~ Project ~

Tech4CDM

Wind Energy

In PERU

Project financed by

SIXTH FRAMEWORK PROGRAMME

The TECH4CDM project, developed over 2008 and 2009, and financed by the European Union under the Sixth Framework Programme of R&D, has as its primary goal, the promotion of renewable and efficient energy technologies, paying special attention to overcoming technological barriers, as well as the analysis of the Clean Development Mechanisms (CDM) of the Kyoto Protocol that may assist in projects based on wind energy, cogeneration, solar thermal and rural electrification through renewable energies.

Both European and Latin American institutions participate in the project, which is coordinated by the Spanish Institute for Energy Diversification and Saving (IDAE). The technological partners participating in the project include: the European Photovoltaic Industry Association (EPIA), the Spanish Wind Energy Association (AEE) and the Solar Thermal Industry Association (ASIT). In the case of cogeneration, the participation of COGEN Spain is essential, as well as that of the Spanish Office for Climate Change (OECC) for the part related to the CDM.

The 5 countries where the project activities are being carried out are Argentina, Chile, Ecuador, Mexico and Peru, and in each of these, local partners contribute, assuring the maximum use of these collaborating forces. Participating entities include: the Secretariat of Energy and the Industrial Union of Argentina, the National Energy Commission (CNE) of Chile, the Ministry of Electricity and Renewable Energy (MEER) of Ecuador, the National Commission for the Efficient Use of Energy (CONUEE) of Mexico and the Centre for Energy Conservation and Environment (CENERGIA) of Peru.

Project activities include the completion of a series of studies of the technologies situation in each country. This document summarizes the main features.

More information at www.tech4cdm.com

Contents

1. PERU

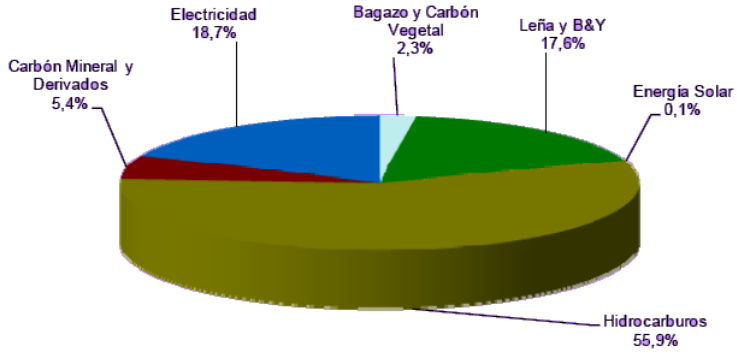
Most relevant information of Peru is shown on the next table:

PERU	2000	2005	2007	2008
General Data				
Population, total (millions)	26,00	27,84	28,51	28,84
Population growth (annual %)	1,5	1,3	1,2	1,1
Surface area (sq. km) (thousands)	1.285,2	1.285,2	1.285,2	1.285,2
Energy and Environment				
Energy use (kg of oil equivalent per capita)	482	498	..	..
CO2 emissions (metric tons per capita)	1,1	1,3	..	..
Electric power consumption (kWh per capita)	678	831	..	..
Economy				
GDP (current US$) (billions)	53,29	79,39	107,29	127,43
Agriculture, value added (% of GDP)	8	7	7	7
Industry, value added (% of GDP)	30	34	37	38
Services, etc., value added (% of GDP)	62	58	56	55
GDP growth (annual %)	3,0	6,8	8,9	9,8
Inflation, GDP deflator (annual %)	3,7	3,0	2,0	1,1
Exports of goods and services (% of GDP)	16	25	29	29
Imports of goods and services (% of GDP)	18	19	22	27
Foreign direct investment, net inflows (BoP, current US$) (millions)	810	2.579	5.343	..

Peruvian information (Source: World Bank).

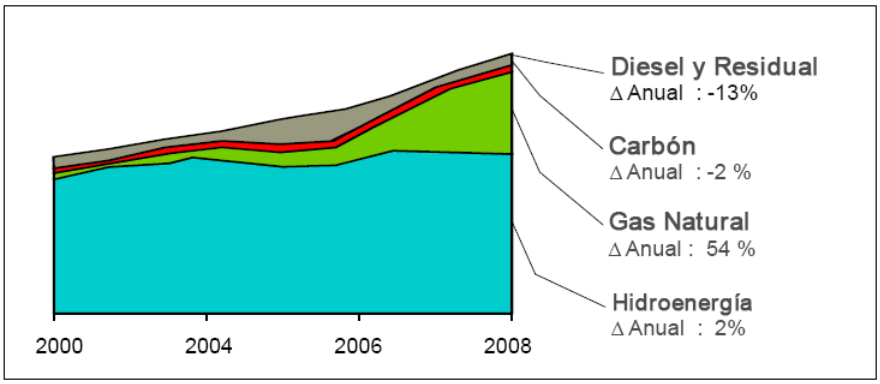
2. PERUVIAN ENERGY CONTEXT

The final energy consumption in Peru in 2007 was 518,982 TJ, surpassing a consumption of 20,861 TJ for 2006. With 56.9% of the total, Hydrocarbons are the most used energy source, followed by electric power, with a very important hydro energy component:



Final energy consumption, year 2007 (Source: MEM).

As to electric energy, the installed capacity in 2007 reached 7,059 MW, with an energy production of 29,857 GWh. As a matter of fact, hydraulic energy is the most contributing source to electric generation in Peru, although the use of natural gas in electric energy generation has significantly increased during the past five years, as shown in the following chart:



Evolution of energy sources used for electricity generation (Source: MEM).

Furthermore, annual electricity demand, with an annual average of8%, is due among other aspects to the strong development of mining and manufacturing activities at a prior stage of the international crisis. Even if the country's macroeconomic

conditions maintain this growth level and in the last five-year period investments on electricity have grown at an annual rate of 27%, it is still necessary the execution of new projects to ensure electric power supply.

Relevant agents of Peruvian energy sector

Ministry of Energy and Mines (MEM):

An integral part of Executive Power, the Ministry of Energy and Mines is the central body governing the energy and mines sectors. Its purpose is to formulate and evaluate policies of national scope regarding sustainable development and environmental matters of mining-energy activities, in tune with the general policy and the government plans.

The Supervisory Organism of Investment in Energy and Mines (OSINERGMIN):

OSINERGMIN is a public body whose mission is to regulate, within a national scope, the compliance with legal and technical regulations related to activities in the electricity, hydrocarbon and mining subsectors, as well as the compliance with legal and technical regulations related to environment conservation and protection in the performance of the said activities.

The National Institute for the Defence of Competition and Intellectual Property (INDECOPI)

INDECOPI is a specialized public body whose functions are the market promotion and protection of consumer rights.

Peruvian Committee for Economic Operation of the System (COES):

COES is a non-profit private body with Public Legal capacity, conformed by all the National Interconnected Electric System Agents (SEIN), generators, transmitters, distributors and free users, and whose decisions are mandatory for Agents. Its purpose is to coordinate SEIN short-, mid- and long-term exploitation at the minimum cost, assuring the system's security and the best exploitation of energy resources, as well as planning the development of SEIN transmission and Short-Term Market management.

Centre for Energy Conservation and the Environment (CENERGÍA):

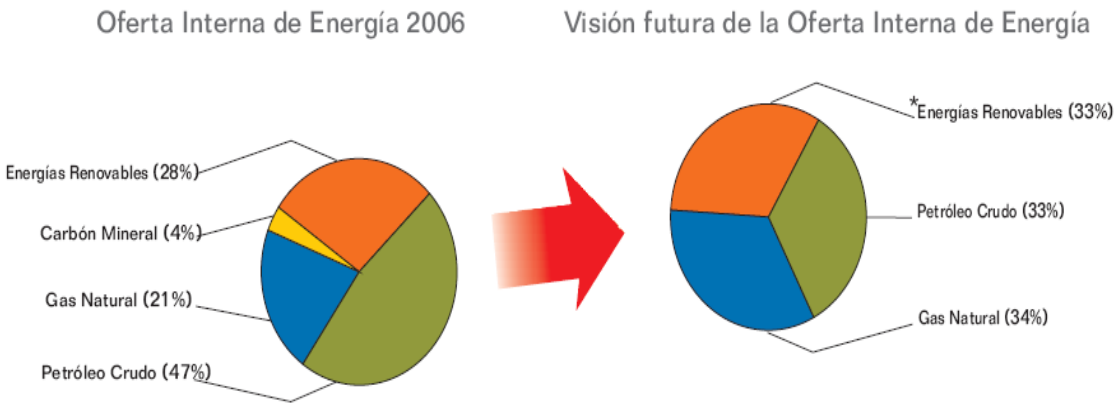
This is a non-profit body that promotes energy efficiency for all the economic activities in Peru. It does research on behalf of energy sector regulatory institutions, and implements projects aimed at establishing good practices for energy use in firms by carrying out studies on prevention and mitigation measures of negative impacts on the country environment as a result of productive activities and services. CENERGIA is pioneer in developing productive activities and services in the country.

Peruvian energy policy

The energy policy in Peru is developed according to the following main guidelines:

- To diversify the energy mix to ensure a reliable and timely supply for energy demand, in order to guarantee the country's sustainable growth.
- To promote private investment in the energy sector with clear and stable rules.
- To promote and implement energization jobs in rural and isolated zones in the country to enlarge the demand coverage and improve people's standard of living.
- To promote an efficient use of energy.
- To promote regional energy integration.

The purpose of the Peruvian government is to shift from an energy mix based essentially on hydrocarbons and achieve the ensuing energy distribution, where renewable energy, oil and natural gas are present in equal shares:



A future approach to the energy mix (Source: MEM).

The approval of both laws on the promotion of electric energy generation from renewable energy sources, and another regarding the efficient energy use accounts for the effort the Peruvian government is making in the renewable energy and energy efficiency sectors.

Regulatory and legal framework

Peru is a country with specific laws regarding renewable energy and energy efficiency:

- Legislative Decree No. 1002, dated May 2008, "Law for the Promotion of Electricity Generation with Renewable Energies".
- Law No. 27345, dated September 2000, "Law for the Promotion of an Efficient Energy Use".

Respectively, the development of new electric generation through the use of Renewable Energy Resources (RER) and the promotion of an efficient use of energy are declared of national interest and public necessity.

1. Renewable Energies

In order to promote the use of RER, the "Law for Investment Promotion on Electricity Generation and Renewable Energies" (Law 1.002) was enacted in May of 2008, along with its corresponding Regulations through Presidential Decree No. 050-2008-EM dated October 2008.

The main investment incentives set forth by the Law and its Regulations are:

- Objective national consumption percentage of electric power, fixed every 5 years, to be supplied with RER-based electric generation, excluding hydroelectric plants. For the first five-year period the said percentage amounts to 5%.
- Through energy auctions to be supplied with RER, the awarded investor is guaranteed a steady price (offered in auction) for energy poured into the grid during the supply contract term for up to 20 years. For the first auction the total installed capacity quota amounts to 500 MW.
- Priority to load dispatch and access to transmission and distribution networks.

These incentives are applicable to such renewable resources as biomass, wind, solar, geothermal, tidal or hydroelectric up to 20 MW.

There are also tax incentives, such as accelerated depreciation benefits of up to 20% annual, for investments in hydroelectric projects and other renewable resources, as established by Legislative Decree No. 1058 (June, 2008). The "Regulation for Anticipated Recovery of the Tax on General Sales (IGV)" is also offering tax incentives for these resources.

Regarding rural electrification, it is the MEM, through the General Directorate of Rural Electrification (DGER-MEM), the one with competence pursuant to the Law N°28749, "Law on Rural General Electrification".

Finally, to point out that Peru has a law for promoting geothermal energy (Law No. 26848 and its corresponding Regulations).

2. Energy Efficiency

Energy efficiency is deemed to be a permanent and long-term activity, for which a series of action lines have been set forth as part of the national strategic plan. Through Law No. 27345 regarding the "Promotion of Efficient Energy Use" and its corresponding Regulations, subsequently approved in year 2007, it is envisaged to

develop a national culture for an efficient energy use in coordination with all the country's educational and economic sectors.

The most outstanding aspects of the law and its corresponding regulations are:

- A culture of efficient energy use (UEE), developing educational actions at all levels.
- UEE sector programs: residential, production and services, public and transportation, among others.
- UEE dissemination, replicating successful actions and experiences all over the country. And likewise promoting cogeneration and distributed generation.
- Development of capacities and opportunities, certification of consultants and energy services utilities.

Other regulations have been approved after the enactment of Law N° 27345, supporting development of efficient energy use, i.e., Decree on "Energy Saving Measures for the Public Sector": This decree compels to the replacement of less efficient bulbs with more efficient ones. Such is the case of incandescent lights, being replaced by compact fluorescent bulbs. This affects also electromagnetic ballasts, to be replaced with electronic ones. Moreover, the public sector shall purchase lighting equipment showing an energy efficiency eco-label in accordance with the guidebook on energy efficiency.

In addition to the various legislative texts, other actions are being developed within the field of efficient energy use promotion. Next are the most representative ones:

2009 – 2018 Referential plan for efficient energy use

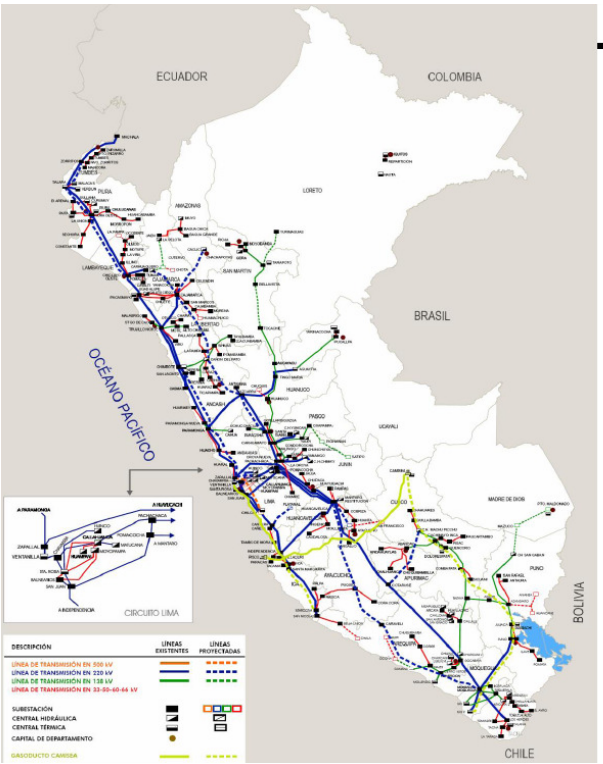
The plan promotes the implementation of energy efficiency actions in all consumption sectors through good practices and an efficient use of technology.

Minimum energy efficiency standards guidebook and energy efficiency eco-label guidebook

In coordination with INDECOPI and the relevant institutions, the MEM proposes the "Minimum energy efficiency standards guidebook" and the "Energy efficiency eco-label guidebook", so as to provide relevant, comparable and reliable information regarding energy efficiency of household energy consuming equipment. These guides will allow better end user orientation for choosing more efficient equipments, thus motivating manufacturers to adopt energy efficiency improvement methods.

The Peruvian electrical system

The National Electrical System covers 80% of the national surface area, with an installed capacity of 7,059 MW. The National Electric Power Interconnected System (SEIN) has an installed capacity of 5,983 MW and a production of 27,709 GWh, with a maximum confirmed demand of 3,966 MW in the year 2007. The national electrical system and main data for 2007 are stated in the following chart:



Sistema Eléctrico Nacional 2007

En el ámbito nacional

Cobertura Eléctrica	:	80,0	%
Consumo per cápita	:	943	kW.h/hab
Potencia Instalada	:	7 059	MW
Producción	:	29 857	GW.h
Ventas	:	24 621	GW.h
N° de Usuarios	:	4,4	Mio
Facturación (C.Final)	:	1 825	Mio US$

En el SEIN

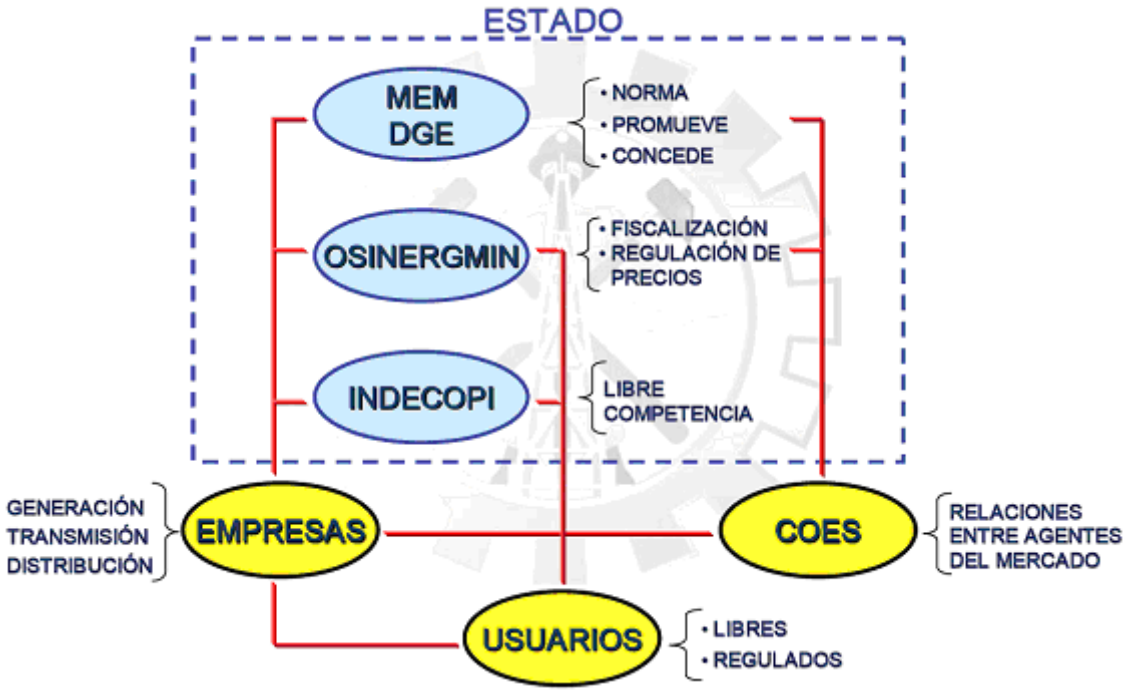
Potencia Instalada	:	5 983	MW
Producción	:	27 709	GW.h

Líneas de Transmisión

220kV	:	5 677	km
138kV	:	3 636	km

National Electrical Grid, 2007 (Source: CENERGIA).

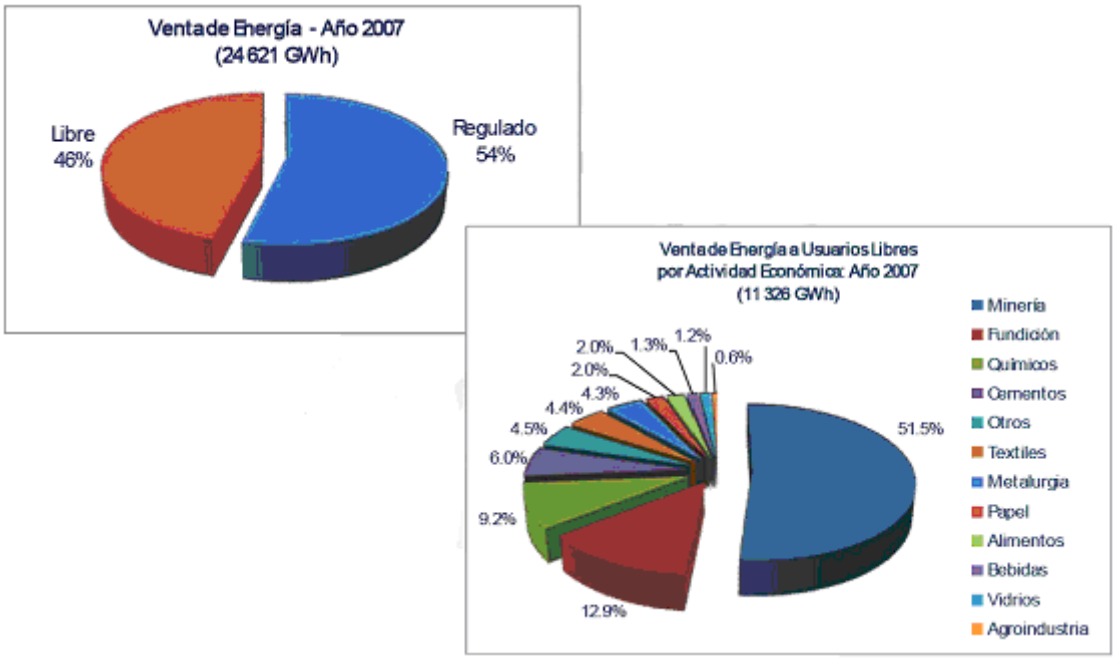
The organisation of the State engages government bodies such as MEM, OSINERGMIN and INDECOPI that interact with electric firms, either private or public, system operator and users, as shown in the following figure:



Electrical system organization (Source: CENERGIA).

Regarding the SEIN's effective capacity, the projected offer as to year 2008 is 5,207 MW, which would represent a capacity reserve of 844 MW.

The electric market consists of free (46%) and regulated (54%) users, as shown in the following chart.



Electric Market, 2007 (Source: CENERGIA).

3. ANALYSIS OF THE WIND ENERGY SECTOR

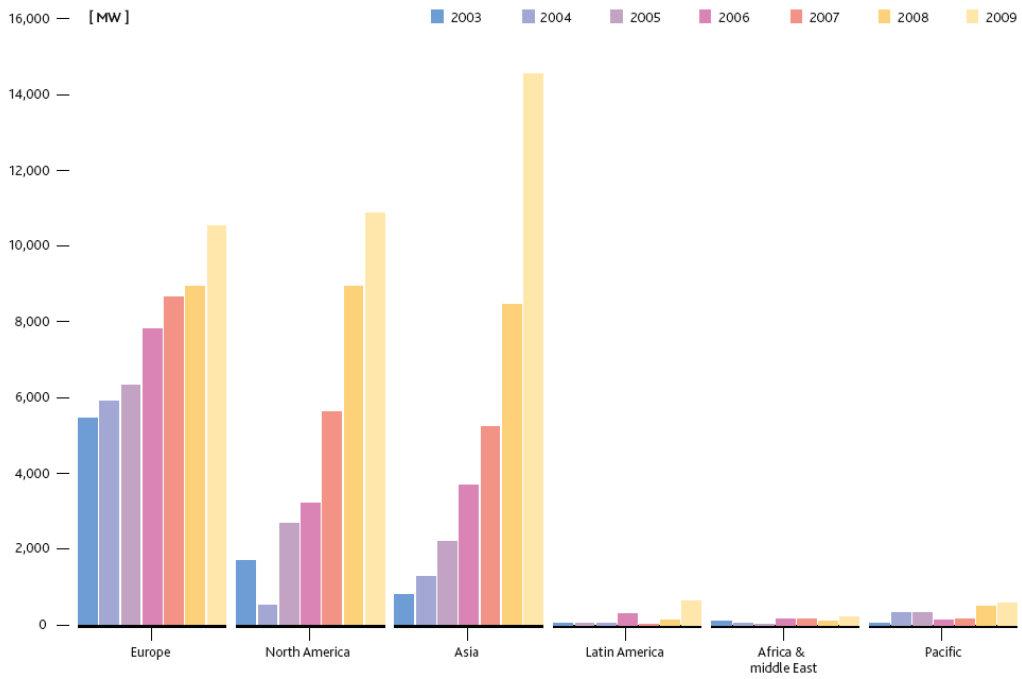
Wind energy in the world and in Europe

Wind energy has reached such a high level of development that it may be currently described as a clean, economically-competitive energy source having a maturely exploited technology. Derived from a natural source that is both renewable and non-contaminating, wind turbines are capable of producing electricity at competitive costs in comparison to other traditional energy sources, allowing wind energy to position itself over the past years, as the most rapidly growing energy source in the world.

The wind energy market is developing with an annual growth rate of around 30%, having surpassed 2500 MW in 1992, reaching 94,000 MW on the 1st of January of 2008, offering sufficient energy to satisfy the needs of some 50 million homes, and over 120 million people. (Source: AEE).

The fight against global climate change has, in large part, motivated the increase in wind energy, as it avoids carbon dioxide emissions without producing other contaminants associated with fossil fuels or nuclear generation. An energy development of this type proves favourable and tends to be accepted by society as it avoids the production of gas contaminants or long-term waste products. According to current data, electric generation by wind farms has prevented some 18 million tons of CO2 emissions in 2007 from thermal power stations of coal, gas or fuel oil, thus helping to comply with the commitments of the Kyoto Protocol.

As it has developed in the market, the costs of wind energy have reduced greatly. While the factory costs of the wind turbines have increased with the rise in price of the raw materials, primarily steel, which vary in function with the technology and machine size, affecting the costs of generation with a wide margin due to differences in project sizes, fundamentally resulting from the variable wind characteristics of the sites. The successful business of wind energy has attracted the attention of all sorts of new investment markets and new participants.



Annual installed capacity by region 2003-2009 (Source: Global Wind Energy Council).

Europe leads the world market in wind energy, both in what is referred to as installed potential as well as the industry of the sector, and we can currently confirm that wind farms have been created in practically every geographical area of the continent. The production of electrical energy in systems connected to the network through wind energy is being consolidated in many European countries as a way of diversifying the current energy structure.

According to the annual report of BTM Consulting, there is a predicted increase in wind energy potential in Europe, from the period of 2007 to 2011, of some 59,150 MW, followed by North America, with an increase of some 33,050 MW over the same period. In reviewing the data from the International Energy Agency for the year 2005, it is found that Spain was predicted to be the second country in the world in terms of largest percentage of energy demand covered by wind energy. This prediction was verified as Spain in fact reached 9.5 % in the year 2007, only surpassed by Denmark having a value of 20.10%.

Today the wind energy industry has surpassed the R&D stage, operating in an industrial manner, with technical reliability, economic efficiency and virtually no environmental impact.

The current series machines have considerable power (of some 850 to 3000 kW), permitting the wind farms to reach important total production potentials, with significant levels.

	1982	1992	2002	2006	Incremento (%)
Potencia Nominal (kW)	55	225	850	2000	36.36
Diámetro del Rotor (m)	15	27	52	80	5.33
Área Barrida (m^2)	177	573	2124	5027	28.40
Altura de la Torre (m)	20	30	50	85	4.25
Producción Anual (MWh)	110	520	2550	5605	50.95
Peso Total / Góndola rotor inc. (T)	6.7/2.9	22/10.8	80/26.5	286/104	42.6 / 35.86
Coste Estimado (Euros)	66600	250000	850000	2400000	36.0
Producción/Área Barrida (kWh/m^2)	621	907	1200	1114	1.79
Peso Góndola/Área Barrida(kg/m^2)	16.3	18.84	12.47	20,68	1.26

Chart of the evolution of wind turbines over the period from 1982-2006

There are different supplemental pricing systems for the energy retribution. Regulatory frameworks should offer adequate remuneration so as to guarantee the economic viability of the projects. The regulatory frameworks include:

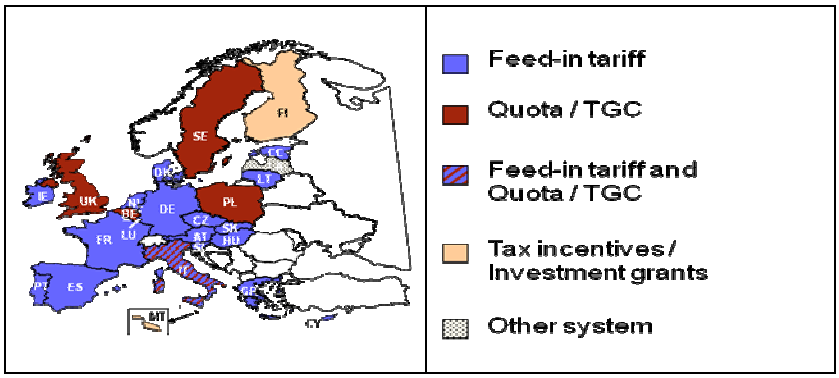
- Feed-in Tariffs (FIT): Renewable energies are integrated into the electrical system with a guaranteed rate during a determined period. The market sales price depends on the requirements of the electrical system, based on an initial price. In addition, the FIT may offer incentives added to the average price of the electric power market (in the case of Spain). Within the FIT system, there are two options: remuneration depending on production of the wind farm (the case of Germany and France) and independent of the farm

production level. This is the case in Spain where remuneration may be a regulated price or is set at the rate of the Electric Power Market.

- Tradable green certificates (TGC): Based on the determination of a goal quota for renewable electrical energy generation. Renewable generation is sold at a price determined by the electric power market and there are also additional earnings for the sale of certificates of emissions rights. Prices depend on the goal quota that is determined by the certificate market.

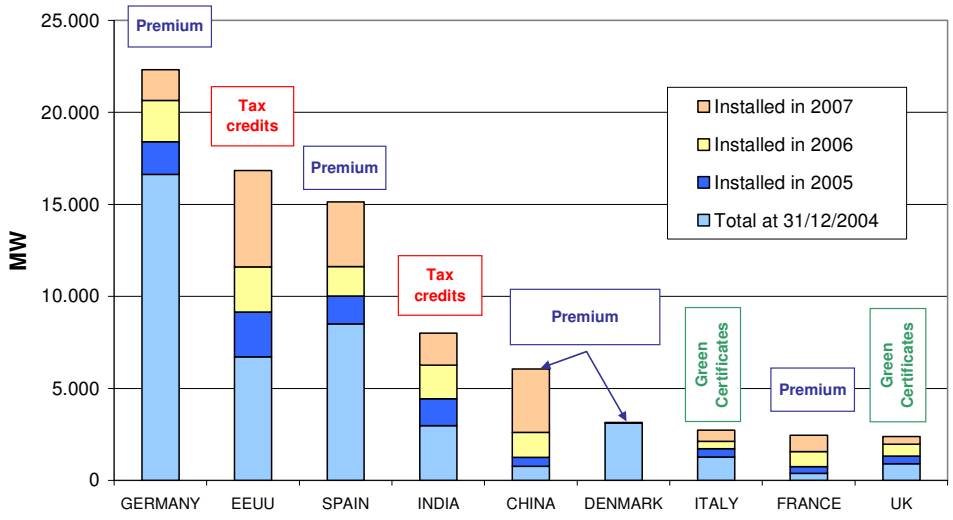
- By public sector bidding processes.

- Tax incentives and investment grants.



Prominent regulatory systems within the European framework (Source: Fraunhofer)

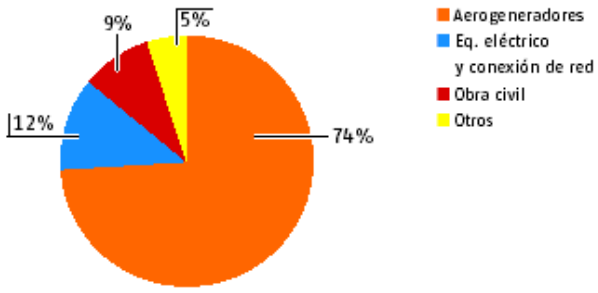
When comparing the effectiveness of the retributive mechanisms, the systems based on premiums and tax incentives are found to be more effective than those based on other support mechanisms, as shown in the following graph:



Comparison of retribution methods by country (Source: EWEA, WWEA y AEE)

In addition, those countries having certificate mechanisms had energy sale prices that were higher than those countries with Feed-in Tariff systems, without having significantly more renewable energy generation facilities.

The specific investment in wind farms (€/MW) has progressively decreased by almost half over the past 20 years, due to the increase in size, the standardization of products caused by increasing demand and improved technologies. However, over recent years this trend has changed, with an increase being observed in this parameter due to, on the one hand, the fact that the increased size has not absorbed the cost reduction, and on the other hand, due to the increased complexity required of the machines for network integration. It is also important to note the increase in steel costs which according to current predictions will increase at a rate equal or above 3%, driven by a strong increase in international demand.



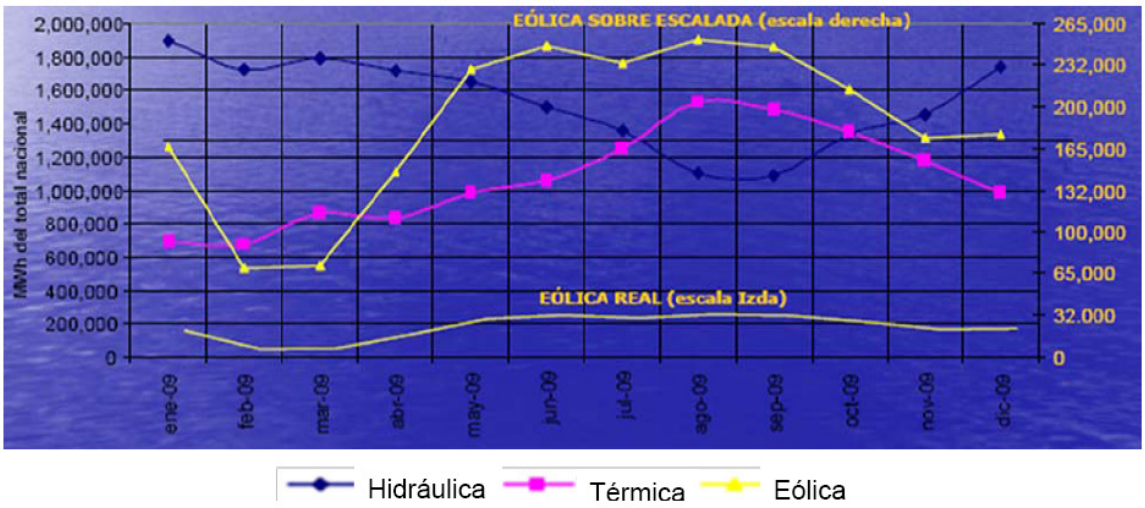
Distribution graph of investment costs (Source: AEE).

Wind Energy in Peru

- **Current Status:**

Although the installed capacity at the moment for this Andean country has barely reached megavolts, there is a wind power potential exceeding 22 GW. And according to the Wind Atlas of Peru, the regions of Ica and Piura, located on the coasts, are the regions having the largest usable potential, with some 9,144 MW and 7,554 MW respectively, having winds registering between 5 and 7 m/s.

The country's demand for electrical energy is registering high growth rates. On the other hand, the generation of electrical energy is fundamentally hydroelectric, dependant on rainfall, and there also is a large participation of natural gas. Regarding natural gas, the distribution network for the country is not sufficient for the high demand levels, although the government is attempting to amplify the gas main. Based on the current situation, it is clear that the country needs to diversify its energy matrix so as to assure the energy supply, and wind energy, with its high potential in the country, offers an excellent opportunity. Additionally, studies exist which indicate that the hydroelectric power regime and the wind power regime will unite over the year. As shown in the following figure, there was high hydroelectric production from December to May and a stable regimen of favourable wind resources from May to November:



Complementary wind and hydroelectric energy (Source: Energía Eólica S.A.).

The goal of Law 1.002 is to promote investment in the generation of electricity through renewable energies, including wind energy. The Law predicts the awarding of 500 MW of renewable energy. This awarding is by order of merit and it does not exceed the maximum award rate including each participating technology indicated in the bases so as to cover the total energy required. The required energy will be distributed between the renewable sources in the following manner:

Energy	Biomass Technology	Wind technology	Solar technology	Total
GWh/year	813	320	181	1314

Initial assignment of required energy by technology.

The awarding will be made for each technology and OSINERGMIN will set the maximum award rates for each technology through a bidding process that will be determined by a mechanism of energy auctioning between investors so as to cover the quota of renewable energies. This mechanism has been designed to guarantee the investors a profitability of no less than 12%. Those technologies that do not reach their quota of required energy will be covered by the subsequent technology of lesser price. The first award process for bidding was developed in 2009, and in early 2010, the results of the bid process will be published. The phases of energy bidding are:

Phases of the Energy Bidding	
Bidding Bases	Ministry of Energy and Mines MEM
Bidding Information	Supervising Agency of the Investment in Energy and Mining OSINERGMIN
Participant Registration	OSINERGMIN
Invitation and Sale of Bases	OSINERGMIN
Maximum rate of Adjudication for each Technology	OSINERGMIN Committee
Bid offer presentations	Investors
Qualification and publication of the bidder relations in the auction	OSINERGMIN
Adjudication by merit	OSINERGMIN

Phases of the energy bidding process.

In the specific case of wind energy, the assigned power is of 100 MW. MEM has awarded some 60 temporary concessions for studies of wind generation, equalling over 9 GW of power.

One of the most important aspects of wind power technologies is its integration in the network. In the Peruvian case there has been an initial study made, indicating that the maximum permitted wind energy in the network is some 375 MW, although a later revised report made by the COES has established that potential at 640 MW.

- ## Regulatory framework of the sector

The regulatory framework affecting the wind energy facilities, in addition to that expressed in the previous section, is defined by the following documents:

The Electric Concessions Law (LCE) (1992) regulates activities related to the generation, transmission, distribution and marketing of electric power.

In the Regulations (1993) of the Law, the rights and obligations for entities developing power generation activities were established, including: presenting the technical and economical information to COES and OSINERGMIN, assisting in technical inspections, compliance with the rules of environmental conservation and of the National Cultural Heritage, etc.

D.L. 28.832, "to assure the efficient development of Electrical power generation" was issued in 2006 and deals with the problem of generation deficit, introducing changes so as to encourage investment in new generation.

- ## Barriers to wind energy

Technological Barriers:

The technologies of wind energy are mature and well developed, particularly in more developed countries where the market has reached a level of maturity. In the case of Peru, it is a new market in which there are technological barriers which may impede its growth. The following is an analysis of the main barriers detected:

- **Network integration:**

The main problem to be solved is that of integrating into the system, a considerable generation contingent with incorporation priority, whose availability is random, free of location and fragmented, and who in situations of instability, will disconnect from

the same, requiring the rest of the generation to increase its participation share in the complementary system services, so as to ensure proper functioning.

Additionally, the fact that wind farms are generally located in areas with low population densities must be considered, as these areas typically have weak electrical supplies requiring reinforcement and improvement. Further, the Peruvian electrical system is radial and not very redundant.

The emergence of voltage dips and the control of reactive energy are also particular features of network integration.

- **Lack of qualified project designers, installers and maintainers:**

The wind energy market in Peru is a recent one, implying the existing need for various services related to this technology, including the need for engineering, installation and maintenance services. In addition to the scarcity of services, there is also a lack of qualified project developers, installers and maintainers. In other words, the wind market is not a developed and mature market.

4. RESULTS

Proposed measures

- **Network integration:**

The use of predictive measures. There are in fact, different methods of prediction, in order to estimate a value for the wind energy, and these methods vary between the use of statistical models and physical models, or a combination of both. Similarly, the prediction may be based on the estimation of production for a set of wind farms, or it may use various methods of prediction for one individual farm, with the goal of improving the understanding and therefore, increasing the results.

It is also necessary to coordinate with the electrical companies and wind farm promoters in order to solve the problems resulting from wind farm network integration. An example of effective coordination with the system operator is the control centre of renewable energies (CECRE), created by the Spanish Electricity Network. This centre is unique in the world and it controls and coordinates the generation of all of the producers of wind energy installed in Spain.

With regards to the adequacy of the voltage dips, it is recommended the use of technology that complies with the determined requirements offers a response to such dips in the wind farms. Countries having advanced uses of these technologies, as is the case in Europe, have defined these requirements.

Finally, the control of reactive energy may be carried out through the retributive supplements for the maintenance of the reactive regulation.

- **Lack of qualified project designers, installers and maintainers:**

A regulatory framework is necessary so as to boost the use of these technologies and increase the market's development. The publication of Law 1.002 supporting the generation of electricity through renewable energies is a fundamental point in the history of wind energy in Peru. Of the 500 MW that were auctioned off, in accordance with Law 1.002, 100 MW were assigned to wind energy. Interest on behalf of the

country's promoters is such that the temporary concessions that have been granted by MEM have exceeded 9 GW of power.

Reinforcing the technical abilities of the agents in the sector through training courses. For this, reliance on the experience of European countries with increased knowledge is essential. For example, the promotion of alliances so as to permit technological transfer between international engineering companies and the local engineering companies would be a useful measure.

5. REFERENCES

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