I certify that all material in this thesis that is not my own work has been identified and that no material has been included for which a degree has previously been conferred on me.

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An analysis of the current and future prospects of wind energy in Castilla y Leon

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Abstract

The wind energy in Castilla y León is one of the main energy sources and is more developed than in other communities of Spain, this is because of the good location of Castilla y León and the efforts made by the autonomic government and the regional companies.

Castilla y León is a very suitable region for this type of energy because it is a rural community and located in a plateau in which there are sustained winds. It has obtained information about the current situation of the wind energy in this community and with this information, a research has been done to develop the wind energy in Castilla y León and in this way increase the performance of the energy and get more economic costs. The main advantage is that the wind energy is a renewable source which makes it interesting develop of this energy and the major disadvantage is its availability due to this energy depends on the presence of relatively strong winds, for this reason, alternatives have been researched to make it more productive. Taking advantage of that the wind power is a renewable energy source, a project have been done to study the viability of the replacement of the nuclear power in Spain using wind energy.

The obtained results confirm the viability of this energy and the necessity to keep developing this energy because today in Castilla y León and Spain this is the main renewable energy and still it could be more developed y make Spain a country more respectful with the environment.

Keywords: Wind, Energy, Power, Spain, Castilla y León, Renewable
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Introduction

1.1 History of the Wind

Humans have used the power of wind since thousands of years ago. The first use we have evidence is as a form to transporting. In 5,000 BC, the Egyptians used the wind to propel their boats and until the invention of steam engine this was the main form to move in rivers and seas.

The first wind machines we know were invented in the region of Sijistan, between Iran and Afghanistan at Century 6th AC, this machines were vertical-axis and were used to grind grain and pumping water. Years after, especially in Greek islands, horizontal-axis windmills were started to use, these had the particularity they can regulate the capitation surface rolling up the sails.

In 13th Century, windmills was introducing in Europe. Beginning the 14th century Netherlands were who more improved and these were used to drain water in the Rhine delta, to elaborate oils and paper, to process wood in sawmills, etc. they constructed windmill until 65kW but with the industrial revolution their use decreased a lot.

Another region in which the windmills were widely used was Denmark, where at the end of 19th Century, it was estimated a power of 200MW for industrial and domestic purposes.

In the decade of the 70, return the interest for wind power due to that the price of oil was increasing. This kind of energy was developed to produce electricity, and nowadays, the wind energy is another more alternative to generate electricity [1].

1.2 The Wind Turbine

The wind turbine unlike the windmill is basically a machine where the power of wind is transformed in electric power. The electricity produced by the wind turbines can be distributed trough the electric grids for any uses.

Today, the common design for wind turbines is the horizontal axis wind turbine. In consequence this wind turbine is the most employed. Below we described it more important components.

1.2.1 The rotor

The blades and hub comprise the rotor. Nowadays, a big part of the turbines are upwind and with three blades, though also some wind turbines are downwind and with two blades, the wind turbines with one blade have been little use. The large turbines use commonly the pitch control system. The blades are made mainly of composite, at the beginning these were made with fibreglass reinforced plastic (GRP) and sometimes with wood/epoxy laminated.

1.2.2 Drive train

Drive train is formed principally for low-speed shaft, a gearbox, and a high speed shaft. Other components of drive train are support bearing, couplings, mechanical brake and the rotating parts of the generator. The gearbox works for adapt the rotor speed to a high speed for the generator, they exist two types of gearbox, parallel shaft and planetary. There one type of generator, low-speed generator where gearbox is not necessary, this reduces the size of nacelle and the weight of structure among other things.

1.2.3 Generator

The generator is where the mechanical energy is transformed en electric energy. The most part of wind turbines use synchronous or induction generators. These have the disadvantage that requires a practically constant speed.
Normally the wind turbines that are connected to the grid used induction generators because they have advantages like rugged, cheap and easy to connect to the grid.

1.2.4 Nacelle and yaw system

The nacelle protects all the inside machines and components of weather.
The yaw orientation system is used so that the wind comes into contact with the rotor in right direction all the time. The most wind turbines have a large bearing that join the tower with the nacelle and a motor that is used for orient the nacelle in the wind direction. The mechanism is controlled automatically by a weathercock installed in top of the nacelle.

1.2.5 Tower and foundation

The height of the tower measures usually between 1 and 1.5 times the diameter of rotor. The foundation is responsible to maintain firm and rigid the tower, and this is so important to it can resist possible coupled vibrations between the rotor and tower.

1.2.6 Controls

A wind turbine requires an important system of control. It need controlled in the best way possible all the factors for get the most power possible. A wind turbine control system is composing for the next components:

Sensors - Speed, position, flow, temperature, current, voltage, etc.

Controllers - Mechanical mechanisms, electrical circuits, and computers.
Power amplifiers - Switches, electrical amplifiers, hydraulic pumps and valves.
Actuators - Motors, pistons, magnets, and solenoids.

1.2.7 Balance of electrical systems

The wind turbine comprises other electrical components not only the generator as for example cables, switchgear, transformers yaw and pitch motors [2].

1.3 Types of Turbines

The wind turbines can be classified in many ways; the main form is based in the position of the axis, horizontal or vertical, and then explained a little more thoroughly.

1.3.1 Horizontal-axis machines

The mostly of horizontal-axis machine are of three blades, though it has of two or one blade. The reason because are more useful the turbines of three blades is that this are more silent than turbines of two blades and turbines of one blade are not used because of its asymmetry and the problems that this entails. On the other hand, they can be classified like upwind, if the rotor is in front, or downwind, if the rotor is behind of the tower. Upwind is the most used in large wind turbines due to that in this scale, both need a yaw orientation system. These types of turbines, like the mayority, have more power if their size is bigger (in Figure 1, we see an approximation of how the power is increased); for these reason every year the wind turbines are constructed bigger.

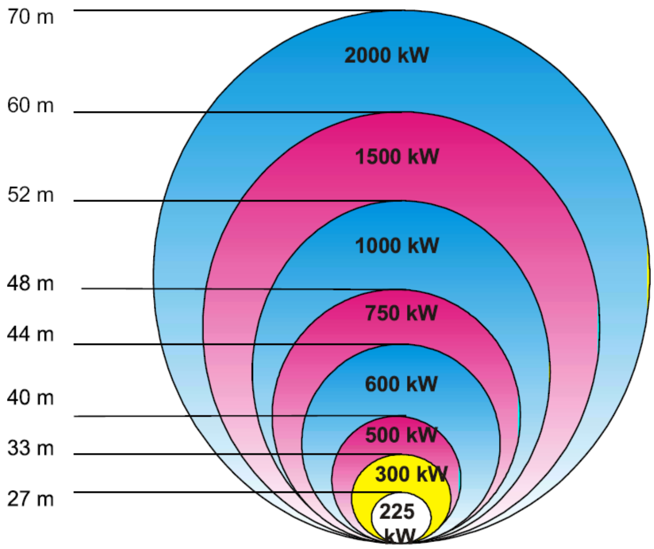

Figure 1 Power increase relative to the size of the turbine

1.3.2 Vertical-axis machines

The main advantage of vertical-axis turbines is they do not need to be oriented and the gearbox and the generator are at ground level, other advantages are that this machines do not support stress/strain cycles caused by gravity as happen in horizontal-axis machines, on the other hand the main disadvantages of these turbines are the ease of suffering fatigue due to the resonance of the structure, the changes within each cycle in the wind torque can do to appear unwanted power periodicities at the output and a good fixation of the structure is difficult. The main rotors used to produce electricity energy are Darrieus, Musgrave y Evans.

Darrieus rotor. This is a catenary-shaped rotor with two or three thin curved blades with an airfoil section. The main feature of this rotor is that these rotating blades can only be stressed along their length.

Musgrove rotor. This rotor has been specifically designed to ensure fail-safe shutdown in strong winds. This is achieved by having blades that are vertical during normal power generation, but tip or turn about a horizontal point during shutdown.

Evans rotor. This rotor type also includes fail-safe shutdown features. This is achieved by allowing the vertical blades to change pitch about a vertical axis during shutdown [3].

1.4 Current Technologies

Nowadays, the wind technology is quite developed; the major companies producing wind turbines in the entire world have the control of 54.3% of this market. These companies have in their catalogues wind turbines between 800kW and 7.5MW [4].

The most installed model of the Danish company Vestas have 2MW of power and is design to work with low or middle winds, between 4 and 25m/s and a rated wind speed of 12m/s, the diameter of rotor is about 90m with gearbox of three-stage planetary/helical and power regulation is pitch regulated with variable speed, these are a few characteristics [5]. The Gamesa company (Spain) use very similar technology and its more used model is also of 2MW, these wind turbines have a wide range of diameters of rotor and long of blades [6]. The American company GE Energy is installing its model of 2.5MW and this model use practically the same technology than previous models [7].

On the other hand it is the German company Enercon that has developed an ingenious system where is not necessary a gearbox and it transforms the mechanical energy in electrical in Enercon’s annular generator that this generator“is a low-speed synchronous generator with no direct grid coupling. Output voltage and frequency vary with the speed and are converted for output to the grid via a DC link and an inverter which allow for high speed variability” with this it gets reduce friction and increase the life of the wind turbine among other things [8].

1.5 Wind Energy to Electrical

The wind turbine has the function to transform the wind energy in electric energy through of a simple process and at the same time complicated.

The wind turbine only can capture the 16/27 part of all kinetic energy that the wind have, this limit was established by the German physicist Albert Betz in the law known by his name. Until today, the Betz's limit hasn't been surpassed by a wind turbine. In the Figure 2, we can see how all machines are under the Betz's limit. [9].

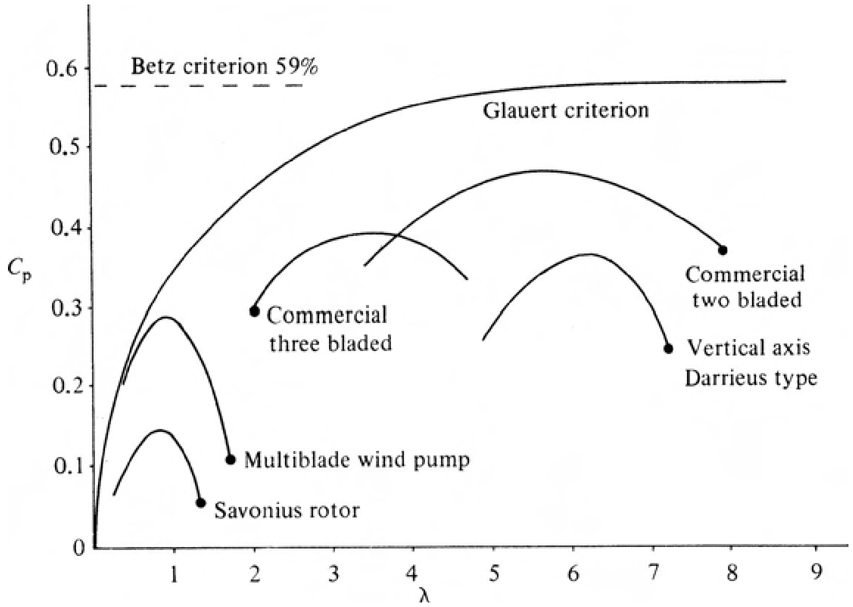

Figure 2 Power coefficient Cp as a function of tip speed ratio λ for a range of machine types.

In rotor speed is normally distinguished 4 different regions, the region where the speed is less than cut-in speed, here the turbine don't work because the speed is minimum, in where the speed is between cut-in speed and rated speed, it is here where the wind turbine start to work but this doesn't generate all power that it could produce, the part between rated speed and cut-out, in this section it is generated all power that it is possible by the wind turbine, and the last region is after cut-out, where the turbine is automatically disconnected so that the hard winds can not destroy the machine.

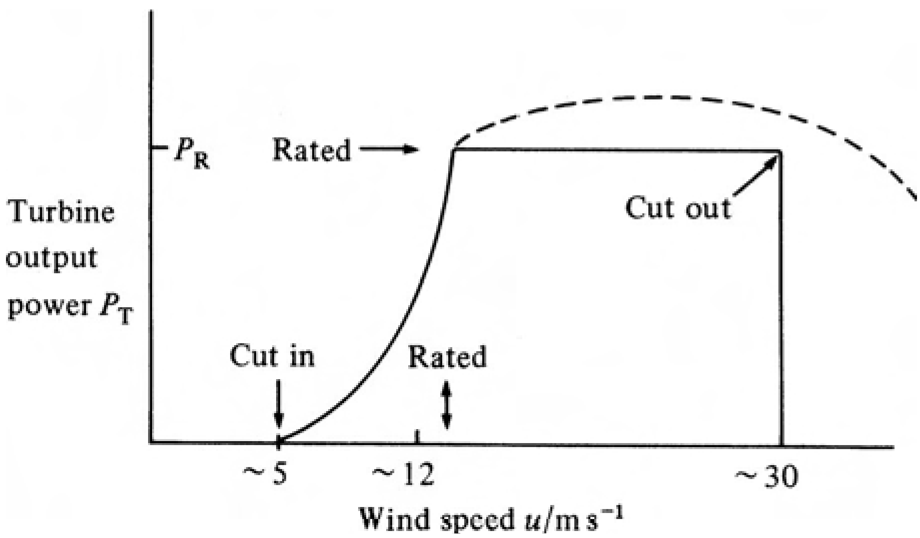

Figure 3 Wind turbine operating regions and power performance.

Normally, the wind turbine works in the cut-in and rated speed region. There are two extreme theoretical conditions of operation:

1- *Variable rotor speed for constant tip-speed ratio λ, hence constant power coefficient.* This is the most efficient mode of operation and captures the most energy. In this mode energy capture is increased through the ability of the variable speed turbines to cut in at wind speeds less than for constant speed turbines.

2- *Constant (fixed) turbine rotational frequency, hence varying power coefficient.* This is less efficient than the variable speed turbines discussed above. However, he use of standard induction generators in these turbines allows easy grid connection. [3].

Once that the wind turbine has captured all the possible energy of wind, subtracting the aerodynamic lost that are around 21% of maximum exploitable, only the 38% of the total energy reaches the gearbox, here the rotation speed is adapted to the revolutions per minute that the generator needs. The losses on the gearbox are approximately the 4% and in the bearings the 0.5% so the generate only have the 33.5% of all energy, and due to that the performance in the generator is 0.85, la total energy that it can be obtained of the wind is solely the 28% of the energy of beginning[10].

The turbine-grid connection consists of electrical conductors, transformers, and switchgear to enable connection and disconnection. All of this equipment must be thermally rated to handle the expected current. In addition, the electrical conductors must have large cross-sectional areas so as to ensure that the voltage drops between the turbine and the point of connection to the electric grid is minimal [2].

Wind turbines should not degrade the power quality of the distribution network. To do so, all wind turbines should conform to international standard for wind power quality (IEC, 2000b). This standard lists the following data as being relevant for characterizing the power quality of a wind turbine:

- Maximum output power (10 min average, 60s average and 200 ms average values),
- Reactive power (10 min average) as a function of active power,
- Flicker coefficient for continuous operation as a function of network source impedance phase angle and annual average wind speed,
- Maximum number of wind turbine starts within 10 min and 120 min periods,
- Flicker step factor and voltage step factor at start-up as a function of network source impedance phase angle,
- Harmonic currents during continuous operation as 10 min averages for each harmonic up to the fiftieth [9].

2

Current Situation in Castilla y León

2.1 Production

The production of wind energy in Castilla y León has been increased a lot in the last decade. Castilla y León did not produce any megawatt per hour in 1997 and it has passed to produce 7,682,002 MWh in 2009[11-12]. This increment is caused mainly for the good situation of the community to construct wind farms and the government aids to foment the alternatives energies.

Castilla y León produces the 20.91% of the entire Spanish production of electric energy who come from the wind [12]. Due to this, Castilla y León is the autonomy that more wind energy produce in Spain.

To get this production of electric energy, the autonomic community have 204 wind farms distributed for all the community with a total power of 4804 MW, the province that has more wind farms is Burgos, who accumulate 69 with a power of 1575.22 MW(Data updated to January 2012)[13].

This numbers going to continue increasing in Castilla y León due to that 25 wind farms are being constructed and they will provide in total 754,100kW[14]. We need to add the wind farms with the administrative authorization, this wind farms are 99 and if all of these are constructed they will contribute with 1,831,220 kW to the power of wind energy in Castilla y León [15].

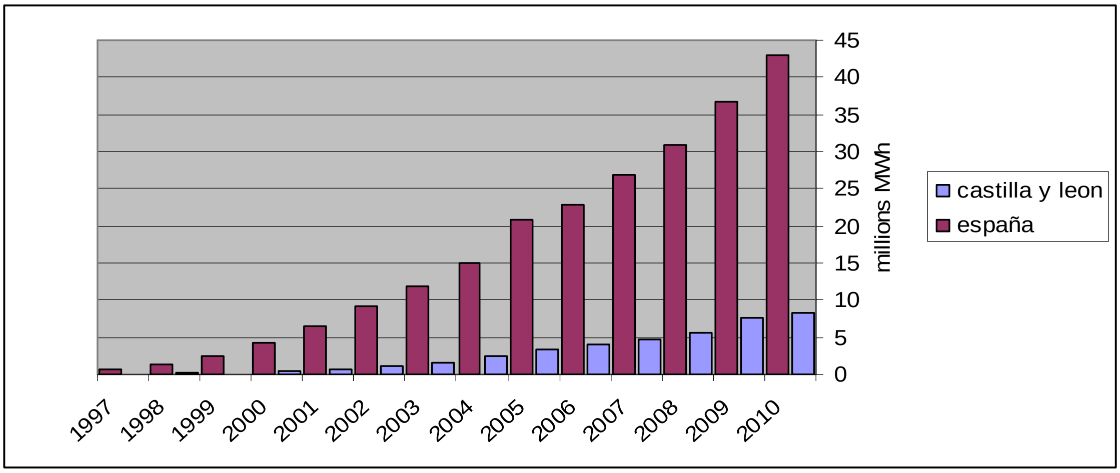

Figure 4 Comparison of production of wind energy in Castilla y León and in Spain

2.2 Property of the wind farms

The promoting societies of the wind farms in Castilla y León are pretty divided. Big companies of the renewable sector as Acciona energy or Iberdrola, a electric company that it started work with the hydroelectric power and today it is world leader in the wind sector, that work in the entire world Medium companies that they are promoters of a few wind farms as the Ider group and small companies that only are created for the constructed of the wind farm and the capital comes from private individuals of the area as can be Eólica Sierra de Ávila, S.L [13].

The fact of that small companies are created for the construction of a wind farm with capital of the area is good particularly for the area because this generates employed and rich for the area and the income are for area too. On the other hand if the company is a multinational these incomes go outside the autonomy in the most of cases.

2.3 The wind energy is creating a cleaner energy in Castilla y Leon

Castilla y Leon is generating every day more wind energy and other renewable energies but we do not know if the increased of these energies are becoming the energy of Castilla y Leon in a cleaner energy. If we shown the production data of other energy sources we will see how the production of alternative sources is increased every year and the no renewable sources like nuclear or thermal energy are decreased.

The average capacity of all the wind farms that are in working in Castilla y León is 23.54 MW, but if we see the average capacity of the wind farms that are in construction this is 30.16 MW, almost 7 MW more per each wind farm. These data mean that the wind technology is better every year and this form we can generate more power [13-14].

Today, the average power of a wind turbine in Castilla y Leon is 1,209 kW, that in comparison with the average power of a wind turbine in construction is 1899 kW, the increased of the power is around 700 kW, here we can also see the improve of the technology in wind energy[13-14].

2.4 Producers of wind turbines

The companies that produce wind turbines a world level are few, for this reason, in Castilla y León is also small the number of companies that construct wind turbines. Only nine companies have installed wind turbines, the Spanish company Gamesa has provided wind turbines to 116 wind farms, this is more than the half, the multinationals Vestas, Alston-Ecotécnia and Made have provided a lot of turbines, that represent the 35% of the wind farms and turbines for 17 wind farms are been provided by other 5 companies[13].

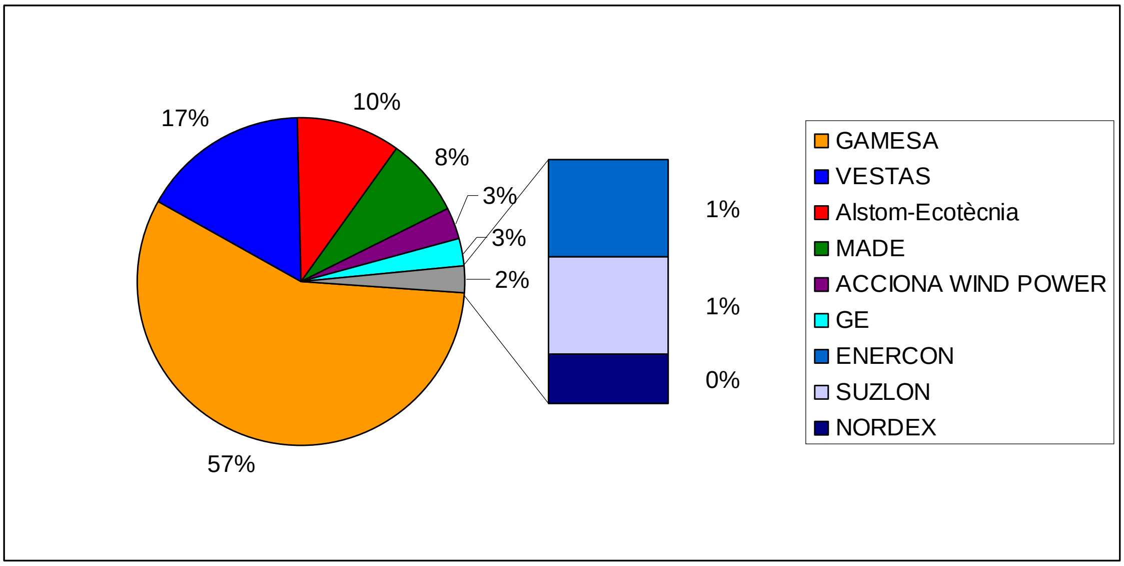

Figure 5 Production companies of wind turbines in Castilla y León.

2.5 Support and promotion of wind energy by the government

In Spain, two types of production regimes are differentiated in the evacuation of energy to the distribution grids, ordinary regime of electric energy generated and special regime. Ordinary regime is the regular regime of energy evacuation, and special regime is complementary to ordinary regime and it is applied to the evacuation of energy that come from treatment of waste, biomass, hydraulic, wind, solar and co-generation to the distribution and transport networks [16].

The production special regime is regulated by royal decree 661/2007, of May 25 whereby was established a system of temporally incentives for installations that required these incentives to stay in a free market situation [17]. These tariffs and bonus that the national government offers have the proposed promote the creation of energetic installations of the types mentioned in the before paragraph. The high grow of wind energy was due largely for these aids, because without theirs would be hardly practicable the construction of a wind farm. In the last years, the bonus in special regime is being decreased. There two ways to sell the generated energy in a wind farm, in regulated tariff, this tariff is for wind energy of 8.1270c€/kWh or you can sell the energy in production market and obtain a bonus that these are 2.014 c€/kWh today. These prices are for the first 20 years, after this, the regulated tariff is 6.792 c€/kWh and the bonus do not exit for the sell in production market [18].

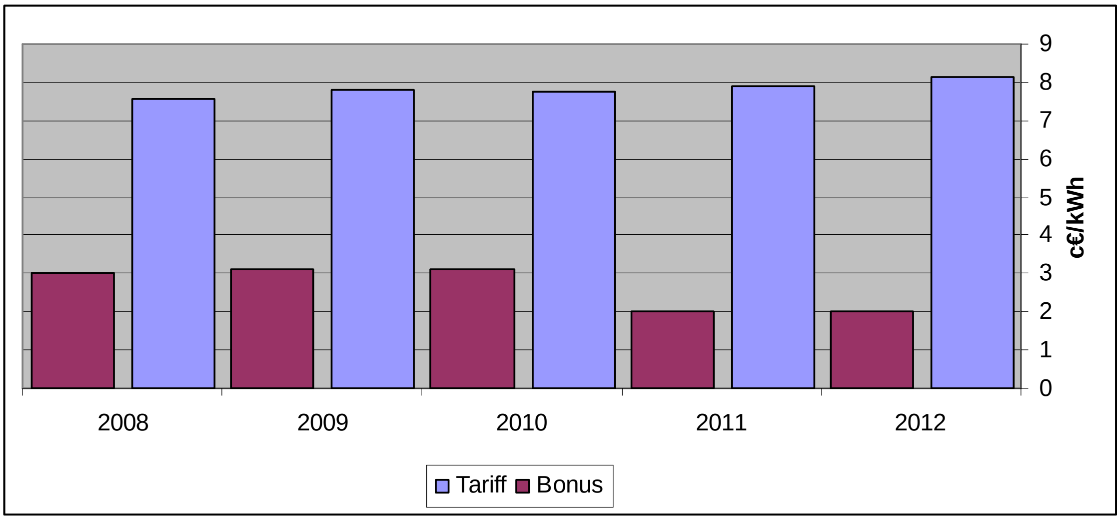

Figure 6 Value of the tariff and bonus in wind energy in Spain.

The aids that we have described before are offered by the state government, and the regional government that it is called Junta de Castilla y León does not offer any aid for wind installations with high power, only offers aids for wind installations of low power and it going as far as to subsidize the 35% of the installation[19].

2.6 Overview of wind energy in Spain

The wind energy in Spain is very developed, but the community where it is more developed is Castilla y Leon, due to which this community have the most part of installed megawatts of wind energy in its fields. In contrast, Castilla y Leon is not the autonomy with more megawatts for square kilometre because it has a large surface, for this reason, autonomies like Galicia or Navarra have more megawatts for square kilometre

Autonomies	MW installed	Surface (Km2)	kW/Km2
ANDALUCIA	3.030	87.598	34,59
ARAGON	1.737	47.720	36,40
CANARIAS	146	7.447	19,61
CANTABRIA	32	5.321	6,01
CASTILLA Y LEON	4.811	94.225	51,06
CASTILLA-LA MANCHA	3.594	79.462	45,23
CATALUÑA	936	32.113	29,15
CIUDAD DE CEUTA	-	19	-
CIUDAD DE MELILLA	-	13	-
COMUNIDAD DE MADRID	0,1	8.028	0,01
NAVARRA	966	10.390	92,97
COMUNIDAD VALENCIANA	1.087	23.255	46,74
EXTREMADURA	0,02	41.635	0,00
GALICIA	3.279	29.574	110,87
ISLAS BALEARES	4	4.992	0,80
LA RIOJA	446	5.045	88,40
PAIS VASCO	153	7.235	21,15

PRINCIPADO DE ASTURIAS	348	10.604	32,82
REGION DE MURCIA	190	11.313	16,79
SPAIN	20.759	505.989	41,03

Table 1 MW of wind energy installed in Spain by Autonomies

In fact, the wind potential in Castilla y Leon is not really high, due to that the average speed of the winds is not too high, but this community has a continuity in its wind, with many hours of wind each day, and with the new wind turbines which start to work with speeds really lows is possible exploit the power of the wind the mostly part of the year.

2.7 Wind energy potential

2.7.1 Average wind speed

Comparing Spain with other countries of Europe like could be United Kingdom, Denmark or the north area of countries like France, the average wind speed is lower in the most of Spain than in these areas and not all these countries are developing this technology in its fields, so if they start to use the wind energy they will have a large part of it energy cover with this technology.

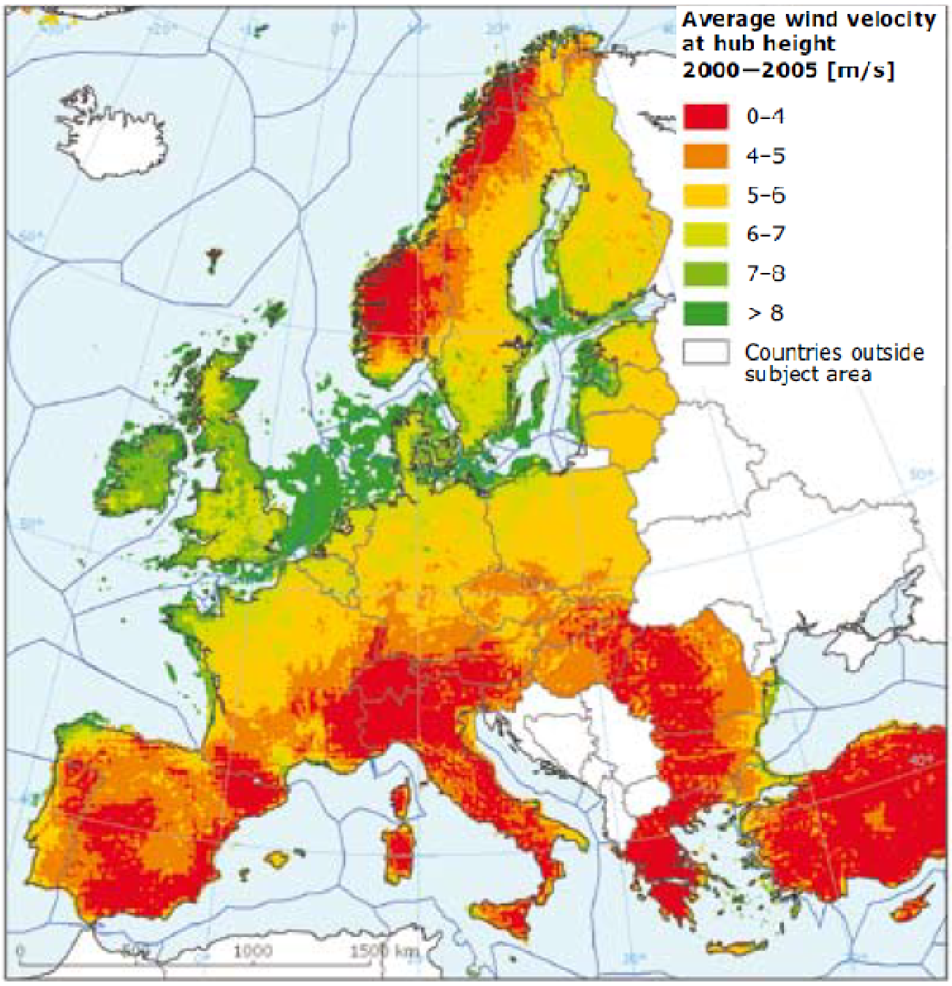

Figure 7 Average wind speed at 80m in Europe

Castilla y Leon is not one of the communities of Spain with higher average speeds in its territory, autonomies like Galicia or Navarra or provinces like Cadiz have more average speed in a large area of its territory as we can see in the follow figure.

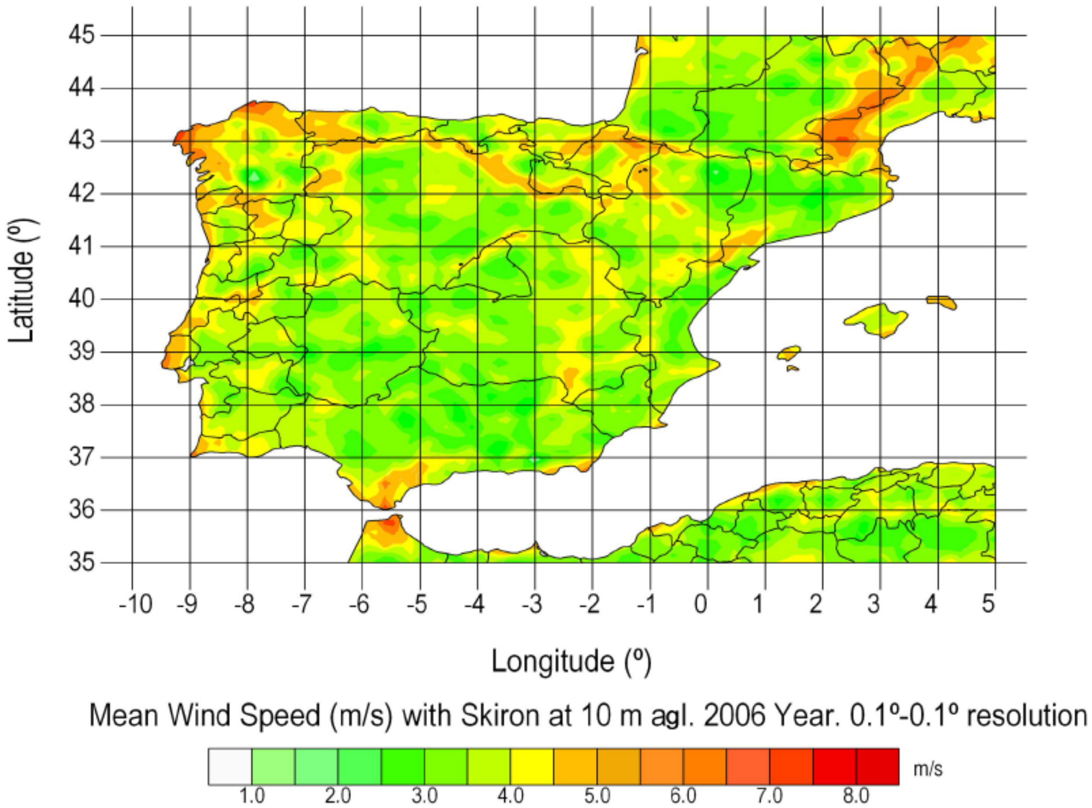

Figure 8 Average wind speed at 10 m in Spain

In the above figure we can also see that Castilla y Leon has large areas with relatively high average speeds, and with the technology that the wind turbines are using today, they could start to work with lower speed as we can see in the following sections.

2.7.2 Power of the wind

The power of the wind is a factor that is quite related with the wind speed because the same mass with more speed makes more power.

The power and the average speed along with the load-hours of the wind are the main data which are necessary contemplate to choice the emplacement of a wind farm. One of the main advantages In Castilla y Leon is it has many load-hour, because as we can see in the following figure of powers or in the previous figure of average speeds exist communities with more potential to construct wind farms but they have not constructed many wind farms like Castilla y Leon.

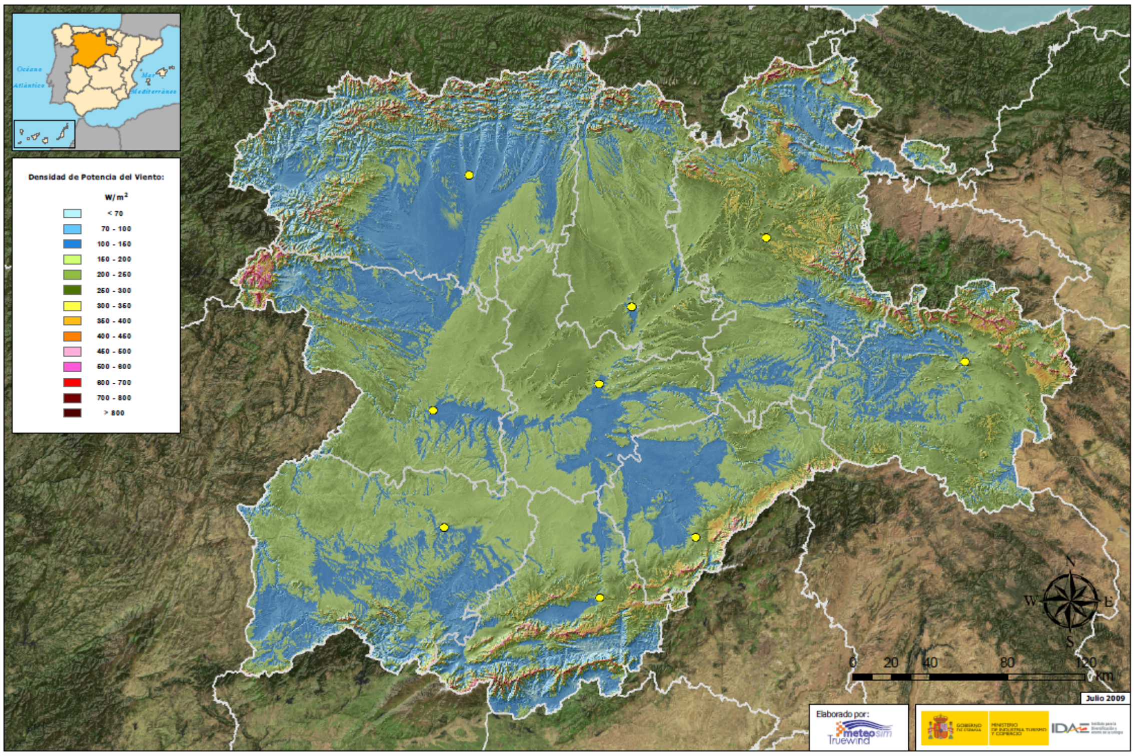

Figure 9 Average wind speed at 80m in Castilla y Leon

Another advantage of Castilla y Leon to construct wind farms is as which is a plateau is quite flat and for this reason the installation costs are cheaper than in mountain terrenes, although as we can see in the map, the more powerful areas are in mountain areas, in the next sections we can see where are situated the wind farms.

2.7.3 Qualities of Wind turbines

Today in Castilla y Leon, wind turbines of many companies are working although mainly the Danish Vestas and the Spanish Gamesa are the turbine manufactures of the most of wind farms. Each one of these have implanted in the area the more versatile model for it adapted its qualities with the wind speed and the power in the area, for example, Gamesa have installed mostly its model GX9 – 2.0MW in different sizes of blade, with rotors of 97, 90, 87 and 80 meter of diameter. On the other hand the most used model of Vestas is the V90 de 1.8 and 2.0 MW and also have 2 turbines of the model with 3 MW each one installed in experimental wind farms.

These wind turbines are a good model to adapt with the characteristics of Castilla y Leon because it has a cut in speed of 4 m/s and a rated speed of 12 m/s (these speeds can change slightly according the model) and as we can see in the figure, Castilla y Leon has a lot of areas with average speeds between 6-6.5 m/s and enough areas between 6.5-7 m/s, so if the wind maintained this speed all the year, the turbines would stop never. Although this is not possible, the truth is that with these average speeds, they get to maintain the optimal speed along much time at the year [5-6].

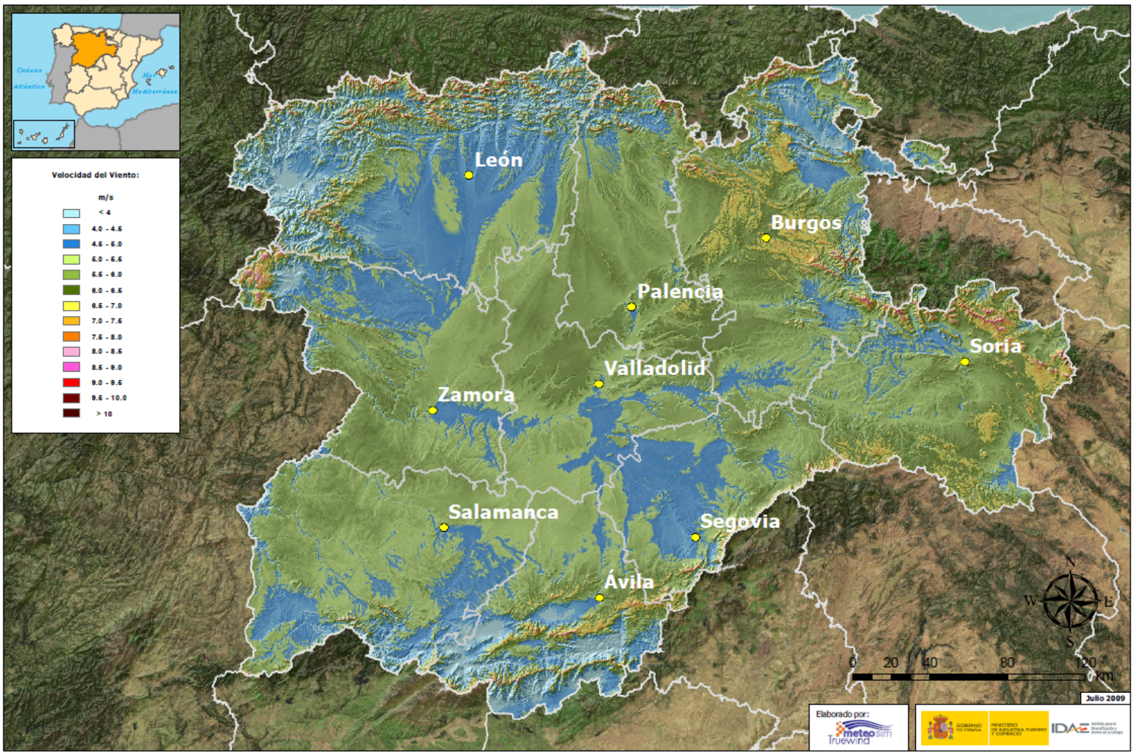

Figure 10 Density of average power at 80 m in Castilla y Leon

3

Overview of some wind energy projects

3.1 Opinion about the current and past situation of wind energy in Castilla y León

Castilla y León is the autonomy community that it has more installed power of all energy sources that are contemplate in the special regime and it also the largest producer of wind energy (4811MW in 2010) is followed by Castilla La-Mancha and Galicia. This wind development has been a success by the form in that Castilla y León has kneed to exploit its wind potential [20].

The wind energy developed in Castilla y León has been regulated by the wind power plan of Castilla y León.

3.1.1 The wind power plan of Castilla y León

The wind power plan was worded by the “Ente Regional de la Energía de Castilla y Leon” at the request of “Junta de Castilla y Leon”; the plan had as objective when it comes into force the following points.

- Exploit the maximum of the energetic potential of the wind that the autonomy has. This is to carefully manage for it developed under the energetic point of view, socioeconomic and environmental.
- Properly Project and conserve the natural resources that can be affected by the implantation of these installations.
- Take part to cover the energy necessities in some place that are underdeveloped and for some utilization using no contaminants energies.
- Promote the economic developed, technologic, and industrial in local and regional level.
- Improve the quality of energetic distribution in Castilla y León [21].

The wind energy is highly developed in Castilla y León due to the wind energy plan mainly. This has been so good for Castilla y León because it has produced an ordered grow of the wind energy.

3.1.2 Small wind energy

Another form of wind energy is the small wind energy. This technology is not used regularly in Castilla y León. In Spain, It is hard to see an American multi-blade windmill for pumping water or a small wind turbine for the electricity production in an isolated house in a rural area.

Castilla y León offers aids for small wind energy as we commented before (2.5) and it is a good form to developed this kind of energy because in isolated areas like it can be small farms with this kind of energy in combination with some another kind of energy (solar, diesel engines) It could build energetically self-sufficient houses and that would avoid the installation of many small distribution networks.

3.2 How improve the situation.

The wind situation in Castilla y León in a short future is not going to be easy because with the economical crisis many aids are decreasing. These aids are decreasing more for the wind energy than for other sources because everyday is energy more rentable and it can make competence to other energy sources as thermal or hydroelectric.

3.2.1 Wind power plan review

The main problem that has the wind energy in Castilla y Leon is that the wind power plan by which the wind farms have been developed in Castilla y Leon in a sustainable and ordered way, respecting natural areas, areas for migratory birds and other things is that the plan has not been updated for twelve years and it is obsolete. This updated is necessary because the technology has changed and now it is possible to install wind farms where before was not productive. The wind power has evolved in another way than it was expected when the plan was wrote and for this reason will be necessary and beneficial for Castilla y León and it good development in wind energy the review this plan. In this way Castilla y León could continue to be one of the world regions with better management of wind power [22].

3.2.2 Special regime

In Spain, it exist a high difference in tariffs and bonus between energies that take part of the special regime group. we comment in the section (2.5) these kind of aids for wind energy but the problem for the wind energy it is the aids for photovoltaic solar energy because these aids are between 5 and 6 times bigger that the other sources (48,8743cent€/kWh regulated tariff for photovoltaic energy at 2012)[18]. Due to this high difference, the government spends a lot of money in solar energy that it is not a productive energy and if all of this money would be used in the other sources of special regime, these would be more profitable. For this reason the government should review the tariffs for all of kinds of regime special energies, and for example adequate the price of the photovoltaic solar energy with the rest of sources and this way the wind power will be more competitive.

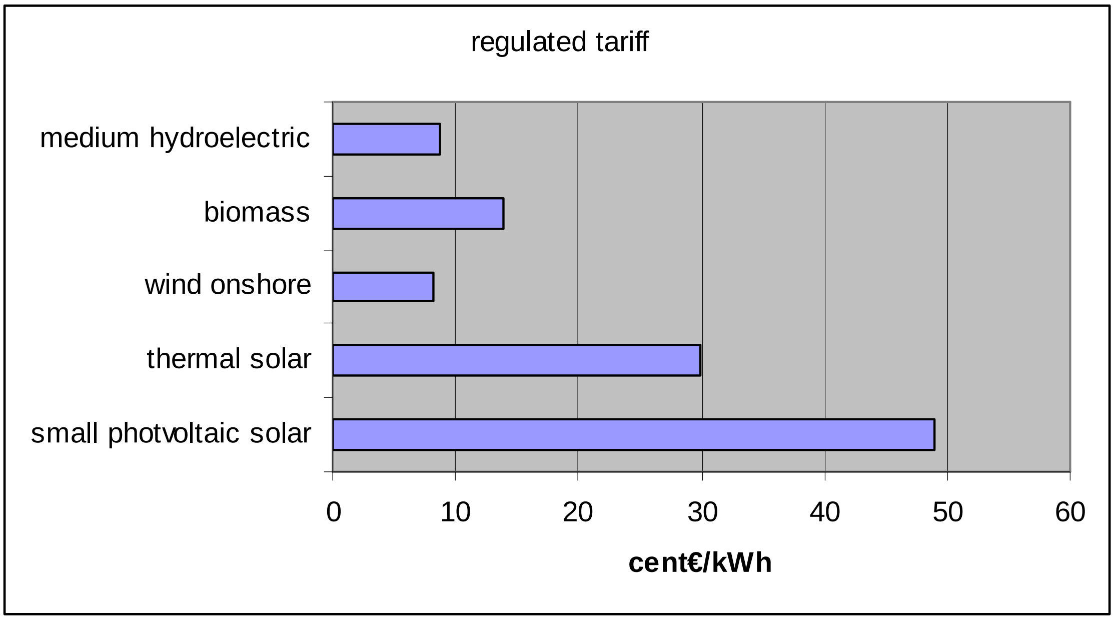

Figure 11 Regulated tariff for different special regime types of energy

3.3 Singular projects

3.3.1 In Castilla y León

3.3.1.1 Experimental wind farms

The govern of Castilla y León through EREN have developed a serial of experimental wind farms since year 2000 that have as objective to certificate the design of the installed models and its power curves, It also studies as affect the connexion of these wind farms to the electrical grid. Today it has 5 wind farms in study:

- "Pozalmuro" experimental wind farm situated in Soria province with one wind turbine of 1.5MW, model BEG MICON NM 64 C of Vestas Company. It started to work at 2001.
- "Dos Picos" experimental wind farm situated in Palencia province with two wind turbines of 800kW each, models MADE AE59 and MADE AE56 of Made Company. It started to work at 2004.
- Experimental wind farm situated in Pías (Zamora) with one wind turbine of 2MW, model Gamesa G80 of Gamesa Company. It started to work at 2002.
- Experimental wind farm situated in Lubián (Zamora) with one wind turbine of 2MW, model Gamesa G87 of Gamesa Company. It started to work at 2004.
- "La Ruya" experimental wind farm situated in Palencia province with one wind turbine of 2MW, model ECOTECNIA 1.670 of Ecotecnia Company. It started to work at 2003[23].

This kind of projects are good for improve the developed of wind energy in Castilla y Leon, and for the next wind farms to be built have the data and information of these experimental wind farms and it serve to choose the appropriate model for get the highest production of the wind farm.

3.3.1.2 "Aeropila" project

Another very interesting Project is the "Aeropila" developed by Besel Company.
The project is a combination between solar(a solar panel) and wind energy (a wind turbine) and the energy produced that is not use is stored in a hydrogen battery through a process of electrolysis, of this way we can have electricity without the fluctuations of the wind and the sun.

Castilla y León should promote projects of research and developed like this because this kind of research will help us for have a planet supplied for renewable energies in the next years. Normally in Spain, it is not common spend much money in R+D and I consider that is very necessary and the national and autonomic government should offer more subventions for this kind of projects [24].

3.3.2 In other parts of the world

3.3.2.1 Edison project in Denmark

Denmark is the country that has best exploited wind energy from all time, it has installed 3,734 MW (2010), 1077MW less than Castilla y Leon but Castilla y Leon has twice of surface. Denmark is the country which has more kilowatts installed per habitant and per surface (0.675 kW per habitant and 86.6 kW per square kilometre in 2010), the 21% of its electric generation come from wind, but due to the wind fluctuations and the variation of electric demand a large part of the wind power is wasted [25]. Denmark exchanged electric energy between Germany and the Nordic countries, importing when they need it and exporting when they have excess. In the last 8 years, West Denmark has exported the 57% of the wind energy produced and East Denmark the 45%. For this reason, Denmark is working in a project to can be more independent of other countries, this project is called Edison and its purpose is to use the electric cars batteries as energy storage when it has excess of wind energy and use the electricity of the cars when the population needs energy [26].

The Project has as objective the large utilization of electric cars and these are used to stock the energy, of this way the penetration of wind energy could be around the 50% of the entire electric system of Denmark. Buy an electric car by a Danish person is not very expensive because it only has the IVA taxation while petrol cars have 180% of the car price plus IVA in taxation and the price of the oil is also very expensive.

Edison project will realize a real-life test on Bornholm, a little Danish island with 40,000 habitants [27].

I think that if this Project Works would be a very interesting project to develop in Castilla y Leon and in this way we will do a more efficient use of the wind power. This is a very ambitious and expensive project, but if it works in the entire Denmark, this will be a option that could generated many benefits and the most important, it would increase the profitability of wind energy that is main problem with this kind of energy, and with this system would be resolved this problem in a large part. In addition it will promote the electric car use.

3.3.2.2 First island in the world supplied with renewable energies

Hierro Island is situated in Canary Islands (Spain). It is the smallest island in this archipelagic with 10,500 habitants and 276 square kilometres of surface and it is developing a pioneer project in the world through which will supply only with renewable energies all the electric necessities of the island.

Today the electric necessities of the island are supplied with a thermal central of diesel-oil with a power of 13 MW and the electricity is transported from the central to the place of use through medium voltage networks (15kV) [28].

The project will construct a wind farm and a pumping hydroelectric central to replace the thermal central that only would be used if the two central systems could not supplied the electric necessities of the island, it can happen if one of the two system do not works for any problem.
The hydraulic central will have 4 turbines with a total of 11.3 MW of power and a net jump of 682 meters that it will be used when the wind farm can not supplied all the electric necessities.

The wind farm will have 5 turbines of 2.3 MW each one and the generated energy will be used to supply the island and the excess of electric energy will be used for pump water from the inferior deposit to the superior of the hydroelectric central, the pumping central will have 16 pumps, 2 of 1.5 MW and 14 of 0.5 MW [29].

This type of combination of renewable energy sources is necessary to produce energy without the petrol necessity, for this reason Castilla y León with a hydroelectric generation of 5,779,298kWh(2009) and with the mountain systems that is surrounded would be another option for combine the wind energy to harness better all the generated energy[12]. Projects like this make to think about the renewable energies and how one region can supply all its electric necessities with renewable energies, for this reason we can think that Castilla y Leon or Spain could supply all its necessities with this kind of energies if it work really hard and spend a lot of money for this purpose.

4

Excel program to replace the nuclear power with wind energy

4.1 Introduction

The wind energy in Spain and Castilla y León is a profitable energy source and it could be more exploited today.

Therefore, we have tried to make a program that helps us to calculate the viability to replace any kind of energy with wind energy. The program has been done replacing nuclear power, but the program could be applied for any kind of energy sources like thermal plants of coal or oil.

This program calculates a basic budget for the quantity of power installed of one kind of energy you want to replace and with this information, we can see the viability of the project that we want to do, only knowing a few figures of the energy that we want to replace.

4.2 Overview

We have tried to make this program a simple and fast way to calculate approximately and in a general way the cost that the total or partial replacement of the nuclear energy with the wind energy in Spain and specially in the Castilla y León community that is the community about we have written in this research.

The used program has been Microsoft Excel 2003 in Spanish version so maybe some functions change lightly respect the English version or for example in the use of the "," or the "." that the use is the contrary. Basically, basic operations such as multiplication and division have been used, but despite of the simplicity, the results are very useful for the Spanish government and its communities, in this case Castilla y León.

The Excel spreadsheet developed for the project is shown in Figure 12 below:

	A	B	C	D	E
1	Substitution of nuclear energy with wind energy				
2	Cells surrounded with a thick black line can be modified to obtain the results infunction to the data.				
3					
4	Nuclear power				
5	Total installed		2000	MW	
6	Total produced		61977	GWh	
7	Wind energy				
8	Total installed		20203	MW	
9	Total produced		50000	GWh	
10	Wind megawatts necessary for one nuclear megawatt		12,5212	WindMW/NuclearMW	
11	Hectares needed per wind megawatt		22,5	Ha/WindMW	
12	What percentage of nuclear power you want to replace per wind energy?				
13			90	% of the total	
14	Nuclear energy that we want to replace				
15			1800	MW	
16	Total wind energy needed				
17			22538	MW	
18	How much of this new wind energy should be installed in castilla y leon?				
19			50	% of the total	
20	Total wind energy installed in castilla y leon				
21			11269	MW	
22					
23					
24		*Territory (m2)*	*New Power Installed (MW)*	*Used Surface (Ha)*	*Used Territory (%)*
25	Spain	504750	22538	507109	1,00
26	Castilla y León	94273	11269	253555	2,69
27				*Spain*	*Castilla y León*
28			*€/kW*	*Millions €*	*Millions €*
29	Electrical Instalation		130	2.930	1.465
30	Civil Engineering Work		120	2.705	1.352
31	Connection		84	1.893	947
32	Wind Turbines		1100	24.792	12.396
33	Promotion		61	1.375	687
34	*Total*			33.695	16.847

Figure 12 Appearance of the program

4.3 Explanation of each cell

The meaning of each cell is explained to understand better the program and in this manner is easier for the user to know the data that he should introduce and get the expected results. At the end of the name of the cells, we have write the name of the cell in this way is easier to recognize the cell in the excel sheet.

The first two cells are about the nuclear power that we have in the country, later we could choose the percentage of this energy that we want to replace for wind energy.

Total installed (C5) – in this cell, we should introduce the nuclear power that there is installed in Spain. This cell can be modified because it is a value that can change during the years when nuclear plants shut down and replaced by other energy sources like in this case we can do with the wind energy.

Total produced (C6) – in this cell, we should introduce the value of the production of nuclear power. this value also can be changed because it is a data that change every years depending of the number of used hours that the nuclear plants have worked that year, for this reason the best it is to have the data actualized to the last year.

The two following cells are practically the same cells that the previous two but these ones correspond to the wind energy.

Total installed (C8) – in this cell, we should introduce the power of the wind energy that there is installed until today in Spain. This one is another variable because every year more wind farms are installed and if the data are current data the results will be more precise.

Total produced (C9) – in this cells, we should introduce the production of electric energy in a year by the wind energy, the year of this figure should be the same of the previous cell (total installed (C8)) if we do not, the results will be wrong.

Wind megawatts necessary for one nuclear megawatt (C10) – this cell is the most complex to understand, as we can see, the same quantity of installed megawatts of the different energies do not generate the same quantity of gigawatts hours produced each year due to that the number of hour that each energy source is working is different, for this reason the nuclear power have a better performance than the wind energy, so we will need to install more megawatts of wind energy that the nuclear megawatts that we want to replace. This cell is automatically calculated with the figures introduced previously.

Hectares needed per wind megawatt (C10) – as the title of the cell says, we should introduce the aerial surface in hectares occupied by each megawatt installed.

In the following cell appears the question “What percentage of nuclear power you want to replace per wind energy?” (C13) so we should simply answer the question introducing in the cell the percentage that we want to replace, this percentage should be a value between 0 and 100.

Nuclear energy that we want to replace (C15) – this cell is automatically generated with the figures previously introduced. Basically, the cell transforms the previously introduced percentage in installed megawatts of nuclear energy that we will replace with wind energy.

Total wind energy needed (C17) – in this cell, the number of megawatts that we should install in wind energy is calculated automatically. So we finally have the number of megawatts that we need to construct in wind energy and in this manner start to work in the budget.

How much of this new wind energy should be installed in Castilla y León? (C19) – The previous data were for Spain in general due to we want to replace the nuclear plants that are working in Spain with wind energy. Therefore, as this project is about Castilla y León, we can choose what percentage of the wind energy we want to install in Castilla y León.

Total wind energy installed in Castilla y Leon (C21) – this cell calculates simply the percentage that we have introduced previously in megawatts of wind energy to install.

Territory (m2) (B25:B26) – in the next section of the table, we should introduce the surface of Spain and the surface of Castilla y León in Square kilometres as indicated in the title of the cell. The cell can be changed only if we want to change the country or the autonomy and get other results.

New Power Installed (MW) (C25:C26) – in this section only is shown the power that we want to install that have been calculated previously.

Used Surface (Ha) (D25:D26) – in this section is calculated the number of necessary hectares for the installation of these wind turbines; this result is given in hectares.

Used Territory (%) (E25:E26) – here, the program give us the result for the total surface percentage of Spain or Castilla y León that would be used with the installation of all of this wind farms.

The following table is an economic Budget of the installation costs to install the megawatts of wind energy that the program has calculated previously. This table divides the budget in 5 main parts that usually the wind farms are divided to show the budget in a general way.

- Electric installation (C29:E29)
- Civil engineering work (C30:E30)
- Installation (C31:E31)
- Wind turbines (C32:E32)
- Promotion (C33:E33)

Here, the only that we need to do is to introduce the approximated price that usually is spend to make this work or to get this material, this price should be introduced in Euros per each installed kilowatt and then automatically the program will create the following two columns with the Budget to Spain and Castilla y León.

4.4 Working

The working of the program is very simple, we introduce the figures in the cells that are rounded in Black with the data that we have described in the previous section and the program automatically calculate the Budget and the needed surface for the replace of the wanted quantity of nuclear power.

Once we have introduced all the data that the program asks us, this program does a chain of simple mathematical calculations to calculate the results. In this section we explain these calculations.

The cell “Wind megawatts necessaries for one nuclear megawatt” is calculated dividing the gigawatts of the production of nuclear power over the installed megawatts, this is divided over the division between the gigawatts of the production of wind energy and the megawatts installed of this energy.

C10 = (C6/C5)/(C9/C8)

The cell “Nuclear energy that we want to replace” is calculated multiplying the installed megawatts of nuclear power by the percentage that we have selected in the C13 cell and dividing by 100 to eliminate the percentage

C15 = C5*C13/100

The cell “Total wind energy needed” is calculated multiplying the value of nuclear megawatts (C15 cell) by the proportion between wind megawatts and nuclear megawatts and in this way the megawatts of wind energy that we need to install are calculated.

C17 = C15*C10

The cell “Total wind energy installed in Castilla y León” has been calculated multiplying the total wind energy that we need by the percentage of wind power that we want to install in Castilla y León and then dividing by 100 to eliminate the percentage.

C21 = C17*C19/100

The two cells “Used Surface (Ha)” have been calculated multiplying land occupied by one installed megawatt in hectares, by the number of megawatts that will be installed in Spain or Castilla y León.

D25 = C25*$C$11
D26 = C25*$C$11

The two cells “Used Territory (%)” have been calculated dividing the “used surface” by the territory of Spain and Castilla y León multiplied by one hundred to express it from square kilometres to hectares and all of this multiplied by one hundred to eliminate the percentage.

E25 = D25/(B25*100)*100
E26 = D26/(B25*100)*100

The following ten cells are all practically the same operation. These cells are multiplying the price per each kilowatt of work or material (electric installation, civil engineering work, installation, wind turbines, promotion) by the installed megawatts in Spain or in Castilla y León and then, all of these cells are divided by one thousand for that the results are in correct unity system, multiplying by one thousand to pass to kilowatts and then to divided by one million to express in millions of Euros.

D29 = C29*$C$25/1000
D30 = C30*$C$25/1000
D31 = C31*$C$25/1000
D32 = C32*$C$25/1000
D33 = C33*$C$25/1000
E29 = C29*$C$26/1000
E30 = C30*$C$26/1000
E31 = C31*$C$26/1000
E32 = C32*$C$26/1000

E33 = C33*$C$26/1000

In these two “total” cells one for Spain and the other one for Castilla y León have been added the previous partial budgets and in this way we have obtained the total budgets.

D34 = SUMA(D29:D33)
E34 = SUMA(E29:E33)

4.5 Other applications

This simple program can have other many applications making simple modifications of the program.

The more simple modification would be to use the same program but for another autonomic community and it would work with only changing the surface of the territory and the name. It also would be easy to use with other countries and regions that want to know an approximate budget of the cost to replace the nuclear energy; it would be only introducing an easy data to get.
The program also could be used to replace another kind of unwanted energy today as thermal plants of coal or oil and we also can change the energy with that we replace the unwanted energy, this energy could be any other renewable energy different of wind energy like solar energy, hydroelectric energy or the energy obtained with the power of the waves. The changes that we need to do for this application would be bigger but in any case they would be simple.

Another very simple change, it is the currency exchange, and we need to change the prices from Euros to sterling pound or American dollar, for example.

Therefore we can see that this program is simple and easy to use but it is very versatile and it can help us to get fast budgets and if we introduce real values, we will get really good results.

All the figures that have been calculated in the section 5.2 have been calculated with this program using real figures obtained in official web sites of Spain and similar to the data used by the companies today for its statistics and budgets.

5

Substitution of nuclear energy with wind energy

5.1 The nuclear energy in Spain today

In the year 2010, the production of electricity through nuclear energy in Spain was of 61977 GWh, this is equivalent to 20.61% of the production. The nuclear is the second source in electricity production behind of natural gas (31.71%) y in third place is the wind energy (14.56%). In terms of primary energy, the nuclear is the third producer with 12.23% behind the oil and natural gas, in primary energy terms the wind energy only produce the 2.85% of the total [30-31].

The nuclear energy has many advantages like abundance of fuel, low cost of the production, non-emission of CO2, an operation around 8000 hours each year. However, the main disadvantage of the nuclear energy is the production of radioactive waste and as it is known these waste are very dangerous for the health and it is not known how many years is the duration of the radioactivity, for this reason treatment of these waste should be very careful and safe. The radioactivity of this energy is the reason why the people want that this energy is eliminated. In Spain this energy suffers a construction moratorium since 1984 and today with the liberalization of the electric sector would be possible the construction, but would be very difficult to get all the permissions and licenses [32-33].

In Spain the nuclear energy is 7641 MW installed that mean that the nuclear energy is only the 37% of total wind energy installed (20203 MW) but the nuclear produces 41% more electricity than the wind energy [34]. Through these data, we can see that the main disadvantage of the wind energy is its relatively low operation period. In Spain, a wind turbine operates each year around 2500 hour [35].

5.2 The cost of nuclear energy

The study that we have realized for the possible substitution of the nuclear energy through the wind energy in Spain and concretely in Castilla y León has been realized using approximations and estimations for the price and surface for megawatt installed and for the megawatts that are necessary to install. This study has for objective to get the economic cost of the substitution of the nuclear energy and the surface that we need to can install all of these wind farms.

Obviously the approximations have been realized without to think in that the wind is an energy source that is not available during the entire day because it is random and depends of the wind. For this reason, to substitute the nuclear energy in a 100%, thermal plants, hydroelectric energy and other sources should be used combined to supply the electric demand in the moments when the wind energy can not provide the demand because of the lack of winds.

The main data used have been the electric production through nuclear energy in 2010 (61977 GWh) and 7641 MW installed, the production of wind energy was 43784 GWh with 20203 MW installed. Therefore if these regimes of production are maintained with the available megawatts we obtain that it is necessary the installation of new 28598 MW of wind energy to cover the 20.61% of the production of nuclear power in 2010. 28598 MW are the 141.55% of the wind power installed today so the inversion that will be necessary to install all of these megawatts will be very important [30-31, 34].

Castilla y León has installed the 23.23% of total of wind energy in Spain, hence for this study have been supposed that Castilla y Leon would maintain the percentage of wind power installed so it should be constructed 6643 MW[31]. The budget has been calculated using the average cost per megawatt in the areas of electrical installation, civil engineering work, connection, wind turbines and promotion. The price of the wind turbines have been calculated through the price of the most installed wind turbine in Castilla y León and also in Spain today, the turbine of 2 megawatts. In the table below we can observe these budgets for Spain and Castilla y Leon [36].

		Spain	*Castilla y León*
	€/kW	*Millions €*	*Millions €*
Electrical Instalation	130	3.718	864
Civil Engineering Work	120	3.432	797
Connection	84	2.402	558
Wind Turbines (2MW)	1100	31.458	7.307
Promotion	61	1.744	405
Total		42.754	9.931

Table 2 The cost of the nuclear energy

As we can see the complete disappearance of nuclear energy in Spain would have a very high cost, and if Castilla y León continued maintaining the percentage of installed power it would be an inversion of 10,000 millions of euros approximately.

To calculate the surface that we would need for the construction of 10,000 MW, we need to know how many hectares are needed approximately for each megawatt. A wind farm of standard extension and with 40 MW using wind turbines of 2 MW usually use a surface of 700-900 hectares, so if we realize the calculations for the most unfavourable situation, 900 Ha for each 40MW, a megawatt will occupy approximately 22.5 hectares.

Accordingly if we extrapolate the data for the megawatts that we need to install we will get that it is necessary to use 149468 Ha of surface in Castilla y León. Castilla y Leon has a surface of 94273 square meters, so the surface use for the wind farms installed to substitute the nuclear power will be 1.58% of the Castilla y León territory [37].

	Territory (m2)	*New Power Installed (MW)*	*Used Surface (Ha)*	***Used Territory (%)***
Spain	504750	28598	643455	1,27
Castilla y León	94273	6643	149468	1,59

Table 3 Used territory by new wind power installed

5.3 How to cover the peaks and valleys in demand

It is obviously that the energy demand by the users is not the same at the morning that at the night or in a Tuesday or a Sunday, on the other hand it is also obviously that not every day of the year the wind is the same, and the wind has not the same peaks and valleys of production that the electric demand can have and these are not even similar.

For the reason that previously shown, the calculations made in the section before would be well only if the demand and the generation were constants, but as we can see in the picture shown bellow, the demand is quite periodic and more or less it is possible to foresee the energy consumption with enough time to activate emergency systems as we can see in the other picture.

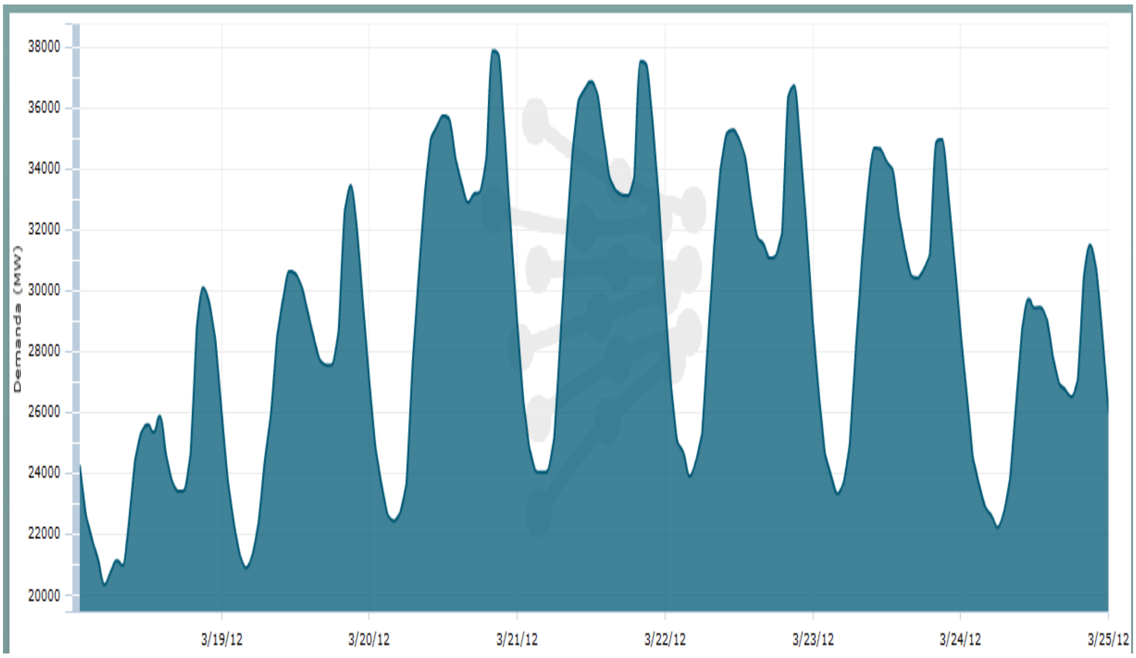

Figure 13 Demand of energy during a week.

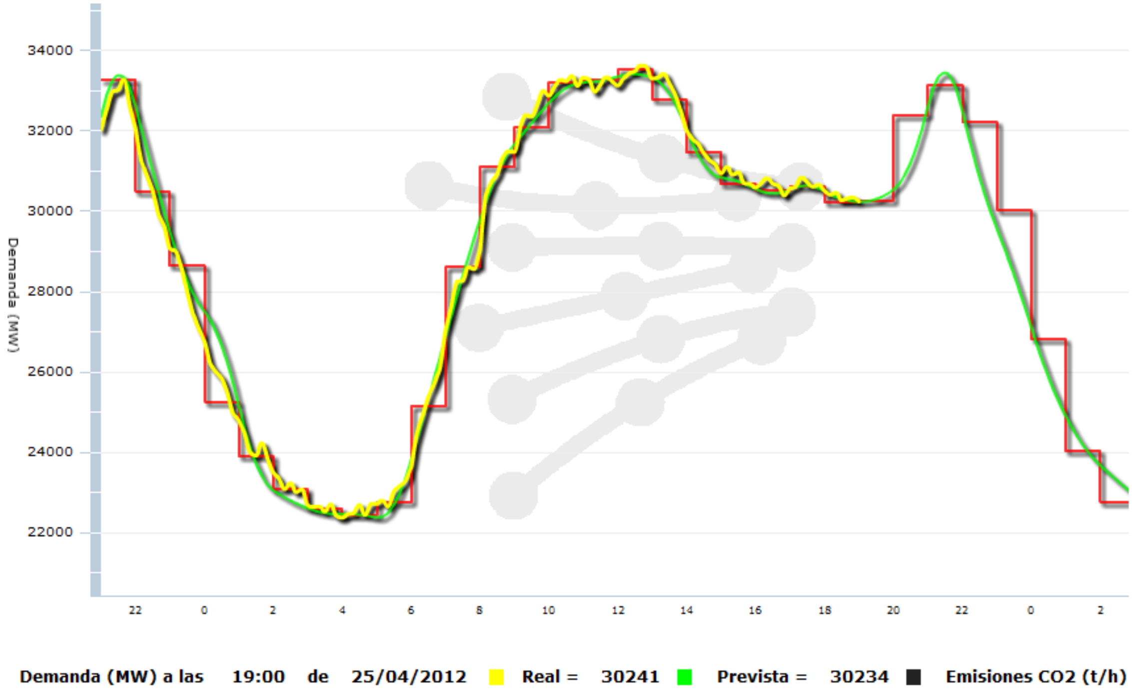

Figure 14 Demand in real time (yellow) with the prevision (green)

Therefore, having knowledge with enough time about how much the electric demand is going to be used in each moment, the idea is to cover the peaks and valleys with the building of pump hydroelectric plants as we can see the example in the isle of Hierro (see section 3.3.2.2), the pumped of the water to make work the hydroelectric plants would be with the extra generation of electricity with wind energy. Castilla y León is surrounded by mountain ranges, that are where the wind farms are installed and the hydroelectric plants could be installed there. The wind farms and the hydroelectric plants are installed in the same areas and this is good because this could be used to expend less money in access for machinery and electrical network.

The installation of pumped hydroelectric plants, the current thermal plants and other renewable energies would help to support the wind energy and to exploit all its potential. If all the communities make an effort with the renewable energies, Spain will be a Spain without nuclear power and therefore, a Spain energetically cleaner.

6

Conclusion and future work

During this work about the wind energy in Castilla y León, we have verified the current state of this energy in this community and we have compared this state with the state of other communities and regions. We have also written about the future perspectives of this energy in Castilla y León, the approximated costs of replace the nuclear power with wind energy. Other interesting themes we have written have been the possible developed of wind energy in Castilla y León in an efficient way and respected with environment.

The main conclusion we can obtain once made this project is that wind energy is a profitable renewable energy and for this reason is necessary to continue using this energy in this region; in addition Castilla y León has an appropriate wind for this energy in a large areas of its territory. For this reason, the autonomous government and the state government should continue supporting this energy for that companies continue to build wind farms and in this way will increase the developed of this region, this develop is bigger in rural areas because the wind farms are being built there. The wind farms in rural areas are very profitable for these zones because today these areas are forgotten for the governments and anyone invert money in these zones.

Another conclusion is that Castilla y León with the big developed that it has of this kind of energy should investigate and invert more money to develop this energy and for that each day is more efficient and profitable. For these causes, in the future, Castilla y León should initiate some projects of R&D and other risky projects as is the project that is being developed in Denmark and we described briefly in 3.3.2.1 section.

Finally, we know that the petrol is not infinite and sooner or later the petrol will be unavailable and for this reason, we can not mainly depend of one energy source. The second reason because we should substitute the petrol is for the climate change and the greenhouse effect ,that as we know, the CO_2 is the main gas in cause this effect and it is produced in the combustions, for example in a thermal plant or in a petrol car. Mainly for these two reasons, we should try to develop other energy sources like wind energy, solar or another type.

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AN ANALYSIS OF
THE CURRENT AND FUTURE PROSPECTS
OF
WIND ENERGY IN CASTILLA Y LEON

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PRELIMINARY REPORT

Introduction

Nowadays, the wind energy is one of the most profitability renewable energy sources and one of the most constructed in the entire world. Every year, new and current technologies are developed or improved, so we can generate more energy with the same wind force that makes your profitability is better every year.

This kind of energy has used during more than twenty five years in Spain, and how Spain has optimal conditions for use of this energy, each year, more megawatts of wind energy are installed and nowadays, it is the most important renewable energy source in Spain.

One of communities that more has committed in this energy has been Castilla y León, this is the community with more power installed with 4,804 MW installed in beginning of 2011[1]. And each year, including the crisis problems, these data are increasing though less than 5 or 6 years ago.

Castilla y León's location, in north sub-plateau of Spain, makes that large number of wind farms can be situated in these fields and mountains.

Aims and Objectives

To assess the current state of wind energy provision in Castilla y Leon and to evaluate its prospects in the next 5 to 10 years. This information will be separated in 4 main blocks.

To compare the level of consume of wind energy with other kinds of energy in Castilla y León. This comparison will be done under the point of view of wind energy like a renewable energy, comparing with other forms of renewable energy in Castilla y León. And also, comparing the wind energy with all energy sources, like can be thermal or nuclear energy.

The wind energy is not the definitive energy source. We need other support sources because if there is not wind, we will not have energy for ours necessities. Combining wind energy with other kinds of alternative energy like solar or hydroelectric energy in the suitable measure will do we can get a sustainable electric supply system and this will be environmentally friendly for the Castilla y León's community.

Under the economic point of view, how cost effective is wind energy, the cost to produce one megawatt, time to amortize the installation and all of this compared with other energy sources used in Castilla y León like coal, hydroelectricity, oil etc.

What the steps are that Castilla y León should make to continue developing wind energy and how we can take advantage on all the potential that the wind have in this community.

Methodology

Desk based research of wind energy provision in Castilla y Leon, so to can complete all proposal objectives of the best possible way. There will also be searching for information about other sources of energy to make comparisons with wind energy.

Comparison of the provision of wind energy to other forms of renewable and conventional energy sources. This we can do it with all the information we have compiled about wind energy and other energy sources in Castilla y León

Based on current energy provision, and expected demand in the next 5 to 10 years, develop and evaluate scenario models of wind energy provision using appropriate software (MATLAB or Excel).

Obstacles

The main obstacle will be that a large parte of information that I will utilize it will be in Spanish, so I will need to translate a lot of technical texts.

Another obstacle will be that to get information for graphics and tables will be necessary to obtain information of many sources because it is necessary to search information about many kinds of energy, and each kind of energy is administered by different organisms.

Current situation

Nowadays, the developed of wind energy in Castilla y León is highly developed, with 4,804 MW accumulated is the community that more accumulated power have installed followed by Castilla La-Mancha and Galicia with 3,709 and 3289 MW respectively. It also was the autonomy that more power installed, 917 MW, nearly tripling the second one in the list, Catalonia with 327 MW [1].

Castilla y León has in total, 196 constructed wind farms and other 112 in constructed or administrative process, so we can think that these data will increase in the next years despite the crisis [2-4].

In 2010, Castilla y León produced 8361 MWh with the entire wind farms installed in this autonomy and it consumed a total of 12607 MWh in the same period of time [5]. The produced energy for all the renewable energy sources duplicate the consumed energy, so the half of the renewable energy produced in Castilla y León is consumed by other autonomies of Spain.

The renewable energy 2011-2020 plan has for objective that for 2020 the 20% of consumed energy in Spain come from renewable sources [6]. Therefore, it will be necessary continue to invest in alternative sources considering that in 2009, consumption of renewable energies was 11.1% [7].

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			Week 01	Week 02	Week 03	Week 04	Week 05	Week 06	Week 07	Week 08	Week 09	Week 10	Week 11	Week 12	Week 13	Week 14	Week 15	Week 16	Week 17
Proposal project	Week 01	Week 01																	
Preliminary report	Week 02	Week 03																	
Literary review	Week 03	Week 08																	
Research	Week 04	Week 08																	
Write introducction	Week 05	Week 07																	
Develop charts	Week 07	Week 10																	
Interim report	Week 09	Week 09																	
Writting report	Week 06	Week 14																	
Proof reading	Week 15	Week 16																	
Final hand	Week 17	Week 17																	