an objective of 11% renewable energy in the total primary energy consumption by 2015 (Figure 15). Moreover, it considers that approximately the $\frac{3}{4}$ parts of the renewable energy will come from hydro energy, bio fuels and wind energy (Figure 16). (Generalitat de Catalunya 2006a, 208-211; Government of Catalonia 2007b.)

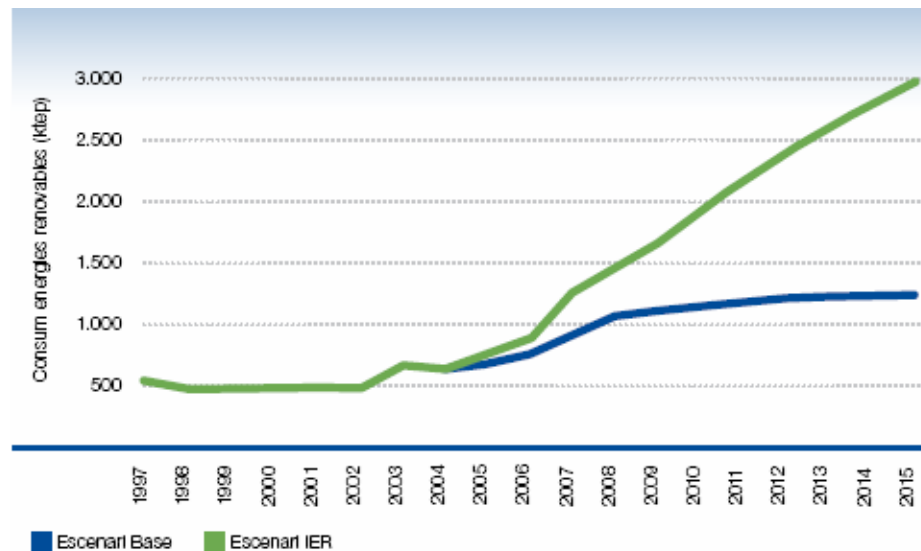


FIGURE 15. Estimated evolution of renewable energy in Base and IER scenario (Generalitat de Catalunya 2006a, 210).

4.2.1 Aims to different renewable energy sources

The Energy Plan of Catalonia sets targets to Catalonia in order to meet the obligations on renewable energy and greenhouse gas. In Table 6 these targets are presented.

TABLE 6. Targets to renewable energy sources (Generalitat de Catalunya 2006a).

Aims to renewable energy sources	Situation in 2003	Target for 2015	
		Base	IER
Hydroelectric power	2320 MW	2371 MW	2475 MW
Biomass	289,6 ktep	616,7 ktep	1527 ktep
Wind power	86,7 MW	1300 MW	3500 MW
Solar power	2,2 MW	26,4 MW	150 MW

In Figure 16, the shares of different renewable energy sources by 2015 are presented if the Intensive energy efficiency and renewable energy (IER) scenario can be accomplished. In this case, the shares of biomass and wind power would increase a lot whereas the share of hydroelectric power would increase only a little bit. Overall, its share among the renewable energy sources would decrease. The

estimated increases of wind power and biomass are shown in Figure 17 and Figure 18. In the area of solar power, both the Base scenario and the IER scenario predict increase. The IER scenario estimates, however, much greater increase. In the Base scenario, the area of thermal solar power captures would be 400 000 m² and the power would be 26.4 MW by 2015. In the IER scenario, the numbers are much higher. It predicts that the area of solar captures would be 1 250 000 m² and the installed power would be 100 MW. (Generalitat de Catalunya 2006a, 217-218, 220-221, 225, 231, 236, 256.)

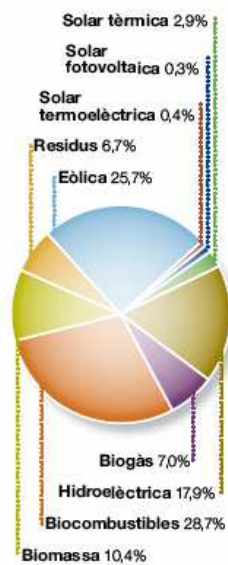


FIGURE 16. Shares of renewable energy sources by 2015 in IER scenario (Generalitat de Catalunya 2006a, 211).

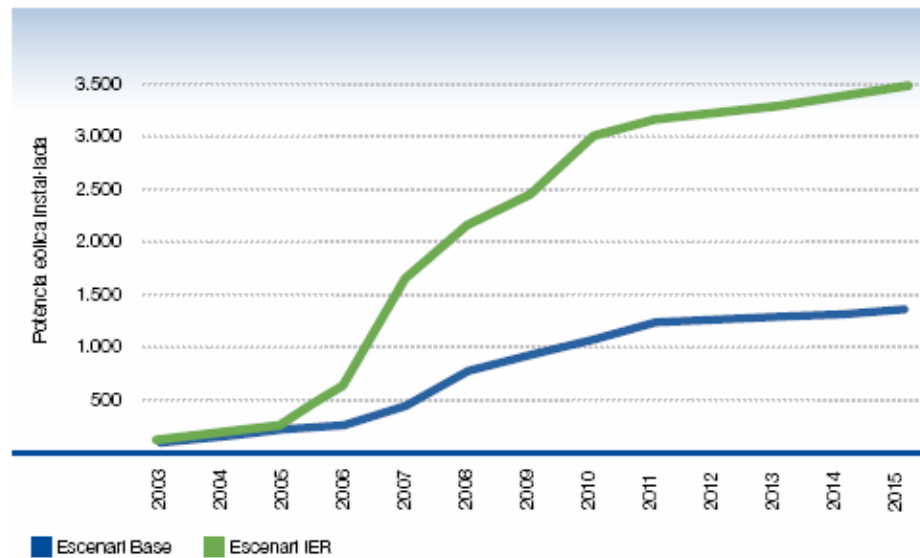


FIGURE 17. Evolution of wind power in two scenarios, MW (Generalitat de Catalunya 2006a).

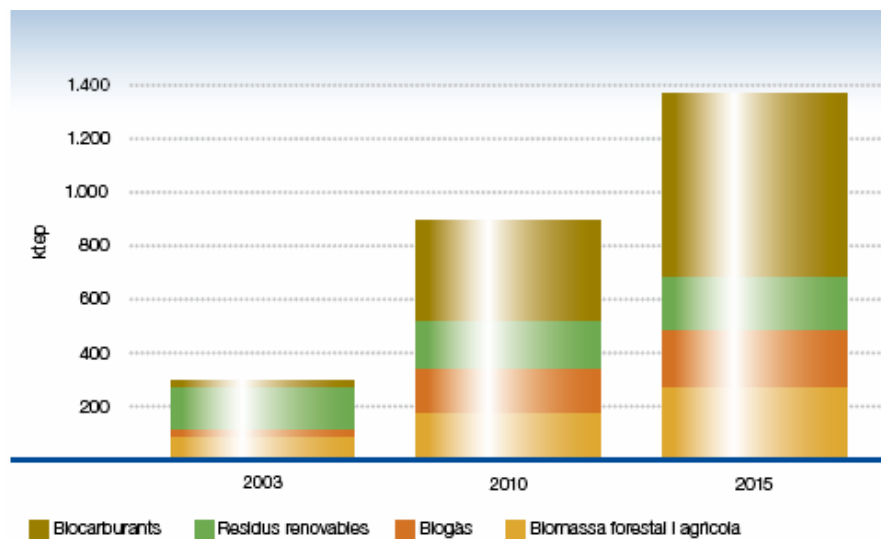


FIGURE 18. Estimated evolution and production of biomass in IER scenario (Generalitat de Catalunya 2006a).

4.2.2 The main directive methods to meet the obligation of CO₂ reductions

The Government of Catalonia has prepared a plan to decrease the CO₂ emissions in Catalonia. This plan is called the Framework Plan for Climate Change Mitigation in Catalonia 2008-2012. The plan co-operates with the Catalan Energy

Plan 2006-2015 which also fights the climate change. The central objective of the Framework Plan for Climate Change Mitigation in Catalonia 2008-2012 is to promote the investments as well as legal technical, financial, incentive, support and co-operation programs with the public and private sectors in order to achieve a reduction target. Its aim is also to promote the reduction of emissions from production processes, and to encourage the use of the alternative fuels. The plan contains numerous action points to meet this aim. The main focus is, however, divided into three programs. (Generalitat de Catalunya 2008c, 40.)

Program 1 concentrates on reducing the emissions from diffuse source sectors (non-ETS sectors). The main focus is on agriculture, construction and the use of dwelling, service sector, wastes, transport and travelling, industries not covered by ETS, and on reducing fluorinated gas emissions. In Program 2, the main focus is to support the industries covered by the emission trading system. The aim is to reduce domestic greenhouses gases, and to encourage the industry to use the flexibility mechanisms of the emission trading system. Since sometimes it is difficult to locate the emissions of a certain area of living, the 3rd program aims to cross-cutting action to mitigate climate change. This means that the government's agencies have to set an example to the public, and to produce and distribute information about the issue. In addition, the goal is to increase public awareness in the issues that are related to global warming. Trying to make cultural change is not easy but if awareness is arisen, changes can be made. More specific information and all the action points can be found from the report Framework Plan for Climate Change Mitigation in Catalonia 2008-2012. (Generalitat de Catalunya 2008c, 42-83.)

4.3 Finland's and Catalonia's distance to EU's obligations

Both Finland and Catalonia have to do major changes to their energy production and consumption habits to achieve the targets on emission reduction and renewable energy. The current situation and the targets are presented in Figures 20 and 21. The aim is to achieve the targets piece by piece in a linearic way. Both sides have the same target to increase the share of renewable energy by 10%. The

difference is, however, that Catalonia's target is set for 2012 (greenhouse gas emissions) and 2015 (renewable energy) and Finland's targets are for 2020. Despite the difference in time, Catalonia's targets are in line with EU's and Spain's targets to comply the Kyoto Protocol. (Generalitat de Catalunya 2006c, 7; Valtion ympäristöhallinto 2008b.)

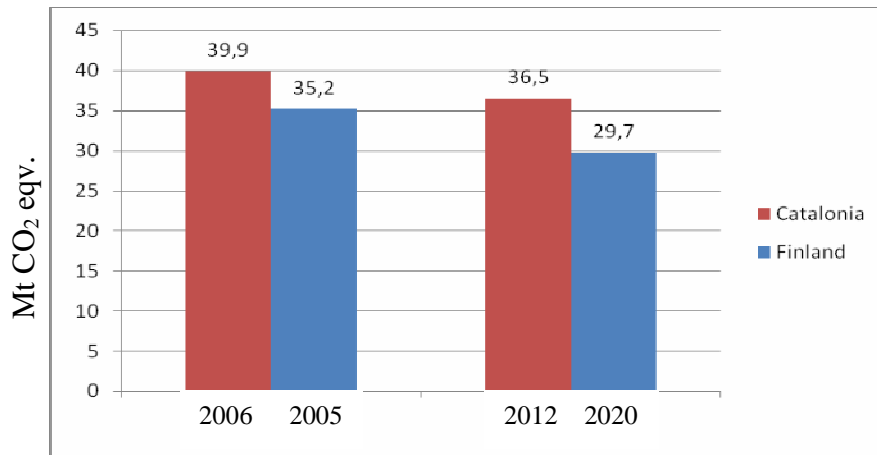


FIGURE 19. Catalonia's and Finland's greenhouse gas emissions and targets in non-ETS sector.

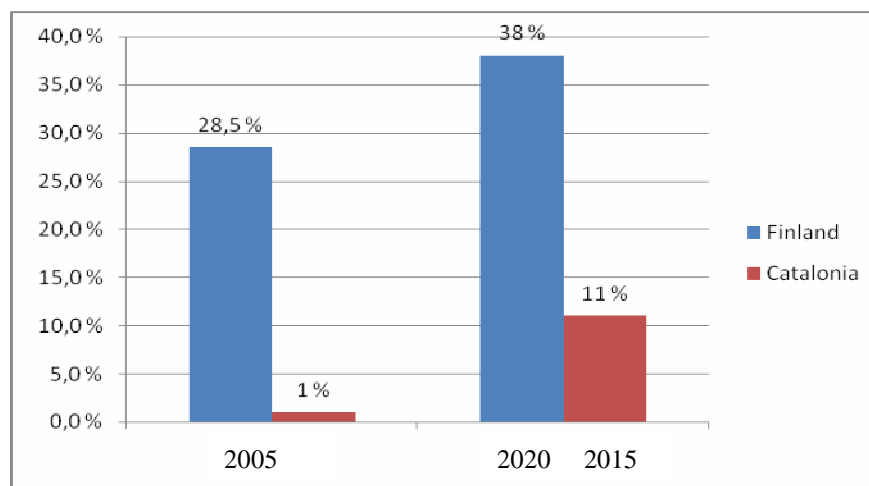


FIGURE 20. Catalonia's and Finland's renewable energy situation and targets.

It is clear that Finland's and Catalonia's emissions outside the emission trading system were greater than are accepted by 2020 (Finland) and 2012 (Catalonia).

Since the emissions are greater than that, units have to be bought from other participants, or use the flexible mechanisms. Both Finland and Catalonia will face difficulties to achieve targets since both of its emissions have been increasing during the years, and it seems like that trend is going to continue without dramatic actions. Finland's natural resources make it possible to increase the use of renewable energy, especially bioenergy. It requires, however, changes to supporting and directing systems so that they are more environmentally concentrated than at present. Catalonia has also opportunities to increase especially the amount of wind and bioenergy. Reaching the targets is hard, if even possible. Even though there is will and ambitiousness to reach targets, reality fights back. The targets can be too hard to achieve because financial expenses might be too high. Whether Finland and Catalonia will be willing to use enough money and that way reach the targets in time, will be seen.

5 CONCLUSIONS

Energy consumption in Finland and in Catalonia has increased a lot during the last few decades. This is a natural path since the standard of living has grown and the way of life has changed more and more towards consumption. However, the trend to consume and especially the consumption of fossil fuels cannot continue like this. There have already been severe environmental effects because of the increased energy production and consumption. Luckily, many quarters have now admitted this problem, and actions have been taken. For example, the European Commission has set strict obligations to its member states to decrease their harmful emissions. As a part of EU, Finland and Catalonia have to make their own part in this agreement. The share of renewable energy in energy production has to be increased, and greenhouse gas emissions have to be decreased. Finland is already in a good path in the use of renewable energy sources, thanks to its natural resources. On the contrary, in Catalonia the use of renewable energy sources is minor. Despite the difference in the current situation, both have to increase the use of renewable energy by approximately the same amount, 10%. Greenhouse gases have to be decreased by 16% in the sector outside of the emission trading system (ETS) in Finland by 2020. Catalonia, on the other hand,

has to reduce its non-ETS emissions by 8.5% by 2012 according to its own Framework Plan for Climate Change Mitigation in Catalonia 2008-2012 (approved by European Commission). Despite the will, it is clear that both parties will face problems with their targets. Reaching the obligations demands several actions starting from single consumer's behavior to major political decisions.

This project enlarged my knowledge about Finland's energy situation and gave me whole new information about the energy situation in Catalonia. In addition, the energy and climate package of the EU and the emission trading system became more understandable to me. EU's establishments are complex, and it requires more to understand them than what one can achieve just with quick glance. Earlier I have not realized how much energy consumption has grown in Finland during the last four decades. Harmful emissions have also grown in the meantime even though major improvements have been made to minimize them. On the contrary to energy consumption, I already had a fairly good impression of Finland's diverse energy sources and the use of renewable energy. What I did not know was the energy situation in Catalonia, and that how little renewable energy is used there. I think that the climate and energy package of the EU bring very big challenges to Finland and Catalonia. It will be interesting to see how both of them will achieve the obligations, or if the obligations will be achieved at all. I am also wondering how the European Commission will feel and react if one or more member states cannot reach their obligations. I would not be surprised if there were punishments. However, I am sure that those will not help the member states to work harder to achieve the targets.

It was not always easy to find information for this project. I faced difficulties when I was trying to find information about Catalonia and its energy situation. The most of the time the information was in Catalan or in Castilian. Castilian was easier to understand but with Catalan, understanding problems were bigger and online translators were used a lot of times. My tutors in Universitat Politècnica de Catalunya (UPC) were, however, very helpful, and if I had problems they helped. On contrary to Catalonia, information about Finland was fairly easy to find and, of course, there was no language problems. I would have liked to find more updated information about renewable energy in Catalonia. Of course there was

information available, but it was mostly from year 2003. There were also some updated statistics from previous years, but more precise information was missing. This is, though, partially because of language problems.

Since Catalonia has planned to enlarge especially its biomass and wind power production in order to reach its targets, it might be a good opportunity to Finnish companies, to offer their knowledge and skills to Catalonia. Finnish companies that are concentrated to renewable energy technology have excellent knowledge, and therefore there might be suitable co-operation projects there. It would be a good idea to investigate in the situation at the very least.

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