RENEWABLE OUTLOOK 2007: characterization of the various existing and emerging renewable energy technologies, considerations for business strategy

Alberto Biamonti and José Figueiredo

Engineering and Management Department, Instituto Superior Técnico

Technical University of Lisbon

* Corresponding Author, alberto.biamonti@gmail.com

Abstract

Research and acquisition of data relating to renewable energies, analysis and consideration of these elements, development of models in accordance with a levelized cost methodology for application to the considered technologies and consequent comparative appraisal. The levelized cost evolution curve for each technology, as a function of the investment year, provides a platform for strategic consideration on the possible developments of investment in renewable energies at short, medium and long term. The data were acquired from professional's sources, consulting reports and from professional energetic association's publications and, when possible, confronted with academic studies. The developed model allowed developing numerical data to construct progression curves which allowed a cost evaluation among the technologies analyzed. Using the 2008 data, a levelized cost for the same year was developed and, by introducing factors such as: inflation curve, status of the art for each technology, estimated evolution of OPEX and CAPEX experience curve, it was possible to extrapolate the levelized costs for each technology and for each year of investment, through 2030. From the analysis of the levelized costs and the study of the different technologies, some strategic reflections emerged on the evolution profile of the wind energy and the distributed generation. A study of the wind turbine generators' market was made to decide upon the best strategy for turbine's procurement. Threats to the centralized generation business of an electric supply company were identified and a study was made on the opportunities available for the distributed generation business.

Keywords: Renewable energies, levelized cost, technologies, turbine, distributed generation

1. Introduction

The energy is the prime platform to sustain economic growth. Without primary, copious and relatively inexpensive energy sources it is not possible to assure economic development either in developed nations or in under developed countries, but especially in the emerging ones [1].Thus, the energy sector fulfill a primary role to characterize the economic growth trend at short, medium and long terms.

Currently, the generation of energy intensively utilizes fossil fuel: oil, gas and coal. The massive utilization of this kind of fuel provokes serious global threats: unreliability of supply and geopolitical confrontations caused by the fossil fuel occur repeatedly, fossil fuel costs suffers sharp increase and the growing emission of CO_2 provokes serious environmental concern. The necessity to alter the course of electric generation became evident and resources are directed toward nonpolluting and renewable energy sources. The electric sector is entering in difficult transition phases which demand massive investments in research and technical development. To assure energy supply from renewable sources is an essential condition for civilization and economical growth [2]. With this in mind it is crucial to analyze the technical evolution of the renewable energies technology, prospecting their potential and economic viability at medium and long terms.

Thus, this article aspires to characterize the various renewable energy technologies, either existing or emerging, to foresee their economic feasibility at medium and long term and to formulate alternatives for a utility's position toward this new market, in order to be able to plan a secure strategy. This study was prepared in the *Direcção de Planeamento Energético da Energias de Portugal, S.A.* (Energetic Planning Department of EDP). To elaborate this work an intensive investigation and data's research was developed using sources related to the renewable energy industry. With the information obtained, various analysis and considerations were made. A model using the Microsoft Office Excel, elaborated in accordance with the levelized costs methodology, was applied to the technologies being considered, in order to obtain a meaningful comparison of the respective energy generation investment costs [3], [4]. This paper is structured as follows:

In Part I we proceed to the "Survey and Analysis of the renewable technologies", through three sections:

- Technology description: the economic factors are identified and a depiction is made of the methodology used to foresee the world's installed capacity for each technology;

- Computation of the levelized costs: development of a model to project the technologies' energies cost, at long term;
- Operational conclusion: the experience curves of the renewable technologies are analyzed (cost reduction vs. installed capacity), a relative comparison and specific analyses were conducted for the strategically more appealing technologies.

In Part II we unfold some "Strategic Considerations" through two sections:

- Distributed Generation, threats and opportunities: the threats that the centralized generation will be facing from the distributed generations are analyzed and business opportunities available to an utility company explored;
- Strategic analysis for turbines' procurement: the wind turbines' market is analyzed jointly with the evolution of their cost, together with an analysis of the different procurement strategies available to the utilities generating electricity;

At the end of the paper we draw a conclusion outlining the work achieved its strengths and limitations and recommendations for further study were made. A list of abbreviations is presented at the very end.

Part I - "Survey and Analysis of the renewable technologies"

2.1. General specifications

The sources of renewable energies are hydro, wind, solar, biologic, ocean and geothermal. In order to be able to generate electric energies from these sources different technologies are being developed. In this paper the energies with greater significance were analyzed for the chosen period - 2008 through 2030. The following technologies were studied: small hydro, wind onshore, wind offshore, solar photovoltaic (PV), solar thermoelectric, biomass, biogas, ocean waves, ocean tides and geothermal.

Forecasts were made of the installed capacity (from 2008 through 2030) and the identification was made of the economic factors (for 2008), for each technology. The economic factors are: learning through duplication of the installed capacity, CAPEX, OPEX (fixed and variables factors), FOM, VOM, annual operating hours, exploitation life, WACC, construction time and nominal capacity. For the particular case of biomass it is necessary to add the fuel cost, the lower heating value, its efficiency and the plant auxiliary consumption.

To be able to construct a curve forecasting the technology's installed capacity, it is necessary to acquire data from different sources which do not specifically forecast for technology, but for type of energy; as an example the sources forecast for the solar energy but do not provide data for solar photovoltaic or thermoelectric. Consequently, the curves to forecast the installed capacity for each technology were constructed from the forecast curves for the respective type of energy. Since the bibliographic sources only assumed discreet values, i.e. provide data only for some but not for all the years between 2008 and 2030, it became necessary to use criterions that, through the information available, would allow the construction of a forecast curve. Lacking a methodology (mathematical model) to prepare a curve under these conditions, we choose to assume a simple average of the installed capacity for the year for which the sources were providing information and we draw a curve with a greater adjustment coefficient (R^2) related to the averages. It has to be emphasized that it is not always possible to make forecasts recurring to historical dada since the renewable are relatively new and do not provide noteworthy historical data of the installed capacity. Some technologies don't even have any installed capacity yet.

The economic factors, with the exception of WACC for which data provided by EDP was used, were acquired from a variety of sources and a simple average of these data was taken to select the data to be used for the *Renewable Outlook* 2007. The *economics* for each technology are represented in figure 1.

	CAPEX2008 €/installed kW	OPEX2008 €/netMWh	Initial FOM2008 % of OPEX	Working Hours2008 hours	Learning Curve slope 2008	Economic Lifetime years	WACC %	Fuel Price €/ton	Typical Plant Size MW	Construction Period years
Onshore	1116	22,00	80%	2190	0,92	20	6,87%	0,0	20	1
Offshore	1913	39,00	82%	3200	0,91	20	6,87%	0,0	210	2
Solar PV	5337	43,00	75%	1402	0,82	25	7,80%	0,0	1	1
Solar Thermo	3447	59,00	75%	1840	0,91	25	7,80%	0,0	75	2
Biomass	2097	15,00	80%	6483	0,93	25	7,80%	55,0	35	2
Biogas	2272	21,00	80%	5870	0,92	20	7,80%	2,8	10	2
Wave	3754	56,00	80%	3242	0,87	20	7,80%	0,0	24	2
Tide	3643	48,00	80%	2716	0,90	25	7,80%	0,0	110	2
Geothermal	2304	42,00	58%	6833	0,90	30	7,80%	0,0	50	2
Mini Hydro	2410	13,00	80%	3242	0,95	35	7,33%	0,0	5	2

Figure 1: Economics per technology

2.2. Computation of the levelized costs

There are significant differences among the various electric generating technologies with regard to construction time of the plant, annual utilization hours, exploitation life, CAPEX and OPEX. So it is difficult to provide a meaningful individual appraisal since it cannot be made using these factors separately. In this work, the levelized cost methodology was used to compare the various energy generating technologies. The levelized cost technology allows quantifying the unit cost of electric power produced during the commercial exploitation life of the project [4]. The result represents a weighed mean value, allowing for a direct comparison of the various alternatives. This methodology considers the total energy produced during the active life of the plant, as well as the cash flow for the total investment, the cash flow for operation and the fuel cost (only for the biologic energy), deducting the weighted cost average of the initial capital (WACC), to obtain the current cost of the produced electric, per unit. The formula used to compute the leveled costs of electric power produced is as follows [3]:

(1)
$$LC = \frac{\sum\left[(I_t + M_t + FC_t)(1+r)^{-t}\right]}{\sum\left[E_t(1+r)^{-t}\right]}$$

LC - Levelized Cost
I_t - Investment cost for year *t*
M_t - Operation and maintenance cost for year *t*
FC_t – Fuel Cost for year *t*
E_t - Energy produced in year *t*
r - Discount rate or actualization

The levelized costs for each technology under consideration were computed by means of a model developed using the Microsoft Office Excel. The total cost of a technology includes: production costs and environmental costs (the latter not included in this study). The production cost of electricity per unit is the aggregate of the investment's levelized costs, exploitation and fuel costs. This analysis used real values, considering inflation. To compute the latter, the euro inflation rate of 2.5% [4] was used, assuming that it remains constant.
The nominal CAPEX considered only appears in the year the investment is made, therefore is null in the following years. The exploitation costs, VOM and FOM, are always present throughout the life of the plant and, since the analysis is made with real values, its evolution has to be considered. The VOM and FOM growing rate for the various technology is shown in figure 2.

	Small hydro	Wind onshore	Wind offshore	Photovoltaics	Solar thermal	Biomass	Biogas	Waves	Tide	Geothermal
% of inflacion	50%	50%	25%	0%	0%	50%	50%	0%	0%	50%

Figure 2: Growing tax for VOM and FOM considered in the modelation

As we can verify in figure 2, the CAPEX growth for the different technologies is distinct from and inferior to, the inflation rate. This is due to the fact that, in absolute terms, all technologies are in a relatively immature stage and, as such, will benefit from the economic effect of experience, which will compensate for the growing rate of inflation. In relative terms, the different development levels justify a minor or larger costs' growing rate. Less developed technologies have costs at lower growing rates.

The fuel nominal cost for biomass and biogas is calculated by the following formula:

(2)
$$FC = RMC \times \frac{1}{LHV} \times \frac{1}{\left[E \times (1 - AC)\right]} \times 860$$

FC - Fuel nominal cost [€/MWh]
RMC - Raw material cost [€/ton]
LHV - Lower Heating Value [kcal/kg]
E - Plant efficiency
AC - Auxiliary cost

The evolution of the raw material cost parallels the inflation.
The discount rate used was based upon the average weighed capital cost at real values. Its conversion was made through the use of the following formula:

(3)

$$r = \frac{1 + WACC_{no\min al}}{1 + Inflation}$$

The number of operating hours is shown in section 2.1. Since it is not possible to realistically foresee the plants' operating hours, the calculations were made assuming that they will remain constant throughout the period under consideration. Considering that the calculations were based upon the net power output (nominal plant capacity) for each technology, and in order to obtain levelized costs for energy unit, it was necessary to establish the equivalent operating hours of the plant, discounting the WACC yearly operating hours, all in accordance with the equivalent annual cost method. This makes sense in the perspective of return on investment, i.e. the plant's nominal operating hours have a financial significance in term of cost and earnings. It has to be noted that the plant's nominal functioning hours only begin on the date of commercial operation, thus they exclude the construction time (1 to 2 years). Figure 3 shows the annual equivalent costs for the different technologies assuming 2008 as the investment year .

	Small hydro	Wind onshore	Wind offshore	Photovoltaics	Solar thermal	Biomass	Biogas	Waves	Tide	Geothermal
LC 2008	55,88	56,35	79,9	310,43	185,38	79,93	52,27	143,42	141,58	59,5

Figure 3: Levelized cost for the 2008 investment year [€/MWh]

As previously mentioned, we are dealing with technologies in their infant stage, the majority having very intensive capital requirements. Therefore, it becomes necessary to analyze the levelized cost's variation as a function of the investment year. It can be anticipated that with the growing of the world's installed capacity, the technologies' CAPEX will tend to decrease in virtue of the learning curve. So, in the future investments in technologies with no current economic appeal will show up. Taking this into consideration it was calculated a reduction of the CAPEX based upon a duplication of the installed capacity. The values for the year 2008 were obtained but there was the necessity to obtain an estimate for the evolution of these values through 2030. Since the technology for wind onshore, wind offshore, biomass, bio gas and geothermic are in a more advanced stage of development than the others, it was assumed that the their learning curve will tend to decrease more rapidly. The values for the biological and geothermic energies will grow lower since these are well known technologies. With regards to the solar technologies the learning curve will remain flat since these technologies are less developed. The waves and tides technologies are new and, therefore, their learning curve will rise in the short term and it will remain high and constant thereafter. The small hydro technology has a very low learning curve and it will remain flat, since it is a well known technology. Figure 4 shows the evolution of CAPEX's learning factors by duplicating the technologies' capacity.

	2008	2010	2015	2020	2025	2030
Wind onshore	8%	8%	6%	6%	6%	6%
Wind offshore	9%	8%	6%	6%	6%	6%
PV	18%	18%	18%	18%	18%	18%
Thermoelectric	9%	9%	9%	9%	9%	9%
Biomass	7%	5%	5%	5%	5%	5%
Biogas	8%	5%	5%	5%	5%	5%
Waves	13%	20%	20%	20%	20%	20%
Tide	10%	15%	15%	15%	15%	15%
Geothermal	10%	9%	5%	5%	5%	5%
Small hydro	5%	5%	5%	5%	5%	5%

Figure 4: Evolution of the learning factor by duplication of installed capacity

After obtaining the world's installed capacity for each technology we consider that the CAPEX reduction occurs in a continuous fashion. It will not necessarily reduce when a duplication of the installed capacity occurs. In order to obtain CAPEX for different investment years, and taking into consideration that the learning curve for duplication of capacity remains constant within the periods, it is sufficient to make a logarithmic transformation. Through the results obtained it is possible to determine the levelized costs for each technology, as a function of the investment year (see figure 5).

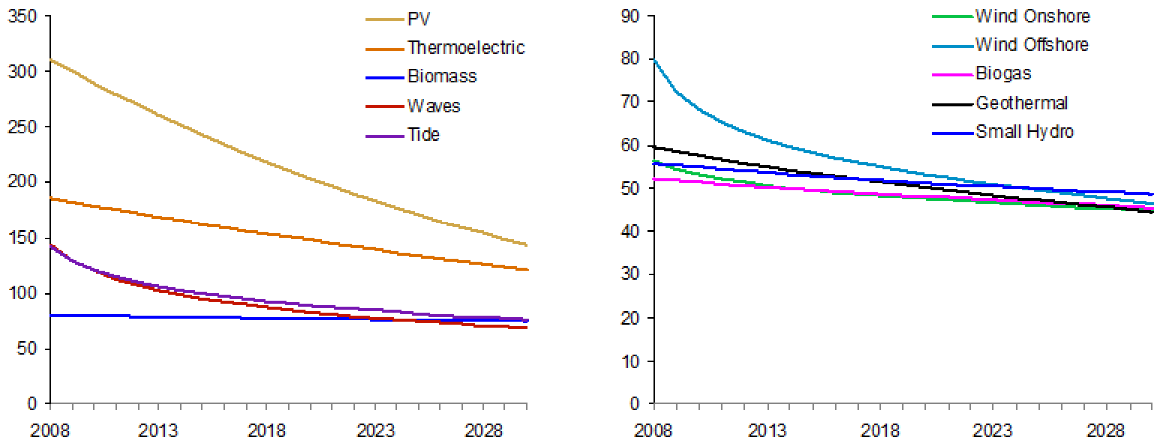

Figure 5: Technologies levelized cost curves as a function of the investment year (2008-2030) [€/MWh]

2.3. Operational conclusion

The more recent technologies undergo a larger reduction of the levelized costs when comparing between 2008 and 2030 (see figure 7). Renewable energies are in their majority capital intensive and, since a CAPEX reduction depends upon the installed capacity (due to the learning from the duplication of the installed capacity), the more recent technologies will experience a greater duplicating capacity (see figure 6). Their CAPEX will experience a large reduction due to the learning curve and consequently the levelized costs of these technologies will tend to contract when compared with the ones with larger degree of development. Figure 7 shows that the technologies with a larger degree of development will continue with lower levelized costs for investments to be made in 2030.

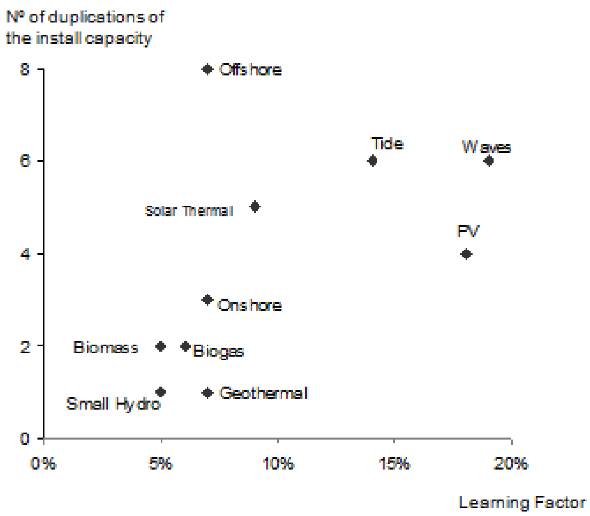

Figure 6: Technologies‘ nº of duplications of installed capacity for 2008 through 2030

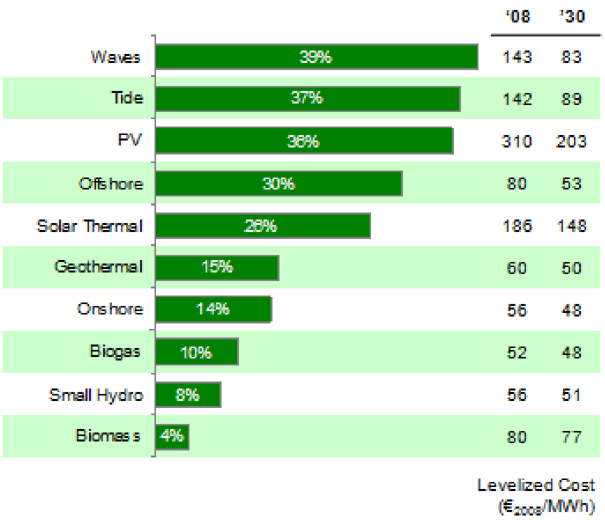

Figure 7: Levelized cost reduction per technology

The biogas, wind onshore, small hydro and geothermal technologies experience the lowest levelized costs; however, there are other factors which may limit the growing of some of these technologies. The biogas plants have a very limited capacity (10 MW) and require proximity to the raw material sources. Consequently, it doesn't represent an attractive technology for large utility companies; the small hydro technology is lacking suitable sites (with special regard to developed nations). The geothermal technology has almost all of its potential already in use. It can be anticipated that the onshore wind technology will be the one receiving large investments since it has low levelized costs and a great technical potential, as shown in figure 8.

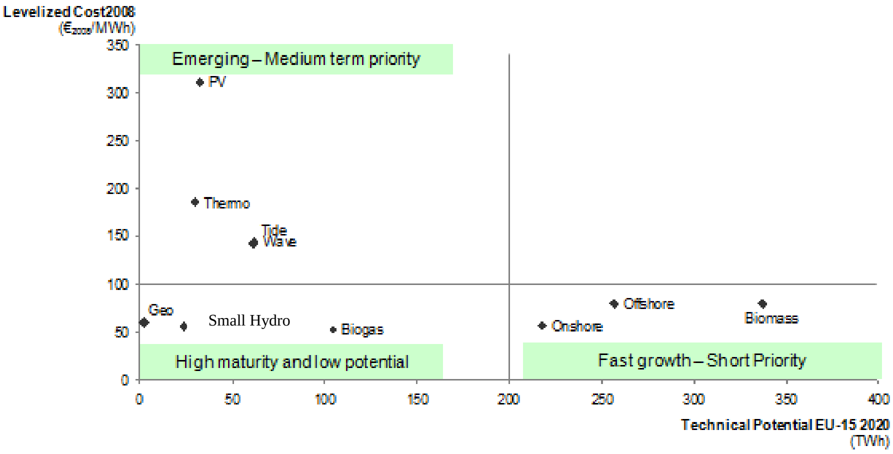

Figure 8: Technologies' levelized cost analysis and its technical potential

From an analysis of figure 8 it is possible to conclude that the PV, thermoelectric, waves and tide technologies will not have investment priority due to a high cost and lower potential. The geothermic, small hydro and biogas technologies offer low costs, but their reduced potential will be a barrier to investment. The biomass and the onshore and offshore wind technologies offer high potential and low costs. It can be anticipated that future investments will be directed toward these technologies. However, investments in the biomass technology may be limited due to the following factors: cost of fuel weigh heavily on the biomass' cost, the availability of raw material is not stable and its cost highly depends upon the supplier's proximity.
As already stated, the wind technologies are the more attractive. Although the producing hours and the capacity of a typical offshore installation are superior to the onshore one, generating greater annual energy, the offshore elevated CAPEX and OPEX costs produce higher levelized costs. Therefore, at least for the near future, the onshore wind technology offers better investment opportunities than the offshore technology. It is possible that in the future, through intensive R&D efforts, the offshore technology can reduce its costs, leveling the differences with the onshore.
The solar energies suffer from very high costs and have low potential (see figure 8). An analysis of the per capita Gross Domestic Product (GDP) of the nations as a function of the solar potential (figure 9) makes it evident that the nations with higher GDP per capita have lower potential.
In addition solar technologies have high costs and this factor may limit the growth of these technologies. For these reasons solar energies are not attractive to large utility companies. However, it can be anticipated that PV technology may have a future in the distributed generation [6], as can be seen in figure 10.

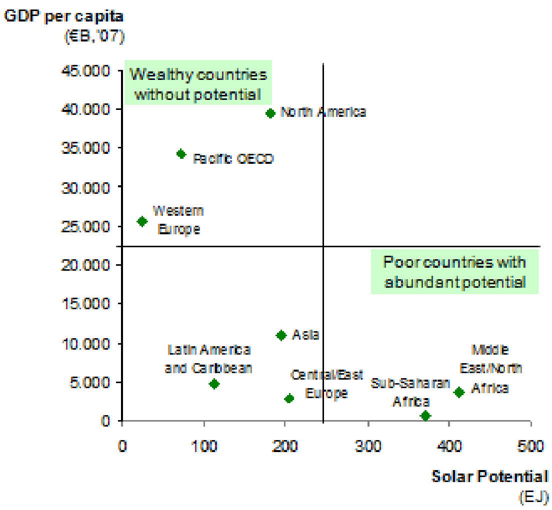

Figure 9: Solar potential and GDP per region
Font: [5]

.

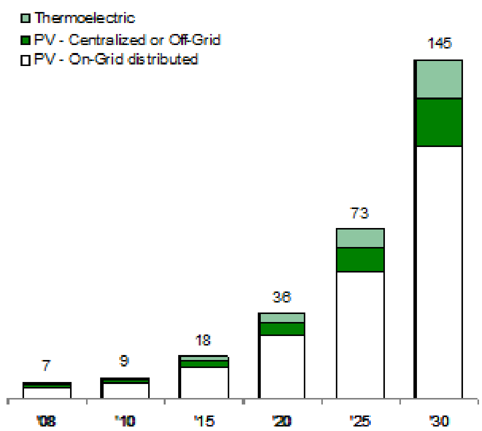

Figure 10: Solar install capacity evolution per type of generation [GW]
Font: [6]

Part II – "Strategic Considerations"

3.1. Distributed Generation, threats and opportunities

Basically there are three technologies available to distributed generation: photovoltaic panels, small wind turbines and small gas generators. Currently these technologies are not economically viable, i.e. the investment made by the consumer is not justified when compared with the alternative to acquire electricity from utilities. Nevertheless, it is expected that these technologies will begin to be competitive starting in 2015/2020 [6] and that the installed capacity of this type of equipment will increase. Figure 10 shows that the majority of the solar photovoltaic capacity will be in the distributed generation. Once competitive, these technologies will attract large investments with the consequence that there will be lower consumption of energy from centralized generation, in percentage terms. This situation is worrisome for the utilities companies since there will be a reduction of consumption of electricity generated by their power plants. It can be anticipated that in 2030 the production of centralized electricity may suffers a 30% reduction in the Iberia Peninsula due to the installation of photovoltaic panels in the houses [6]. This being the case, it is imperative to analyze the business opportunity available to the utilities companies in order to reduce to a minimum the negative impact to their business represented by the distributed generation. Although the impact of the distributed generation could be significative, the centralized generation of electricity will continue active since it is unthinkable that the former could satisfy the overall demand for electricity. Utilities will continue to produce centralize electricity but they may venture into the distributed generation business to reduce their losses. Utility companies may diversify in *Energy Service Company* (ESCO). An ESCO company provides consulting services; know how, financing and equipment maintenance to the distributed generating plants so that their clients may obtain a reduction in the consumption of energy lowering their electric costs.

There are various business models that are available. Utility companies may choose the model which best suit their business in order to rise the company's value and provide a service to their clients. Five different business models were identified and analyzed: performance contract, equipment leasing, sale and maintenance of equipment, marketing the excessive energy and energy consulting.

The first three models represent different forms of sale and installation of the equipment, as it is analyzed below.

<u>Performance contract</u>

The ESCO installs the equipment and provide maintenance free of charges. Once the plant is in operation the client establish the quantity of energy and saving. The contract foresee that the client will pay to the ESCO a percentage of the energy saving, during a predetermined period of time, at the end of which the client will own the equipment at no cost. This business model is risky to the ESCO since it carry the total cost of the equipment and the client will pay back only when there would be energy saving. With this model the utility must be assured that the client will obtain energy saving and, in order to obtain a profit, that the value of the saving contracted will exceed the equipment and maintenance costs.

<u>Leasing/sale of equipment</u>

These are two similar form of business. With regard to leasing, the equipment is installed by the ESCO and the client will pay an established monthly payment. At the end of the leasing period the ESCO has already absorbed the cost of the equipment, maintenance costs, financial costs and profit. In the event of a direct sale the client pay for the equipment and for the maintenance. To be viable, this model shall ensure that the total cost to the client is lower than the client's energy saving.

<u>Excess energy transaction</u>

This business model is subsequent to the purchase of the distributed generation plant by the client. In the case of photovoltaic panels, for example, they produce electricity even when they are not used. In this situation, ESCO may purchase the excess of energy produced, at a price higher than cost to the client, the latter making a profit. This business model allows ESCO to profit on the equipment installation and provides benefits to the client in addition to energy saving.

<u>Energy consulting</u>

Prior to the purchase of the equipment, ESCO may provide energy consulting services to establish the solutions and the equipment that best suit the client's necessities and at the same time optimize energy savings. Suggestion on the choice of the three models mentioned above, which best suite the client, may also be made.

There are three market segments available to ESCO: large sites (hospitals, universities, hotels, and industries), communities (condominiums, skyscrapers) and individual houses. ESCO companies experience different types of difficulties entering these market segments. The sector of the large sites offers fewer difficulties to enter into while the individual houses offer the highest. In an initial phase it is advisable to conquer market quota

facilitating the entrance and, subsequently, entering in other segments. It has to be noted that the large sites sector represents a lesser risk to ESCO since they have a wider dimension and a large concentration of energy consumption.
Even though it is recognized that the distributed generation has great potentiality, there are certain doubts that may delay its entrance in a large scale in Portugal. Distributed generation requires the development of grids allowing the flux of energy both ways (smart grids). The latter would allow the client to consume utilities' furnished electricity when the electricity he generates is not sufficient to satisfy his needs, but he would be able to sell to the utility the electricity he produces in excess. In addition to the problems related to the management of the grids, the economic viability of adapting the network to a distributed generation system must be studied. In a centralized system there are costs such as: losses caused by the transmission of the electricity and cost for grid extension and maintenance. To a system of distributed generation the mentioned costs are avoided but it will be necessary to make huge investments to adapt the grids to the distributed generation requirements. Figure 11 schematizes the above situation.

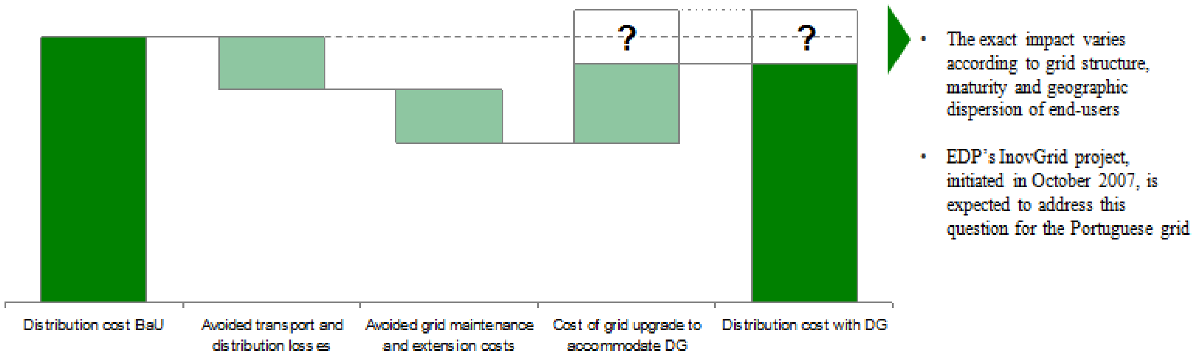

Figure 11: Cost comparison between current and distributed systems

3.2. Strategic analysis for turbines' procurement

In section 2.3 above, it was concluded that wind onshore is the most attractive to investment technology. Given that the cost of the turbines suffers from inflation - it accounts for 64% of the technology's CAPEX - it is important to analyze the progression of turbines' price and to scrutinize the procurement strategies to the utility companies to enter the market. The price of the turbines suffered a large escalation and it is anticipated that it will continue to rise up till 2012 [8] since the factors that influences the increase of price are superior to the ones provoking a decrease (see figure 12).

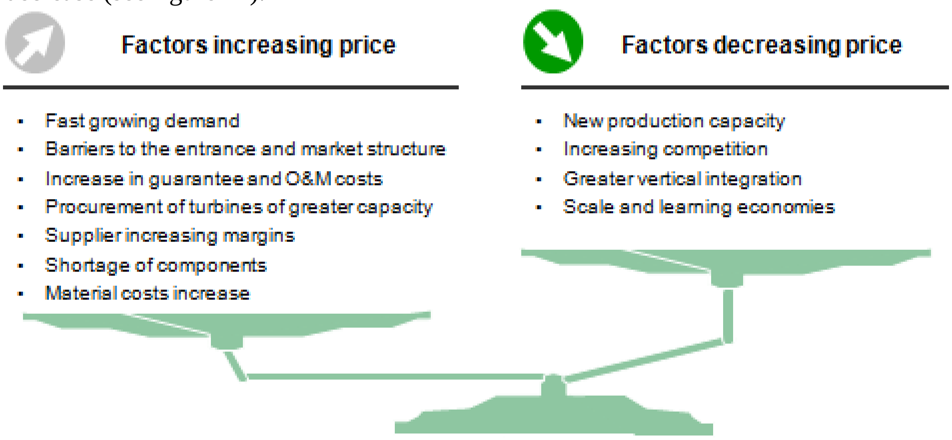

Figure 12: Comparison between factors influencing price

After 2012 it is anticipated that the price of the turbine will experience a reduction since, in the long term, factors causing price decreases will increase in strength and height [9].
Three procurement strategies are compared: acquisition of the turbines' manufacturer, procurement contracts, and management by the turbine manufacturer of the utility's wind plants. Figure 13 schematizes the advantages and disadvantages for each of these procurement strategies.

	Pros	Cons
Acquisition of the turbines' manufacturer	• Strategic affinity with utility including internationalization • Impact reduction of the turbines' increasing prices • Easier and faster way to increase installed capacity • Greater security to accomplish planed expansion • Greater flexibility to enter in markets with regulation for local production	• Strong dependency in the supplier expansion strategy • Takeover large technological risk due to few diversification • If prices reduce in the short term and the production capacity increases, the acquisition investment may not be rewarded
Procurement contracts	• Diversification of the technological risk • Independence from suppliers' strategy • Greater flexibility to change supplier	• Good contracts can only be obtained by large companies • Greater effort to ensure large capacity contracts • Greater insecurity to realize long term strategies • Greater impact in the event of increases in the turbine price • Limitation to achieve affinity strategies • Lower flexibility to enter in markets with regulation for local production
Management by the turbine manufacturer of the utility's wind plants	• Possibility to recover delays in renewable capacity	• Dependence on supplier strategy

Figure 13: Pros and cons of the procurement strategy for wind turbines

From the above model it is possible to conclude that the supply of the turbines greatly depends on the utility's wind strategy. A company with a strong commitment to wind energy and considering the acquisition of a turbine manufacturer will have to consider the turbine price progression and the manufacturer profits. The main benefit in the acquisition of a manufacture, in addition to ensure supplies, is the assurance that, in case of severe price inflation, the added manufacturer profit will revert to the utility. In figure 14 it is represented the growth of the price of the wind turbines and its forecast through 2012. After 2012 it is expected that the price will tend to soften (curve in the figure green zone) but it is not possible to foresee with accuracy the price after 2012 and, therefore, the portion of the curve under consideration only provides a trend. It is obvious that a decrease of the price of the turbine not necessarily result in the contraction of the margins of EBIT, yet, in this case, a reduction will materialize because there will be a greater competition among the suppliers which will cause a leveling of the suppliers market [10]. In A situation (figure 14), the vertical integration of the utility may represent an excellent option since it will allow to absorb the effect of inflation, rewarding the investment. In the situation represented by B, the vertical integration would not be advisable since the investment would not be rewarded during the short period in which the effect of inflation is minimized.

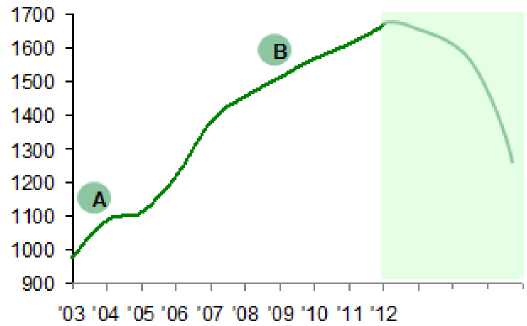

Figure 14: Integration decision and evolution of turbines' price [$/kW]
Font: [8]

4. Conclusion

There is a great political, social and economic pressure in the electrical sector to alter the energy sources currently in use. A large majority of the electric energy used is generated from pollutant and finite sources, emphasizing the need to expand the use of renewable sources. This new situation compels the companies producing energy to adjust their investments toward renewable energies. Different alternatives for investment exist since there are six sources of renewable energies (hydro, solar, ocean, wind, biologic and geothermal) requiring different technologies for their exploitation. To position themselves in the market and to develop a

suitable strategy to exploit the renewable energies, utilities producing energy must have a deep knowledge of the status of the art for each renewable alternative.
In Part I of this research we conducted an exhaustive description of the different technologies in qualitative and quantitative terms, followed by an analysis and reflection on these elements and, the subsequent development of a model based upon the levelized costs methodology, to be applied to each technology. Subsequently a comparative analysis was made among the different technologies. We also studied the market of wind turbines and various strategic procurement scenarios were analyzed, integrated in various trends of wind power growth. A study was made on the opportunities available to a utility company to enter in the business of distributed generation utilizing renewable energies.
This study allows comparing the available technologies in global terms based upon the costs elements without considerations of return on investments, for each technology. This global analysis permits to identify the technologies which have potentialities for exploitation, but do not take into account the applicable local regulations, thus not allowing considering the return for each technology. It has to be noted that different regulations applies to each renewable energy and according to a particular country. In order to define a strategy for renewable energies for a particular nation, it is necessary, in addition to a familiarization with the applicable regulations, to elaborate a levelized cost analysis based upon specific data (CAPEX, OPEX, annual hourly utilization, potentiality, WACC). Obviously, the atractivity to venture in a particular technology alters in function of geographical conditions. If it were possible to continue with this investigation these questions would be among the first to be researched.

5. List of abbreviations

CAPEX - Capital Expenditure, investment cost per unit power [€/kW].

OPEX - Operational Expenditure, operation and maintenance costs per energy produced [€/MWh]

WACC - Weighted Average Cost of Capital

7. References

[1] Lomborg, Bjorn, 2001, The Skeptical Environmentalist – Measuring the Real State of the World, Cambridge University Press

[2] IPCC, 2001, Intergovernamental Panel on Climate Change, Contributions of Working Groups I, II and III to the IPCC Third Assessment Report, Cambridge University Press

[3] NEA/IEA, 2005, Projected Costs of Generating Electricity, Nuclear Energy Agency, Internacional Energy Agency

[4] Alonso G., 2007, Economic Analysis of the Levelized Cost of Electricity Generation

[5] BCE, 2007, Relatório Anual, Banco Central Europeu

[6] IEA, 2006c, World Energy Outlook, International Energy Agency

[7] EPIA, 2007, Solar Generation IV, European Photovoltaic Industry Association

[8] NEF, 2007, TURBINE PRICES 2002-2007: CHASING HIGH TARIFF MARKETS?, New Energy Finance

[9] Merril Lynch, 2007, Wind Turbine Manufacturers-Here Comes Pricing Power, Asari Efiong

[10] HSBC, 2007, Power for a New Generation - A Primer for the Global Wind Sector, HSBC Global Research