# Renewable Energy: Impacts upon the Environment, Economy and Society

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***Abstract*—This paper presents the relationship among energy, economy and society. It discusses about the development of societies and energy; energy and structure of societies. It also characterized the environmental impacts from the use of energy sources derived from fossil and renewable resources. Human evolution is closely linked to energy, since the beginning of time man has to know it and seeking it ever more on the environment. He began to enjoy and benefit from its potential fossil and renewable resources. It is discussed the environmental impacts from energy production and utilization, contribution to greenhouse gases and other pollutants emissions. The use of more efficient technologies, along with the application of sustainable energy policies has contributed to a general reduction in the intensity of $CO_2$ emissions by energy production and consumption.**

***Index Terms*—Energy, Economy, Society, Environment, Relationship.**

## I. Introduction

Over the centuries, man has used energy from many sources to meet their food needs, housing, transportation, health and improve their living conditions. The two main sources of energy, the sun and nuclear fission, and their relative abundances, influenced and still do in the current human activities. As alternating forms of social grouping of men, so too would be changing the use of energy resources. The primitive savages who hunted and collectively, their food in nature depended primarily on their own energy. Today in much of the world population is able to resort to fossil fuels, but also in developing countries makes the use of animal power, human strength and wood fuel [1].

Whatever type of energy used, the man always had to expend energy to meet their survival needs. Vast supplies of fossil energy allowed countering the increase in population. Birth rates remain high while the reserves of energy, especially fossil fuels are declining. That's how we look to the future, when the world population to be served has nearly doubled compared to the present day. We are concerned to know what strategies can be applied to meet a demand for energy increased so tremendously.

Before we can draw up plans to introduce greater efficiency and renewable energies in the current energy matrix, it becomes necessary to gather much information about the costs of energy used in different processing systems for the production and distribution of goods essential for survival of mankind. Such costs must be brought into confrontation with the energy supplies that would be available. Accordingly, this paper is to explore the interdependencies between energy, economy and their impacts on society. It is my hope that such analysis as a basis for understanding the context and that in fact the economic process in any society defines the profile of energy production and consumption, as well as its impact on society as a whole.

## II. Development of Societies and Energy

Societies throughout history of mankind in order to ensure their basic survival needs - food and health, housing and safety - always found itself closely linked to energy supply, so the energy in all its forms is part of their own nature of man. Along this route, man has used energy from many sources. Starting with your own energy and sunlight (solar energy), then passed to the wood fuel, animal traction, force of water and wind. Later it was developed into power of machines powered by wood, coal, oil and nuclear energy. The man power used to modify or manipulate the land, water, plants and animals in order to provide himself food, clothing and shelter materials. Discover, control and use power forward took the man's primitive life to a stable civilized. Man is the only animal capable of thinking creatively and using science and technology, getting benefits from energy and other environmental resources.

Energy is also used to control disease organisms; to obtain and purify and store water, to produce antibiotics and other chemical drugs, and to implement various public health measures. Although public health is an aspect of security, is both to stability are also associated with the protection of men among themselves, a group of people against the actions of other rival groups. Social harmony depends not only on the rules set by governments but also the efficiency of police and

Manuscript received September 20, 2011. This work was supported in part by the State Government of Maranhão through Foundation for Research and Technological and Scientific Development of Maranhão (FAPEMA) – Brazil under PhD scholarship (BD-00007/08) and Economics Department of University of Aveiro.

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military forces used to enforce the law. Both governments and police forces and military spend enormous amounts of energy. In so-called "civilized societies" of developed nations in the world today, the amount of energy used by the government and police and military forces is significantly higher than that used to grow food for the population governed [2].

The availability of surplus energy enables the man creates more complex structures that the first hunter-gatherers. The present state of utilization of energy resources represents a dramatic change in relation to that one of a recent past in the search for adequate food was the main concern of the man and ran their activities. According to White [3] the evolution of man can be broken down into three main stages: (1) population "wild" in the hunter-gatherers who lived from natural feeding, (2) population "barbaric, primitive agricultural and pastoral societies and (3) "civilization", the development of machines and intensive use of fossil energy to produce food and other useful items. These steps are all related to changes in supplies of energy used by man. White [3] considered that *"this would have stayed indefinitely at the level of savagery if I had not learned the amount of power under his control"*. This includes the total amount of energy controlled by man and the surplus energy that he has higher than necessary to meet the essential needs of food, clothing, shelter and health.

Energy use has accommodated the modern society in such way that societies with little access to energy resources present consequently lower evolutions than for other societies that have increased access to energy. Countries located in continents like Africa, have very low rates of energy consumption, but the poverty rate is high due to lack of technology supported by strong energy sources. With the lack of energy the Government weakens and impoverishes society. Given the continued dependence of man on energy, and knowing perfectly fits an overall historical society constantly seek new outlets for production, without which you cannot get a strong, competitive economy [4].

It may be noted that currently, at what humankind has done and continues to do in pursuit of energy kind. We highlight here the oil, which continues to keep wars. Countries seek power over that coveted energy potential, which is able to influence society in such way that moves a country and makes the mankind drives through essential principles for harmony between peoples. It is also evident that so-called developed countries are those with greater energy consumption, this because they need energy to keep all their energy potential and technology, it can be noted by observing that countries like the United States and much of Europe where energy consumption is very high, thus causing pollution indexes thunderous. However, we can highlight concerns about the relentless pursuit of energy, a quest that will surely come to an end.

The government assumes leading role in the development of each society, and must provide access for the whole society to energy resources, acting as a valve which regulates how much and how to use energy resources, which cannot be neglected, governments can fulfill its role of accessibility to all energy forms becomes a major factor for the evolution of a society, but that does not fulfill that role will eventually contain the development of its population in addition to harming the environment [5]. Energy is essential for the development of any society. Given the constantly evolving experience that is in modern society and knowing that it is highly linked with this indestructible goods called energy, should be imposed on society information about the rational use and respect the environment, from which it is extracted, so that we do not achieve results in the formation of a harmful at all, thus implying the reverse evolution [6].

## III. THE ENERGY AND STRUCTURE OF SOCIETIES

The hunting-gathering societies were small, rarely more than 500 individuals and were simple. As the demand for food and shelter was time consuming and a lot of energy, almost there were no other individual and collective activities. However, with the development of agriculture, became available larger amounts of food, fiber and energy surplus. Concurrently, there are, in human societies, the greater interdependence among people and more incentives to increase productivity [7], [8], [9]. This factor was also important the fact that, as they increase their output of food, also increased the stability of food supplies. Companies once forced to be nomads to monitor their food supply has improved with regard to safety and permanence. Even in primitive agricultural societies, food production was still the principal activity of man and as a consequence, their social interaction remained relatively narrow. The introduction of animal draft power in crop production released greater amounts of time and energy of man. This surplus of energy and more time allowed the man to participate in several new activities, which led to making more complex social systems.

The water wheel and windmill added new forms of energy to those who initially had used the man in their production processes, particularly in the food production system. Now, instead of using draft animals whose feed and care require energy, man resorted to force of the water and wind. With this change, the man was to have more power at less cost (calculated in terms of human energy expenditure) than in the past. Thus, the amount of surplus energy available to the society was largely increased.

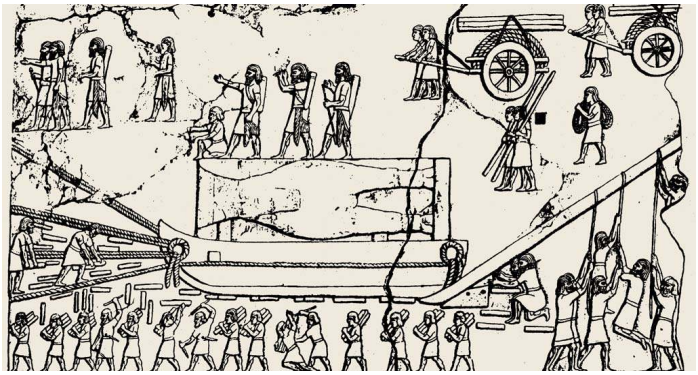

Fig.1. Transport of solid stone monument in 660 bC. [10]

The invention of the steam engine was a highly significant milestone in energy use, as marking the beginning of the use of fossil fuels as primary energy source. This machine, and later those who used coal and liquid fuels, has given the man an

immense power to control their environment and change the whole economic structure, political and social society, while there is greater stability and expertise of work.

The society´s structure of the first hunter-gatherers was minimal. At most, a boss or a group of elderly people ran the camping or village. Most of these leaders were forced to hunt and collect together with other members, because they were scarce surplus food and other vital resources to allow it work at all times a chief or a village council. The agricultural development has altered this pattern of work monotypic. The primitive family farm could reap 30 to 10 kg of grain per kg sown. Part of this surplus food/energy was returned to the community and ensured the maintenance of non-farmers, such as chiefs or village councils, doctors, priests and even warriors. The non-farmers in those primitive societies assumed the government and ensured the stability and security to the farmer population, so that could increase the surplus of food production/energy [11], [2].

Under favorable conditions in agriculture and improving agricultural technology began to obtain considerable energy surplus and as a result, there have been major population groups or even cities. With the population concentration in larger cities, appeared the specialization of tasks. Specialists such as masons, carpenters, blacksmiths, merchants, traders and sailors, proved more efficient than the non-experts. Goods and services provided by artisans-technologists have determined an improved quality of life, a higher standard of living and, for most societies, an increased stability.

Egypt, during the reign of the Pharaohs, is a striking example of a primitive society that had environmental resources in favor of establishing a stable agriculture, which created an efficient agricultural technology. The Nile brought water to the cultivated land and valuable nutrients, which replaced those crops of cereals and other products taken from the soil. Thanks to its periodic flooding, the Nile deposited nutrient-rich sludge to arable land, which thus remained productive. He was also a source of water for irrigation trustworthy. Furthermore, and with equal importance, had to consider the hot climate of Egypt is highly conducive to agricultural production. This productive agricultural system sustains 95% of Egypt's population directly involved in agriculture, and provided enough surplus food/energy to keep 5% of population that does not worked in agriculture. To sustain the small ruling class, a relatively small quantity of food energy was enough. The naturally isolated location of Egypt ensured protection against intrusions without requiring large expenditures to sustain a military class. Consequently, the 5% of the population engaged in agriculture were not used by the Pharaohs as slave labor to build pyramids and storing these goods and materials for a life that, according to the Egyptians believed would follow the life on Earth [2].

Throughout this period, the Egyptian population has remained relatively constant because of demand made by the heads. Once the men were in excess sufficiently capable to work were used to build the pyramids. These men were forced to perform many hours of hard work and were literally “used until death "during a period of a few years of slave labor. When they died, were replaced by new elements selected from among the redundant workers. All this was done without compromising the fundamental agricultural system that required the efforts of almost all the Egyptian people. During the age of the Pharaohs, which occupied the years from 2780 to 1625 b.C., Egypt had a population of about 3 million, far less than the 38 million nowadays. An excess energy of 5% in about 3 million people is not much. In per capita basis of 100-150 kcal[1] per day, equivalent to 10-15 kg of wheat per person per year. In relation to 3 million, the total reaches 30-40 x 106 kg of wheat per year surplus [11], [2].

The construction of the pyramid of Cheops over 20 years has used an amount of energy that equaled the surplus energy produced during the life of about 3 million Egyptians. During the construction period, the labor force was applied to some 100,000 slaves per year. Assigning each slave 300 to 400 kg of food per year, the total cost would have been 30-45 x 106 kg, or the whole of the surplus food/energy from agriculture in Egypt. In later periods of Egyptian history, similar levels were used to maintain large military forces that won some of the neighboring countries of Egypt. These military operations have provided some additional land and food and often conquered peoples were brought to Egypt as slaves. However, long distances in desert regions that the Egyptian troops were forced to travel and limited supply of these military operations. It was necessary to spend large amounts of energy only to protect the roads and transport military supplies.

On other occasions, when the population increased greatly in relation to land resources and agriculture, there is no longer in Egypt surplus agricultural resources. Under these conditions on overcrowding and failure instead of surpluses, the Egyptian society was only able to sustain itself. Sometimes, under these pressure conditions, there were civil wars and social problems. Such conditions often led to declines in effective population size, since those societies were not productive either unstable in agriculture and in other essential activities.

Thus, the primitive history of Egypt is an excellent example of the role that energy, measured in surplus food/energy, played in the structure and activities of a primitive society. Although the structures of the societies of today are much more complex, the energy continues to be an important factor in the development of mankind. Humanity will have to adapt and find new energy potential, as it did throughout its history. New energies come exhaustible or not, clean or not, but they will be distributed equally? It does not help the vast energy production if the same will not be distributed and enjoyed by all people equally.

## IV. Energy and Environmental Impacts

The production and use of energy have environmental and social consequences locally, regionally and globally. These

[1] Historically, the definition of a calorie was a quantity of heat required to increase by 1 degree Celsius temperature of 1 gram of water. With the development of measurement technique, it was found that the specific heat was not constant with temperature. So we tried to standardize it to a narrow range and calorie was then redefined as the heat exchanged when the mass of one gram of water from 14.5°C to 15.5°C. A kcal is the amount of energy required to increase up by 1 degree Celsius temperature of 1 kilogram (kg) (equivalent to 1 litter) of water. Thermodynamics: An Engineering Approach, 5th edition by Yunus A. Çengel and Michael A. Boles.

impacts are spread over the lifetime of a system of energy based on fossil resources and can manifest itself in a shorter time scale, medium or long term. Proper assessment of these impacts and their inclusion in decision-making process on energy is a key to ensuring a sustainable energy sector [12]. Local impacts, although affecting a small group of people can be extremely important, especially if involving occupational diseases and accidents affecting workers or members of the public. Local impacts are also more relevant to renewable technologies. For example, concern over the development of wind farms typically refers to visual intrusion on landscape and noise emissions [13]. However, large thermal power plants or renewable energy or fossil fuels also can have adverse effects on local resources related to excessive consumption of water, soil and groundwater pollution, or deforestation. The sustainable energy strategies of the plan of the United Nations Development Program (UNDP) presented some examples of regional impacts related to energy production, such as acid deposition, habitat destruction, large-scale displacement of people due to construction and operation of projects large hydroelectric or radiation due to accidents at nuclear power plants [12]. Globally, the link between energy and the effects of global warming around the world is documented. Other relevant global impacts include loss of biodiversity and land degradation.

The European Commission [12] states that impacts should be evaluated over their lifetimes. Although EC presents uncertainties for the long term impacts such as global warming or high level radioactive waste disposal. Likewise, Weisser [14] recalls that in economies where the carbon has a fixed price or emissions of greenhouse gases (GHGs), embarrassed, do not respond adequately to GHG emissions in the life cycle in the production of electricity, can be advantage for transnational technologies, which makes the accounting for significant emissions within the lifecycle of a project outside the boundaries of laws and policies to mitigate greenhouse gases.

This section examines the impacts of different electricity generation technologies based on literature review. Section *A* focuses on the close relationship between energy and environment, detailing trends in $CO2$[2] emissions from the consumption of primary energy and electricity generation activities, outlined in the Kyoto Protocol and European Union regulatory in promoting environmental performance in the energy sector. The impacts of the activity of electricity production are described in section *B* for both fossil fuels and the main renewable energy technologies. This section discusses in detail the environmental and social impacts of hydroelectric, biomass and wind energy technologies, discusses the effects of integration on the electrical system and discusses the social acceptance of these technologies.

[2] There are six greenhouse gases recognized under the Kyoto Protocol. The analysis focuses principally on $CO_2$. This is the most important anthropogenic greenhouse gas accounting for 82% of total emissions greenhouse gas emissions in EU-27 and 79% of emissions of greenhouse gases in Portugal in 2005.

### *A. Energy and environment*

Energy production and consumption is strongly associated with the environmental pressure on the planet. For example, emissions of $SO_2$ (sulfur dioxide), greenhouse gases and other $CO_2$ and $NO_x$ (nitrogen oxides) for a certain period, depends on the amount of electricity produced and the technological mix of plants operating in each electrical system for some period. The actions of each of the fossil fuels, nuclear and renewable operate with the efficiency of each production center represent the key mechanisms available to assess the environmental performance of the electricity system of a country.

According to the report of the European Environment Agency [15] for the EU-15[3], the main factors responsible for reduction of $CO_2$ emissions from the system for producing electricity and heat are the improvement in efficiency, fuel substitution derived from coal to gas and to a lesser extent, increasing the share of renewable energies. Portugal is a particular case in which $CO_2$ emissions are heavily dependent on rainfall conditions. The emission level shows significant variations in relation to fluctuations accentuated hydropower production, which is heavily dependent on annual rainfall. However, the close relationship between energy consumption and $CO_2$ emissions from the energy sector is evident.

Fig. 2 shows the close relationship between energy consumption and $CO_2$ emissions worldwide. World consumption of primary energy is increasing and between 1990 and 2004 grew 29%. $CO_2$ emissions showed a similar trend in 2004 also had increased about 27% compared to 1990. The small difference between the rates of increase allows a small reduction in $CO_2$ emissions per unit of energy consumed.

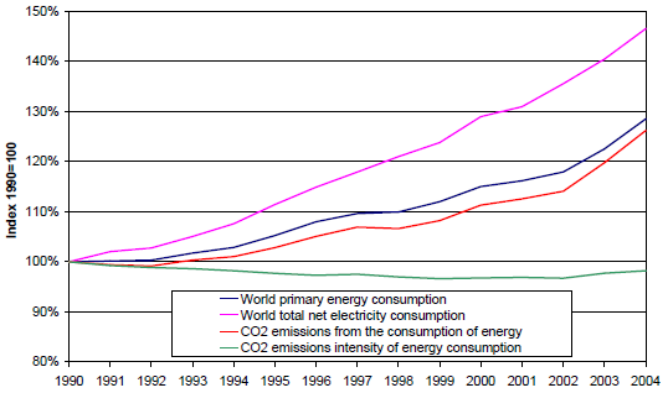


Fig. 2. Trends in global consumption of energy and electricity, $CO_2$ emissions and $CO_2$ emissions intensity of energy consumption [16].

At EU-15 there is a general trend of increasing consumption of energy, as shown in Fig. 3. However, the use of more efficient technologies and renewable energy, along with some structural changes that occur in members of the EU and the introduction of specific policies and measures, contribute to a

[3] Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Spain, Portugal, Sweden and United Kingdom.

less significant increase in $CO_2$ emissions. As a result, between 1990 and 2005, $CO_2$ emissions per unit of energy consumption dropped by 12%.

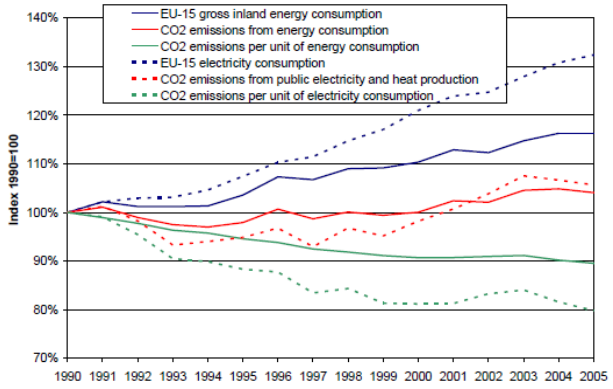


Fig. 3. Trends in the EU-15 and electric energy consumption, $CO_2$ emissions and intensity of $CO_2$ emissions from energy consumption [16]-[17].

Demand for electricity is growing fast and, to some extent, offset the increase in consumption of the environmental benefits achieved through technological advances and fuel switching. A similar effect occurs in the transport sector. Transport emissions in the EU-15 increased significantly during the same period as a result of a continued increase in demand for road transport. This has offset much of the decline in other sectors [15]. In general, the $CO_2$ emissions associated with energy consumption and real electricity showed a downward trend between 1990 and 2005, indicating movement toward the mix of less carbon intensive fuels in Europe.

Energy production and consumption are the major emission sources of greenhouse gases (GHGs) in the EU. Fig. 4 shows that in 2005 the $CO_2$ emissions produced by industry in Portugal and the EU-27. About 90% of total $CO_2$ emissions in Portugal are related to energy, which means they are a result of the activities of energy consumption. This figure rises to 94% in EU-27. Particularly relevant is the role of the sector of electricity and heat. About a third of $CO_2$ emissions deriving from fossil fuels to produce electricity, with each core is able to send millions of tons of $CO_2$ annually.

Limit the concentration of $CO_2$ in the atmosphere requires a reduction in $CO_2$ emissions across the economy. The electricity generation sector has some special characteristics that makes it an important target for reducing $CO_2$, as pointed out by Johnson & Keith [18] in relation to emission sources distributed in the sector of transportation, electricity generation plants can achieve reductions depth with minimal impact on energy infrastructure, property and centralized management of the power industry regulation and facilitates the producers have gained considerable experience in recent years with increasingly tight controls on conventional pollutants, and it is unlikely that producers of electricity movement for the least-regulated as could happen for the industry.

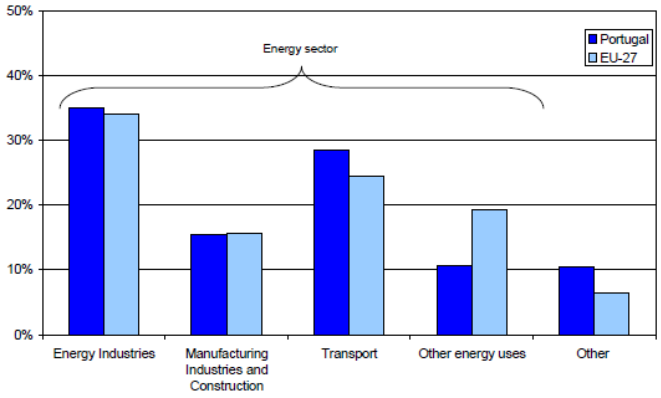


Fig. 4. Percentage of $CO_2$ emissions of air pollutants by activity in 2005, EU-27 and Portugal [16]-[17].

In Portugal, in 2005, $CO^2$ emissions from the operation of a coal were about 844g/kWh [19]. Whereas from the operation of central CCGT[4] this value was about 375g/kWh [20]. The results of Hondo [21] indicate that, even nuclear power plants emit approximately 24g $CO_2$/kWh during its life cycle, particularly uranium enrichment. The wind power plants are responsible for 29g $CO_2$/kWh mainly released during the construction and installation. Renewable energies have generally low $CO_2$ emissions and are heavily favored by environmental regulations for the energy sector.

An important factor in future development of energy sector and the definition of current and future energy policy is the Kyoto Protocol. Under the Kyoto Protocol, the EU pledged to reduce emissions of greenhouse gases to 8% during the first commitment period, from 2008 to 2012. This objective is shared between the Member States under a legally binding burden-sharing, which sets emission targets for each individual Member State. In particular, Portugal could increase the average emissions of 27% of 1990 emissions level. Growth reduction in electricity consumption will be crucial in the environmental point of view, especially in relation to consumption of electricity generated by fossil fuels. The renewable energies sources do not produce $CO_2$ (or very little), do not throw radioactive waste, and generally have significantly lower levels of other pollutants. Improving the environmental performance of fossil fuel plants is also essential and can be reached with the increasing use of abatement technologies effectively and improve efficiency. The need to reduce the pressures imposed on the environment through the use of energy worldwide and in the continuing effort to promote and utilize renewable energies sources and supplemented by changes in consumer of energy behavior.

### *B. Impacts of electricity production activity*

There is growing recognition of the importance of social and environmental impacts of the production of electricity. As described in the previous section, the energy production

[4] Combined Cycle Gas Turbine. A production plant uses a combined cycle gas turbines and associated steam in a single center, both producing electricity from the burning of same fuel. The heat in the exhaust gases of gas turbines is recovered to produce steam necessary to drive the steam turbine. Thermodynamics: An Engineering Approach, 5th edition by Yunus A. Cengel and Michael A. Boles.

process involves, in which the shares of producers of electricity cannot be adequately reflected in market prices of product. The Energy Information Administration [22] classifies the externalities attributable to electricity generation in four categories: air pollutants, greenhouse gases, quantity and water quality and land use values.

Clarifying the full costs of energy production for regulators and policy makers is particularly critical because of the non-price differentiation between suppliers of electricity produced from different sources with emissions of pollutants potentially very different. The basic purpose of social accounting is to make explicit the full magnitude of the direct costs and environmental costs of electricity derived and supported by society in order to influence decision makers in making investment decisions in the energy sector to improve the welfare social [23].

Develop defensible estimates of externalities are a complex and costly exercise [24]. Externality values for the production of electricity have been developed in the U.S. and Europe. Freeman III [25] and the Energy Information Administration [22] present some key studies on estimates of external environmental costs that result from adding the ability of a system for generating electricity.

The European Commission, together with the Department of Energy launched a joint research project to assess the environmental externalities of energy use in 1991. During the project, an accounting framework for the operational assessment of external costs of energy technologies, called ExternE (Externalities of Energy) was developed. The U.S. suspended its participation in the project at the end of the first phase. The methodology and results are widely accepted and have been used to support other studies and projects, some relating to different sectors or regions as APERC [26], Venema & Barg [23], Nuclear Energy Agency [27], HEATCO [28] among many others[5].

TABLE I
OVERALL RESULTS OF THE EXTERNE

| Technologies models | Air pollution impacts ($PM_{10}$) and other impacts | Greenhouse gas impacts |
|---|---|---|
| Biomass technologies | High | Low |
| Existing coal technologies (no gas cleaning) | High | High |
| Natural gas technologies | Low | High |
| New coal technologies | Low | High |
| Nuclear | Low | Low |
| Wind | Low | Low |

*Source: Adapted from European Commission [29].*

In general, as shown in Table I, wind power technologies are environmentally friendly with respect to emissions of pollutants, including emissions of greenhouse gases. However, the results also indicate some variation of external costs attributed to wind due to noise impacts or other utility, mainly depending on local conditions of each park studied. Nuclear technologies have low emission levels and generate low external costs, even considering the low probability of accidents with high consequences. As for biomass, due to the large number of technologies, changes in external costs are high, although in general they produce greenhouse gas emissions very low in their life cycle. The gas technologies are clean with respect to conventional pollutant (not including greenhouse gases), but depending on the efficiency of the technology can impact on climate change due to $CO_2$ emissions. Coal technologies generate high emissions of $CO_2$, even for new, more efficient technologies. Old coal plants are highly polluting units for each type of pollutant considered [29].

For fossil fuels, global climate change is very fundamental question that dominates the current energy policy. For nuclear fuel, potentially large consequences of an accident, and long-term impacts of radioactive waste are the key to the major decision. The expansion of renewable energy technologies has resulted in a growing opposition in certain portions of affected local population on account of the impacts of increasing usefulness. Potential impacts on the local ecosystem by, for example, hydro, offshore wind farms or biomass plantations in particular have raised objections from interest groups that traditionally consider green renewable energy technologies as a viable alternative instead of nuclear energy [30]. The calculations of Mirasgedis *et al.* [31] indicate that mortality associated with the effects of air pollution and the effects of global warming are the major components of externalities attributed to conventional power plants.

For biomass power plants, the external costs associated with global warming are considered void and the impacts of high priority are close to those identified for the plants to conventional oil. As for wind farms and hydroelectric plants, the main external cost refers to the noise and accidents. Although renewable energy sources are generally associated with lower external impacts on the power plants that use fossil fuels, particularly coal, are not entirely free of impact. In fact, significant negative impacts were studied for the most common renewable energy technologies used.

*Impacts of hydroelectric*

As for the hydroelectric sector, a large number of benefits or positive impacts can be described in Almeida et al. [32], U.S. Department of Energy[6] and World Bank[7]:

- Energy impacts associated with: the economic value of electricity and energy supply, economic benefits of potential reserves, drive dynamic response of these technologies and emissions avoided. Furthermore, it is a source of domestic energy and renewable. REN [33] notes that high levels of availability and production flexibility are two major advantages of hydropower.
- Impacts of water resources, associated with the contribution to irrigation, water supply and minimum in stream flows during the dry season.

[5] A list of related projects can be found in ExternE at http://www.externe.info/.

[6] For more details, check on http://www1.eere.energy.gov/windandhydro/hydro_ad.html.

[7] For more details, check on http://www.worldbank.org/html/fpd/em/hydro/ihd.stm.

- Socio-economic development impacts associated with the creation of new activities or sports-related tourism, generating new jobs and diversifying the economy. Agricultural activities can also benefit from flood control and water availability. Most hydropower installations are required to provide public access to the reservoir to allow him opportunities to exploit.

However, some important disadvantages or negative impacts are also reported in the literature [32], U.S. Department of Energy, World Bank, International Rivers Network[8]):

- Environmental impacts associated with loss of habitat and biodiversity, loss of fish stock, landscape changes or obstruction of movement of migratory fish. Dams also change the pattern of river flow, reducing its overall volume and seasonal variations. All parts of the ecology of a river may be affected by changes in their flow.
- Energy impacts. The capacity of electricity generation is heavily dependent on rainfall conditions.
- Socioeconomic impacts. New hydro can compete with other land uses that may be more valued than electricity generation. Local people could lose their homes and lands. Local cultures and historic sites can be invaded.
- Loss of local convenience. Noise and vibration due to construction activities can disturb the local wildlife and human populations nearby.

A detailed description of the impacts of hydropower can be found at the World Bank, along with a description of possible mitigation measures.

The World Commission on Dams [34] supports the idea that the dams have been promoted as an important means for meeting water and energy needs and long term strategic investment with the ability to deliver multiple benefits. Regional development, job creation and promotion of an industry base with export potential are often cited as benefits. However, these benefits must be weighed against the environmental and social impacts of large dams. The huge investment required to build large dams, and its enormous impact social, environmental and economic projects makes them highly controversial.

*Impacts of biomass*

Bioenergy is a heterogeneous aggregation of different feed materials, conversion technologies and use of energy resources thin. In the European context, the biomass is taken to include agricultural and industrial waste as a potential source of fuel for heating and electricity [35]. The main positive and negative impacts of biomass technologies in the literature are listed below:

- Environmental impacts. As with other forms of combustion, burning wood emits air pollutants. The amount and type of pollutants depend on both the specific combustion process involved and the extent of controlled burning. Compared with fossil fuel combustion plants fed with forest residues emit similar levels of nitrogen oxides, but significantly less sulfur dioxide [36].
- Energy impacts. Among renewable energy sources, biomass is one of the few resources whose availability is not dependent on weather conditions, seasonal and diurnal and can be stored for use on demand [37]. This represents an important advantage, allowing the production of electricity more predictable. Moreover, a source of domestic energy, contributing to the diversification of the fuel mix and supply security.
- Socioeconomic impacts. The bioenergy projects involving energy crops could have significant contribution to rural incomes, or increased employment. Energy crops can lead to changes in patterns of agricultural work and make positive contributions to diversify the rural economy [37]. Results of surveys on local public opinion of a biomass gasifier proposed in the UK indicate that the potential impact on employment was further confirmed the benefit [38].

Emissions from transport and infrastructure requirements and associated the new capacity of biomass can result in adverse reaction from segments of the local community [37]. Upreti [39] gives some examples to show that the major obstacle to the promotion of biomass energy is the opposition of local people.

In general, biomass technologies have fewer environmental impacts compared to conventional sources. Moreover, important benefits for rural populations and contribute to the security of electricity supply. However, there are significant local impacts that may raise questions and generate opposition to the development of biomass power stations. The effects of pollutant emissions are a major concern with the loss of quality of life caused by increased traffic and the installation of the plant.

*Impacts of wind energy*

Studies have been published concerning the impact of wind energy development on the environment, economic development, on the functioning and security of the electricity system as well as the final cost of delivered energy.

Manwell *et al.* [40] notes that the development of wind energy has positive and negative impacts. On the positive side, the authors point out that wind energy is generally considered environmentally friendly compared to conventional power plants for electricity on a large scale. However, the more wind turbines are installed, the importance of their negative impacts becomes more noticeable.

The problems most often cited for the wind farms are the sound and visual impacts of wind turbines on the landscape of public opinion. Other concerns cited include the impact on birds and wildlife and issues regarding the integration of wind energy into electricity grids linked to perceived insecurity, high cost and low efficiency. Other effects are less frequently reported electromagnetic interference and land use [41]-[42].

- Avian interactions with wind turbines:

  The development of wind farms can adversely affect the birds due to collision and electrocution of birds foraging

[8] For more details, check on http://www.irn.org/index.php?id=basics/impacts.html.

habits change, reducing the available habitat and change in breeding and nesting. Positive aspects of this technology can also arise, such as protection areas, land supply, hunting and protection of nesting birds or indiscriminate hunting [40]. There is no consensus among experts about the importance of the impacts of wind farms on birds. According to Travassos *et al.* [43] and Fielding [44] indicate that studies in this field are far from homogeneous. The results depend on issues such as the location of wind farms, the type of birds analyzed, or weather conditions. The ExternE report on wind energy [45] assigns a medium priority for this impact and concludes that the existence of European studies and experience provide no evidence of significant impact for collisions of birds in the turbines. In contrast, Drewitt and Langston [46] concluded that although many of the studies are either inconclusive or indicate that the effects are not significant for a particular kind of place and season, this should not be used as justification for failure or bad rating future developments. According to these authors, there are relatively few studies that indicate significant impact that the improper location of wind farms can adversely affect wild bird populations.

- Visual impact of wind turbines:

  Wind power installations have been heavily criticized for being a new element and they are sometimes located in highly visible locations in order to exploit the wind conditions [47]. The impacts of landscape are sometimes aggravated by the fact that sites with good wind resources are precisely the areas that are exposed upland valued for their scenic qualities, so they are environmentally sensitive [48].

  Authors such as Bishop and Miller [49], Manwell *et al.* [40] and Kaldellis *et al.* [47] agree that a major public concern and an important factor in determining public opposition to wind farms is the visual impact. The ExternE project considers the visual intrusion of turbines and related equipment, such as an impact that high on wind energy projects [45]. Regarding the visual impact of wind turbines are not well established and evaluation of the landscape is quite subjective [40]. Bergmann et al. [50] study on attitudes of people in relation to renewable energy indicates that the aesthetic pleasure of a proposed wind energy is a controversial issue. Some people feel that wind farms are enjoyable to watch and represents renewable energy, while others consider them intrusive and a visual damage to the landscape.

  Wolsink [42] examined some works on public attitudes in favor of wind power, concluding that the visual impact of wind on the landscape is by far the dominant factor to explain why some oppose the use of wind power, while other support. Devine-Wright [41] presents the view that despite the predominant emphasis of the literature on the visual impacts of turbines, there is little evidence that wind turbines are universally perceived as ugly.

  The view on the visual impact of wind on the landscape varies between different countries and so the emphasis on aesthetics of a wind farm varies from country to country. Moreover, studies in the UK reveal that the preservation of valued landscape motivates most of the opposition (see, e.g. TNS [51] and Warren *et al*.[52]).

*Noise from wind turbines:*

Noise levels can be measured, but the public's perception of the noise impact of wind turbines is very subjective. The ExternE project gives high priority to the impact and supports the idea that, while technical adjustments can be expected to reduce the problem, public awareness of the effects of noise of the wind turbine can still be significant [45].

Wind farms can be built without significant injury to the convenience, since the turbines are placed at a sufficient distance from homes. Appropriate planning requirements are essential to minimize this impact, but as Manwell *et al.* [40] noted, because of the wide variation in individual tolerance to noise, there is no completely satisfactory way to predict the adverse reactions.

Both mechanical and aerodynamic noise produced by wind turbines decrease with improved technology [40]-[48]. According Kaldellis *et al.* [47] due to the current output at low speed. However, studies such as Van den Berg [53] has shown that there is not an insignificant issue. This author studied the noise of a wind farm in Germany, where residents of more than 500 meters from the park reacted strongly to the noise, as residents up to 1900 meters distance expressed annoyance. The main conclusions were that the actual noise levels were considerably higher than expected, and that wind turbines can produce sound with an impulsive character, further increasing the discomfort.

## V. Summary and Conclusions

Human evolution is closely linked to energy, since the beginning of time man has to know it and seeking it ever more on the environment. He began to enjoy and benefit from their potential. Thus obtained, greater adaptation to the environment that was often hostile and consequently sparsely inhabited. Respecting the means and knowledge of each period of evolution, man became sovereign in the environment, acquired with so much more responsibility, while that on the environment imposed serious changes to meet its development. As it evolved, the company acquired powers stemming from the nature and gradually increased his power over her, needing to preserve the environment in order to continue its development in a healthy way. The primitive man first discovered, the potential energy contained in his body, received power to feed itself and the rest was consumed in the transportation and protecting other animals. Primitive man learned to use the energy contained in your body and thus dominate other species and survive in poorly relevant to the human race. Started to use the energy contained in the animals that could tame and over time learned to use this trick to get around, from horses and wagons to trains and aircraft. Moreover, he discovered the fire and according to Loftness [10] the first discovery of man using fire as energy for cooking was their food and keep warm. With the discovery of fire and of course, the mastery over it, began to prepare their best food, and not rely solely on the sun for lighting. Still used the fire to

defend themselves against other animals or dangerous places that used to live. Thus, there is clearly a capability that the man had since primary season to adapt to the environment in which they live. According to the conditions that were exposed, he learned to manage them so that you could take greater advantage to themselves and to society. From the moment I learned to take advantage of the benefits the fire, such as energy, brought to him, the man managed to improve their living conditions, therefore, enabled him to enjoy greater comfort in their day-to-day living day best in their community.

Over time, different energy sources were being explored allowing the evolution of man and society, with this development and from the moment the man was able to provide energy in a comprehensive manner the entire society. Currently available are several potential energy and have as main sources of energy, petroleum, coal, essential for society to evolve until the present time, however, there is great concern about the indiscriminate use, since attitudes yesterday are already reflected in many of the conditions in which we find ourselves. Energy production and use have unquestionable environmental impacts, contributing significantly to greenhouse gases and other pollutants. The use of more efficient technologies, together with the implementation of sustainable energy policies has contributed to an overall reduction in the intensity of $CO_2$ emissions from energy consumption, particularly evident in Europe. However, the overall increase in energy consumption often outweighs the environmental benefits achieved as described for the particular case of Portugal. The need for renewable energy called for the implementation of environmental legislation, where the environmental performance of electricity generation is a priority line of action. Important steps include ratification of the Kyoto Protocol and a large set of European directives: the promotion of electricity produced from renewable sources, creating the Emissions Trading Scheme and limiting emissions from large combustion plants.

Renewable energies have generally lower emissions than conventional power stations, making them strongly favored by the environmental regulations for the energy sector. However, renewable energy technologies are not free of negative impacts, although the public attitude in relation to renewable energy is generally positive, local people may react negatively to specific projects. In the particular case of wind energy impacts on the ecosystem, noise pollution (noise) and negative impacts on the landscape have been reported. By using variable production technologies such as wind power to generate electricity differs from electricity generation by conventional power plants. Fluctuations in wind energy production occur in random pattern and must be compensated by the scalable production capacity compared to conventional production system [54]. Because of this, wind power does not work as simple fuel savings because it cannot be controlled easily and accurately predicted [55].

To properly assess the potential effects of wind on the system cost of electricity compared to other existing production systems should take into account the fuel savings and emissions avoided. Both the amount of $CO_2$ reduction and additional costs attributed to the system depends on the characteristics of the electricity system under analysis. As the report stresses the EWEA [56] the size and flexibility inherent in the power system are crucial aspects that determine the system's ability to accommodate large amounts of wind.

Holttinen and Hirvonen [57] conclude that wind energy contributes to the reduction of end use of fossil fuel emissions, but in high levels of penetration, an ideal system may require changes in the mix of conventional capacity. Also Rosen et al. [54] notes that a growing range of fluctuations is a challenging phenomenon and the resulting effects cannot be ignored, nor the operation of the power system, or in long term planning for the expansion of wind energy. Variations of wind power will affect the scheduling of conventional power plants to an extent that depends on forecasting, as well as the flexibility of conventional energy producers in the geographic area of the system under consideration [56]. Although the possible impacts of wind energy should not be overlooked, it is important to recognize that the systems without the wind energy also have significant variability [58]. So EWEA [56] points out that both supply and demand of electricity are variable and the variability of wind power can be provided in large measure. Regarding possible negative impacts associated with the irritation of noise intrusion and disturbance of the landscape ecosystem, its magnitude is specific to the local aspect. The installation of wind turbines is a critical issue in determining the level of impact [40]-[45].

In general, wind power can provide an important contribution to reducing fossil fuel consumption and meet international environmental commitments. However, interconnection capacity, the combination of the existing capacity of production and characteristics of the wind power system to have a significant effect on how the variable production is assimilated by the system and on the extent of their contribution to meet the needs of modern society. The extent of this contribution deserves to be evaluated in economic terms via methods of economic and financial evaluation for these projects and their costs in order to ensure proper integration of wind power to meet current and future energy needs.

## REFERENCES


[1] Cook, E. (1976). *Man, Energy and Society*. W.H. Freeman, San Francisco, 478 pp.

[2] Cottrell, F. (1955). *Energy and Society*. Greenwood Press, Westport, Connecticut, 330 pp.

[3] White, L.A. (1943). *Energy and the evolution of culture.* Am. Anthropol. 45, 335-354.

[4] Willrich, M. (1978). *Energia e política mundial.* Rio de Janeiro, Agir, 237 p.

[5] Hinrichs, R.A. and Kleinbach, M. (2004). *Energia e meio ambiente*. São Paulo, Thomson, 543pp.

[6] Hammond, A.L. (1972). *Energy options: challenge for the future*. Science, 177, 875-876.

[7] Service, E.R. (1962). *Primitive Social Organization*, Random House, New York, 221 pp.

[8] Lee, R.B. & DeVORE, I. (eds.). (1976). *Kalahari Hunter-Gatherers.* Havard University Press, Cambridge, Mass. 408 pp.

[9] Bews, J.W. (1973). *Human Ecology.* Russel and Russel, New York, 312 pp.

[10] Loftness, R.L. (1984). *Energy handbook*. 2nd ed. New York, Van Nostrand Reinhold, 763 pp.

[11] Fakhry, A. (1969). *The Pyramids.* University of Chicago Press, Chicago, 272 pp.

[12] UNDP – United Nations Development Program. (2000). *Sustainable Energy Strategies: Materials for Decision-Makers.* Available at http://www.undp.org/energy/publications/2000/2000a.htm; Accessed September 27, 2010.

[13] European Commission. (1998). *ExternE. Externalities of Energy.* Vol.7 Methodology 1998 update.

[14] Weisser, D. (2007). A guide to life-cycle greenhouse gas (GHG) emissions from electric supply technologies. *Energy*, Vol. 32 (9), pp. 1543-1559.

[15] EEA – Energy and Environment in the European Union. (2006). *Tracking progress towards integration.* EEA Report No 8/2006. Available at http://reports.eea.europa.eu/eea_report_2006_8/en; Accessed June 14, 2009.

[16] Energy Information Administration – Independent Statistics and Analysis. (2007). *Forecasts & Analysis*. Available at http://www.eia.doe.gov/. Accessed October 22, 2008.

[17] EEA – European Environment Agency. (2007). *Annual European Community greenhouse gas inventory 1990-2005 and inventory report 2007* EEA Report No 7/2007. Available at http://reports.eea.europa.eu/technical_report_2007_7/en; Accessed October 22, 2008.

[18] Johnson, T. & Keith, D. (2004). Fossil electricity and $CO_2$ sequestration: how natural gas prices, initial conditions and retrofits determine the cost of controlling $CO_2$ emissions. *Energy Policy*, Vol. 32 (3), pp 367-382.

[19] EDP (2006), *Report and Accounts, 2005.* Notebook sustainability. Available at www.edp.pt.

[20] Turbogas (2006), *Environmental performance report 2006*. Available at www.turbogas.pt.

[21] Hondo, H. (2005). Life cycle GHG emission analysis of power generation systems: Japanese case. *Energy*, Vol. 30 (11-12), pp. 2042-2056.

[22] Energy Information Administration. (1995). *Electricity Generation and Environmental Externalities: Case Studies*, September 1995, *U.S. Department of Energy*, Washington, DC. Available at http://www.eia.doe.gov/cneaf/electricity/external/external_sum.html. Accessed June 22, 2010.

[23] Venema, H. & Barg, S. (2003). The Full Costs of Thermal Power Production in Eastern Canada. *International Institute for Sustainable Development*, Canada, July 2003. Available at http://www.iisd.org/publications/pub.aspx?pno=591. Accessed July 18, 2009.

[24] Rowe, R., Lang, C. & Chestnut, L. (1996). Critical factors in computing externalities for electricity resources. *Resource and Energy Economics*, Vol.18 (4), pp. 363-394.

[25] Freeman III, A. (1996). Estimating the environmental cost of electricity: an overview and review of the issues. *Resource and Energy Economics*, Vol. 18 (4), pp. 347-362.

[26] APERC – Asia Pacific Energy Research Centre. (2005). *Renewable electricity in the APEC region. Internalising externalities in the cost of power generation, Japan*. Available at http://www.ieej.or.jp/aperc/. Accessed November 27, 2009.

[27] NEA – Nuclear Energy Agency. (2003). Nuclear Electricity Generation: *What Are the External Costs?*. OECD. Available at http://www.nea.fr/html/pub/ret.cgi?id=4372. Accessed May 16, 2009.

[28] HEATCO. (2006). *Developing Harmonised European Approaches for Transport Costing and Project Assessment. Final Technical Report*, 15 December 2006. Available at http://heatco.ier.uni-stuttgart.de/. Accessed September 24, 2010).

[29] European Commission. (2003). *External Costs. Research results on socio-environmental damages due to electricity and transport.* Directorate-General for Research.

[30] Krewitt, W (2002). External costs of energy— do the answers match the questions?: Looking back at 10 years of ExternE. *Energy Policy*, Vol. 30 (10), pp. 839-848

[31] Mirasgedis, A., Diakoulaki, D., Papagiannakis, A. (2000). Impact of social costing on the competitiveness of renewable energies: the case of Crete. *Energy Policy*, Vol. 28 (1), pp 65-73.

[32] Almeida, A., Moura, P., Marques, A. and Almeida, J. (2005). Multi-impact evaluation of new medium and large hydropower plants in Portugal centre region. *Renewable and Sustainable Energy Reviews*, Vol. 9 (2), pp. 149-167.

[33] REN (2006) *"Potencial hidroeléctrico Nacional. Importância socio-economica e ambiental do seu desenvolvimento"*, November 2006. (In Portuguese).

[34] World Commission on Dams. (2001). *Dams and development: A new framework for decision making.* Overview of the report by the World Commission on Dams, December 2001. Available at www.poptel.org.uk/iied/docs/drylands/dry_ip108eng.pdf. Accessed September 28, 2010.

[35] McKay, H. (2006). Environmental, economic, social and political drivers for increasing use of woodfuel as a renewable resource in Britain. *Biomass and Bioenergy*, Vol. 30 (4), pp. 308–315.

[36] Miranda, M. and Hale, B. (2001). Protecting the forest from the trees: the social costs of energy production in Sweden. *Energy*, Vol. 26 (9), pp. 869-889.

[37] Thornley, P. (2006). Increasing biomass based power generation in the UK, *Energy Policy*, Vol. 34 (15), pp. 2087–2099.

[38] Upham, P Shackley, S. (2007). Local public opinion of a proposed 21.5 MW(e) biomass gasifier in Devon: Questionnaire survey results. *Biomass and Bioenergy*, Vol. 31 (6), pp. 433-441.

[39] Upreti, B. (2004). Conflict over biomass energy development in the United Kingdom: some observations and lessons from England and Wales. *Energy Policy*, Vol. 32 (6), pp. 785–800.

[40] Manwell, J., McGowan, J. and Rogers, A. (2002). *Wind energy explained: Theory, design and application.* John Willey & Sons, England.

[41] Devine-Wright, P. (2005). Beyond NIMYism: towards an integrated framework for understanding public perceptions of wind energy. *Wind Energy*, Vol. 8, pp. 125-39.

[42] Wolsink, M. (2007). Wind power implementation: The nature of public attitudes: Equity and fairness instead of 'backyard motive. *Renewable and Sustainable Energy Review*, Vol.11 (6), pp. 1188–1207.

[43] Travassos, P., Costa, H., Saraiva, T., Tomé, R., Armelin, M., Ramirez, F., Neves, J. (2005). *Wind energy and conservation of birds in Portugal*. SPEA, Lisboa.

[44] Fielding, A., Whitfield, D. & McLeod, D. (2006). Spatial association as an indicator of the potential for future interactions between wind energy developments and golden eagles Aquila chrysaetos in Scotland. *Biological Conservation*, Vol. 131(3), pp. 359-369.

[45] European Commission. (1995). *ExternE. Externalities of Energy.* Vol.6 Wind and Hydro", EUR 16525, 1995.

[46] Drewitt, A. & Langston. (2006). Assessing the impacts of wind farms on birds. *Ibis*, Vol.148 (s1), pp. 29-42.

[47] Kaldellis J., Kavadias K. and Paliatsos A. (2003). Environmental Impacts of Wind Energy Applications: 'Myth or Reality?'". *Fresenius Environmental Bulletin*, Vol. 12 (4), pp.326-33.

[48] Moran, D. and Sherrington, C (2007). An economic assessment of windfarm power generation in Scotland including externalities. *Energy Policy*, Vol. 35 (5), pp. 2811– 825.

[49] Bishop, I. and Miller, D. (2007). Visual assessment of offshore wind turbines: The influence of distance, contrast, movement and social variables. *Renewable Energy*, Vol. 32 (5), pp 814-831.

[50] Bergmann, A., Hanley, N. and Wright, R. (2006). Valuing the attributes of renewable energy investments, *Energy Policy*, 34 (9), pp 1004-1014.

[51] TNS. (2003). Attitudes and knowledge of renewable energy amongst the general public, August.

[52] Warren, C., Lumsden, C, O'Dowd, S and Birnie, R. (2005). 'Green On Green': Public perceptions of wind power in Scotland and Ireland, *Journal of Environmental Planning and Management*, Vol. 48 (6), pp. 853 –875.

[53] Van den Berg G. (2004). Effects of the wind profile at night on wind turbine sound. *Journal of Sound and Vibration*, Vol. 277 (4-5), pp. 955-970.
[54] Rosen, J., Tietze-Stockinger, I., Rentz, O. (2007). Model-based analysis of effects from large-scale wind power production, *Energy*, Vol. 32 (4), pp 575–583.
[55] Olsina, F., Roscher, M., Larisson, C. and Garcés, F. (2007). Short-term optimal wind power generation capacity in liberalized electricity markets, *Energy Policy*, Vol. 35 (2), pp. 1257–1273.
[56] EWEA – The European Wind Energy Association. (2005). *Large scale integration of wind energy in the European power supply: analysis, issues and recommendations*. Dec. 2004. Available at http://www.ewea.org. Accessed May 13, 2009.
[57] Holttinen, H. and Hirvonen, R. (2005). *Power system requirements for wind power*. in: Ackermann, T (Eds.), Wind power in power systems.
[58] Dragoon, K. and Milligan, M. (2003). Assessing Wind Integration Costs with Dispatch Models: A Case Study of PacifiCorp" National Renewable Energy Laboratory, NREL/CP-500-34022.

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