MSc Program

Renewable Energy in Central and Eastern Europe

# Promoting Renewable Energy Technologies

An Analysis and Evaluation of National Support Measures for Electricity Production from Renewable Energy Technologies with a Special Focus on Poland

A Master's Thesis submitted for the degree of "Master of Science"

supervised by **Gustav Resch**

Cosima Steiner
London, September 2010

## Affidavit

I, Cosima Steiner, hereby declare

1. that I am the sole author of the Master's Thesis "Promoting Renewable Energy Technologies – An Analysis and Evaluation of National Support Measures for Electricity Production from Renewable Energy Technologies with a Special Focus on Poland", 112 Pages, bound, and that I have not used any source or tool other than those referenced or any other illicit aid or tool, and

2. that I have not prior to this date submitted the Master's Thesis as an examination paper in any form in Austria or abroad.

London, September 2010

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Cosima Steiner

## Abstract

My thesis represents the final document for the Masters of Science Program "Renewable Energy in Central and Eastern Europe". The objective was to carry out a thorough analysis and evaluation of support measures available to stimulate the deployment of electricity production from renewable energy sources and to dedicate a thorough research of the matter to Poland's renewable energy policy.

I chose Poland's energy policy as subject-matter because of my professional three-years work experience (2006-2009) at the Austrian Trade Commission in Warsaw.

The core question addressed is which policy measures are generally available to support electricity production from renewables and, in particular, which measures have been implemented in Poland. What are their key elements? How well are they working? Further issues addressed were the main barriers to the deployment of technologies for generation of electricity from renewable sources in Poland and effectiveness and efficiency of the current support scheme. Finally, I looked at the experience of a Western European country and the possible implications for Poland's trajectories.

The method of approach was to first generate a general framework of reference by providing the reader with an overview of the rational of renewable energy policy, possible policy design and performance. Subsequently, an analysis of the status quo of Poland's power sector was conducted and the significance of renewables in the country's energy policy was researched. Thirdly, I used statistical approaches to analyze efficiency and effectiveness of national policy measures with the help of specific indicators. Finally, I set Poland's support scheme for renewable electricity in relation to policy tools and developments in the country I am currently living and working in, the United Kingdom.

The main results of the analyses are as follows:

- Renewables have traditionally accounted for a small share in Poland's primary energy production and consumption due to the importance and availability of coal for energy production.
- Renewable energy sources can and will play an ever more significant role in Poland's future energy mix, but a number of obstacles remain.

- Poland has a large natural endowment favorable for renewable energy. The highest potential for electricity production from RES in Poland lies in biomass and wind power.
- The main support mechanisms for renewables are a quota system and a green certificate scheme.
- Onshore wind power capacity has shown the most dynamic growth amongst renewable energy sources in Poland over the last few years.
- Poland's policy for promoting onshore wind has a relatively low effectiveness.
- Calculations show that wind power investment is currently not feasible without the option of selling renewable energy certificates. In terms of policy efficiency, the results seem to indicate that wind power is over-incentivized.
- Support mechanisms should regularly be evaluated, adapted and improved to reduce existing barriers and remove efficiencies.
- Poland's policies are a few steps behind the British regulations, which should make it attractive for Polish policy makers to observe the latest developments in the United Kingdom and their possible implications for their country. British experiences can offer valuable conclusions and could even prevent a duplication of research efforts.

It can be concluded that Poland has to remove significant obstacles that hold back expansion to make full use of its potential for electricity production from renewable sources. As the analysis of policy efficiency and effectiveness have shown, there is great potential for policy adaptation and improvement, including the elimination of administrative burdens and the reduction of technical and financial risks of obtaining access to the grid.

Moreover, the green certificate system should be reviewed and – if necessary – adapted on a regular basis to guarantee a smooth development of the market.

Observing the experiences of other countries should prove beneficiary as it allows for a steeper learning curve. The case of the United Kingdom for example demonstrates the possibilities of introducing complementary measures to green certificates, which stimulate the development of small-scale technologies.

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# LIST OF ABBREVIATIONS

## Institutions

| | |
|---|---|
| BOS | Bank for Environmental Protection (PL) |
| DECC | Department of Energy and Climate Change (UK) |
| EC | European Commission |
| EC BREC | Polish Institute for Renewable Energy |
| EEG | Energy Economics Group |
| EIU | Economist Intelligence Unit |
| EREC | European Renewable Energy Council |
| EU | European Union |
| GUS | Polish Central Statistical Office |
| HM Treasury | Her Majesty's Treasury (UK) |
| IEA | International Energy Agency |
| IGA | International Geothermal Association |
| IMGW | Polish Institute of Meteorology and Water Management |
| IPIEO | Polish Institute for Biofuels and Renewable Energies |
| KAPE | Polish National Energy Conservation Agency |
| NAO | National Audit Office (UK) |
| NFOSIGW | National Fund of Environmental Protection and Water Management |
| OECD | Organization for Economic Co-operation and Development |
| Ofgem | Office of the Gas and Electricity Markets (UK) |
| PAIZ | Polish Information and Foreign Investment Agency |
| PGE | Polish Energy Group, Górnictwo i Energetyka S.A. |
| PIGEO | Polish Chamber for Renewable Energies |
| PKE | Poludniowy Koncern Energetyczny S.A. |
| POLPX | Polish Power Exchange |
| PSEW/PWEA | Polish Wind Energy Association |
| RAB | Renewable Advisory Board (UK) |
| REC | Regional Environmental Centre for Central and Eastern Europe |
| RESTATS | Renewable Energy STATisticS Database (UK) |
| S.A. | Spółka Akcyjna (Aktiengesellschaft) |
| TEW | Polish Hydropower Society |
| URE | Polish National Energy Regulator |

## Units

| | |
|---|---|
| bn | billion |
| EUR | Euro(s) |
| GJ | gigajoule |
| GWh | gigawatt hour |
| ha | hectare |
| J | joule |
| kW | kilowatt |
| kWh | kilowatt hour |
| m | metre |
| $m_2$ | square meter |
| $m_3$ | cubic meter |
| mn | million |
| Mtoe | million tons of oil equivalent |
| MW | megawatt |
| $MW_{el}$ | megawatt electric |

| | |
|---|---|
| MWh | megawatt hour |
| $MW_{th}$ | megawatt thermal |
| PJ | petajoule |
| PLN | Polish Zloty |
| TJ | terajoule |
| TWh | terawatt hour |
| Wh | watt hour |

**Terms**

| | |
|---|---|
| APV | Adjusted Present Value |
| CCL | Climate Change Levy |
| CHP | Combined Heat and Power |
| CoO | Certificate(s) of Origin |
| CPI | Consumer Price Index |
| DCF | Discounted Cash Flow |
| DSO | Distribution System Operator |
| EIA | Environmental Impact Assessment |
| ERU | Emission Reduction Unit(s) |
| FiT | Feed-in Tariff(s) |
| GC | Green Certificate(s) |
| GHG | Greenhouse Gas |
| JI | Joint Implementation |
| MSc | Master of Science |
| NAP | National Allocation Plan |
| NFFO | Non-Fossil Fuel Obligation |
| NPV | Net Present Value |
| OP IE | Operational Programme Infrastructure and Environment |
| p.a. | per annum |
| PV | Photovoltaics |
| PVIFA | Present Value Interest Factor of Annuity |
| R&D | Research and Development |
| RE | Renewable Energy |
| RES | Renewable Energy Source(s) |
| RES-E | Renewable Electricity |
| RES-H | Renewable Heat |
| RET | Renewable Energy Technology |
| RHI | Renewable Heat Incentive |
| RO | Renewables Obligation |
| ROC | Renewables Obligation Certificate(s) |
| SHP | Small Hydro Power |
| SHPP | Small Hydropower Plant |
| TGC | Tradeable Green Certificate |
| TPEC | Total Primary Energy Consumption |
| TSO | Transmission System Operator |
| yoy | year on year |

# 1 INTRODUCTION

Fossil fuels have traditionally dominated Poland's energy production. The country is the European Union's largest producer of coal: Hard coal and lignite are the main source of electricity generation and primary energy supply. Until recently, renewable energy sources have only played an insignificant role.

Interest in renewables as a source of energy, policy design to encourage the development of renewable energy sources (RES) and investment activity has lately gained momentum due to

- mandatory targets set by EU directives (an RES share on gross electricity consumption in Poland of 7.5% by 2010 and 15% of energy from RES by 2020),
- national commitments laid down in the development strategy of the RES-sector according to which Poland's share of RES in the primary energy balance should reach 10.4% by 2010 and 12.9% in 2017,
- greenhouse gas (GHG) emission reduction target defined by the Kyoto-Protocol,
- increasing demand for energy due to rapid economic development in Poland and the threat of a shortage of supply in energy and
- public concern about Poland's dependence on energy supply from other countries and a strive for diversification of energy.

Considerable barriers and risks obstruct the deployment of renewable energy, and the government has introduced policy measures to overcome these hurdles.

The objective of this diploma thesis for the Master's of Science (MSc) degree in "Renewable Energies in Central and Eastern Europe" is to analyze and evaluate the policy measures available to promote the deployment of electricity generation from renewable energy sources and to focus on the support mechanisms implemented in Poland.

The country is an interesting subject for such an analysis as it still has a relatively low level of energy production from renewables but a very high potential for development. Natural endowment, good economic progress and the growing need for substitution of fossil fuels (especially coal) with alternative clean sources of power provide an encouraging framework for rapid deployment in the near future.

The focus of the study is renewable electricity. The heat and transport sectors are discussed on a very general level and otherwise largely remain outside the scope of my thesis.

The discussion of Poland's renewable energy policy scheme is structured into four main steps:

First, the rational for renewable policy measures in general is described: What are the main barriers for the adoption of renewable energy technologies, which risks are associated with renewable energy projects, what kind of role can national governments play in stimulating the diffusion of renewables, which support measures are available and how can the success of these policies be assessed.

This is followed by an analysis of the Polish energy sector and the significance of renewable energy sources for the country's energy policy. A few large players supply the country with electricity by burning coal in large combined heat and power (CHP) plants and dominate Poland's power market. However, European Union Directives and international agreements on greenhouse gas emissions oblige countries to reduce their use of fossil fuels. To stimulate the production and use of renewable energy, the Polish government introduced incentives and a regulatory framework with renewable energy targets, which power generators and distributors have to fulfill. Nevertheless, major barriers on the political, regulatory and financial level still block the diffusion of renewables, and the amount of electricity produced from renewable sources is only a fraction of what can and should be achieved by the year 2020. Stepping up the efforts is a prerequisite to reach the goals laid out in the regulations.

Thirdly, the current and future potential of renewable energy sources for electricity production in Poland is evaluated and – based on this examination - effectiveness and efficiency of selected Polish policy measures are discussed.

A fourth step introduces the international perspective: Due to its political and economic history, Poland is a relative latecomer with respect to renewable energy policies. Various countries of the European Union have implemented different support schemes. Poland is not the only country, which uses a combination of an obligation and certificate scheme to incentivize its renewable energy industry. Consequently, other country’s experiences offer conclusions for future pathways of Polish RES-policies. The United Kingdom (UK) employs an incentive scheme very similar to Poland’s, but has done so for much longer than Poland and was therefore chosen as a comparative example. The UK’s experiences are discussed to provide possible guidance and to draw further conclusions for Poland’s future trajectory.

The thesis is largely based on course material from the New Energy “Renewable Energy in Central and Eastern Europe” Master of Science Course (Course program 2007 – 2009) and on publicly available literature. I carried out research on the internet and attended presentations on the topic. Additional resources included documents and statistical material published by Polish and international institutions. I could also gather considerable knowledge about the subject matter while working for the Austrian Trade Commissions in Warsaw and London, performing research for Austrian companies and exchanging views and experiences with colleagues and experts active in the sector.

Power plant modeling and the financial calculations were carried out using Microsoft -Excel spreadsheets and the RetScreen© software. RetScreen© was developed and is promoted by RetScreen© International, the Clean Energy Decision Support Center, an initiative by the Minister of Natural Resources Canada.

# 2 POLICY MEASURES FOR THE DEPLOYMENT OF RES

The last two decades saw heavy activity by administrative bodies to introduce policies that promote renewable energies. The need for those policies is often attributed to a number of existing barriers and hindrances that put renewables at a competitive disadvantage to conventional energy.

The following chapter describes the main barriers that block the development of renewable energy sources (RES), looks at risks associated with RES-projects, focuses on the role of national governments in overcoming these hindrances and elaborates on popular policies to enable an enhanced RES-development. The main focus of the assessment lies in renewable electricity (RES-E) while renewable heat (RES-H) and the transport sector are discussed only very briefly.

## 2.1 Major Barriers to Renewable Energy

Barriers that leave RES-technology projects at an economic, regulatory and/or institutional disadvantage in comparison to conventional forms of energy supply occur on several dimensions. While some of the conditions increase the cost of renewable energy relative to other alternatives, a significant part could be considered as an unfair discrimination against RES, i.e. a market distortion (Beck/Martinot (2004), IEA (2003)).

### 2.1.1 Costs and Pricing Distortion

Renewable energies are often considered being more expensive than fossil fuels. However, a cost comparison is quite difficult as several factors can distort the view.

Public subsidies to incumbent technologies (in the form of direct payments, tax incentives, guarantees, R&D spending etc.) can lower final energy prices and put RES at a competitive disadvantage. Abolishing subsidies for the fossil fuel and nuclear industry has proven to be difficult for political reasons. Many policies focus on overcoming cost barriers by funding renewable energy projects rather than reducing subsidies for fossil and nuclear power.

Secondly, even though capital costs for renewable energy technologies are often higher on a cost-per-unit basis (EUR/unit of installed capacity), a look over the period of a full life cycle might paint a different picture. A true comparison between RES and conventional technology ideally focuses on their overall life time, including initial capital costs, future fuel costs, future costs of operation and maintenance, decommissioning, equipment lifetime etc. This, however, is a complicated task as it is hard to predict the future prices of fossil fuels, which have experienced considerable fluctuations in recent history.

Thirdly, power-pricing rules can distort the real value of energy fed into the grid by renewable energy sources. A pricing scheme where a RES-power plant receives only the wholesale price for the electricity it feeds into the grid ignores that the installation is often located close to the customer and the electricity it produces does not require long transmission and distribution. The latter are however necessary for energy produced by centralized generation facilities that are far from the customer. Moreover, as RES-output is often resource-dependent (like in the case of wind or sun) and cannot be entirely controlled, utilities are inclined to use lower pricing schemes for RES-E based only on the value of energy produced without any reward for capacity value. Some utilities also only pay an average price for RES-E at peak times, when power is more valuable.

Transaction costs are usually higher for renewable energy projects due to unfamiliarity with for e.g. technology, uncertainty over projects and availability. Therefore, the process of resource assessment, siting, permit, planning, developing, and negotiation with the utility usually come with much higher transaction costs than the project development of conventional power projects. Even though higher transaction costs might not necessarily be a market distortion, they make renewable energy projects less attractive. The connection to the grid, for example, can be a burdensome and lengthy process adding substantially to the total cost of the project.

Finally, the cost of environmental externalities is in the majority of cases not fully accounted for when the viability of a project is calculated. The burning of fossil fuels has a huge impact on the health of nature and people, but these social costs are hard to evaluate. Several western states have started to develop a regulatory approach to reduce greenhouse gas emissions from the electric power industry by using a cap-and-trade scheme, which attempts to internalize some of the internal costs. An example is the European Union (EU)'s Emission Trading Scheme.

### 2.1.2 Legal and Regulatory Barriers

In many countries, renewable energy development is subject to a legal and institutional patchwork with different and often contradictory laws, regulations, policies and administrative procedures. Power utilities frequently hold a dominant position in the economy to produce, transmit and distribute electricity. They guard their position well by making it very costly or even impossible for RES-projects to sell their electricity to the utility. The incumbents usually place high costs on transmission access, which is in some cases a prerequisite due to the remoteness of power generation facilities like wind farms or biomass power plants from populated areas. Naturally, safety and power quality risk from non-utility power-generation sources have to be ensured; However, utilities tend to set interconnections requirements that go beyond what is considered practical or necessary. Excessive liability insurance requirements also put high cost burdens on small power generators (e.g. small photovoltaic (PV) systems feeding into the grid).

High costs or a lack of standards for connection and transmission often discourages renewable energy projects. Regulations based on industry tradition (standards and codes) might prove unapt for new technologies. Sometimes regulations block renewable energy by transmission access rulings or right of way disputes. Restrictions on siting and construction of RES-power plants could be in place due to height, noise, aesthetics, safety or environmental considerations (e.g. bird migration in the case of wind farms, Natura 2000 protection).

In addition, more often than not, renewable energy must compete with financial and regulatory systems that have evolved to promote the development and use of fossil fuels and nuclear power. These existing schemes often discriminate against the use of renewable technologies.

### 2.1.3 Market Considerations

Individual consumers or project developers can face difficulties in accessing funds to invest in renewable energy technologies due to lack of collateral, poor creditworthiness, payback periods that are too short compared to the investment lifetime or uncertainties about the longevity of feed-in tariffs or purchasing power agreements.

Lack of information, experience and familiarity with a given technology lead to perceived performance uncertainty and higher technical risk than with conventional energy sources. Consequently, requirements in terms of equity capital, rates of return or technology selection and resource assessment are usually higher than for proven systems. Utilities are frequently biased against unfamiliar technologies and ignore them in their development plans. Poor past performance might trigger more unwillingness to consider improved versions of a system and increase the alleged technical and financial risk to invest in renewable energy even further.

The energy market is also a very specific sector, where skilled personnel is required to install, operate and maintain technologies, but usually it is not available in large numbers. Consumers, lenders, project developers, managers, regulatory bodies often lack skills and information about RES-technologies, its characteristics, costs and benefits. This gives rise to uncertainties and blocks decisions.

## 2.2 Risks of an Investment in RES

Investments in renewable energy technology projects are associated with different risks that affect the cost of projects and give them a major competitive disadvantage over conventional energy.

In line with the arguments on barriers to the deployment of RES-technologies, the various risks fall into a few broad classes, which are described below. However, it is important to notice that the description is not exhaustive and that not all of the risks mentioned are specific to renewable energy projects (de Jager/Rathmann (2008), Mitchell et al. (2006)).

### 2.2.1 Project Level Risk

Project level risk is specific to the selected technology and project, especially during its construction and operation phase. The construction phase could see a time and cost overrun or the inability to fulfill technical specifications and the underperformance of a construction contractor. Assumptions could prove unrealistic; delays cause higher costs of equipment and service. During the operation phase performance risk of the installation and the availability of resources might arise.

### 2.2.2 Financial Risk

Financial risk relates to adverse changes in financial and/or economic parameters, which increase cost of capital and availability of funds. Examples are interest rates, currency exchange rates or inflation rates. The last financial crisis caused the postponement of a number of RES-projects due to sudden lack of funds.

### 2.2.3 Market Risk

Market risk includes price and volume risks for producers of RES-E on both the demand and supply side. In a liberalized market, electricity prices are volatile, and hedging against this price volatility can prove very costly for small, less diversified generators.

A generator's revenue depends on the volume he can sell, which is strongly influenced by the type of public RES-support mechanism that is in place. A quota system, for example, with the obligation for energy distributors to provide a certain amount of energy from renewable sources, changes the total demand for renewable energy in an economy.

On the supply side, current and future price and availability of commodities such as biomass are important considerations for the feasibility of a project.

### 2.2.4 Regulatory or Institutional Risk

Regulatory or institutional risk refers to uncertainties that occur due to the design of or adverse changes in the policy context or of an existing support scheme. Complicated and opaque regulatory requirements that make acquisition of permits or the connection to the grid a cumbersome process, affect the profitability of a project. Another example is the lack of clear rules over how long a support mechanism will be in place, which increases the risk and costs of a venture.

The quality of the legal system also plays a vital role, as an investor needs to be able to rely on laws regulating business conduct as well as contracts and agreements with their business partners and the possibility to enforce his or her rights.

#### 2.2.5 Geopolitical Circumstances, Force Majeure

Geopolitical circumstances such as wars, strikes, nationalization and force majeure like natural catastrophes can play an important role when developing a renewable energy project.

### 2.3 The Role of National Governments

National governments should formulate policies that support an efficient and effective functioning of the energy market, including renewable energy policies that increase the role of RES in the economy (Sawin (2004), Johannson et al. (2004)).

The government's objective should be to:

- Develop an overall energy strategy that incorporates renewable energy and sustainability.
- Integrate the energy strategy into the policies of other sectors such as agriculture, transportation, construction, urban planning, infrastructure development, healthcare and education.
- Analyze the potential contribution of renewable energy to the overall energy plan.
- Formulate clear goals and targets for RES within the country's energy strategy.
- Establish market transparency and a level playing field for renewables to encourage investment.
- Increase public awareness for the costs and benefits of renewables through campaigns and education programs.
- Promote the development of human resources for RES by educational agendas and professional training.
- Build strong institutions on the national level to set and act on priorities and strategies and to formulate and implement policies and regulations.

Examples of measures that remove barriers to renewable energy sources are

- the reduction of subsidies for conventional fuels;
- the provision of temporary subsidies for RES to help alleviate the burden of high initial cost;
- the creation of temporary incentives on the customer's side to increase demand;

- the adaptation of standards and licensing procedures to the requirements that are biased against new technologies;
- addressing the lack of adequate standards for new technologies and
- securing grid access for renewable electricity under transparent conditions.

Risk reduction is an important feature of support mechanisms for the deployment of renewable energy. However, the state should not interfere when there are market instruments available that can transfer the risks to other parties, reduce the cost of capital of a project and make it bankable from the investor’s perspective. Contracts with suppliers and service companies, performance guarantees, insurances and other financial derivatives are examples of instruments provided by the market. It must not be the objective of public policies to reduce the costs for these types of risks.

Instead, governments need to consider elements of renewable energy projects that make them unable to compete with conventional energy production in existing markets and design public policies in order to derive measures to overcome these obstacles. This could be in the form of concrete obligations such as the share of RES in energy production (enforced RES-quota, standards and legislation), financial support schemes and/or dedicated administrative procedures.

## 2.4 Support Schemes for Renewable Energies

A number of different market-based instruments are available for governments to subsidize renewable electricity. They can be classified into investment support such as capital grants by a public body (direct subsidies), tax exemptions or reductions on the purchase of goods and operating incentives like feed-in tariffs (FiT), Green Certificates (GC), tender schemes and tax exemptions or reductions on the production of electricity. Due to differences in potential and costs of the various RES-technologies, it is often not sufficient to use one single support instrument. Combinations of different measures are common, for example granting direct subsidies or soft loans in addition to a main support instrument in the form of feed-in tariffs or quota obligations combined with a Green Certificate scheme (EC (2008), Bode/Groscurth (2008)).

### 2.4.1 Investment Support

One of the major barriers to RES are high initial capital costs that often coincide with the investor's inability to convince potential creditors to provide funding. Investment support can take the form of

- direct subsidies,
- low-interest loans and loan guarantees that lower the cost of capital for the investor,
- fiscal incentives like investment tax credits or
- rebates, i.e. refunds of a specific share of the cost of a technology or a share of total installation cost that reduce the investors' risk.

The biggest advantage of fiscal and financial incentives (also those with an operating support character) is that they can be easily linked to existing fiscal and financial structures. Corporate investors can use tax credits to deduct their investments against corporate income tax or carry them forward against future tax payments. The latter, however, works only in countries where the tax burden is very high; otherwise, the deductions are not significant enough.

The main criticism of investment incentives is that they provide insufficient motivation for the development of an efficient and dynamic market. They do not offer mechanisms that drive down technology costs or increase efficiency of use, even though they do reach part of this by economies of scale.

Fiscal incentives have the drawback of not creating long-term certainty on investments, which means higher risk for developers of RES-projects. There is also a potential danger of creating tax havens, where the efficiency of renewable energy generation becomes less important.

### 2.4.2 Operating Support

Operating support per MWh produced generally plays a more significant role than investment support. Existing measures fall into quantity-based market instruments, i.e. instruments that fix the volume of renewable electricity to be generated and price-based market instruments with a set price to be paid for renewable energy.

#### ***2.4.2.1 Quantity-Based Market Instruments***

##### *2.4.2.1.1 Quota Obligations*

Quota obligations compel certain market participants (consumers, suppliers or producers) to obtain a specific share of their total electricity from renewable energy. The system is often combined with a mechanism of tradable Green Certificates, which proves the renewable source of the electricity. Generators of RES-E sell electricity at market price and receive an additional income from selling certificates, which are usually issued for one MWh. Should a market participant not abide to the obligation, e.g. a supplier that does not reach their obligation by buying the required amount of Green Certificates, a penalty fee has to be paid.

Trading systems lie at the market-based end of the policy spectrum and should ideally provide a strong incentive for technology cost reductions. The drawbacks are a lack of reference at the initial stage of development, the complexity of the system, the risk of encouraging primarily lower-cost technologies and uncertainty about the support and the stability of the policy targets.

##### *2.4.2.1.2 Tendering*

Under tendering, the government announces a tender for the provision of a certain amount of electricity from a defined renewable energy source and a bidding process for the cheapest offer is initialized. The winning bidder gets a guaranteed remuneration (e.g. via a purchasing power agreement) per kWh of electricity for the contracted period.

The advantages of the tender system are the value that it generates to renewable energy investment opportunities and the competitive element incorporated in its design. However, the system has thus far not proven very successful and the number of projects has been much less than anticipated.

#### ***2.4.2.2 Price-Based Market Instruments***

##### *2.4.2.2.1 Feed-In Tariffs*

In a feed-in tariff scheme, RES-power generators receive a fixed remuneration for each kWh fed into the electricity grid. The tariffs, which are set by the government, are preferential, technology specific and can differ depending on factors like type, age or location of the installation. Tariffs are usually granted for a period of 10-20 years, and reduce market risk for the investor by providing long-term certainty for the price received per kWh.

Critics of feed-in tariffs argue that it is hard to identify the right tariff, that there is a risk of too much or too little support for a certain technology and that tariffs do not provide enough incentives for driving down the cost of renewable energy technology investments.

Consequently, more advanced feed-in systems have been designed in order to promote certain technologies and cost reductions. They are more economically efficient as they add an element of dynamic cost reductions, however administrative costs are usually higher.

Examples are

- stepped reductions in remuneration (stepped feed-in tariff), where the feed-in tariff will be reduced if actual generation is high. In Germany, for example, tariffs are lowered every year to encourage more efficient production of renewable energy. The tariffs decrease year by year at a predefined amount in line with the expected learning curve of the corresponding RES-technology. Profits will be higher at more cost effective sites.
- a premium tariff – where the tariff is linked to actual electricity market prices and producers receive a bonus on top of the electricity market price. This system is implemented in parts of Australia.
- a system like in France where the tariff is fixed within a contract, first from the potential and then from the actual energy production measured during the first five years. Tariffs for new projects are decreasing yearly to account for cost decreases.

#### *2.4.2.2.2 Fiscal Incentives (Reductions on Operating Taxes)*

RES-generators face unfair competition due to externalities. Governments can grant exemptions or reductions from certain operating taxes (e.g. carbon taxes) to alleviate those costs. Most often used are production credits and tax credits, where renewable energy investments or earnings from such investments can be deducted from taxes. Investors benefit from larger cash flow and better loan conditions.

Fiscal measures provide sufficient stimulus only in countries were operating taxes are high and are usually supplementary instruments to other support schemes. They can also take the form of financing packages for final consumers, which provide them with a signal about the benefit of renewable energy.

#### *2.4.2.3 Quantity- vs. Price-Based Instruments: A Comparison between Feed-In Tariffs and the Quota System*

Feed-in tariffs and quota systems have so far proven the most popular measures for deploying electricity production from renewable sources in the European Union. Both instruments can be designed to different objectives towards specific technologies. While feed-in tariffs set the price, the quota model fixes the amount of RES-energy that should be produced[1].

**Table 1: Design of support schemes with different objectives towards specific technologies**

| | **Objective** | |
|---|---|---|
| | **Support of green power as such (independent of source)** | **Support of green power from installations using certain technologies** |
| **Pricing instrument (feed-in tariff)** | Single remuneration tariff per fed-in MWh of green power | Different remuneration tariffs specific to a certain technology type (e.g. PV, wind or hydropower) |
| **Quantity instrument (quota model with certificate trading)** | Single quota (e.g. 25% of green power of total consumption generation) | Different quotas (e.g. 10% wind power, 15% PV of total consumption or generation) |

Source: Bode/Groscurth (2008)

Another essential difference between feed-in tariffs and the quota system is the composition of remuneration. In the feed-in scheme, the generator receives a fixed, all-in income for electricity produced and the renewable component of this energy. The income stream is guaranteed for a certain period[2]. The quota model, on the other hand, rewards the operator with revenues for both the direct sale of electricity and the sale of the Green Certificate, which proofs the “greenness” of the electricity produced. However, the generator has to bear fluctuations in the wholesale electricity price and on the income received when selling the Green Certificates.

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[1] In practice, however, the quota model also defines an upper limit for the price by introducing the penalty charge for non-compliance.

[2] See however, above-mentioned comments on advanced feed-in systems like stepped feed-in tariffs, where remuneration decreases dynamically with the learning curve or premium FiTs that are linked to the market price of electricity.

**Table 2: Arguments for and against feed-in tariffs and the quota model**

| | Feed-in tariff regime | Quota model |
|---|---|---|
| **Arguments for** | So far the most successful regime at developing RES- markets and domestic industries and achieving the associated social, economic, environmental and security benefits.<br><br>Offers investment security and market stability for the investor when set over a relatively long period.<br><br>Relative ease of implementation and high transparency.<br><br>Flexibility, if system is set in a way that payment can be adjusted easily.<br><br>Can "jump start" a market for eligible technologies, if the FiT is high enough and set for a long enough period.<br><br>Provides opportunities for new market entrants and encourages development of small and medium sized units.<br><br>Low administrative cost. | Technologically neutral. In a well operating market, the most cost effective technologies are used first.<br><br>Provides certainty regarding future market share for renewables (at least in theory).<br><br>Compatibility with open or traditional power markets.<br><br>More likely to fully integrate renewables into the electricity supply infrastructure. |
| **Criticism of** | Risk of over-funding, especially if the technology cost reduction is not build into the tariff. Consumers may pay an unnecessarily high price for RES-E.<br><br>FiT favours certain technologies, depending on the size of the tariff.<br><br>Can involve restraints on RES-trade due to domestic production requirements. | Targets can set upper limits that curb investments due to lack of further incentives when the quota is reached. Profitability exists only within the quota.<br><br>More difficult to implement, complex in design, administration and enforcement (market place for GC needs to be established, controlling agency is needed etc.).<br><br>Lack of flexibility, fine-tuning and short-term adjustment is difficult.<br><br>Tends to be more advantageous for large centralized merchant plant and less favorable for small investors.<br><br>Uncertainty about GC price developments leads to risk premiums and higher cost for society. |

Source: Resch (2007), Sawin (2004)

## 2.5 The Performance of Policy Measures

Two main indicators can be used for the assessment of support schemes:

- Effectiveness: A policy's ability to trigger RES-deployment.
- Cost Efficiency[3]: The ratio of the total amount of support received for a renewable energy technology and the generation cost.

### 2.5.1 Policy Effectiveness Indicator

Presented in the table below are different indicators to measure the effectiveness of RES-support schemes and their advantages and drawbacks (Ölz (2008)).

**Table 3: Overview of alternative indicators of policy effectiveness**

| Indicator | Formula | Advantage | Disadvantage |
|---|---|---|---|
| Average annual growth rate | $g_n^i = \left(\frac{G_n^i}{G_{n-t}^i}\right)^{\frac{1}{t}} - 1$ | Based on empirical values | No consideration of country-specific background |
| Absolute annual growth | $a_n^i = \frac{G_n^i - G_{n-1}^i}{n}$ | Based on empirical values | No consideration of country-specific background |
| Effectiveness indicator | $E_n^i = \frac{G_n^i - G_{n-1}^i}{ADDPOT_n^i} = \frac{G_n^i - G_{n-1}^i}{POT_{2020}^i - G_{n-1}^i}$ | Consideration of country specific background | Difficulties in the identification of additional mid-term potential |

$a_n^i$ : Absolute annual growth rate.
$g_n^i$ : Average annual growth rate.
$E_n^i$ : Effectiveness indicator for RES technology i for the year n.
$G_n^i$ : Electricity generation by RES technology i in year n.
$ADDPOT_n^i$ : Additional generation potential of RES technology i in year n until 2020.
$POT_n^i$ : Total generation potential of RES technology i until 2020.

Source: Ölz (2008)

The first indicator looks at the average annual growth rate of an RES over a certain period. This indicator favors small countries and those starting from a low level of RES-deployment.

A second approach is the evaluation of the average absolute growth, i.e. the actual additional capacity or generation during a specified period. It provides a better measure for the absolute increase of renewables in one country; however, it has a bias towards larger economies as the size of the country is not taken into account.

[3] As defined in the "Communication from the Commission: the Support of Electricity from Renewable Energy Sources", *COM (2005) 627 final*.

A third solution sets the average annual additional growth in renewable capacity in relation with the actual renewable energy potential in a given country. The effectiveness indicator is reflected as a percentage of the remaining additional available mid-term potential for RES-E generation. It allows for a better comparison between countries than the other two methods since it is less dependent on size or level of RES-deployment of a country.

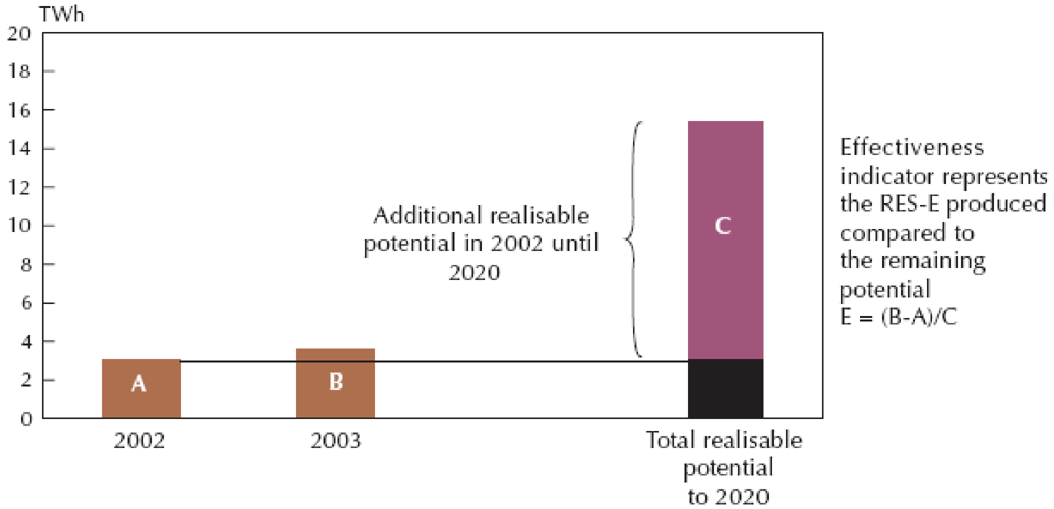


**Figure 1: Example of the effectiveness indicator for a specific RES in a specific country in a specific year**

Source: Ölz (2008)

**Table 4: Definition of RES-potentials**

| | |
|---|---|
| Realizable Potential | Maximum achievable potential, under the assumption that all existing barriers can be overcome and all development drivers are active. It always refers to a certain year and in the long-run tends toward the country's technical potential. |
| Technical Potential | Potential derived from the technical boundaries of a technology like efficiency losses or space restrictions for power plant installation. |
| Mid-term Potential | Realizable potential until a specified time horizon (e.g. 2020). |
| Total Realizable Potential | Sum of achieved potential (cumulative installed capacity) at a given point in time (e.g. 2008) and additional realizable potential in the remaining period up until the specified time horizon (e.g. 2008-2020). |

| | |
|---|---|
| Theoretical Potential | Theoretical upper limit of total energy that can be generated from a specific RES within a defined area, based on current scientific knowledge. It solely depends on physical resources like the average solar irradiation in a certain region). |
| Economic Potential | Potential, which can be exploited in direct competition with conventional incumbent technologies and without any additional support. |

Source: Ölz (2008)

Yet another indicator (not featured in Ölz's discussion) is a measurement of the degree of achievement of a pre-defined goal set on a national level during a specific timeframe. This approach allows for an assessment of consistency of targets of a country. However, the measure favors countries with less ambitious targets as they can reach their pre-defined goals with less effort in terms of actual additional RES-production than countries with more aspiring thresholds.

### 2.5.2 Policy Efficiency Indicator

A policy's efficiency indicator evaluates the level of support, i.e. the amount received per unit of renewable energy produced set against the generation cost of a particular renewable energy source. The smaller the gap between generation cost and level of support, the more efficiently a support measure covers the actual cost. Support levels need to be sufficient to offer a predictable profit for investors and trigger substantial investments in RES. However, they should not exceed real requirements of the technology, since this would create windfall profits.

From the investor's perspective, an efficiency indicator can be established by drawing a comparison between the effectiveness of a support scheme and the expected profit or annuity of a renewable investment project per kWh of energy produced. This relation gives an indication, whether the market diffusion of a policy results from high financial support through an incentive scheme or other factors like low investment risk, market access etc.

The annuity calculates the specific discounted average return on every kWh produced by taking revenue and expenses throughout the entire lifetime of a technology into account (see formula below).

**Formula: Calculating the average expected profit per kWh**

$$A = \frac{i}{(1-(1+i)^{-n})} * \sum_{t=1}^{n} \frac{Income_t - Expenditure_t}{(1+i)^t}$$

*A: annuity*
*i: interest rate*
*t: year*
*n: technical lifetime*

Source: EC (2005)

The comparison of a project's annuity and policy effectiveness allows an assessment of the financial incentives a specific policy scheme offers an investor throughout the lifetime of the RES-power plant.

### 2.5.3 The Integrated Approach

To date various countries have implemented a number of different support mechanisms, and only a limited number of them have proven effective. Non-economic barriers have curbed the effectiveness of renewable support policies (Ölz (2008)), and EU member states are continuously refining their support schemes so as to improve the performance of the measures. Within the European Union, feed-in tariffs and the quota system are the most popular instruments.

FiT have thus far been responsible for most of the growth in RES-capacity and generation in the EU and led to cost reductions through technology penetration and corresponding learning including economies of scale. Where well implemented, they have provided increased predictability and less uncertainty in the market and encouraged private investors to finance projects and R&D as well as banks and other financial institutions to provide capital available for investment.

The record of quota systems has been uneven, but it is argued that they could be the right means of promoting RES once the renewable electricity market is developed, industries are well established and renewables can compete favorably with conventional fuels.

Frankl (2008) argues for moving beyond the "feed-in" versus "quota/Green Certificate" debate, as both systems have a record of success and failure depending on technology and country. He calls for a combination of incentive schemes that are embedded into an entire policy framework, which has a recognizable long-term focus and a clear commitment from government.

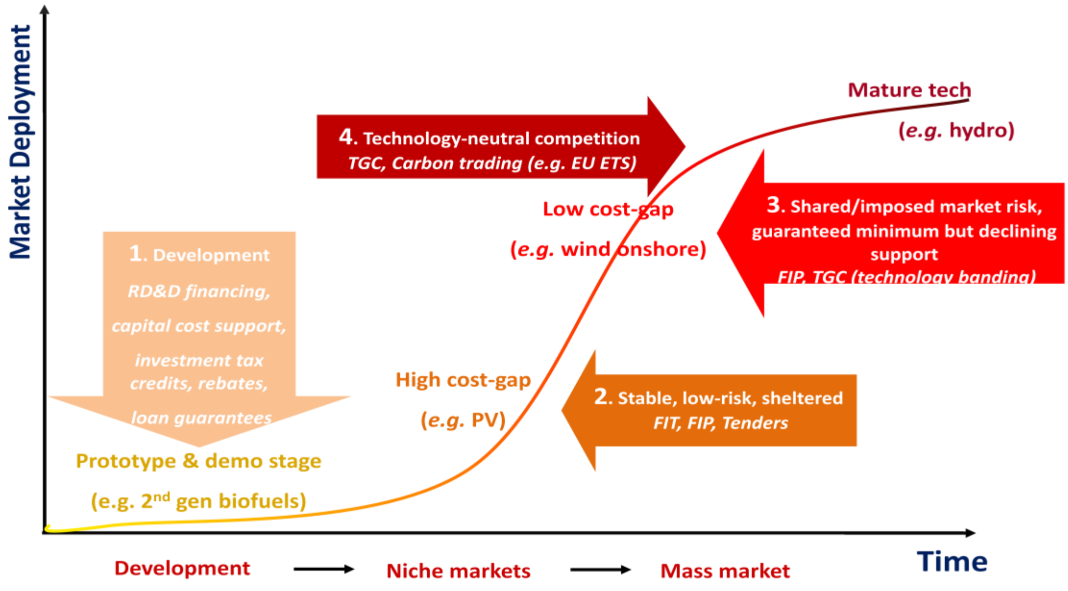


**Figure 2: Fostering renewable energy's transition towards mass market integration**

Source: Frankl (2008)

Precondition for the effectiveness of RES-policies are five principles that are key to formulating policy measures.

**Table 5: Key principles for effective renewable energy policies**

| | |
|---|---|
| **Remove non economic barriers to improve market functioning** | Improve market and policy functioning by removing administrative hurdles, obstacles to grid access, poor electricity market design, lack of information and training and by encouraging social acceptance. Financial incentives are not enough if these obstacles are not removed first. |
| **Establish a predictable support framework** | Create a predictable and transparent support framework to attract investment and to reduce risk to an acceptable level. |
| **Introduce transitional incentives decreasing over time** | Introduce transitional incentives decreasing over time to foster and monitor technological innovation, to keep costs under control and to move technologies quickly to market competitiveness. |
| **Ensure specific support in function of technology maturity to exploit potential of large RES-range** | Ensure development and implementation of appropriate incentives that avoid technology lockout, minimize costs in the long-run and guarantee a specific level of support to the respective RES based on the degree of their technological maturity. The aim is to exploit over time the significant long-term potential of the large range of technologies available. |

| | |
|---|---|
| **Take overall impacts on energy system into account** | Consider the impact of increasing large-scale penetration of renewables on the overall energy system, especially in liberalized markets (e.g. in terms of grid reliability and management and with regards to overall cost efficiency and system reliability). |

Source: Frankl (2008)

# 3 STATUS QUO OF ELECTRICITY PRODUCTION FROM RES IN POLAND

## 3.1 Poland's Energy Market

Poland is the largest producer of hard coal within the European Union, and its dependency on energy imports is among the lowest within the EU. Under the communist regime, Poland developed into an energy-intensive economy, characterized by an inefficient use of energetic resources, with an emphasis on heavy industry, which was depended on imports of cheap energy from the Soviet Union. Production in heavy industry declined and was replaced by much less energy-intensive sectors in the first half of the 1990s. However, a significant increase in industrial output since 2003 has led to a rebound in energy use. Energy consumption in 2007 was the highest since 1997 and will rise further, however the country wants to focus on energy efficiency measures due to growing prices for fuel and EU-legislation on carbon dioxide emissions (EIU (2008)).

Overall, Poland is a net importer of energy. It buys oil and most of its natural gas from abroad, but exports coal and a small amount of its power. Restructuring and liberalization processes in the coal, gas and electricity sectors are proceeding slowly, while powerful lobbies and trade unions prove an additional obstacle for the rationalization of the coal industry.

The main elements of Poland's energy policy are

- energy efficiency;
- energy security including the definition of the country's own resources, diversification of oil and gas supplies, investments in electric infrastructure, restructuring of the market regulators;
- a competitive market;
- emission reduction through clean coal technologies, nuclear power and renewable energy sources, thus keeping the environmental damage of the energy economy at a minimum.

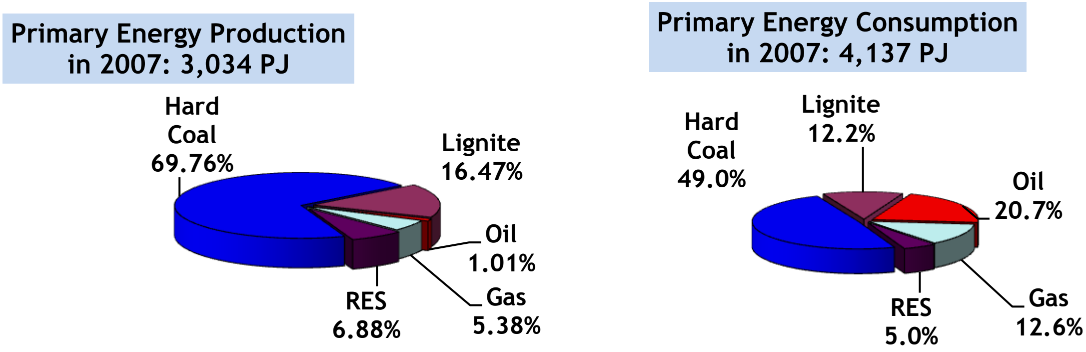


**Figure 3: Primary energy balance in Poland in 2007**

Source: Polish Central Statistical Office (GUS)

## 3.2 Poland's Electricity Market

So far, Poland has been self-sufficient with respect to production and consumption of electricity. Due to higher energy-efficiency, electricity supply has increased only marginally over the past few years, despite the country's strong economic growth. The overall capacity of the Polish power generation sector, which is the largest in Central and Eastern Europe, came to 35,307 MW in 2008. The Polish power consumption is anticipated to grow by 1.0% in 2010 after a 4% fall in 2009 due to the economic downturn. Total electricity power output was 156,178 GWh in 2008 and 150,913 GWh in 2009 (IntelliNews (2010)).

**Table 6: Polish energy market – general information 2008**

| **Population** | **38.6 mn** |
|---|---|
| Generation capacity | 35,307 MW |
| Winter peak demand | 25,120 MW |
| Gross consumption (2008)<br>(end-use + grid losses + own needs in power plants) | 153.5 TWh |

Source: Wahlborg (2009)

Poland's electricity production is highly dependent on coal, which covers more than 90% of its gross electricity demand. Over 95% of electricity is generated in public combined heat and power plants. Hydroelectric and other renewable power generation currently contribute less than 5% to the total generating capacity.

Poland's power infrastructure has started to creak. Official statistics show that more than 43% of Poland's power plants were constructed over 30 years ago. Another 37% are between 20 and 30 years old. Estimates predict that some 10-12,000 MW additional capacity is needed until the year 2020, which is equivalent to an increase of about 800-1,000 MW per year. At the same time, there is the constant requirement to modernize the existing generation plants to increase fuel efficiency and decrease the environmental impact.

Modernization and extension is also imperative for the country's transmission infrastructure. The frequency of power outages is on the rise, and the existing grid (over 13,000 km in length) is not capable of connecting the planned power capacities. According to estimates 3,500-4,000 km of high-voltage power lines need to be erected until 2030 (Krasnodebski et al. (2009)).

In the strife to reduce its dependency on oil and gas from Russia and to fulfill EU-emission targets and $CO_2$-intensity, Poland is focusing on the expansion of energy sources, including renewable and nuclear energy. The idea of erecting nuclear power generation facilities was first discussed decades ago, but the Chernobyl nuclear disaster has left Poles very cautious. The discussion has recently gained momentum, and the Energy Policy for 2030, presented by the Ministry of the Economy in January 2009, contains a detailed atomic power implementation program. Government plans foresee the erection of one or two nuclear power plants by 2020, and analysis of plant locations and possible technologies are under way.

Figure 4 shows the development of Poland's power generation capacity and a projection for its future progress by the electricity grid provider PSE and the Polish Energy Regulator URE. While the importance of coal fired power plants is declining, part of their output is substituted by gas fired installations, hydropower, other renewable energy sources like wind and biomass as well as nuclear power (the latter, however, not earlier than 2020 due to the lengthy development process of a nuclear power plant).

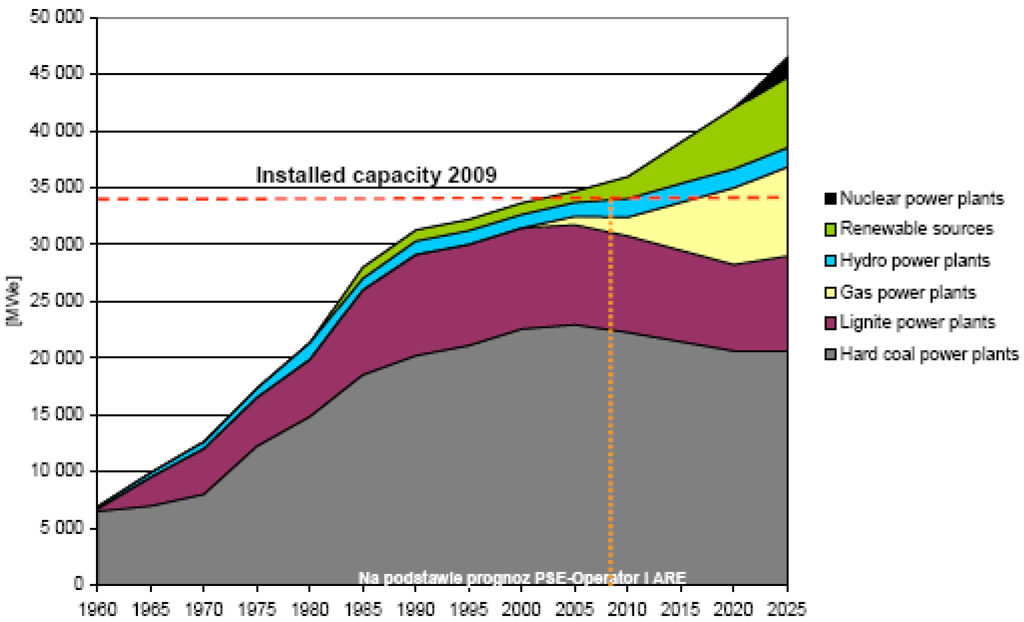


**Figure 4: Generation installed capacities – actual and projection**

Source: Wahlborg (2009)

### 3.3 Market Structure

In the 1990s, Poland's electricity market was broken up in into separate entities dealing with production and distribution. The intention was to privatize all companies with the exception of the grid operator (the national supply grid split off from the rest of the sector). However, privatization processes in both the generation and distribution sectors have been slower than expected. In the late 90ies, concerns of the EU over the electricity generators' long-term contracts held up the privatization of power stations. Since then, political outcries to prevent the "selling-off" of industries of "strategic interest" have hampered further privatization processes.

In course of Poland's entry into the European Union, the electricity market underwent significant liberalization, including a gradual opening of the market to competition. Electricity prices have been raised to market levels, and consumption thresholds were removed gradually. At first, only larger customers could choose among different suppliers, but on July 1st, 2007 the consumption threshold above which customers could switch supplier was removed completely for all users, including households. However, in September 2008 Poland's National Energy Regulator (URE) decided to continue regulating household electricity prices and announced not to free power prices in the so-called tariff group G - incl. households, dormitories and orphanages. In 2010, Group G remains the last cluster of customers whose power tariffs still need to be approved by URE.

The residential segment generates the highest amount (34% in 2007) of Poland's electricity market revenues, followed by industry (31.4% in 2007) and the commercial sector (29% in 2007). (Datamonitor (2008))

## 3.4 Major Players

The Polish electricity sector is dominated by a small number of vertically integrated electricity companies, which generate power and sell it to customers. Besides those big players, a few smaller retail-only companies buy electricity on the wholesale markets and sell it to end-users. Wholesale electricity is supplied by a small number of large companies.

The state owned Polish Energy Group (PGE Górnictwo i Energetyka S.A.) is by far the biggest market player, generating 40.2% of the market's volume in 2007. The other two most significant market actors are PKE (Południowy Koncern Energetyczny S.A.) and Enion S.A., with a 17% and 13.4% market share respectively.

**Table 7: Poland's electricity market share in % of volume 2007**

| Company | Share |
|---|---|
| PGE Company Górnictwo and Energetyka S.A. | 40.2% |
| Południowy Koncern Energetyczny S.A. | 17.0% |
| Enion S.A. | 13.4% |
| Vattenfall | 2.9% |
| Other | 26.5% |

Source: Datamonitor (2008)

The biggest power distributors in Poland are companies Tauron Polska Energia followed by PGE, Energa and Enea. All four companies are state-owned, however the government's privatization plans includes selling off stakes in Enea. When the company went public at the end of 2008, Vattenfall acquired a minority stake.The sale of the 67% still in state hands to equity investors is due in the second half of 2010. Tauron's Initial Public Offering is expected in 2010 and the Polish treasury also mulls sale of 20% in biggest power group PGE, while Energa is likely to be sold to a branch investor at the end of 2010.

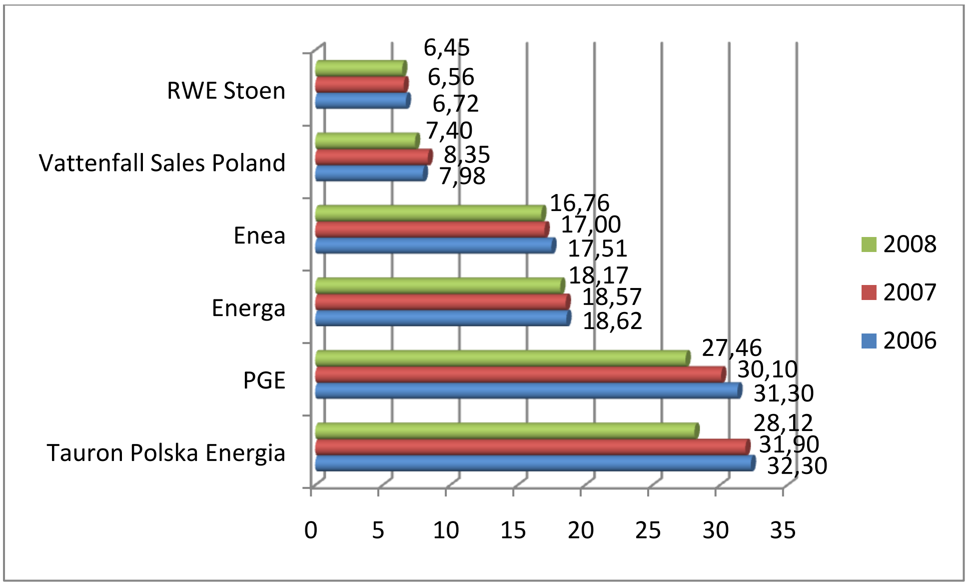


**Figure 5: Poland's biggest power distributors – by power sold on retail market (TWh)**

Source: IntelliNews (2009)

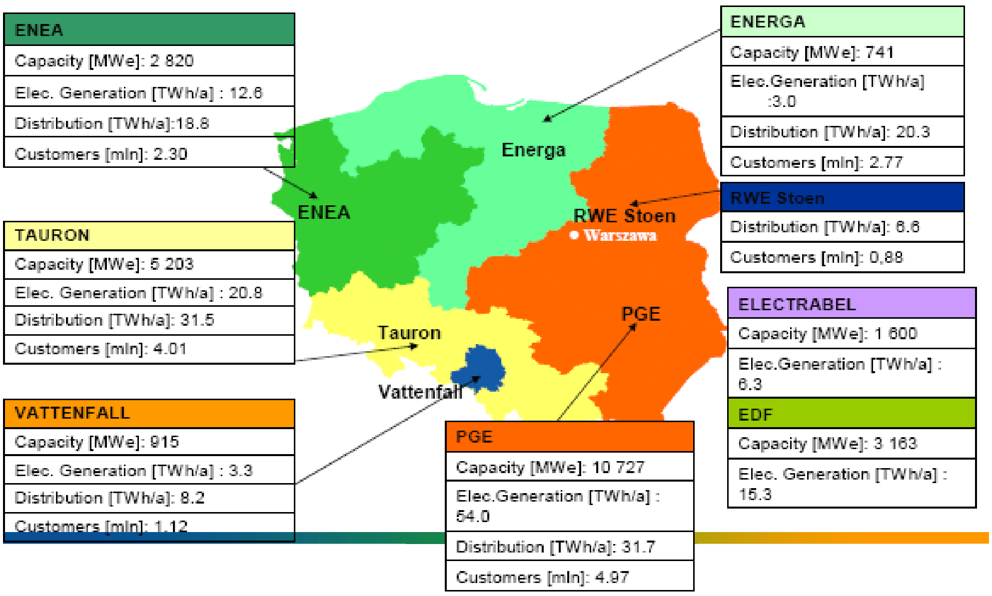


**Figure 6: Polish power sector – map of distribution services**

Source: Wahlborg (2009)

## 3.5 Power Production from Renewable Energy Sources

### 3.5.1 Energy Production from RES

Renewables have traditionally accounted for a small share in primary energy production and consumption due to the importance and availability of coal for energy production. However, the European Union's laws and policies for green energy have had a major impact on the country's energy strategy and regulation. The EU's new Directive on Renewable Energy (Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009) obliges Poland to reach a 15% share of RES in gross final energy consumption by 2020. This very ambitious target together with generous subsidies from the EU should increase the sector's growth significantly in the medium run.

Solid biomass covers the lion's share of RES-generation and contributes over 90% of renewable energy produced in Poland. Biomass is predominantly used for local heating by individual households, but its use for electricity production is constantly increasing due to legal requirements imposed on generators by the Polish government.

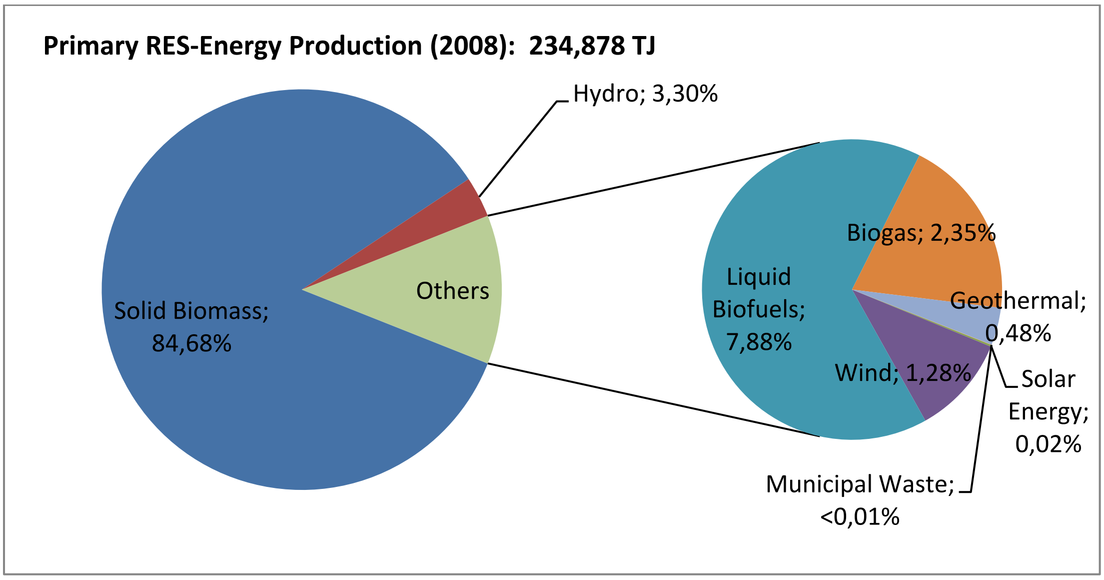


**Figure 7: Primary energy production from RES in 2008**

Source: Polish Central Statistical Office (GUS)

Until now, Poland has exploited only a small fraction of its renewable energy sources, and the technical potential of energy production from RES is much higher than its current output.

### 3.5.2 Electricity Production from RES

In 2008, 156,178 GWh of electricity were produced in Poland (IntelliNews (2010)). Over 90% of this energy was generated by coal- fired power plants, less than 2% by oil and gas fired power plants, approx. 2% by biomass, 1.37% by hydropower, about 0.5% by wind power and less than 0.2% by other renewable energy sources. In 2008, the total contribution of RES to the Polish electricity generation was 4.12%, compared to a 7% target quota for the renewable electricity secto according to a by-law of the Ministry of the Economy for the year 2008.

**Table 8: Total installed capacity for electricity generation from RES in MW**

| Energy Source | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|---|
| **Biomass (solid)** | - | 24 | 24 | 25 | 25 | 33 | 42 |
| **Biogas** | 14 | 17 | 24 | 30 | 33 | 40 | 53 |
| **Wind** | 32 | 35 | 40 | 121 | 172 | 306 | 526 |
| **Hydro** | 841 | 867 | 876 | 915 | 925 | 922 | 292 |
| **Total** | **887** | **943** | **964** | **1,091** | **1,155** | **1,301** | **1,550** |

Source: Polish Central Statistical Office (GUS)

6,440 GWh of electricity were produced by renewable sources in 2008 - an increase of over 200% since 2004, when Poland joined the European Union. Wind power plants produced six times as much electricity as in 2004, and power generation from biomass rose significantly due to a substantial increase in capacity of co-firing plants.

Solid biomass caught up with hydropower as the most important RES in the production of electric energy in 2007, due to the growing popularity of co-firing in large-scale coal-fired power plants (Frost & Sullivan (2008)). Its share in total RES-E supply was approx. 43% in 2007 and increased to almost 50% in 2008.

Even though hydropower has a longer tradition in electricity production in Poland, its potential for large-scale plants is exhausted and no further significant increases are expected.

Electricity generation from wind, on the other hand, has experienced a dynamic development over the past few years. There is evidence for continuing rapid growth in the near future due to the country's natural endowment and a yet underdeveloped wind power market.

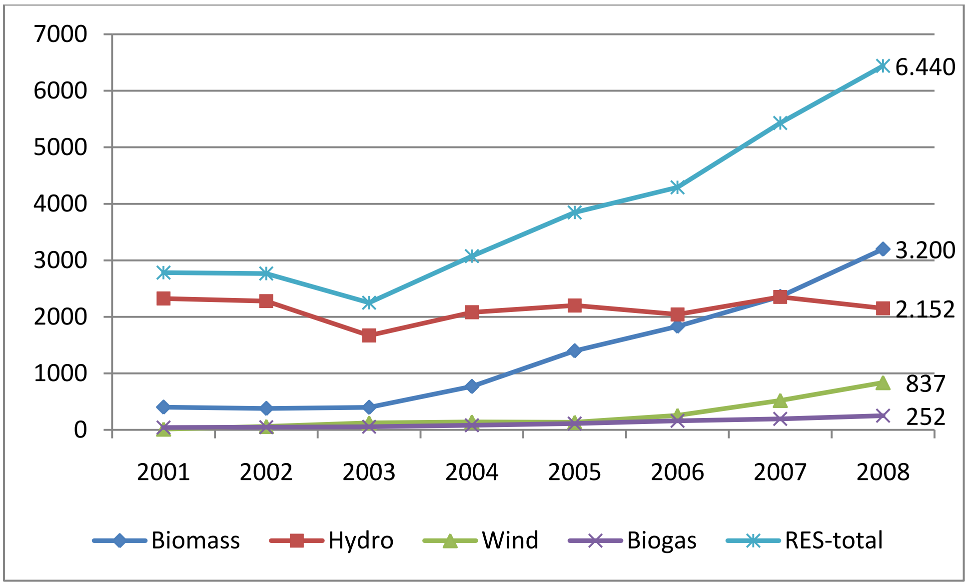


**Figure 8: Electricity generation from RES in GWh**

Source: Polish Central Statistical Office (GUS)

## 3.6 Policy Measures and Regulatory Framework

### 3.6.1 Targets for the Polish RES-Sector

Poland has its own national targets for the renewable energy sector. The primary document are the "Guidelines for Poland's Energy Policy Until 2020", endorsed by the Council of Ministers in 2000, and the "Development Strategy of the Renewable Energy Sector" approved by parliament in 2001. Laid down in the document is the objective to reach a level of 7.5% and 14% share of RES in primary energy balance until 2010 and 2020 respectively. These goals were revised in the second half of 2008 and increased to a share of 10.4% by 2010 and 12.9% by 2017.

The main driving forces behind growth in Poland's RES-sector are binding targets imposed by the European Union on the individual member states. In 2007, the EU committed to the "3x20+10"-target, which has to be implemented by the year 2020.

The target involves three objectives:

1) the reduction of greenhouse gas emissions by 20% relative to 1990,
2) the reduction of energy use by 20% relative to the level of 2005,
3) a 20% share of RES in gross final energy consumption and a minimum 10% share of biofuels and other RES for transport purposes in the fuel mix of the transport sector by 2020.

Objective 3 translates into an obligation for Poland to achieve a 15% RES-share in gross final energy consumption[4] until 2020. Additionally, Directive 2001/77/EC on the Promotion of Electricity Production from RES requires Poland to set a national indicative target for the consumption of electricity produced from RES. As part of the accession treaty, the country has to achieve a 7.5% share in gross electricity consumption until 2010.

**Table 9: Main targets for the Polish renewable energy sector**

| | Quantitative Target |
|---|---|
| **EU mandatory target** | 15% share of RES in final energy consumption in 2020 |
| **EU mandatory target** | 10% share of RES in final energy consumption in transport in 2020 |
| **EU indicative target** | 7.5% share in RES in gross electricity consumption in 2010 |
| **EU indicative target** | 5.75% share of biofuels consumption in petrol and diesel use for transport in 2010 |
| **national short-term target** | 10.4% share of RES in the primary energy balance by 2010 |
| **national long-term target** | 12.9% share or RES in primary energy balance by 2017 |

Source: European Commission, Polish Ministry of the Economy

### 3.6.2 Quota Obligations and Certificates of Origin

National policies to support the promotion of RES are stipulated in Poland's Energy Law Act of 1997 and later amendments (URE (2009)). The law lays down the principles and terms of energy production, transmission and use as well as the authorities responsible for the energy economy. The Energy Regulator regulates energy and fuel markets, especially by granting and revoking licenses for energy enterprises involved in the generation, transmission or trading of energy and approving tariffs (for both electricity and heat).

[4] Renewables' consumption comprises the direct use of renewables like biofuels, electricity and heat produced from renewable sources. Gross final energy consumption includes all energy used by households, industry, services, agriculture and the transport sector as well as transmission/distribution losses for electricity and heat and the fuels' own consumption in the heat and electricity-production process.

In 2001, an amendment to the Energy Law Act introduced the concept of power purchase obligations, i.e. the obligation for electricity suppliers that provide households with low-voltage electricity (main providers) to purchase power produced from RES. In 2003, the system of certificates of origin (CoO) was implemented, an obligation for companies selling power to end users to obtain certificates to prove that a certain percentage of their electricity was generated from renewable sources. In case of non-compliance with the power purchase obligations, distribution companies (theoretically) had to pay a compensation fee.

Lack of enforcement of legal and financial consequences for distribution companies that did not fulfill their obligations led to further significant revisions of the Energy Law Act in 2005 and in 2007. In 2005, the trade of Green Certificates (CoO) was introduced, and in 2007, further legal changes resulted in the requirement of a license for renewable energy generation regardless of the power installed. (Previously, only generators with a capacity of 50 MW and more had to obtain a license). Furthermore, higher percentage rates for green energy purchase obligations were introduced. In 2008, the quota obligation was extended until the year 2017.

Today, energy enterprises selling electricity to end consumers in Poland’s territory have to prove that a minimum share of their annual sale of electricity is produced by renewable energy sources. These shares are determined by the Ministry of Economy in accordance with EU regulation and specific RES-E -quotas have been defined.

**Table 10: Main targets for the Polish renewable electricity sector**

| Year | Quota | Year | Quota |
|---|---|---|---|
| **2007** | 5.1% | **2014** | 11.4% |
| **2008** | 7.0% | **2015** | 11.9% |
| **2009** | 8.7% | **2016** | 12.4% |
| **2010-12** | 10.4% | **2017** | 12.9% |
| **2013** | 10.9% | | |

Source: European Commission, Polish Ministry of the Economy

The 10.4% share in 2010 corresponds to the target of 7.5% RES in gross electricity consumption set by the EU according to Directive 2001/77/EC. In 2007, 2008 and 2009, Poland did not meet these targets and it is unlikely that it will deliver in 2010 (currently between 4 and 5% of electric energy are produced from renewable sources).

**Table 11: Development of RES-E support schemes**

| Support | Scheme | Year | Development |
|---|---|---|---|
| INVESTMENT SUPPORT | Feed-in tariff | 2000 | Feed in tariffs, obligation for utilities to buy green electricity from sources <5MW, price same as for final consumers |
| | Quota obligation | 2001 | Quota obligation (7,5% in final sale balance) for electricity suppliers and distribution companies, no strict penalty |
| | | 2002 | Obligation to achieve quota (7,5%) and to prove origin of electricity for suppliers and distribution companies, no strict penalty defined |
| | | 2003<br>2004 | Obligation to achieve quota (7,5%) and to prove it (CoO) for electricity suppliers and producers (TPA) , penalty defined 30%, introduction of biomass co-firing as eligible RES-E |
| | Quota obligation +TGC | 2005<br>2006 | Obligation to achieve quota (7,5%) and to prove it (CoO) for electricity suppliers and producers (TPA) , introduction of CoO (TGC) trade; penalty followed by voluntary charge for non-compliance (240 PL/MWh); biomass co-firing as eligible RES-E but demand for increasing of biomass use from energy crops and wastes by 2014; increased quota (from 7,5 do 9% in 2010), distribution companies obliged to buy "physical" green electricity by the market price of "black" electricity |
| | | 2007 | Increase of the quota obligation from 9% in 2010 to 10,4% (compliance with EU 2001/77/EC directive). |
| | | 2008 | Extention of quota obligation until 2017 |

Source: Michałowska-Knap (2008)

Table 11 summarizes the development of Poland's support schemes for RES-E since the year 2000. The support mechanism of choice is the described quota system, which was introduced in 2001, following a short experience with feed-in tariffs. Regulation and enforcement mechanisms were regularly adjusted to deal with implementation problems - especially the non-enforcement of penalty payments. This resulted in the current design of a quota scheme, combined with tradable certificates and regulated "buy-out" and penalty fees in case of non-compliance (Michałowska-Knap (2008)).

### 3.6.3 Price Regulation and Trade of Green Certificates

#### *3.6.3.1 Price Formation*

In compliance with the Energy Law Act, electricity suppliers ("main providers") selling to end-consumers which have not used their right to choose a provider are obliged to purchase all green power generated by certified RES-generators within their area of responsibility and pay them a certain guaranteed price.

The guaranteed price corresponds to the average electricity price of the previous year and is determined by the Energy Regulator. Renewable power stations have to have access to the electricity grid if they fulfill all the administrative and technical requirements. Only green electricity generated in Poland (i.e. in the area of responsibility of the main providers) is eligible to receive a guaranteed payment for the green power they feed into the grid.

All energy companies that sell electricity to final consumers and which are connected to the Polish grid must comply with the RES-E-quota requirements. The quota is expressed as a percentage of the amount of electricity sold by the company. The obligation can be fulfilled by using any renewable technology or combination of technologies.

According to Article 9e of the Energy law, the amount of electric energy generated by a renewable energy source is certified by green certificates. Energy enterprises which produce or trade in electric energy and deliver to end users have the choice between:

• obtaining such certificates and applying for their redemption at the Energy Regulatory Authority, or

• payment of a buy-out price, i.e. a substitution fee calculated in accordance with a formula provided by the Energy Law.

The quota obligation is fulfilled when the redeemed certificates (or the collected substitution charges) reach the pre-determined target share in a given energy enterprise's yearly sales to end-users.

The compensation fee is calculated yearly by a formula defined in Article 9a of the Polish Energy Law:

**Formula for calculating the compensation fee for Green Certificates**

$$\boldsymbol{O_z = O_{zj}\, x\, (E_o - E_u)}$$

*$O_z$: compensation fee per MWh expressed in PLN*
*$O_{zj}$: discounted unit compensation fee: 240 PLN per MWh*[5]
*$E_o$: amount of electric energy (expressed in MWh) for which a certificate of origin needs to be presented in a given year*
*$E_u$: amount of energy (expressed in MWh) for which a certificate was presented by energy producers in a given year*
*($E_o$ - $E_u$): extent, to which the obligation is not fulfilled*

[5] CPI-adjusted every year

If an energy company that sells electricity to final consumers does not comply with the quota requirements, i.e. does not present the required amount of certificates or does not pay the substitution fee to URE, it receives a fine (penalty charge) of 130% of the substitution fee (see Art. 56.16, Polish Energy Law) for its non-compliance with the obligation.

#### *3.6.3.2 Trade of Green Certificates*

Green Certificates are traded on the Polish Power Exchange (POLPX), a platform for fulfilling energy contracts between buyers, sellers and financial intermediaries. RES generators first need to register their certificates on a special account; the GCs are then converted into property rights and are finally traded on the exchange.

Consequently, generators of green electricity have two different types of income. They receive the average market price for electricity as calculated by URE and the revenue from selling certificates of origin on the power exchange POLPX.

Trading of GCs on POLPX started at in December 2005. Back then, the substitution fee was 240 PLN/MWh and the first certificate was sold for 175 PLN/MWh (28.12.2005). Certificate prices subsequently increased throughout the year and reached 240 PLN/MWh in December 2006.

The GC-prices on POLPX fluctuate within a certain bandwidth, for e.g. on July 8th, 2010 between 274 PLN and 274.10 PLN[6]. Statistics show that the substitution fee has a direct influence on certificate prices: the trading price of a certificate will typically settle close to and not surpass the substitution fee (267.95 PLN/MWh in 2010). However, RES-E has been exempt from the excise tax since 2009, which led to prices slightly above the substitution fee on several occasions since the introduction of excise-tax exemption.

Substitution fees are re-calculated yearly subject to CPI and the fulfillment of the RE-E-obligation by utilities as discussed above. The substitution fee was fixed at 242.20PLN/MWh in 2007, 248.46 PLN in 2008, 258.80 PLN/MWh in 2009 and 267.95 PLN/MWh in 2010.

[6] Exchange Rate on July 8th, 2010: 1 EUR = 4.08 PLN

On July 8th, 2010, total income per MWh of green electricity could be calculated as follows:

**Table 12: Total income of green electricity per MWh on July 8th, 2010**

| | Price in PLN | Price in EUR[1] |
|---|---|---|
| **Average price for electricity in 2009** | 197.21 PLN/MWh | 48.33 EUR/MWh |
| **Market price for Green Certificates** | 274.00 PLN/MWh | 67.15 EUR/MWh |
| **Expected total income for 1 MWh of electricity** | 471.2 PLN/MWh | 115.49 EUR/MWh |
| | | |
| **Substitution Fee** | 267.95 PLN /MWh | 65.67 EUR/MWh |
| **The penalty for non compliance (1.3x standard charge)** | 348.33 PLN /MWh | 85.37 EUR/MWh |

[1] Exchange Rate July 8th, 2010: 1 EUR = 4.08 PLN

Source: URE (2010)

#### *3.6.3.3 Analysis of the Price Formation*

Suppliers, who can “buy-out” their obligation to fulfill a certain RES-E quota, will typically not pay higher prices for green certificates than the current substitution fee. Consequently, the substitution fee acts as a price cap for green certificate prices. However, this price cap is not obligatory and past data has shown how prices may rise above it.

The price index exceeded the substitution fee once in December 2006, on several trading days in 2008 and on various occasions in 2009. A possible explanation for overshooting in 2008 is that traders expected a rise of the substitution fee in the near future. Indeed the substitution fee for 2009 was only publicized in May 2009.

In contrast, the significant rise in GC-prices in the second half of 2009, sometimes even higher than PLN 274/MWh, is only partly a consequence of the traders’ expectations of a substantial increase in the substitution fee for 2010. It mainly reflects the modification of the excise duty rules for electricity (since March 31st, 2009), which resulted from the necessity to translate EU-legislation into the Polish legal system. A tax exemption for RES-E was introduced which led to a rise of the certificate prices even above the level of substitution charges.

Although prices are completely flexible on the downward side and may even fall to zero, an unlimited banking option ensures that a short- or medium term oversupply of certificates will not cause the price to drop that far. Prices are expected to be positive in the future due to higher RES-E- quotas, which gives an incentive to hold back certificates and can cause speculative demand.

Since purchase of renewable electricity by the suppliers of last resort is mandatory, renewable generators have a certain income security. In comparison to a feed-in-tariff, however, uncertainty remains regarding future electricity prices over the lifetime of the plant and the price development on the GC-market. Nevertheless, the system offers an incentive to react on market prices, which is one of the advantages of green certificate schemes.

Altogether, income levels for suppliers of renewable electricity are relatively secure in the Polish system. A rise in electricity prices can be expected in the long-run, and price fluctuations within a year do not affect renewable generators. The banking option should ensure that GC-prices, which have been relatively stable in the past, remain steady in the future.

The Green Certificate system does not differentiate between the sizes of different technologies. This non-discriminatory approach to technology may lead to excess return for low-cost renewable plants. Relatively low revenue triggers wind power developments in preferable wind-sites but excludes investments in more expensive technologies, especially small, capital intensive installations like photovoltaics. Over the long-run, electricity prices or GC-prices (through increasing substitution fees) will need to rise in order to guarantee significant increases in RES-E generation.

**Table 13: Development of electricity and certificate prices 2006-2010**

| n = | 2006 | 2007 | % Δ | 2008 | % Δ | 2009 | % Δ | 2010 | % Δ |
|---|---|---|---|---|---|---|---|---|---|
| **Avg. electricity price in previous year in PLN/MWh** | 117.49 | 119.70 | 1.8% | 128.80 | 7.6% | 155.44 | 20% | 197.21 | 26% |
| **Market price for 1 GC in PLN on July 8th** | 200.00 | 240.4 | 20% | 241.39 | 0.4% | 263.05 | 8.9% | 274.00 | 4.1% |
| **Income for 1 MWh RES-E in PLN** | **317.49** | **360.1** | **13.4%** | **370.19** | **2.8%** | **418.49** | **13%** | **471.21** | **31%** |
| **Substitution Fee in PLN** | 240.00 | 242.20 | 0.91% | 248.86 | 2.7% | 258.8 | 3.9% | 267.95 | 3.5% |

Exchange Rate July 8th, 2010: 1 EUR = 4.08 PLN

### 3.6.4 Fiscal Incentives

Producers of green electricity are eligible for an exemption from excise tax (*Stawka akcyzy na energię elektryczną*) on electricity produced. The excise tax currently amounts to 20 PLN/MWh and is refunded after the submission of the CoO.

### 3.6.5 Grid Connection

The Energy Law Act gives priority to RES-E by obliging the grid operator to enter into a connection agreement with a generator seeking a connection and to purchase and transmit green power unless it is technically or economically not feasible.

The connection process consist of the issuance of a connection condition, the conclusion of a grid connection agreement, the construction of the grid equipment, the determination of the connection fee based on the actual outlays born on realization of the connection, an evaluation of the technical reception and the conclusion of a sales agreement.

In general, a generator of renewable electricity has to bear the cost of interconnection, extension and strengthening of the grid. Wind power plants have to obtain an expert's report on the influence of a particular power plant on the national grid system. However, small RES installations that generate electricity from renewable energy sources and whose capacity does not exceed 5 MW are subject to a reduced connection fee of 50% (estimated on the basis of the actual investment incurred for connection). Until the end of 2010, these reduced charges also apply to systems whose capacity exceeds 5 MW.

### 3.6.6 $CO_2$-Trading Scheme and Joint Implementation Mechanism

European Union legislation has been an important driver behind the growth in the renewable energy sector in Poland. Increase of RES in the total energy balance is considered to strengthen EU energy sustainability and to address ecological issues such as climate change and $CO_2$-emissions. Besides mandatory and indicative EU-targets for the Polish RES-sector, the country is obliged to transpose the rules of the European $CO_2$-Emissions Trading Scheme into national law. A registry for $CO_2$-allowances has been set up, and $CO_2$-limits are imposed on the industry according to the National Allocation Plan.[7]

[7] United Nations Framework Convention on Climate Change, http://unfccc.int/2860.php

Companies of the primary production industry (energy sector, metallurgy, cement works, paper producers etc.) are assigned a certain amount of certificates and have to either compensate by reducing their $CO_2$-emissions, or by purchasing certain emission rights if their $CO_2$-emissions exceed a certain maximum level.

As a signatory state of the Kyoto Protocol, Poland also attracts project related support through the application of Flexible Mechanisms. Institutional buyers receive $CO_2$-emission reduction certificates for investing in a Joint Implementation (JI) project, which makes the co-financing of RES ventures in host countries like Poland all the more attractive for investors.

The JI Mechanism benefits Poland as a financial source for its green projects. However, it does not create additional $CO_2$-certificates, but Emissions Reduction Units (ERU) institutional buyers are credited with. Poland has signed JI-memoranda of understanding with the Canadian, Dutch and Danish governments as well as with the International Bank for Reconstruction and Development and BASREC – The Baltic Sea Region Energy Co-operation Council of the Baltic Sea States. Among the projects that have been credited four Polish-Danish projects (two wind farms and two landfill projects), two Polish-Dutch projects (thermal biomass and landfill), a Polish-Canadian hydropower-project and a Polish-Japanese project involving a catalyst in a chemical plant[8].

### 3.6.7 Investment Support for the Renewable Energy Sector

Both the European Union and the Polish government set relatively ambitious renewable energy targets that can only be realized with substantial investments in the sector. Financial requirements for the implementation of an RES-project are high and entail considerable commitment from private sources. Public financial support is often imperative to make RES-ventures profitable and to attract private capital. Supported by considerable funds from the European Union, Poland developed a number of programmes and measures, especially grants and loans, aimed at fostering the production and use of renewable energy in the country.

[8] (see website of the Polish Ministry of the Environment Polish Ministry of the Environment, http://www.mos.gov.pl)

#### *3.6.7.1 The EU Structural Funds*

Poland is the main beneficiary of European Union Funds in the funding period 2007-2013, during which it receives over 67 bn EUR for the development of its economy. Around 350 mn Euros have been set aside for renewable energy projects under the program "Infrastructure and Environment", which is administered on the governmental level.

Sub-programs include measures like *9.4. Generation of energy from renewable source* and *9.6. Networks facilitating reception of energy from renewable sources* which provide RES-projects with direct co-financing.

Calls are organized on a regular basis and certain pre-defined conditions apply: Within measure 9.4., for example, only projects with a value of at least 20 mn PLN are eligible for funding. An exception was made for electricity production from biomass, biogas and Small Hydro Power (SHP), where the minimum project value was is 10 mn PLN. The maximum possible funding is capped at 20% of the total project costs or 40 mn PLN. The money is granted in form of ex post refunds for strictly defined eligible costs (i.e. costs related to construction works and infrastructural facilities, purchase or lease of machinery and equipment, acquisition of patents, licenses, know-how or non-proprietary technical expertise and other intangible assets directly related to the project, costs of acquisition of ownership or perpetual usufruct title to land etc.).

As encouraging as this may sound, potential investors have to keep in mind that the application process for EU funds is lengthy and complicated. Applications can only be made while the project is still in the planning phase and no steps for implementations (like construction works) have already been carried out. The principle of cost-refunds means that the beneficiary has to cover the expenditures as they occur and can apply for cost-recovery of eligible costs only after they have already been incurred.

Besides centrally administered programmes, Poland's voivodships have defined priorities and regional programmes, which are especially aimed at supporting smaller projects beneficial for the development of a certain region (project volume less than 20 mn PLN). Concrete requirements and preconditions as well as the sum available depend on the regional development plans and priorities, investment volume and total amount of funds granted to the region.

The Regional Operational Programmes for Western Pomerania, for example, are reserved for investment projects of no less than 3 mn PLN. In Pomerania, on the other hand, the minimum value is 1 mn PLN. In Greater Poland (Wielkopolska) the selection criteria are defined in such a way that aid can only be granted for construction projects concerning power sources of 0.25 to 50 MW. The degree of co-financing varies as well. While Pomerania offers up to 75% refund of eligible cost, between 20,000 and 4 mn PLN are available in Małopolska and Lower Silesia offers 30,000 PLN for RES-projects.[9]

#### *3.6.7.2 National Fund of Environmental Protection and Water Management*

The National Fund for Environmental Protection and Water Management (NFOSIGW) supports projects that protect the environment on a national and regional level. RES-ventures can receive preferential loans, subsidies and equity. The fund’s capital base derives from environmental charges and fees, including compensation payments for non-compliance with the quota obligation and the Green Certificate System. Funding is available for enterprises, municipalities, institutions and NGOs.

There are also 16 smaller regional Funds for Environmental Protection and Water Management, which operate on the regional level. They co-operate closely with the Bank for Environmental Protection (BOS) and other banks specialized in environmental financing. Generally speaking, the NFOSIGW is responsible for bigger projects worth more than 10 mn PLN.

Interested companies have to apply for a loan, applications are received continuously. Companies that have successfully concluded the application procedure are contractually entitled to a low interest loan. The loan amounts to a minimum of 2 mn PLN and could cover up to 80% of the project costs. The interest rate is subject to the reference rate of the National Bank of Poland. Loans for projects in the field of renewable energy come with a minimum interest rate of 2.12%. SMEs have to pay at least 1.75% interest on their loan.

[9] http://www.funduszeoze.pl/download/www-funduszeoze-pl.pdf

In the case of wind energy, for example, aid is granted to low-capacity investments, e.g. wind power plants of up 10 MW, whose total investment value cannot be lower than 10 million PLN. Support is offered in the form of a loan not exceeding 75% of the investment value. In terms of amount, project value has to range from 4 to 50 million PLN. The interest is fixed at a certain percentage per annum (subject to the reference rate of the National Bank), and the term of loan is 15 years with the option of deferment of principal amount repayment dates. If certain conditions are met and project objectives are accomplished earlier than assumed, up to 50% of the loan amount may be amortized.

In March 2009 the Polish government announced an additional 1.5 bn PLN for RES-projects in the form of preferential loans which will be administered by the NFOSIGW during the period 2009-2012. About 40% of the budget are earmarked for certain biomass projects (heat generation up to 20 $MW_{th}$, co-generation up to 3 $MW_{el}$, heat and electricity production from biogas), 25% for wind energy projects of up to 5 MW capacity, 20% for geothermal and hydropower plants and 15% for highly efficient co-generation without the use of biomass. In a first step, the programme takes only projects with a minimum value of 10 mn PLN into consideration. In the future also smaller project volumes of less than 1 mn PLN will be able to qualify for funding.

#### *3.6.7.3 The Environmental Protection Bank*

The Environmental Protection Bank is a commercial bank that specializes in financing environmental protection and water management projects. It supports RES-projects of companies, local governments and individuals by granting soft loans at a discounted interest rate for a lending period of up to five years. Funds are provided for projects such as geothermal plants, heat pumps, solar collectors, small hydropower plants, biomass boilers with less than 5 MW capacity and for the production of biofuels.

#### *3.6.7.4 The EcoFund*

The EcoFund is a non-profit organization, which was established by the Ministry of Finance in the early 90s. Its scheduled operations ended in 2009. The fund’s main objective was the implementation of projects with environmental benefits such as emission reduction or protection of endangered species on a national and regional level. RES-projects could receive support in the form of low interest loans and grants covering between 10 to 30% of the project costs for a private investor and up to 50% of the project costs for municipalities.

## 3.7 Major Barriers for the Deployment of RES in Poland

### 3.7.1 Political Level

Significant expansion of RES-capacity requires a strong commitment from a country's government. Poland has a long tradition in coal production and powerful lobbies. Thus far, Polish governments have lacked the determination to design a coherent and powerful long-term strategy for renewable energy technologies. RES are an important part of Poland's future energy mix; however, the focus still lies on traditional power sources. Clean coal technologies have created a lot of buzz lately and a strategy for building the first nuclear power plant has been brought forward. The nuclear agenda is a priority for the government, and it installed a state secretary for nuclear energy in the Ministry of Economy.

Frequent changes in the energy law and uncertainties about regulations, fees and taxation have led to considerable irritation among investors in the renewable energy sector. For example, recent changes to the already complicated regulation for grid connection of wind power plants have caused uproar among developers of wind parks.

### 3.7.2 Regulatory Level and Grid Infrastructure

Administrative barriers are comparatively high in Poland: It usually takes a lot of time and effort to obtain the approval of documents by Polish authorities and to provide for all the required expert analyses and reports. Bureaucratic red tape is especially cumbersome in the wind energy business, with issues ranging from obtaining a zoning plan to acquiring land, providing an environmental analysis, getting a building permit and receiving a grid connection agreement. Dealings with the grid operator and very opaque conditions of access are frequently a source of frustration for the project developers. Additionally, many areas are not open for development for wind parks as they are protected by Natura 2000.

Poland's lack of a well-developed transmission and distribution network remains a major challenge for the expansion of the country's electricity market. The Polish grid infrastructure requires significant investment to enable the connection of various energy sources including RES. Even though subsequent governments defined grid extension and improvement as their priority, plans change frequently and often never reach the stage of implementation.

Regulations for the extension of the existing grid are ineffective and impose a financial burden on the investors as they force them to co-finance the transmission connections with the national grid. The investor, who first connects to the grid in a given place, is often solely responsible for the associated cost, while companies that connect later can profit from the extended or modernized infrastructure.

### 3.7.3 Financial Level

Renewable Energy projects are investment intensive and electricity production from renewable energy sources is more costly than the relatively cheap production of power with coal. Poland's RES-industry is still under-developed and there is little room for economies of scale. The installation costs range from 900 EUR to 1,150 EUR per kW for electricity generated using wind energy to as high as 3,953 Euro per kW for electricity generated using solar photovoltaic technology (Frost & Sullivan (2008)).

Individual investors often struggle to raise funds, and the financial crisis and its aftermaths furthered limited access to private equity. Public money is available through EU sources as well as support schemes by the Polish government and national institutions. However, mainly large-scale projects in the wind and biomass sector benefit from these programs, and smaller grants for individual investors are not plentiful.

Renewable energies suffer from a competitive disadvantage, since the large amount of pollutants emitted when electricity is generated from coal are not yet factored into the energy price. Tariffs for electricity are relatively low in Poland as coal is available in abundance and the cheapest means of electricity production. Moreover, URE still regulates end-consumer prices and keeps them at a relatively low level. However, a significant increase in electricity prices can be expected in the long-run, because producers will be held accountable for their $CO_2$-emissions by the European Union's emission trading scheme. Until then, financial assistance and government support for renewables in the form of subsidies, a preferential compensation scheme, the quota regulation and the green certificate trading system are imperative for the feasibility of renewable energy projects.

## 3.8 Current Status of Electricity Production from Renewable Sources

The highest potential for electricity production from RES in Poland lies in biomass and wind power. Hydropower's possibilities for expansion are limited, even though the development of a network of small hydropower plants could be an attractive option. Power-generation from biomass overtook hydropower (2.360 GWh and 2.352 GWh respectively) for the first time in 2007.

Biogas currently plays only a minor role in energy production; however, it is gaining importance not only as a source of heat-generation but also for production of electricity. Poland has a vast agricultural endowment, and small-scale biogas units will prove beneficial for development in rural areas.

Geothermal and photovoltaics are still insignificant sources of electricity production: Geothermal waters are not hot enough to produce electric energy (they are used for heat purposes), while PV is still too expensive for mass deployment and considered a niche technology by decision makers.

### 3.8.1 Solid Biomass

Poland is one of Europe's leading countries in terms of biomass resources. The country has plenty of forests (approx. 28% of the country' surface) with a lot of unused wood material. The wood processing industry produces a vast amount of leftovers used as fuel for energy purposes. Moreover, almost 60% of the Polish land area is devoted to agriculture, which also provides a lot of raw material for biomass-to-energy technologies. There is also a considerable area of land for cultivation of fast rotating energy plants and crops.

The northern and western regions of the country, the rural areas, the mountainous regions in the south and the eastern border with Belarus have the biggest biomass-potential.

Policy makers and industry consider biomass one of the most promising renewable energy sources in Poland for large-scale energy production. It currently plays a more important role in heat production than in generation of electricity. However, co-firing wooden material with coal at existing coal-power plants has become a popular method for “green” electricity generation and an easy way for energy generators to fulfill their RES-quotas.

**Table 14: RES-E from biomass – capacity and output**

| Biomass (solid) | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|
| Total installed capacity in MW[10] | 24 | 24 | 25 | 25 | 33 | 42 |
| Electricity generation in GWh (including co-firing!) | 399 | 768 | 1,400 | 1,833 | 2,360 | 3,199.8 |

Source: Polish Central Statistical Office (GUS)

The capacity figures in column 1 of Table 14 refer to dedicated biomass power plants. The installed capacity (42 MW in 2008) would be too low to produce the given electricity output (3,199.8 GWh in 2008). Even at full production (8,760 hours per year), 42 MW capacity could not produce 3.2 TWh. Fact is that most biomass electricity produced stems from above mentioned co-firing carried out on an industrial scale by Poland’s big coal-fired power plants. According to the Polish Information and Foreign Investment Agency PAIZ[11], the total capacity for power-generation from biomass was 233.8 MW in 2009, including both dedicated biomass power plants and co-firing installations.

The Polish government considers co-firing an important means for generating power from renewable sources and expects that by 2010 it could contribute 4% to the overall energy production. Co-firing is responsible for almost half of renewable electricity output, while pure biomass power plants currently produce only 11% of RES-E.

However, dry waste biomass and forestry products are already being used at almost a 100% (Michałowska-Knap (2008)). Poland is one of Europe’s major furniture producers, has a big pulp and paper industry and wood is also utilized for construction purposes. Once the energy regulator started to enforce the quota system, the existing demand for wood met with a sudden increase in demand from the energy sector, which led to price increases and wood shortages.

[10]Note: The discrepancy between a relatively low total installed biomass capacity and a high biomass electricity output is a result of the use of co-firing technologies by industrial coal-fired power plants.

[11] http://www.paiz.gov.pl/sectors/renewable_energy

Consequently, the aim is to substitute biomass from forestry or the wood-processing industry with agricultural waste and energy plantations. The government has stipulated that a large part of biomass should come from sources other than forestry or the wood-processing industry (20% in 2010 and 60% in 2014). The cultivation of energy plants is considered a means for rural development in regions of the country where land is currently not in use or agricultural production is not feasible.

### 3.8.2 Biogas

Until recently, biogas has played a rather insignificant role in Poland's electricity production. However, major changes are expected in the medium-term, since the government strongly supports the technology.

In 2009, there were approx. 150 working biogas installations in Poland, most of them producing gas from landfill and wastewater (sewage sludge). The number of agricultural biogas plants is rather small, but a growing percentage of installations is producing energy from organic and animal waste. The highest potential lies in agricultural biogas (including agricultural waste and energy crops), and a dedicated government program that provides a significant amount of funding will boost the number of biogas plants in rural areas.

The latest amendment of Poland's energy law includes extensive support for the development of biogas plants. The goal is to build 2,000 plants until the year 2020 with a total capacity of 3,000 MW. The government already reserved significant amounts of money to help Polish *gminas* (administrative districts) to build their own biogas plant ("One plant per *gmina*"-program), where agricultural biomass (energy crops, agricultural waste including animal waste) can be processed. This should help Poland to fulfill its RES-targets, push rural development, create jobs and develop a large number of decentralized units, where biomass is processed in small highly efficient co-generation units.

**Table 15: RES-E from biogas – capacity and output**

| Biogas | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|
| Total installed capacity in MW | 17 | 24 | 30 | 33 | 40 | 53 |
| Electricity generation in GWh | 48 | 56 | 82 | 111 | 160 | 251.6 |

Source: Polish Central Statistical Office (GUS)

New figures show that more than 69 MW of biogas capacity existed in 2009[12].

### 3.8.3 Hydropower

Hydropower has the longest tradition in RES-E-production, even though energetic resources are small because of low level and unevenly distributed precipitation, high soil permeability and low land inclination.

Most big hydropower plants are concentrated near the main rivers *Wisła* (more than 70% of capacity). Poland's second largest river *Odra* also offers considerable hydropower potential. Small hydropower units are located in the southern and southwestern parts of the country (Carpatian and Sudetian mountains). Small hydropower plants (SHPP) can also be found near the coast in northern and western parts of the country (Western Pomerania and Pomerania, rivers of the Baltic region).

Until 2007, hydropower was the most important source of RES-E. However, the significance of hydropower in the RES-mix is declining, as large-scale expansion is unlikely in the near future due to the concerns voiced by the local population. Now the emphasis lies on the modernization of existing generators, which could lead to an increase in power output by 20-30%.

Even though hydropower has lost its dominant position to biomass, it still accounts for more than a third of total electricity generated from RES. Besides the big hydropower stations, there are several hundred small hydropower plants with less than 5 MW capacity. In contrast to large hydropower (10+ MW), the number of hydropower plants with up to 10 MW-capacity is increasing.

[12] PAIZ http://www.paiz.gov.pl/sectors/renewable_energy

**Table 16: RES-E from hydropower – capacity and output**

| Hydropower | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|
| Total installed capacity in MW | 867 | 876 | 915 | 925 | 922 | 929 |
| Hydro – 1 MW | 63 | 77 | 72 | 72 | 72 | 74 |
| Hydro – 1-10 MW | 164 | 184 | 174 | 181 | 178 | 183 |
| Hydro – 10+MW | 640 | 615 | 669 | 672 | 672 | 672 |
| Electricity generation in GWh | 1,671 | 2,082 | 2,201 | 2,042 | 2,352 | 2,152.2 |

Source: Polish Central Statistical Office (GUS)

### 3.8.4 Wind Power

Poland is the leading country in Central and Eastern Europe regarding the potential for wind energy development. It has very good wind conditions, while total onshore wind power capacity is still relatively low. There are many profitable locations and development possibilities, which have attracted the attention of a large number of international investors and led to a rapid growth in investment projects.

The erection of wind parks has recently seen a dynamic increase. While hardly any windmills could be spotted in 2000 (5,000 MWh of total power output), wind power currently contributes about 13% to RES-E-generation (up from approx. 10% in 2007 and 6% in 2006). The project pipeline for the near future is promising, as a significant number of wind farms has received official clearance including documents securing connection to the grid. Feasibility studies for further sites are currently under way. Foreign companies from countries with experience in offshore installations are also evaluating the Polish market.

The Polish government has ambitious plans for the expansion of capacity. Despite the fast pace of development, bold targets like the 2,000 MW that were supposed to be installed by the end of 2010 and a 2.3% share in total electricity production in the same year cannot be reached within the given timeframe. Obstacles such as opaque and complicated administrative procedures and the protection of areas with the most promising wind conditions by Natura 2000 legislation make the erection of wind farms both on- and off-shore a challenging venture. Moreover, the financial crisis put a break on the dynamics due to lack of funding for projects.

**Table 17: RES-E from wind power – capacity and output**

| Wind power | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|
| Total installed capacity in MW | 35 | 40 | 121 | 172 | 306 | 526 |
| Electricity generation in GWh | 124 | 142.3 | 135.5 | 256.1 | 521.6 | 836.8 |

Source: Polish Central Statistical Office (GUS), Polish Wind Energy Association

### 3.8.5 Photovoltaics

Photovoltaic (PV) technologies have not received a lot of attention as a means for green power production due to their very high investment costs.

PV installations for electricity generation exist only on a very small scale in Poland and in small units, such applications for energy generation for single traffic lights. Solar energy is mainly used for heat generation in private households.

According to the Polish Central Statistical Office, the cumulative photovoltaic capacity came to 0.638 $MW_{el}$ in 2007. The future development of the market will depend on cost effectiveness of the technology.

### 3.8.6 Geothermal Energy

Poland has one of the biggest geothermal reserves in Europe, contained in three sedimentary provinces that lie under approx. 80% of the county's surface. However, no geothermal power plants exist in Poland since temperatures are too low and the conditions for geothermal power production are not ideal. Temperatures range between 20 to 50 degrees in some areas and between 50 to 100 degrees in others and are as such better suited for heat generation. Exploitation has been mainly concentrated in space heating and balneology, while greenhouse heating, fish farming and timber drying are on an experimental scale.

# 4 FUTURE PERSPECTIVES OF RES-DEVELOPMENT

Poland has vast areas with favorable wind conditions, big forests and an important agricultural sector, which are all favorable for energy production from RES. Furthermore, the costs of natural resources, land, labor and the general cost of doing business are still lower than in the EU-15.

Poland's reliance on coal for energy production is unsustainable and the EU is pressuring the country to curb $CO_2$-emissions. European and national regulations are forcing energy producers and heavy industry to reduce the amount of $CO_2$ they blow into the air, which pushes them towards cleaner coal technologies and renewable energy sources. An attractive short-term option is the co-firing of biomass in CHP plants or the substitution of imported gas or oil by biomass.

European Union legislation has led to policy reform and legal amendments in Poland. Not only do companies have to comply with regulations regarding the minimum amount of renewable energy sources in their fuel mix, they also benefit from a more reliable energy law and incentives for RES-production.

Poland faces the need for massive investment in its energy infrastructure, whose current capacity will not be able to cope with future energy demand. Progress to expand the infrastructure is quite slow, however Poland benefits from high EU-subventions that directly benefit the national grid and production facilities.

Biogas plays an important role in the government's current energy policy. It is also a strategy for rural development, and farmers are being motivated to install small biogas installations in their grounds. The agriculture and agro-industry industries are very strong in Poland, and support from their lobbies increases the likelihood of the implementation of the government's ambitious plans.

The country's decision makers place high priority on energy independence and consider it a matter of national security. The current reliance on Russian oil and gas worries some. The aim is to decrease the need for imports from Russia. Alternative energy sources receive a special attention in the respective discussions, and it is widely acknowledged that renewable energy sources can and will play a significant role in Poland's future energy mix.

## 4.1 Poland's RES-Potential: EC BREC's Perspective

To contribute to the discussion and to stimulate awareness, the Institute for Renewable Energy (EC BREC) published a paper with a thorough analysis of Poland's RES- potential[13]. Each renewable energy source (final energy, including electricity and heat purposes) is examined for its theoretical, technical, real economic and market potential[14]. The institute defines

- **theoretical potential** as the maximum potential which could theoretically be achieved given the availability of Poland's natural resources (wind, biomass, water etc.). It is, however, of little practical relevance.
- **technical potential** as the maximum capacity that could be realized with the best technologies that are currently available.
- **economic potential** as the economically feasible exploitation of a renewable energy source given the country's economic circumstances, financial framework, support policies and social acceptance. It includes all those factors that allow the achievement of economically satisfying results for the investor.
- **market potential** as the best-case implementation scenario by 2020. Since market barriers prevent a fast and efficient realization of economically feasible projects, market potential is typically only a fraction of the economic potential.

The difference between each type of potential varies for each RES and is influenced by factors like investment cost, natural endowment, policy and regulations, environmental protection, energy infrastructure, availability of technology etc.

[13] Wiśniewski (2007)
[14] Wiśniewski (2007), Michałowska-Knap (2008)

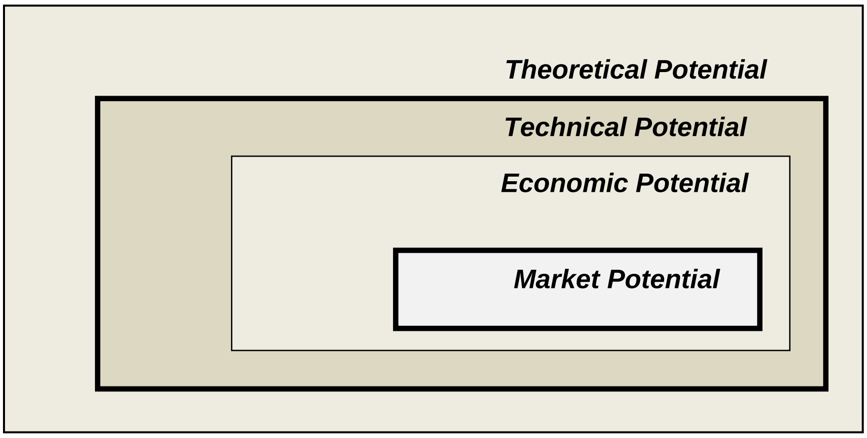


**Figure 9: Illustration of different classifications of RES potential by 2020**
Source: Wiśniewski (2007)

The following chapters elaborate on the potential for each renewable source of energy.

### 4.1.1 Biomass

Poland's theoretical biomass potential is hard to quantify as it includes all available woody biomass as well as organic waste, energy plants and energy crops. Moreover, these resources can produce all three forms of energy: electricity, heat and fuel.

EC BREC calculates that given Poland's natural endowments and the current technical standard, it should be possible to produce 926,950 TJ from biomass sources annually: 479,166 TJ from energy plants, 237,044 TJ from solid dry waste biomass, 175,809 TJ from wet organic waste and 34,931 TJ from forestry wood.

However, financial and legal barriers lower the economically feasible level of exploitation to about 65% of Poland's technical potential. The country's real economic biomass potential, expressed as final energy, is 600,168 TJ according to EC BREC's estimate.

Solid dry wood and forestry wood are currently almost in full use, contrary to some of the other biomass-sources like energy plantations or wet waste. However, the institute expects a surge in market share of biomass in Poland's overall energy production due to its feasibility, availability and legal requirements (including a quota for biofuels).

The market potential, i.e. the prospective energy output from biomass, by the year 2020, is 533,118 TJ (final energy) with the market potential of solid dry waste biomass, forestry wood and energy plantations equaling its economic potential.

**Table 18: Real economic potential of biomass and its use in 2006 – final energy**

| Biomass | Economic potential | Use of potential in 2006 | |
|---|---|---|---|
| | TJ | TJ | % |
| **Solid dry waste biomass (combustion)** | 165,931 | 160,976 | 97.0 |
| **Forestry wood** | 24,452 | 24,452 | 100 |
| **Biogas (wet waste)** | 123,066 | 2,613 | 2.1 |
| **Energy plantation** | 286,718 | 4,056 | 1.4 |
| • cellulosic | 146,600 | 0 | 0 |
| • Sugar and starch - bioetanol | 21,501 | 2,558 | 11.9 |
| • Rape seed -biodiesel | 37,980 | 1,498 | 3.9 |
| • Corn silage & related - biogas | 81,638 | 0 | 0 |

Source: Wiśniewski (2007), Michałowska-Knap (2008)

### 4.1.2 Wind Power[15]

Following the “rule of thumb” that 1 MW of installed capacity requires 10 ha of land and given the fact that 50% of Poland’s area offers favorable wind conditions, EC BREC calculates a theoretical wind power potential of 2,049 TWh (7,376,400 TJ) onshore and 374 TWh (1,346,400 TJ) offshore per annum given current technological standards.

However, the Polish Institute of Meteorology and Water Management (IMGW)[16] argues that various restrictions like Natura 2000 protection and other environmental limitations, building restrictions, structural and urban areas and limits to efficiency lower the technical potential to approx. 30% of the theoretical potential: 2,582,355 TJ (717.38 TWh) - 2,514,950 TJ (698.65 TWh) onshore and 67,405 TJ offshore (18.47 TWh).

With amortizations and yields in mind, investors finance only the most lucrative wind power projects, i.e. the best combination of wind conditions, connection costs and wind costs. Under present circumstances, the economic potential is constrained to

[15] A more detailed analysis of wind power potential can be found in Chapter 5, where the efficiency and effectiveness of Polish wind power policy is evaluated.
[16] Lorenc (1998)

only 15% of the technical potential or 377,242 TJ (104.80 TWh) onshore and 67,405 TJ (18.73 TWh) offshore. A total capacity of 49 GW onshore and 5.5 GW offshore are feasible according to Wiśniewski (2007).

EC BREC also estimates that the most optimistic wind power market development (market potential) until the year 2020 are 14.7 GW of installed onshore wind power generating 113,173 TJ (31.44 TWh) of electricity annually and 550 MW offshore power (i.e. one big offshore wind farm) with an output of 6,740 TJ (1.87 TWh) per annum.

In their 2006-„Assessment of wind energy development opportunities and potential in Poland until 2020"[17], the Polish Wind Energy Association (PSEW) describes a rise of onshore capacity to approximately 13,400 MW as a feasible scenario[18]. The analysis does not include offshore potential or technological improvements like higher turbine capacities, but emphasizes how the elimination of legal and administrative barriers is a necessary precondition to achieve this potential.

The PSEW-scenario looks unattainable from today's point of view. It would have required a yearly development of 1,000 MW of wind power capacity per annum from 2006 onwards, a pace that has not been witnessed over the last few years. Total installed capacity was 724 MW at the end of 2009.

**Table 19: Real economic potential of wind power and its use in 2006 – final energy**

| Wind power | Economic potential | | Use of potential in 2006 | | |
|---|---|---|---|---|---|
| | TJ | TWh | TJ | TWh | % |
| **Wind power** | 444,648 | 123.52 | 922 | 0.26 | 0.2 |
| **Onshore** | 377,242 | 104.80 | 922 | 0.26 | 0.2 |
| **Offshore** | 67,405 | 18.73 | 0 | | 0 |

Source: Wiśniewski (2007), Michałowska-Knap (2008)

17 http://www.psew.pl/en/files/assessment_of_wind_energy_development_opportunities_and_potential_in_poland_until_2020.pdf

18 A more recent PSEW-scenario predicts very dynamic growth of installed capacity in the wind power sector, amounting to almost 13 GW in 2020 (11 GW in onshore wind farms, 1.5 GW in offshore wind farms and 600 MW in small wind turbines). The share of wind power in electricity production would increase to 24% in 2020 and almost 45% in 2030 http://psew.pl/en/files/rap_sum_en3.pdf).

### 4.1.3 Hydropower

Estimates for Poland's theoretical hydropower potential trace back to the 1950s, when Professor Alfons Hoffmann from the Polytechnic University in Gdansk developed a register of theoretical and technical hydropower potential. He estimated that Poland's rivers and waterways offered a theoretical potential of 23 TWh/year and a technical potential of 12 TWh/year. The Polish Hydropower Society (TEW) provided an expertise for the Ministry of the Economy where it described Poland's economic hydropower potential as 8.5 TWh per annum.

However, register and expertise were published long before Natura 2000 regulations came into play. Since then, environmental protection of large areas and community activism against hydropower projects made the implementation of a number of hydropower projects impossible, most prominently the development in the Cascades of the lower *Wisła*, which could theoretically produce 3.5 TWh of electricity per year. These limitations reduce both the technical and the economic hydropower potential to 5 TWh or 18 PJ per year– according to EC BREC[19].

It is highly unlikely that any large-scale hydropower project can be realized in the medium run. Any additional capacities will most likely come from SHPPs with a maximum of 10 MW. EC BREC claims that Poland's hydropower capacity in 2020 could amount to 1,176 MW, with a yearly power output of 3,100 GWh or 11 PJ of electricity.

TEW, however, argues that a further development of small units is only possible with a change of policy and attitude of public bodies towards hydropower, i.e. the existence of a comprehensive strategy and development plans, clear-cut regulation and a reduction of administrative barriers. This change of paradigm would also provide a boost for projects bigger than 10 MW and consequently increase market potential significantly.

[19] Wiśniewski (2007), Michałowska-Knap (2008)

**Table 20: Real economic potential of hydropower and its use in 2006 – final energy**

| Hydropower | Economic potential | | Use of potential in 2006 | | |
|---|---|---|---|---|---|
| | TJ | TWh | TJ | TWh | % |
| Hydropower | 17,974 | 4.99 | 7,351 | 2.04 | 40.9 |

Source: Michałowska-Knap (2008)

### 4.1.4 Solar Energy

Solar radiation on Polish territory amounts to 1,123 EJ annually (theoretical potential). 27,188,000 TJ of solar radiation reach inhabited areas ever year (technical potential). Even if it is possible to derive the theoretical and technical potential from these figures, they do not give any indication of the true possibilities to harvest solar energy in 2020.

For a realistic estimate of Poland's real economic solar thermal potential, a differentiation between the use of solar energy for domestic hot water and space heating is needed.

To determine hot water potential, EC BREC analyzed the demand of all residential buildings in Poland that are not connected to a district heating system and have a minimum of three units. Buildings with only one to two units were excluded from the analysis, as installation costs are too high. Hotels, guest houses, pensions etc. were included in the calculation. The institute estimated that 60% of total hot water demand could be prepared using solar thermal technology, i.e. 35,492 TJ yearly (economic potential) and that the market potential until 2020 amounted to 40% of economic potential, i.e. 14,597 TJ of final energy collected by 12 mn $m^2$ of solar collectors.

For space heating potential EC BREC examined the possibility of combined hot water and heating systems in residential areas and concluded that about 61% of all residential area could be heated with a combination of traditional heating systems and solar heating, while approx. 30% could profit from a combi-system of solar heating and hot water. Consequently, the economic potential of solar space heating was identified as 46,661 TJ per annum with a market potential of 10% of its economic potential by 2020, i.e. 4,666 TJ to be provided by 2.6 mn $m^2$ of solar collectors.

Taking hot water and space heating together, EC BREC concludes that 14,756,253 $m^2$ of solar thermal collectors (or 0.39 $m^2$ of collectors per inhabitant) could produce final energy of 19,263 TJ in 2020 (market potential). [20]

Currently, there are only dozen photovoltaics installations working in Poland, most of them standalone systems generating a few to a few thousands Wh of energy. Installation costs are still high and experience with the technology is low. In 2009, the most powerful installation was a 60 kW system, and a total capacity of 431 $kW_{el}$ was installed in 2006 with autonomous systems accounting for approx 75%.

EC BREC does not see any developments of large, centralized solar installations in the MW-level in Poland, but predicts a growing interest in autonomous small-scale installations due to falling costs and increasing profitability. Judging from developments over the last years and similar experiences in the solar thermal industry, Wiśniewski (2007) predicts an annual growth rate of capacity of 40% until the year 2020, when photovoltaic technology will reach an economic (and market) potential of 159 TJ.

**Table 21: Real economic potential of photovolatics and its use in 2006 – final energy**

| Photovoltaics | Economic potential | | Use of potential in 2006 | | |
|---|---|---|---|---|---|
| | TJ | TWh | TJ | TWh | % |
| **Photovoltaics** | 159 | 0.04 | 0.2 | 0 | 0.1 |
| **Solar Thermal** | **Economic potential** | | **Use of potential in 2006** | | |
| | TJ | | TJ | | % |
| **Solar Thermal** | **83,153** | | **150** | | **0.2** |
| Domestic hot water | 35,492 | | 150 | | 0.4 |
| Space heating | 46,661 | | 0 | | 0 |

Source: Michałowska-Knap (2008)

### 4.1.5 Geothermal Energy

Poland has one of the biggest geothermal reserves in Europe that occur under about 80% of its landmass. However, there is little in the form of thermal springs or outflows. Temperatures range between 20 to 50 degrees in some areas and between 50 to 100 degrees in others and are as such better suited for heat generation rather than power.

[20] Wiśniewski (2007), Michałowska-Knap (2008)

Even though it should be possible to access geothermal sources in 70% of the country, the main prerequisite for the future development is a reduction of the investment costs. With 7,000 wells already drilled all over Poland, it would be appropriate to develop additional projects, albeit mainly for localized space and district heating purposes rather than big installations.

Poland's geothermal potential occurs in the form of deep geothermal sources that can be used for heating plants (district heating systems) and shallow sources than can be exploited on an individual basis by geothermal heat pumps.

It is hard to estimate the theoretical and technical potential of Poland's deep geothermal sources since it involves substantial geological exploitation and measurements while it is never certain that drilling efforts are successful.

Given the status of exploration and available technology, Michałowska-Knap (2008) and Wiśniewski (2007) calculate a yearly economic potential of 4,200 TJ for geothermal energy, and forecast an exploitation of almost 100% of this potential by 2020 thanks to financial funding for geothermal purposes available through the EU.

To determine the economic and market potential of heat pumps, Wiśniewski (2007) observes how these systems are typically installed in new buildings, usually private houses of 200-300m$^2$ in size, housing one to two families or larger luxurious multi-family houses with up to 2,000 m$^2$. Given building statistics and assuming that an average of 6% of residential buildings with above mentioned characteristics install heat pumps, the economic and market potential for heat pumps in 2020 amounts to 8,167 TJ.

**Table 22: Real economic potential of geothermal and its use in 2006 – final energy**

| Geothermal | Economic potential | Use of potential in 2006 | |
|---|---|---|---|
| | TJ | TJ | % |
| **Geothermal** | **12,367** | **1,535** | **12.4** |
| Deep (for district heating) | 4,200 | 535 | 12.7 |
| Shallow (individual, heat pump) | 8,167 | 1,000 | 12.2 |

Source: Michałowska-Knap (2008)

### 4.1.6 Summary and Evaluation

Poland was using an average of 17% of its economic RES-potential in 2006. According to EC BREC's market potential scenario it should be possible to increase this share to 60.1% by 2020[21].

Table 23 summarizes the installed capacities needed to reach market potential in 2020.

Table 24 recaps the real economic potential for each RES, its use in 2006 and the market potential in 2020 (as analyzed by EC BREC).

**Table 23: Installed capacity (heat and electricity) to generate market potential in 2020**

| RES | Renewable Heat | | Renewable Electricity | |
|---|---|---|---|---|
| | indicator*: $MW_h$/TJ | MW | indicator*: $MW_{el}$/TJ | MW |
| **Solar Energy** | | | | |
| collectors: hot water | 0.58 | 8,515 | | |
| collectors: space heating | 0.50 | 2,333 | | |
| photovoltaic systems | | | 0.42 | 7 |
| **Geothermal Energy** | | | | |
| heat plant | 0.04 | 158 | | |
| heat pumps | 0.10 | 817 | | |
| **Biomass** | | | | |
| small boilers (pellets, brikets) | 0.13 | 9,452 | | |
| heat plant (wood chips) | 0.10 | 2,445 | | |
| co-generation (heat/electr.) | 0.03 | 3,111 | 0.01 | 933 |
| biogas (wet waste) | 0.02 | 1,505 | 0.01 | 1,054 |
| biogas plant (crops) | 0.02 | 1,668 | 0.01 | 1,167 |
| **Hydropower <10 MW** | | | 0.11 | 1,176 |
| **Wind Power** | | | | |
| onshore | | | 0.13 | 14,700 |
| offshore | | | 0.08 | 550 |
| **TOTAL** | | **30,003** | | **19,587** |

* necessary capacity to produce 1 TJ of energy

Source: Wiśniewski (2007)

[21] Wiśniewski (2007), Michałowska-Knap (2008)

**Table 24: Real economic potential and its feasible use in 2006 and 2020 (final energy)**

| RES | Real economic potential (final energy) | | Use of economic potential in 2006 | | | Feasible use of economic potential in 2020 (market potential) | | |
|---|---|---|---|---|---|---|---|---|
| | TJ | TWh | TJ | TWh | % | TJ | TWh | % |
| **Solar Energy** | **83,312.2** | | **149.8** | | **0.18** | **19,422.2** | | **23.3** |
| thermal | 83,152.9 | | 149.6 | | 0.18 | 19,262.9 | | 23.2 |
| hot water | 36,491.9 | | 149.6 | | 0.41 | 14,596.8 | | 40.0 |
| space heating | 46,661.0 | | 0 | | 0 | 4,666.1 | | 10.0 |
| photovoltaic | 159.3 | 0.04 | 0.2 | 0.00 | 0.11 | 159.3 | 0.04 | 100 |
| **Geothermal Energy** | **12,367.0** | | **1,535.0** | | **12.4** | **12,217.0** | | **98.8** |
| deep | 4,200.0 | | 535.0 | | 12.7 | 4,050.0 | | 96.4 |
| shallow | 8,167.0 | | 1,000.0 | | 12.2 | 8,167.0 | | 100.0 |
| **Biomass** | **600,167.8** | | **192,097.0** | | **32.0** | **533,117.5** | | **88.8** |
| solid dry waste | 165,930.8 | | 160,976.2 | | 97.0 | 149,337.7 | | 90.0 |
| forestry wood | 24,451.8 | | 24,451.8 | | 100.0 | 24,451.8 | | 100.0 |
| biogas (wet waste) | 123,066.3 | | 2,613.0 | | 2.12 | 72,609.1 | | 59.0 |
| energy plantation | 286,718.9 | | 4,056.0 | | 1.41 | 286,718.9 | | 100.0 |
| *cellulosic* | 146,600.0 | | 0.0 | | 0.0 | 145,600.0 | | 100.0 |
| *sugar and starch - bioethanol* | 21,501.0 | | 2,558.0 | | 11,90 | 21,501.0 | | 100.0 |
| *rapeseed biodiesel* | 37,980.0 | | 1,498.0 | | 3.94 | 37,980.0 | | 100.0 |
| *corn sileage – biogas* | 81,637.9 | | 0.0 | | 0.0 | 81,637.9 | | 100.0 |
| **Hydropower** | **17,974.4** | 4.99 | **7,351.2** | 2.04 | **40.90** | **11,114.2** | 3.09 | **62.0** |
| **Wind Power** | **444,647.6** | 123.52 | **921.6** | 0.26 | **0.21** | **119,913.3** | 33.31 | **27.0** |
| onshore | 377,242.5 | 104.80 | 921.6 | 0.26 | 0.24 | 113,172.8 | 31.44 | 30.0 |
| offshore | 67,405.0 | 18.73 | 0.0 | 0.00 | 0.0 | 6,740.5 | 1.87 | 10.0 |
| **TOTAL** | **1,158,469** | 321.82 | **202,055** | 56.13 | **17.4** | **695,814** | 193.30 | **60.1** |

Source: Wiśniewski (2007)

To achieve market potential in 2020 (i.e. producing the amount of energy described in Table 24 (column 4) with the capacities indicated in Table 23), RES capacities have to grow at a yearly average of 9% (see Table 25)[22]. A slower pace of growth of renewable sources like solar energy or geothermal energy would not affect the overall future market share of renewable sources in final energy output substantially. However, a less dynamic growth of wind power and biomass capacity does have considerable effect on the overall outcome.

[22] When looking at the RES-development rates of the last four years in early 2010, it becomes clear that this rate of development has not been reached so far.

**Table 25: Pace of development of use of RES to reach market potential in 2020**

| Renewable Energy Source | Average Pace of Development |
|---|---|
| **Solar Energy** | 42% |
| **Geothermal Energy** | 16% |
| **Biomass** | 8% |
| **of which energy plantation** | 35% |
| **Hydropower** | 3% |
| **Wind Power** | 40% |
| **Average** | 9% |

Source: Wiśniewski (2007)

EC BREC's evaluation of future market potential (2020) was carried out and based on data available in 2006/2007. Developments since then have made it clear that the market potential scenario is unattainable. The global financial crisis of 2008/2009 triggered a significant slowdown in RES-development, which also affected wind park- and biomass projects. Even before the financial markets crashed, despite solid growth the sector never experienced the momentum necessary to achieve the bold 2020-scenario put forward by EC BREC.

## 4.2 Poland's RES-Potential: A Different Scenario

PIGEO, the Polish Economic Chamber of Renewable Energies, released a document in October 2009, which discusses Poland's national roadmap and three different trajectories of the future of energy development up to 2020. The EEG (Energy Economics Group) and the Fraunhofer Institute prepared three development scenarios with the Green-X model: a national target fulfillment scenario (15% by 2020), a European target fulfillment scenario (20% by 2020) and a proactive support-realizable deployment scenario.

PIGEO supports the realization of the proactive support/realizable deployment scenario, which streamlines the energy policy based on an active support of renewable energy sources, abolishes all barriers for development of the whole renewable energy sector and assumes maximum possible technology diffusion[23]. The model assumes a very efficient energy use.

Surprisingly, the scenario provides a different quantitative outlook of installed capacity and generated energy than EC BREC's study.

[23] The EEG also calculated a low energy demand scenario, see Cwil et al. (2009)

- Both the Green-X and EC BREC's analyses focus on the market potential in 2020.

- However, EC BREC assumes a total final energy demand of 3,272 PJ in 2020, while the Green-X model works with a total final energy demand of approx. 2,900 PJ in a low demand scenario and 3,435 PJ in a moderate demand scenario.

- There is a striking difference in the total final energy demand forecast for 2020 for each type of energy in the two different analyses. EC BREC's assumption for gross final electricity demand is almost three times as high as in the low demand scenario of the Green-X model while the latter sees heat demand 44% higher than EC BREC.

**Table 26: Gross final energy demand in 2020**

| Gross final energy demand | EC BREC | Green-X Model |
|---|---|---|
| Electricity | 1,546,050 TJ | 621,907 TJ |
| Heat | 1,131,731 TJ | 1,629,879 TJ |
| Transport | 594,810 TJ | 670,005 TJ |
| Total | 3,272,591 TJ | 2,921,842 TJ |

Source: Wiśniewski (2007), Cwil et al. (2009)

Consequently, RES-shares in gross final energy demand also differ for each type of energy. In the Green-X model, the share of each sector is calculated relative to final energy demand for a pathway that assumes highly efficient energy use (low energy demand). In a moderate demand scenario, the percentage of RES in the energy balance would be lower.

**Table 27: Gross final RES-demand in 2020**

| Gross final RES-demand | EC BREC | Green-X Model |
|---|---|---|
| RES-E | 309,210 TJ | 169,565 TJ |
| $RES_{el}$ share on gross electricity demand | 20% | 27,3% |
| RES-H | 328,202 TJ | 321,839 TJ |
| RES-H share on gross heat demand | 29% | 19,7% |
| Biofuels | 59,481 TJ | 54,260 TJ |
| Biofuel share on transport fuel demand | 10% | 10% |
| Total | 606,893 TJ | 545,655 TJ |
| RES share on gross final demand | 18.5% | 18.7% |

Source: Wiśniewski (2007), Cwil et al. (2009)

In the low demand Green-X model, RES covers 18.7% of gross final energy consumption, which means an overachievement of the obligatory 2020 target (15%) by 3.7%.

Data shows that the heat sector will contribute the biggest share in reaching the target (over 60%). Especially solid biomass will play a dominant role (208,523 TJ in 2020).

In electricity production, the dynamically growing onshore wind sector will account for the biggest part of RES-E in 2020 (65,484 TJ). Offshore wind energy and biomass-generated electricity will also have their fair share.

In the biofuels sector, the scenario suggests relatively high amounts of biodiesel. It does not take second generation biofuels or electricity in transport into account.

PIGEO argues that the realization of the scenario that assumes a highly efficient energy use would improve the energy balance and support the achievement of $CO_2$-emission targets by allowing for and increasing the chance of the development of non-emission sources of energy, especially RES-E. The surplus of 3.7% relative to the 2020-target would allow Poland to sell the extra amount on the EU-market to countries who did not achieve their own targets.

# 5 EVALUATION OF POLISH RES-E POLICY

Onshore wind power capacity has shown the most dynamic growth amongst renewable energy sources in Poland over the last few years. The two indicators for policy evaluation that were discussed in the first chapter - efficiency and effectiveness - will be applied to assess the performance of Polish RES-E policies concerning onshore wind power.

## 5.1 Effectiveness of Polish RES-E Policy Measures: The Case of Wind Power

### 5.1.1 Definition and Formula

The effectiveness of a policy is the ability to deliver an increase of the share of RES-E consumed.

In Chapter 2.5.1, three main alternative indicators to calculate policy effectiveness were presented[24]:

- Average annual growth rate

$$g_n^i = \left(\frac{G_n^i}{G_{n-t}^i}\right)^{\frac{1}{t}} - 1$$

- Average absolute annual growth

$$a_n^i = \frac{G_n^i - G_{n-1}^i}{n}$$

- Absolute growth rate as ratio of additional potential

$$E_n^i = \frac{G_n^i - G_{n-1}^i}{ADD - POT_n^i}$$

$a_n^i = Average\ absolute\ annual\ growth$
$g_n^i = Average\ annual\ growth\ rate$
$E_n^i = Effectiveness\ indicator\ for\ RES\ technology\ i\ in\ the\ year\ n$
$G_n^i = Existing\ electricity\ generation\ potential\ by\ RES\ technology\ i\ in\ the\ year\ n$
$ADD - POT_n^i = Additional\ generation\ potential\ of\ RES - T\ i\ in\ the\ year\ n\ until\ 2020$

[24] Ölz (2008)

### 5.1.2 Calculating Effectiveness

The three different effectiveness indicators for Poland were calculated by using the empirical evidence of wind power generation provided by GUS and PSEW and the 2010-assessment of 2020 onshore wind power market potential by PSEW[25] (11 GW).

However, two adjustments were made to the indicators provided by Ölz (2008):

- Average absolute annual growth:

$$a_n^i = \frac{G_n^i - G_{t-1}^i}{t}$$

- Absolute growth rate as ratio of additional potential

Instead of looking at generation potential to calculate the effectiveness indicator, existing and predicted **capacities** were used to for the calculations.

**Table 28: $\mathbf{G_n^i}$ – Installed wind power capacity**

| i = Windpow.<br>n = 2004 - 09 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 |
|---|---|---|---|---|---|---|---|
| in MW | 35 | 40 | 121 | 172 | 306 | 526 | 724 |

Source: Polish Central Statistical Office (GUS); Polish Wind Energy Association (PSEW)

**Table 29: Market potential of wind power in MW**

| Wind power | Market potential by 2020 |
|---|---|
| Onshore | 11 GW |

Source: PSEW (2010)

The outcomes of the calculation are presented in the following tables.

- Average annual growth rate

**Table 30: Average annual growth rate of wind power 2004-2009**

| Avg. Annual Growth Rate | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 |
|---|---|---|---|---|---|---|
| in % | 14 | 86 | 70 | 72 | 72 | 66 |

[25] http://psew.pl/en/files/rap_sum_en3.pdf

- Absolute annual growth

**Table 31: Average absolute annual growth of wind power 2004-2009**

| Avg. Absolute Annual Growth | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 |
|---|---|---|---|---|---|---|
| in MW | 5 | 43 | 45.67 | 67.75 | 98.2 | 114.83 |

- Absolute growth rate as ratio of additional potential

**Table 32: $E_n^i$ – Effectiveness of Polish wind power support mechanisms 2004-2009**

| i = Wind power<br>n = 2004 - 09 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 |
|---|---|---|---|---|---|---|
| Effectiveness indicator | 0.046% | 0.74% | 0.47% | 1.2% | 2.05% | 1.9% |

### 5.1.3 Evaluation

Both the average annual growth rate and the absolute annual growth are biased measures. Relative growth rates favor small countries and those starting from a low level of RES-deployment. Absolute growth provides a better measure for the absolute increase of renewables in one country; however, it has a bias towards larger economies as the size of the country is not taken into account.

The absolute growth rate as ratio of additional potential allows for a better comparison between countries than the other two methods since it is less dependent on size or level of RES-deployment of a country. The outcome, however, depends on the concrete figure for realizable potential used in the calculation, i.e. how (un)ambitious the deployment goals up to 2020 are.

A look at the third and preferred measure for judging the performance of effectiveness of onshore wind support, the absolute growth rate as ratio of additional potential, reveals a relatively low effectiveness of Polish RES-E policies. It should be noted, however, that the outcomes presented in Table 32 are based on PSEW's ambitious predictions of onshore wind power capacity by 2020. A more conservative approach (see for e.g. EC (2008)) with a lower realizable potential consequently lead to significantly higher outcomes for effectiveness (~2% in 2006 EC (2008)).

In their comparative calculation for the average effectiveness in the period 1998-2005, Ragwitz/Held (2007) calculated an average effectiveness for onshore wind for

Poland of approx. 0.25% - higher than the EU-10 average of 0.22%, but much lower than the EU-15 average of 3.8% or the effectiveness of Germany's policy (8.4%).

The gap between the Western European and the Polish windsectors is a consequence of the country's political and economic reality since World War II. Only in its most recent history has Poland experienced economic prosperity and convergence towards Western European nations. Since the fall of the Iron Curtain, the economy has especially benefited from the country's entry to the European Union. Poland became an attractive trading partner and an important destination for foreign direct investment: Energy companies from Western Europe were among the first to invest heavily in Poland's energy sector.

The EU's *aquis communautaire* was transposed into Polish law, including the Union's renewable energy targets. Now investors can count on a legal framework that reduces their risk to an acceptable level and provides for the necessary incentives that make energy production from RES feasible. Moreover, public funds and especially considerable amounts of EU-funds are available for green energy projects and stimulate the industry.

The results of the calculation of policy effectiveness reflect the development of energy policy and its implementation since Poland's accession to the European Union. Obligations to achieve a certain RES-quota were introduced in preparation for EU-entry and the requirement to prove the quota through Green Certificates was brought in in 2004. However, it was the stricter policy enforcement in 2006, which had a stimulating effect on the wind power sector and led to an increase in policy effectiveness.

In its publication "The Support of Electricity from Renewable Energy Sources", the European Commission (2008) concludes that effectiveness of wind energy promotion policies has been highest in countries with feed-in tariffs and that strong and continuous growth is best achieved with high investment security coupled with low administrative and regulatory barriers. Beside the support scheme itself, non-cost barriers like administrative, social and financial aspects influence the effectiveness of a country's promotion policies.

Poland uses Green Certificates and quota-requirements as support measures for renewable energy, which means less certainty of income for the investors than feed-in-tariffs. Moreover, a number of obstacles for further development remain, including grid-related barriers such as insufficient grid capacity, non-objective and non-transparent procedures for grid connection, high grid connection costs and long lead times until authorization for grid connections is granted.

These remaining obstacles provide important potential for policy adaptation and improvement, including the elimination of administrative burdens and the reduction of technical and financial risks of obtaining access to the grid. The Polish grid is generally rather weak and needs modernization and expansion, especially in some regions with significant wind resources like the northeast of Poland.

Strong support measures (especially EU-co-financed programs) will help to realize investment-intensive projects and stimulate the erection of wind farms.

Clearly formulated guidelines for wind power development in areas with high environmental value (including noise emission standards, local building and development plans, surface forms of nature preservation) would also reduce risks for developers and increase policy effectiveness.

The dynamics of connection of new wind farms has been growing significantly over the past few years. At the end of June 2010, total capacity of installed wind power in Poland already amounted to 1005.6 MW. During the first half of 2010, the capacity of wind power grew by approx. 281 MW, which is almost as much as the total capacity that was installed at the end of 2007.

### 5.1.4 Excursus: Calculating Poland’s Wind Power Potential[26]

Currently, only a fraction of Poland’s vast wind power resources are used for producing energy. Especially the regions along the Baltic coast, in the Northeast of the country, the northern provinces of Warminsko-Mazurskie and Pomerania as well as the foothills in the South (Podkarpackie and Lower Silesia) provide very good conditions for electricity production from wind.

[26] Wiśniewski (2007), PWEA (n.a.)

#### *5.1.4.1 Theoretical Potential*

EC BREC (Wiśniewski (2007)) estimates Poland's theoretical onshore potential at 2,049 TWh and its theoretical offshore potential at 374 TWh (a total of 9 EJ in energy). These estimates are based on certain assumptions with regards to technology (a 25% generation efficiency for wind turbines and a maximum wind capacity penetration in the national power system of 20% by 2020) and the rule of thumb that about 10 ha of land should be reserved for 1 MW of installed capacity.

However, in practice it is possible to harvest only a relatively small share of this potential. Primary constraints include a weak national grid, limited siting possibilities on the area of Poland (urban areas, forested areas etc.), administrative barriers (licensing procedures, legal factors etc.) and social acceptance.

#### *5.1.4.2 Technical Potential*

According to the Polish Institute of Meteorology and Water Management (IMGW), good wind conditions prevail on 30% of Poland's landmass[27]. The most attractive locations are open surfaces where the wind is not obstructed, such as agricultural land which covers approximately 59% of Poland's landmass. However, a significant portion (32% according to the Polish Central Statistical Office GUS) of Poland's surface falls under some kind of environmental protection scheme, for example national parks or the Natura 2000 programme. These areas are usually foreclosed to wind power development. GUS estimates that about 22% of rural areas lie in national parks or other protected areas.

Even though landscape protection does not automatically block an area for the erection of wind farms and the final decision often remains in the hands of local authorities, about 32% of "open" agricultural territory with good or very good wind conditions remains untouchable for wind power development. Another 10% of potential locations are inaccessible due to the nature of the terrain, density of population, existing and planned real estate development, protection due to cultural and historical value of the area and other regional development plans like the enhancement of tourism.

[27] These calculations are, however, a large generalization since no appropriate wind atlas exists for Poland.

Access to offshore sites is also limited for technical reasons (the depth of the sea makes construction in some areas impossible), Natura 2000 protection for large areas of the Baltic coast, sea transport and security concerns. According to EC BREC only 5% of Poland's coast can be considered for wind power development.

Summing up, the following factors limit technical wind power potential:

- Wind conditions: 30% of Poland's landmass has good wind conditions and could provide potential locations for wind farms.
- Environmental protection: Large parts of the country are foreclosed to wind farm erection due to environmental protection schemes (which cover approx. 42% of the area) and other limitations such as density of population, historic value of the site or other regional development plans (ca. 10% of the country).
- Offshore sites are limited to 5% of Poland's coast due to environmental protection (Natura 2000), technical restrictions, transport routes, security concerns.

Under the assumption that 10 ha of land are needed for 1 MW of wind capacity (onshore) and that the efficiency of wind power plants reaches 25% onshore and 40% offshore, technical wind power potential could reach 2,582,355 TJ (717.38 TWh): 2,514,950 TJ (698.65 TWh) onshore and 67,405 TJ (18.74 TWh) offshore by 2020[28].

#### *5.1.4.3 Economic Potential*

The Polish regulator incentivized electricity production from RES with certificates of origin: Yields and return on investment ensure that plots with the best wind conditions and the least limits to development are among the first choices for power plant-erection.

On the basis of the assumption that 30% of the country offers suitable wind conditions and that 10ha should be reserved for 1 MW of capacity, technical infrastructure, environmental protection, urbanization etc. limit the economic wind power potential by 2020 to approx. 15% of the technical onshore potential i.e. 377

[28] Wiśniewski (2007)

242 TJ (104.80 TWh) according to EC BREC. Given the current technological standards, 49 GW of installed onshore wind power capacity seem feasible by 2020.

Regarding offshore wind power, it should be economically feasible to exploit the full technical potential and to install 5.5 GW of generation capacity.

#### *5.1.4.4 Market Potential*

Wiśniewski (2007) sees Poland's 2020-market potential for onshore wind power at a capacity of 14.7 GW by 2020, which would generate 113,173 TJ (31.44 TWh) of electricity yearly[29]. He bases these assumptions on the experience of EU-15 countries like Germany or Spain over the past 15 years: they have only recently been able to exploit more than 20% of their economic potential. Rapid technological progress including increased wind turbine capacities has led to a fast increase of the utilization of potential. Spain, for example, moved from a 10% level of utilization in 2002 to 28% in 2006, according to EurObserv'Er[30]. Referring to these experiences, Wiśniewski believes that the Poland should be able to exploit 30% of its economic potential by 2020.

The market potential for offshore developments is hard to estimate. So far, Poland does not have its own experience in the offshore sector and offshore wind power remains a sensitive political and financial issue. In 2007, it seemed feasible to exploit 10% of Poland's technical offshore potential and install 550 MW of capacity (approx. one big offshore wind farm) that generate 6,740 TJ (1.87 TWh) of electricity annually by 2020.

If this capacity is reached by 2020, wind power would hold a share of 27% in installed RES-E generation-capacity or 16% of all electricity production.

When analyzing the current weight of wind power in the overall mix of electricity production, these figures seem very ambitious. It is rather unlikely that Poland will master the huge technical, financial, environmental and economic challenge of

[29] A recent scenario published by PSEW in 2010 predicts wind power installation of approximately 13 GW in 2020 (11 GW in onshore wind farms, 1.5 GW in offshore wind farms and 600 MW in small wind turbines) and an increase in share of wind power in electricity production to 17% in 2020 and almost 29% in 2030.
http://psew.pl/en/files/rap_sum_en3.pdf
[30] http://www.eurobserv-er.org

realizing a market potential of 14.7 GW of installed capacity by 2020. Between 1,000 – 1,500 MW would have to be put into operation annually – numbers which countries like Germany or Denmark have achieved, but which – despite an obvious rise in dynamics - currently seem not realistic for Poland.

However, Poland remains the most promising wind energy market in Central Europe and the increase in capacity will be dynamic in the short and medium run.

## 5.2 Efficiency of Polish RES-E Policy Measures: Case Study of Onshore Wind Power

Efficiency indicators are a method of assessing government support for a specific RES-technology against the generation cost of that particular renewable energy source (see Chapter 2.5.2). Efficient support measures minimize the gap between generation cost and level of support. If support levels are too low, investment in RES will be low as there is no incentive to invest. If they are too high, investors will collect windfall profits, which have to be borne by the electricity consumer / society.

Since the Polish policymakers argue that wind power will be a dominant driver of renewable energy in Poland in the medium run, a case study was carried out to assess the efficiency of Poland’s support measures for electricity generation from wind. Simplifying assumptions were made to calculate the feasibility of a wind park investment project with and without support measures.

Policy mechanism could take the form of Certificates of Origin, direct subsidies that cover part of the initial outlays, an interest tax shield and increased debt capacity thanks to preferential credit terms available through special funds. The Net Present Value (NPV) method allows to estimate the impact of each support mechanism on the project’s value as it increases NPV by either lowering initial cost (direct subsidies), increasing revenue (CoO), lowering tax (tax shield) or lowering cost of capital (preferential credit).

The example looks at a wind power plant with a total nominal power of 18 MW, or nine turbines with a capacity of 2 MW each. The average yearly production of each turbine is 5,256 MWh per year (30% capacity factor), the total annual output of the wind farm is 47,304 MWh.

The purpose of the investment is electricity production from wind turbines, which would substitute electric power from non-renewable, polluting sources, such as coal. The project will decrease greenhouse gas emissions ($CO_2$) and air pollutants (e.g. $NO_x$, $SO_2$ and dust).

According to the tax consultancy TPA Horwath, the average wind power investment costs are approx. 1.6 mn EUR per MW. The costs of the turbine average 75-80% of total costs, while project development costs and design work amount to approximately 70,000 to 100,000 EUR per MW. Auxiliary road infrastructure cost account for ca. 0.5 mn EUR per MW, while grid connection costs range from 0.5 mn EUR to 0.8 mn EUR for the whole project. A second industry source cited investment costs of 1 mn EUR per MW or 2.8 mn EUR for a 2.3 MW turbine including construction and transformer. Another 10-20% of the turbine costs for the connection to mains and infrastructure should be added.

Based on this information, the following cost assumptions were made:

29.6 mn EUR or 117.50 mn PLN[31] net initial investment costs for nine 2 MW turbines (including development and design, infrastructure, construction, grid connection etc.):

The project's lifespan is 20 years (depreciation of machinery over 20 years).The yearly maintenance costs are set at 1.8% of the machinery's value.

It was assumed that total income of green electricity per MWh (the average price of electricity per MWh plus the market price for a GC) would grow at 3% per annum. This is a conservative estimate: Poland's electricity prices are currently only about 80% of Germany's and have risen by significantly more than 3% p.a. over the last few years, due to market liberalization, price convergence, cost of $CO_2$-emissions, cost of producing RES-E etc. Prices are predicted to rise dynamically in the future along with further market liberalization, rising cost of $CO_2$-emissions, energy imports from abroad etc. In 2009, the Energy Regulatory Office (URE) approved price hikes between 5% and 6.8% in price tariff for households filed by certain vendors. In the original motions, power vendors wanted prices to rise by as much as 17%.

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[31] Exchange Rate July 8th, 2010: 1 EUR = 4.08 PLN

GC prices were 37% higher in 2010 than in 2006 and they will continue to grow in the future: The substitution fee, which is calculated annually and acts as a price cap for GC-prices is CPI-adjusted and subject to the extent, to which the renewable energy quota has not been fulfilled for a given year[32].

The discount rate was set at 12%.

As explained in Chapter 3.6.3, total income per MWh of green electricity consists of the maximum price per MWh of electricity sold to the grid and the market price for green certificates.

**Table 33: Total income of green electricity per MWh on July 8th, 2010**

| | Price in PLN | Price in EUR[1] |
|---|---|---|
| **Average price for electricity in 2009** | 197.21 PLN/MWh | 48.33 EUR/MWh |
| **Market price for Green Certificates** | 274.00 PLN/MWh | 67.15 EUR/MWh |
| **Expected total income for 1 MWh of electricity** | 471.21 PLN/MWh | 115.49 EUR/MWh |

[1] Exchange Rate July 8th, 2010: 1 EUR = 4.08 PLN

In the following example, three support mechanisms were introduced:

1. A possibility of selling renewable energy certificates,
2. credit on preferential terms,
3. a direct subsidy, which covers part of the initial outlays.

The two latter options were researched as support measure being either complementary or alternative to the first (of selling / trading renewable energy certificates).

The calculations for a model with renewable energy certificates were carried out by performing an NPV calculation in Microsoft-Excel.

Calculations for credit on preferential terms and a direct subsidy were performed using the RetScreen© software that was developed and is promoted by RetScreen©

[32] For a detailed discussion, see Chapter 3.6.3 “Price Regulation and Trade of Green Certificates”.

International, Clean Energy Decision Support Center, an initiative by the Minister of Natural Resources Canada[33].

Excel-Spreadsheets and RetScreen© protocols with the results of calculations can be found in the Appendix.

### 5.2.1 A Possibility of Selling Renewable Certificates

For an investment period of 20 years, the project's appraisal without a policy mechanism (incentivization) is negative. The revenue would solely be the product of the current market price for electricity (an average of 48.33 EUR/MWh in 2009) and the electricity produced (47,304 MWh p.a.).

Net Present Value (NPV) for an investment period of 20 years (–12,736,224 EUR), Internal Rate of Return (IRR: 5%) and annuity (-1,813,352 EUR with a PVIFA - Present Value Interest Factor of Annuity - of 7.02%) are all negative.

In Poland, however, producers of renewable electricity can receive additional income from GC per MWh:

On July 8th, 2010 1 MWh of electricity created a total revenue of 471.21 PLN/MWh (115.49 EUR/MWh):

- 197.21 PLN/MWh (48.33 EUR/MWh), i.e. the average market price for electricity in 2009 as calculated by URE) and
- 274 PLN/MWh (67.15 EUR/MWh), i.e. market price for the sale of a Green Certificate on the Polish Power Exchange POLPX[34].

Note: It was assumed that the trade of certificates does not change the firm's risk level. The sale of certificates creates over 60% of the project's revenue. If supply of RES-E increases considerably, the value of certificates might drop and the project's feasibility could deteriorate. However, Poland's energy industry needs to fulfill demanding obligations for electricity generation from RES (2009: 8.7%; 2010: 10.4%). Over the past few years, it has not yet managed to meet any of these targets.

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[33] The RetScreen© software is available free of charge from the RetScreen© International website http://www.retscreen.net and can be used without restrictions.
[34] Exchange Rate July 2010 2010: 1 EUR = 4.08 PLN

With a revenue of 115.49 PLN/MWh starting in year 1, an investment period of 20 years and a price escalation of 3% per year, NPV of the project is positive: 10,503,178 EUR. The annuity is 1,495,416 EUR (PVIFA of 7.02%), and IRR is 17%. The significant impact on the project value derives from a relatively high price of the Green Certificates. Break Even would be reached in year 11.

### 5.2.2 Credit on Preferential Terms

The National Environmental Protection and Water Management Fund offers a preferential loan program, which is a non-subsidy aid form for the wind energy sector in the form of a loan not exceeding 75% of the investment value. The interest is fixed at 6% per annum, and the term of loan is 15 years with the option of deferment of principal amount repayment dates.

Since the maximum amount of the loan cannot exceed 50 mn PLN (12.25 mn EUR on July 8th, 2010), it was assumed that the debt ratio is 41%.[35]

Calculations were carried out using the Retscreen© Tool over an investment period of 20 years.

Under the assumption that a renewable certificate scheme is in place (revenue per MWh = 115.49 EUR), the project's financial analysis gives a positive Net Present Value of 15,917,365 EUR and a debt service coverage of 4.24 years. Equity payback would occur after 4.6 years, simple payback after 5.8 years. After-tax IRR on equity is 23.3%. The highest sensitivity of the key financials lies in the electricity export rate, followed by the initial costs.

Without the renewable certificate scheme and revenue of 48.33 EUR per MWh, NPV is negative (-8,250,483 EUR) and debt service coverage is 1.62 years. Equity payback would occur after 15.0 years, simple payback after 15.1 years. After-tax IRR on equity is 5.2%. Sensitivity is now highest for initial costs, followed by the electricity export rate

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[35] Comment: A preferential credit usually increases the firm's debt capacity. The increase in financial leverage leads to rise in tax shields which increase the firm's value. The argumentation is true only if the financial leverage does not change firm's operational risk.

### 5.2.3 Direct Subsidy Covering Part of the Initial Outlays

The third supporting mechanism that was introduced is a subsidy from EcoFund, which covers 30% of the initial outlays. The subsidy is granted at the beginning of the investment process and under the condition that the project cannot be terminated before a specified date and that it must maintain the required level of renewable energy production. Failing to comply with these conditions would mean having to return the granted funds.

The Retscreen© Tool was used for calculations. Under the assumption that a renewable certificate system is in place and no debt is incurred, NPV for an investment period of 20 years is 18,856,145 EUR, after tax IRR on equity is 23.1% and equity payback is reached after 4.6 years. Sensitivity is highest for the electricity export rate, followed by initial costs.

Without the renewable certificate scheme and revenue of 48.33 EUR/MWh, NPV is negative (-5,079,987 EUR). Equity payback would occur after 10.2 years, after-tax IRR on equity would be 8.5%. Sensitivity is in this case highest for initial costs, followed by the electricity export rate.

### 5.2.4 Social Project-Value[36]

Renewable energy projects create external benefits, which a pure financial analysis does not take into account. By producing clean energy, they reduce emissions in the form of $CO_2$, $SO_2$ and NOx, which are released into the atmosphere when electricity is produced from fossil fuels. Their value for the environment and consequently for society can be assessed by determining the damage avoided by not using coal for electricity production.

Attaching a monetary value to health and environmental impacts of emissions is a complicated task and different approaches have been used (e.g. the European Commission's ExternE (External Cost of Energy)-Project[37] or the contingent valuation method (CVM) based on the price of a ton of $CO_2$). Social effects could gain in importance in the analysis of project value when greater RES-capacity and higher availability of certificates reduce their price, while high capital expenditures for initial investment remain and create barriers of entrance.

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[36] see Płuta et al.
[37] http://www.externe.info/

A project's social value for the investment decision plays a role when external costs are introduced into the calculation of the NPV of energy projects (including fossil fuel, nuclear and RES) and investors receive rewards for the avoidance of environmental and social impacts. A current example are $CO_2$-Trading Schemes that compensate investments by awarding certain credits that can be traded on an exchange.

### 5.2.5 Conclusion

Poland has introduced mandatory RES-E-targets and a market for Green Certificates to create incentives and stimulate RES-E development in general and wind power in particular.

The calculations show that if the power generator receives the average market price for electricity **and** revenue from renewable certificates, they are able to pocket windfall profits. However, wind power investments are currently not feasible without the option of selling renewable energy certificates.

The calculations are based on a simplified model, which fails to take factors like administrative burdens, access to capital, investors' expectations on return and their request for a higher risk premium for the uncertainties that are prevailing in the certificate market (price, duration of certificate system etc.) or other entry barriers like social acceptance into account.

The quota system forces companies to fulfill certain RES-E targets and guarantees producers the uptake of the electricity they generate at an average electricity price. Together with the profits that result from the sale of property rights in the form of Green Certificates, the momentum for creating new renewables capacity is much higher and leads to a dynamic that would not be experienced without the respective policies.

The income earned per MWh of green electricity has the greatest impact on project value besides initial cost. Certificate prices are influenced by the substitution fee, which is determined by URE and therefore very much a political decision. At present there is not enough RES-E-capacity in the market to allow for a higher quantity of certificates that would put downward pressure on prices. This might change in the medium and long-term perspective. Certificate prices could drop, when supply of renewable energy increases.

Summing up, in terms of policy efficiency, the results indicate that onshore wind power is over-incentivized. This general finding is confirmed by alternative assessments as exemplary illustrated next. Figure 10 – published by the European Commission in 2008 - shows the relation between minimum and average costs of onshore wind generation and compares it with the maximum support offered in the respective country (FiT, GC or tax credit). Poland is among the three countries with the largest gap between cost and support level. This difference is the margin enjoyed by the investor.

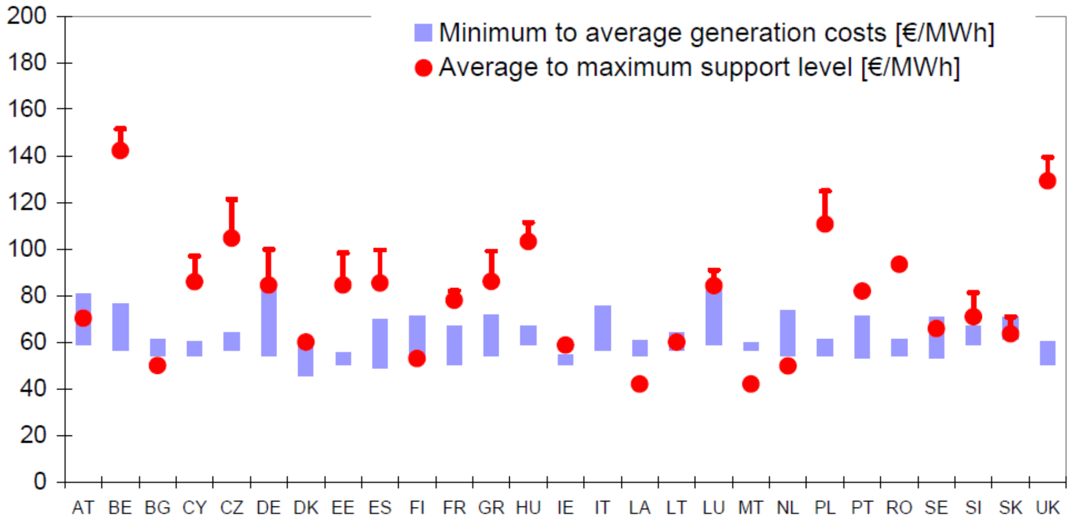


**Figure 10: Price ranges (average to maximum support) for direct support of wind onshore in EU-27 (average tariffs are indicative) compared to long-term marginal generation costs (minimum to average costs).**

Source: EC (2008)

# 6 THE INTERNATIONAL PERSPECTIVE: RENEWABLE ENERGY POLICY IN THE UNITED KINGDOM

## 6.1 Introduction

Four different support schemes currently exist in the member states of the European Union. Feed-in Tariffs are the predominant RES-support measure in most of the member states (for e.g. Austria, Denmark, Germany, Spain), while the Green Certificate System is the main instrument in countries like Belgium, Italy, Sweden, Poland and the United Kingdom. Some countries use a combination of both: The United Kingdom recently introduced feed-in tariffs in addition to its Renewable Obligation (RO) scheme. In Finland, the main support instruments for RES-E are investment subsidies and a tax measure while Malta offers soft loans and grants. Some countries use tendering measures in addition to existing support schemes: Denmark, for example, is tendering off offshore wind power parks and Portugal has been successfully using tendering processes for wind energy capacity. Other countries like Poland or Slovakia offer tax incentives and investment grants as additional support to their feed-in tariff or Green Certificate schemes.

The following pages provide an analysis of the current renewable energy policy in the United Kingdom, whose system of indirect subsidy (Renewable Obligation (quota) and Renewable Obligation Certificates (ROC)) is based on a certificate scheme. Its features have been adjusted substantially over the last few years since its former non-discriminatory approach to all RES-technologies had led to imbalances in outcome. To accommodate for new technologies and avoid over-subsidization of established technologies, a “banding approach” to the ROC allocation system has been introduced, which was later supplemented by a feed-in tariff scheme for installations of less than 5 MW capacity.

Poland’s current RES-policy and deployment of renewable technologies could be compared to the situation in the United Kingdom some years ago. The example of development of capacity and policy of renewables in the UK could therefore serve as a good indicator for possible future policy discussions in Poland.

## 6.2 Overall Energy in the UK

The United Kingdom has had extensive reserves of coal, oil and natural gas and was until recently largely self-reliant for energy in net terms. However, a decrease in coal production and the gradual depletion of oil and gas reserves has led to a growing dependence on imports. Since 2005, the UK has been a net importer of oil and natural gas. Rapidly increasing energy prices and concerns over supply security and climate change have brought the energy topic to the forefront of policy discussions.

Fossil fuels still dominate electricity production: Coal and gas produce about two thirds of the UK's power. Even though coal was the main primary fuel produced in the early 1970s and the UK still has extensive coal deposits, competition with North Sea oil and gas and gas imports have left many pits uneconomic. The decline of coal production accelerated with the liberalization of the energy industry in the late 80s, which led to heavy investment in modern efficient gas-fired power plants. Many older coal-fired power stations had to close.

Natural gas has been extracted from the UK's continental shelf in the North Sea since the late 60s. An extensive gas supply network developed in the 70s and gas gradually replaced coal as a means for commercial and domestic heating as well as electricity generation. While the United Kingdom is still a large producer of natural gas, it is no longer self-sufficient and a rising volume of gas has to be imported.

Oil was discovered in the North Sea in the late 60s and has been extracted since the 70s. In the mid 80s, the UK was the sixth largest oil producer worldwide, but domestic production has since fallen considerably and can no longer meet consumption. The UK has again become a net importer of oil in 2005.

Nuclear power stations produce one fifth of the country's electricity demand, but most of the power stations are ageing and about 50% of the currently 14 nuclear power plants should see decommissioning in the near future. All but one will shut down by 2023. Even though the British people are unenthusiastic about nuclear power, its government[38] has come out strongly in favor of building new nuclear

[38] The term „Government" used in this chapter generally refers to the UK's previous Labour government. In May 2010, a Tory-Liberal Democrat coalition was voted into power and started to introduce rigorous spending cuts. It is very likely that these cuts will also affect renewable energy initiatives and policies. No new strategy had yet been presented by September 2010 and potential changes will only emerge during the second half of 2010 and thereafter.

powerplants. It considers them necessary to meet the growing demand for energy while cutting greenhouse gas emissions.

The government is also committed to increase the relevance of renewable energy sources in the country's energy mix, but it is of the opinion that renewable energy alone will not suffice to cover the increasing energy needs and at the same time substitute production from fossil fuels.

UK production of primary fuels peaked in 2000 and has fallen considerably ever since. It amounted to 176.9 Mtoe in 2008 (or 7,407 PJ), a fall of 4.9% compared to 2007.

**Table 34: UK Primary fuel production in Mtoe**

| | 1980 | 1990 | 2000 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|
| **Production of Primary Fuels** | | | | | | |
| **Petroleum** | 86.9 | 100.1 | 138.3 | 84.0 | 83.9 | 78.6 |
| **Natural Gas** | 34.8 | 45.5 | 108.4 | 80.0 | 72.1 | 69.7 |
| **Coal** | 78.5 | 56.4 | 19.6 | 11.4 | 10.7 | 11.4 |
| **Primary Electricity*** | 10.2 | 16.7 | 20.2 | 17.9 | 14.9 | 13.0 |
| **Total** | **210.5** | **219.4** | **288.7** | **197.2** | **186.0** | **176.9** |

Source: DECC (2009)

1 Mtoe = 41.87 PJ
*Nuclear and natural flow hydro; EUROSTAT convention

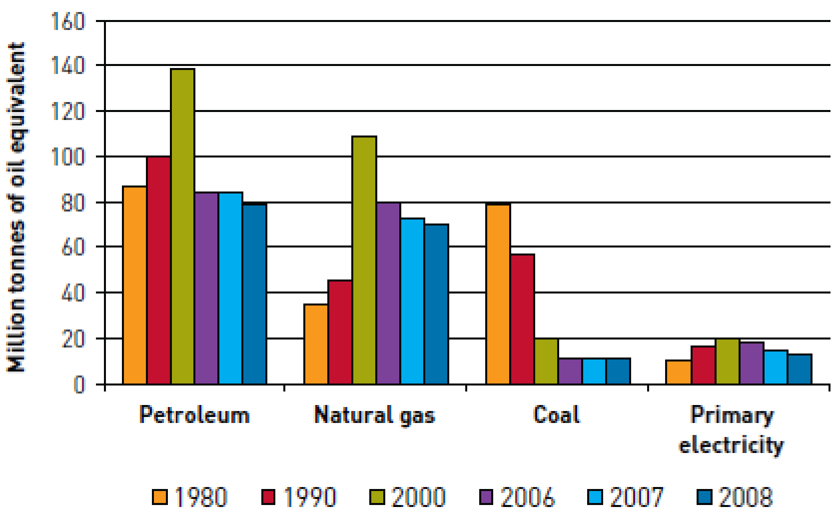


**Figure 11: UK Production of primary fuels**

Source: DECC (2009)

Natural gas consumption and electricity have risen considerably since 1980, while oil consumption has stagnated and the use of coal has fallen.

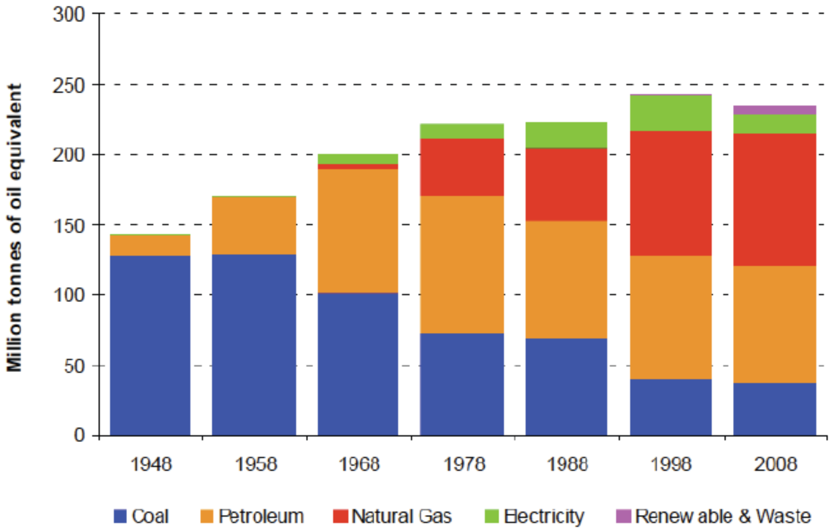


**Figure 12: UK Primary energy consumption**

Source: DECC (2009)

**Table 35: UK Final and primary energy consumption in Mtoe**

| | 1980 | 1990 | 2000 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|
| **Total Final Energy Consumption** | | | | | | |
| | 142.4 | 147.3 | 159.2 | 158.3 | 155.3 | 154.8 |
| **Total Inland Primary Energy Consumption** | | | | | | |
| | 204.5 | 213.7 | 233.7 | 232.6 | 226.5 | 224.2 |

Source: DECC (2009)

Total final energy consumption in 2008 was 154.8 Mtoe (6,481 PJ), down 0.3% from 2007. Total primary energy consumption (without transformation – conversion and distribution - losses) was 224.2 Mtoe (9,387 PJ) in 2008, down 1% from 2007.

**Table 36: UK Final energy consumption in 2008 in Mtoe**

| | 1980 | 1990 | 2000 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|
| **Total Final Energy Consumption** | | | | | | |
| | 142.4 | 147.3 | 159.2 | 158.3 | 155.3 | 154.8 |
| **Total Inland Primary Energy Consumption** | | | | | | |
| | 204.5 | 213.7 | 233.7 | 232.6 | 226.5 | 224.2 |

Source: DECC (2009)

## 6.3 Electricity

The decline of coal and the rise in gas as a fuel source have been the most pronounced change in the UK's electricity mix over the last 20 years. Nuclear power production peaked in the late 90s before falling back. It has been compensated by gas and – more recently – coal. In 2006, coal recorded its highest level in 10 years as a substitute for high priced gas in covering the reduced availability of nuclear stations. It fell back again in 2007 and 2008, when gas experienced another rise. Of all power sources, wind has recorded the highest relative growth since 2000 and has overtaken hydropower in the generation of renewable electricity.

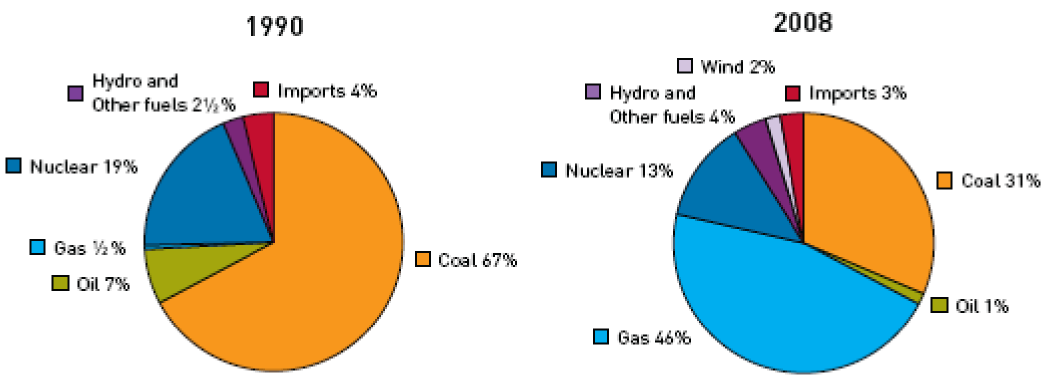


**Figure 13: UK Electricity supplied by fuel type**

Source: DECC (2009)

**Table 37: Electricity supply by fuel type in TWh**

| | 1980 | 1990 | 2000 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|
| **Coal** | 190.0 | 208.0 | 114.7 | 141.8 | 129.6 | 118.9 |
| **Oil** | 33.9 | 21.1 | 5.9 | 5.1 | 4.2 | 5.3 |
| **Gas** | 1.6 | 1.6 | 144.9 | 137.8 | 162.4 | 173.5 |
| **Nuclear** | 32.3 | 58.7 | 78.3 | 69.2 | 57.2 | 47.7 |
| **Hydro** | 7.3 | 7.9 | 4.2 | 3.4 | 3.8 | 3.8 |
| **Wind** | - | - | 0.9 | 4.2 | 5.3 | 7.1 |
| **Other Fuels** | - | - | 8.3 | 12.4 | 11.8 | 11.6 |
| **Net imports** | - | 11.9 | 14.2 | 7.5 | 5.2 | 11.0 |
| **Total** | **265.1** | **309.4** | **371.4** | **381.4** | **379.5** | **379.0** |

Source: DECC (2009)

## 6.4 Fuel Prices

Fuel prices for the industrial sector rose steadily over the last decade. Coal prices increased by 28% (in real terms) in 2008 and were more than 50% higher than ten years before (1998). In the same year, real-term electricity prices also increased by over a fifth (+61% compared to1998), gas prices climbed by 43% (three times higher than in 1998) and heavy fuel oil rose by 42% (four times as much as ten years before).

In the domestic sector, energy prices increased by 16% in real terms in 2008: The price for heating oil rose by over 40%, reflecting the steep rise in crude oil prices in the same year. Electricity prices were 13% higher than the year before, year on year gas prices climbed by 17%. Real prices for domestic energy have risen by 60% from 1998 to 2008, with the price of heating oil increasing three-fold, the real price of electricity by over 70% and the real price of gas by almost 80%.

The development reflects the impact of high energy prices experienced on the international level. The energy discussion has gained additional momentum since the depletion of oil and gas reserves and the retirement of significant nuclear and coal-generating capacity exposes the UK to a higher dependence on gas imports. The end of the country's energy self-reliance raised concerns about energy security and rising fuel costs due to competition for gas on international markets. Consequently, the pace of development of renewable energy sources has accelerated: Support measures and high energy prices have increased the attractiveness of renewables and made their investment feasible.

## 6.5 Energy Production from Renewable Energy Sources

### 6.5.1 Significance for UK's Energy Generation

The British government is committed to raising the proportion of renewable sources for energy production. The share of RES in the United Kingdom's total primary energy requirements in 2008 was 2.5%, up from 2.0% in 2007, 1.9% in 2006 and 1.8% in 2005. In 2008, 2.5% of final energy consumption was from renewable sources, compared to 1.8% in 2007 and 1.5% in 2006[39].

[39] UK National Statistics (2009)

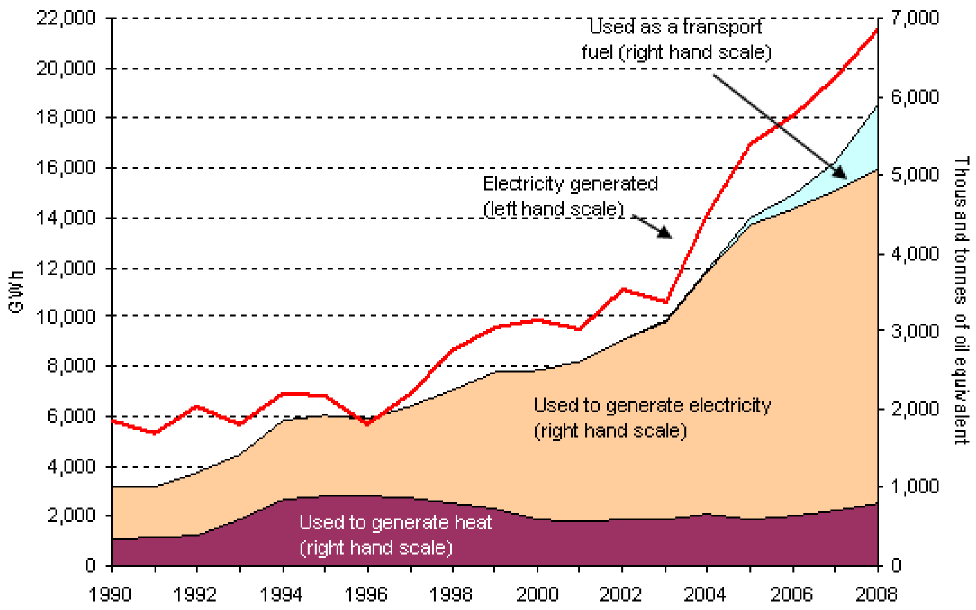


**Figure 14: Trends in the use of renewable energy (heat and electricity) 1990-2008**

Source: RESTATS http://www.restats.org.uk/heat.htm

In 2008, biomass accounted for over 80% of renewable energy sources used, followed by large-scale hydropower and wind. Almost 73% of primary energy use accounted for by renewables went into the generation of electricity, 13.5% into road transport and an equal percentage into heat. Energy generation from RES increased by more than 14% between 2007 and 2008; it is now more than twice the level it was at the turn of the century.

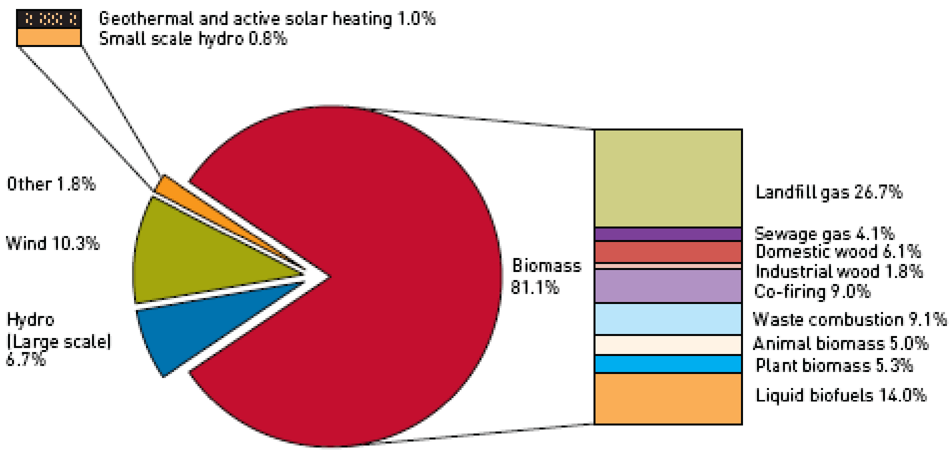


**Figure 15: UK Renewable energy sources in 2008 (Primary energy use)**

Source: DECC (2009)

**Table 38: Total use of renewable energy sources in TJ**

| | 1995 | 2000 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|
| **Geothermal and active solar heating** | 301 | 502 | 1,591 | 1,964 | 2,428 |
| **Wind and wave** | 33 | 3,404 | 15,211 | 18,987 | 25,552 |
| **Hydro (small and large-scale)** | 18,744 | 18,309 | 16,534 | 18,317 | 18,606 |
| **Landfill gas** | 3,341 | 30,610 | 61,324 | 64,791 | 65,896 |
| **Sewage gas** | 5,786 | 7,063 | 8,173 | 8,897 | 10,245 |
| **Wood (domestic and industrial)** | 7,289 | 19,192 | 16,571 | 18,137 | 19,515 |
| **Municipal waste combustion** | 4,220 | 15,692 | 21,466 | 21,792 | 22,533 |
| **Liquid biofuels** | 0 | 0 | 7,863 | 15,144 | 34,562 |
| **Other biomass** | 3,010 | 11,095 | 50,606 | 47,863 | 47,667 |
| **Total** | 42,726 | 105,863 | 199,338 | 215,888 | 247,000 |

Source: DECC (2009)

### 6.5.2 Renewable Electricity

Thanks to a dynamic development of electricity production from wind and biomass, renewable sources had a market share of 5.5% in power generation in the UK in 2008, 0.6% more than in 2007, when it contributed 4.9%. Wind power accounted for 10.3% in the generation of RES-E in 2008 and had a larger market share than hydropower (6.7%) for a second consecutive year. More than 2 GW of wind power plants are now connected to the grid. It took 14 years for the first Gigawatt of capacity to become operational, the second GW took only 14 months.

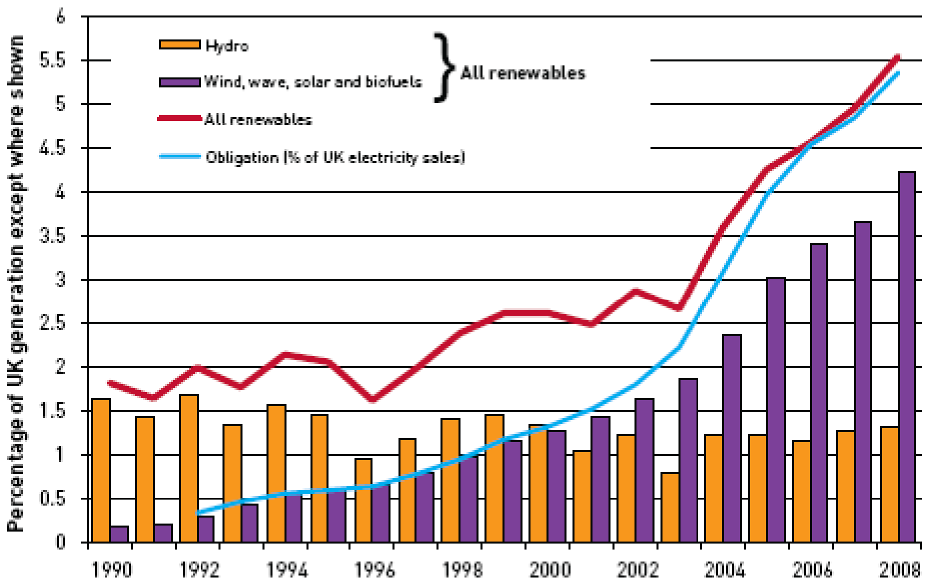


**Figure 16: UK Electricity generated by renewable energy sources in 2008**

Source: DECC (2009)

**Table 39: Percentage of renewable energy sources in UK electricity generation**

| | 1990 | 2000 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|
| **Wind, wave, solar and biomass** | 0.2 | 1.3 | 3.4 | 3.7 | 4.2 |
| **Hydro*** | 1.6 | 1.3 | 1.2 | 1.3 | 1.3 |
| **Total RES** | **1.8** | **2.6** | **4.6** | **4.9** | **5.5** |
| **Renewables Obligation** **(% of UK electricity sales)** | **-** | 1.3 | 4.5 | 4.8 | 5.4 |

Source: DECC (2009)
* Decreased water flow from low rainfall caused lower hydro levels in 2006.

**Table 40: Percentage of electricity derived from renewable sources**

| | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|
| **Overall renewables %-age** (int. basis: RES-E as a percentage of all electricity generated in the UK) | 2.7 | 3.6 | 4.3 | 4.6 | 5.0 | 5.5 |
| **Percentage on a Renewable Obligations basis** (RES-E eligible for the Renewables Obligation as a percentage of electricity sales by licensed suppliers in the UK) | 2.2 | 3.1 | 4.0 | 4.5 | 4.9 | 5.3 |
| **Percentage on a Renewables Directive Basis** (RES-E eligible under the EU Directive – i.e. all renewables except non-biodegradeable wastes – as a percentage of UK electricity consumption) | 2.6 | 3.5 | 4.2 | 4.5 | 4.9 | 5.4 |

Source: RESTATS http://www.restats.org.uk

Total electricity generation from renewables in 2008 was 21,597 GWh, 10% higher than in 2007. It was mainly onshore wind (1,301 GWh, +29% yoy) and offshore wind (523 GWh, +67% yoy) that contributed to this increase. Plant biomass was responsible for 159 GWh (+39%) of RES-E, landfill gas for 80 GWh (+2%) and sewage sludge digestion for 69 GWh (+14%). The co-firing of biomass with solid fuels decreased by 18% compared to 2007 and produced 343 GWh of electricity.

**Table 41: Capacity of renewable energy sources**

| | 2004 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|
| **INSTALLED CAPACITY ($MW_e$)** | | | | | |
| **Wind:** | | | | | |
| **Onshore** | 809.4 | 1,351.2 | 1,650.7 | 2,083.4 | 2,820.2 |
| **Offshore** | 123.8 | 213.8 | 303.8 | 393.8 | 586.0 |
| **Shoreline wave** | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 |
| **Solar photovoltaics** | 8.2 | 10.9 | 14.3 | 18.1 | 22.5 |
| **Hydro:** | | | | | |
| **Small-scale** | 142.9 | 157.9 | 153.4 | 166.2 | 173.3 |
| **Large-scale** | 1,355.9 | 1,343.2 | 1,361.4 | 1,358.7 | 1,456.5 |
| **Biomass:** | | | | | |
| **Landfill gas** | 722.2 | 817.8 | 856.2 | 900.6 | 908.3 |
| **Sewage sludge digestion** | 131.9 | 139.6 | 146.4 | 150.0 | 152.2 |
| **Municipal solid waste combustion** | 300.6 | 314.6 | 326.5 | 326.4 | 375.9 |
| **Animal Biomass** | 86.5 | 86.6 | 88.9 | 114.4 | 114.4 |
| **Plant Biomass** | 89.8 | 99.5 | 132.4 | 189.5 | 193.3 |
| **Total biomass and wastes** | 1,331.0 | 1,458.2 | 1,550.4 | 1,680.9 | 1,744.1 |
| **Total** | **3,771.6** | **4,535.7** | **5,034.4** | **5,701.6** | **6,803.1** |
| **Co-firing** | 146.2 | 308.8 | 310.2 | 247.6 | 226.9 |

Source: DECC (2009) – Digest of UK Energy Statistics (DUKES)

**Table 42: Electricity generated from renewable energy sources**

| | | | | | |
|---|---|---|---|---|---|
| **Generation (GWh)** | | | | | |
| **Wind:** | | | | | |
| **Onshore** | 1,736 | 2,501 | 3,574 | 4,491 | 5,792 |
| **Offshore** | 199 | 403 | 651 | 783 | 1.305 |
| **Solar photovoltaics** | 4 | 8 | 11 | 14 | 17 |
| **Hydro:** | | | | | |
| **Small-scale** | 283 | 444 | 478 | 534 | 568 |
| **Large-scale** | 4,561 | 4,478 | 4,115 | 4,554 | 4,600 |
| **Biomass:** | | | | | |
| **Landfill gas** | 4,004 | 4,290 | 4,424 | 4,677 | 4,757 |
| **Sewage sludge digestion** | 440 | 470 | 456 | 496 | 564 |
| **Municipal solid waste combustion** | 971 | 964 | 1,083 | 1,177 | 1,226 |
| **Co-firing with fossil fuels** | 1,022 | 2,533 | 2,528 | 1,956 | 1,613 |
| **Animal biomass** | 565 | 468 | 434 | 555 | 587 |
| **Plant biomass** | 362 | 382 | 363 | 409 | 568 |
| **Total biomass** | 7,364 | 9,107 | 9,288 | 9,270 | 9,315 |
| **Total generation** | **14,147** | **16,940** | **18,116** | **19,646** | **21,597** |

Source: DECC (2009) – Digest of UK Energy Statistics (DUKES)

Wind was the leading technology for the generation of electricity from RES in 2008. It generated one third of all RES-E, followed by hydropower, which produced 24% and landfill gas with a market share of 22%.

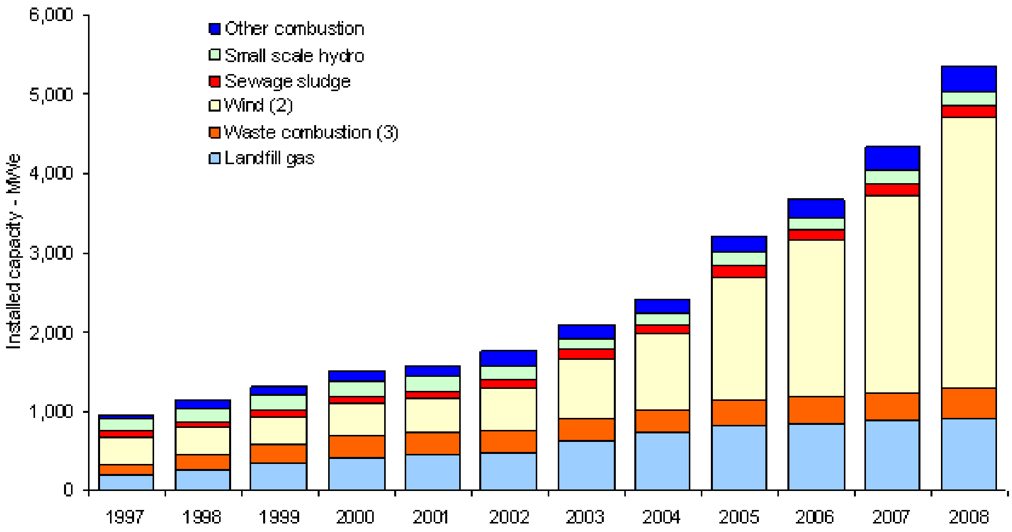


**Figure 17: RES-E generating capacity of RES (excluding large-scale hydro)**

Source: RESTATS http://www.restats.org.uk/capacity.htm

### 6.5.3 Renewable Heat Production

In terms of primary energy, approximately 13.5% of the UK's RES go into heat generation. Direct combustion of biomass accounts for 93% of total renewable heat production, followed by active solar heating and geothermal aquifers.

The use of RES to generate heat has grown over the past few years. Domestic use of wood is the main contributor with a share of 45% in the renewable heat total. Plant biomass became the second most important source of renewable heat in 2008: It overtook the industrial use of wood and wood waste and comprised 16% of total RES-H generated in that year. Further significant growth is expected, especially in the domestic and industrial wood use sectors[40].

### 6.5.4 Liquid Biofuels for Transport

The Renewable Transport Fuel Obligation places a legal requirement on suppliers of fossil transport fuels to ensure that renewable sources comprise 5% of their overall fuel sales by 2010/2011. Biodiesel and bioethanol are sold blended with diesel and petrol.

Liquid biofuels for transport accounted for 14% of renewable energy sources in 2008. Biodiesel and bioethanol consumption in 2008 was 886 and 206 mn liters respectively. In 2007, consumption of biodiesel was 347 mn liters and of bioethanol

[40] UK National Statistics (2009)

153 mn litres, while in 2006 and 169 mn liters of biodiesel and 95 mn litres of bioethanol were consumed[41].

## 6.6 The UK's Renewable Energy Policy

### 6.6.1 Policy Framework

The UK Government published its energy policy objectives in the Energy White Paper "Meeting the Energy Challenge" in 2007. The publication acknowledges that existing policies would only achieve a 5%-penetration of renewable energy and that the government would have to introduce new policies to meet the RES-targets the EU set out for the United Kingdom.

Consequently, a Renewable Energy Strategy consultation document was formulated in 2008 and new regulations were introduced in the Energy Act. The Department of Energy and Climate Change (DECC) was created and incorporated the relevant sections of other Departments.

### 6.6.2 RES-Targets

EU Directives and national commitments determine Britain's targets for the use of energy from renewable sources.

In its UK Renewable Energy Strategy[42], the UK Government defines a path how to achieve the legally binding RES-target of 15% by 2020 (HM Government (2009)). The lead scenario suggests that by 2020 30% of demand for electricity (117 TWh, 2008: 5.5%) – including 2% from small-scale sources; 12% of demand for heat (72 TWh) and 10% of transport demand (49 TWh, up from 2.6% in 2008) should come from renewables.

[41] UK National Statistics (2009)
[42] HM Government (2009): The UK Renewable Energy Strategy

**Table 43: Main targets for the UK renewable energy sector**

| | Quantitative Target | |
|---|---|---|
| **EU mandatory target** | 15% share of RES in final energy consumption in 2020 | |
| **EU mandatory target** | 10% share of biofuels in final energy consumption in transport in 2020 | |
| **EU indicative target** | 10% share in RES in gross electricity consumption in 2010 | |
| **EU indicative target** | 5% share of biofuels consumption in petrol and diesel use for transport in 2010[43] | |
| **national commitments** (embodied in the White Paper published in 2003) | 10% target RES-electricity supplied from renewable energy sources by 2010 | |
| | 20% target of renewable electricity penetration of all electricity power generation by 2020 | |
| **interim national targets** | 4.0% in 2011-12<br>5.4% in 2013-14<br>7.5% in 2015-16<br>10.2% in 2017-18 | shares of renewable energy in the energy mix |

Source: EREC (2009)

### 6.6.3 RES Policy Instruments

#### *6.6.3.1 Support for Renewable Electricity*

##### *6.6.3.1.1 Renewables Obligation*

The government's main support mechanism for RES-E is the Renewables Obligation (RO), which was introduced in 2002 and replaced the Non-Fossil Fuel Obligation (NFFO). The RO places an obligation on UK's electricity suppliers to source an increasing proportion of electricity they supply from RES. The percentage was set at 3% for the period 2002/2003 and will rise to 15.4% by 2016. The target level for 2007/2008 was 7.9%, for 2009/2010 9.1%, for 2010 it is 11.1%. The Renewable Obligation Order was revised in 2008 and the support for eligible technologies extended until 2037.

Electricity suppliers meet their obligation by surrendering one Renewable Obligation Certifcate (ROC) for every MWh sold to the Energy Regulator Ofgem (Office of the

[43] The UK government recognizes that this falls below the reference value (5.75% by energy content) set out in the Directive. Differentiations are allowed when they are "motivated": The UK government's motivation is its lack of confidence that biofuels can be delivered in a sustainable way.

Gas and Electricity Markets) at the end of the year. A supplier who fails to meet its obligation has to pay a buy-out fine to Ofgem, currently (2010/2011) GBP 36.99 (ca. 45 EUR in July 2010) per ROC. The energy regulator does not retain the money but distributes it to all electricity supply companies at year-end according to their number of ROCs held. Consequently, suppliers who have ROCs are rewarded with a share of the fines and receive cash back for their certificates.

Generators of renewable electricity receive ROCs from Ofgem. When generators sell RES-E to the supplier, they often (but not necessarily) sell the ROC too. Thus, the renewable energy generator has two sources of income: the price of electricity and the price for the ROCs. The ROC has its worth for suppliers because it saves them from having to pay the buy-out fine and entitles them to a share of the fines at the end of the year.

Both ROCs and electricity are sold on open markets and prices fluctuate according to demand. ROCs are freely traded and there is a lively speculative market. The fine for not having a ROC is high and possession of ROCs at the end of the year entitles the owner to a share of fines paid by other companies.

**Table 44: ROC-prices**

| Auction Date | Buy-Out Price/ROC | Average ROC Price | Lowest ROC Price | Total No' of ROCs | Co-Fired ROCs |
|---|---|---|---|---|---|
| 24 June 2010 | £36,99 | £49.16 | £48.00 | 243,412 | 5,081 |
| 25 March 2010 | £37,19 | £49.24 | £46.50 | 97,688 | 8,267 |
| 19 January 2010 | £37,19 | £46.25 | £45.00 | 56,382 | 0 |
| 13 October 2009 | £37,19 | £45.52 | £45.50 | 97,842 | 0 |
| 7 July 2009 | £37,19 | £52.90 | £52.65 | 150,506 | 5,336 |
| 7 April 2009 | £37,19 | £52.65 | £52.50 | 148,333 | 7,232 |
| 13 January 2009 | £35,76 | £51.81 | £51.75 | 108,899 | 6,938 |
| 9 October 2008 | £35,76 | £51.34 | £51.20 | 101,185 | 10,143 |
| 8 July 2008 | £35,76 | £53.27 | £53.10 | 143,443 | 4,025 |
| 10 April 2008 | £35,76 | £51.39 | £51.25 | 83,563 | 0 |
| 8 January 2008 | £34,30 | £49.95 | £49.75 | 64,294 | 3,052 |
| 9 October 2007 | £34,30 | £49.27 | £49.11 | 90,720 | 2,265 |
| 17 July 2007 | £34,30 | £48.12 | £47.50 | 59,170 | 7,383 |
| 24 April 2007 | £34,30 | £47.51 | £47.50 | 74,343 | 627 |
| 22 January 2007 | £33,24 | £46.17 | £46.00 | 49,446 | 45 |
| 24 October 2006 | £33,24 | £44.81 | £44.50 | 68,425 | 14,162 |
| 20 July 2006 | £33,24 | £40.62 | £40.60 | 227,909 | 2,000 |
| 20 April 2006 | £33,24 | £40.65 | £40.60 | 261,201 | 500 |

Source: Non-Fossil Purchasing Agency Ltd. http://www.e-roc.co.uk/trackrecord.htm

The combination of the buy-out price and the extent to which suppliers have fallen short of their obligations determines the nominal ROC-value and the total support available for each MWh of RES-E available under the renewable obligation.

So far, renewable electricity targets set forth in the Renewables Obligation have not been met.

**Table 45: The Renewables Obligation: 2002-2009**

| Year | Target | Actual | Shortfall | avg. ROC price GBP/MWh |
|---|---|---|---|---|
| **02/03** | 3.0% | 1.8% | 1.2% | 49.95 |
| **03/04** | 4.3% | 2.38% | 1.9% | 55.09 |
| **04/05** | 4.9% | 3.41% | 1.5% | 45.51 |
| **05/06** | 5.5% | 4.2% | 1.3% | 42.35 |
| **06/07** | 6.7% | 4.64% | 2.1% | 48.05 |
| **07/08** | 7.9% | 4.99% | 3.0% | 54.26 |
| **08/09** | 9.1% | 5.17% | 3.9% | 54.66 |

Source: Constable (2009)

Historically, the RO has been technology neutral. It offered one Renewable Obligation Certificate for every MWh or RES-E generated. This meant however, that established technologies with a shorter and more certain return on investment like landfill gas were more feasible under the scheme than emerging and initially more costly forms of generation like wave and tidal or micro generation.

In 2005, a report for the National Audit Office[44] showed that onshore wind was significantly over-subsidized and that the RO was a very expensive way to save $CO_2$ while failing to distinguish between technologies of varying merits. It provided too little incentives for certain technologies. Excessive subsidies for onshore wind development had even drawn developers to sites with weak wind resources and a severe environmental impact, while renewable electricity projects of higher capital cost but with higher intrinsic merit were starved of investment.

[44] Oxera (2005)

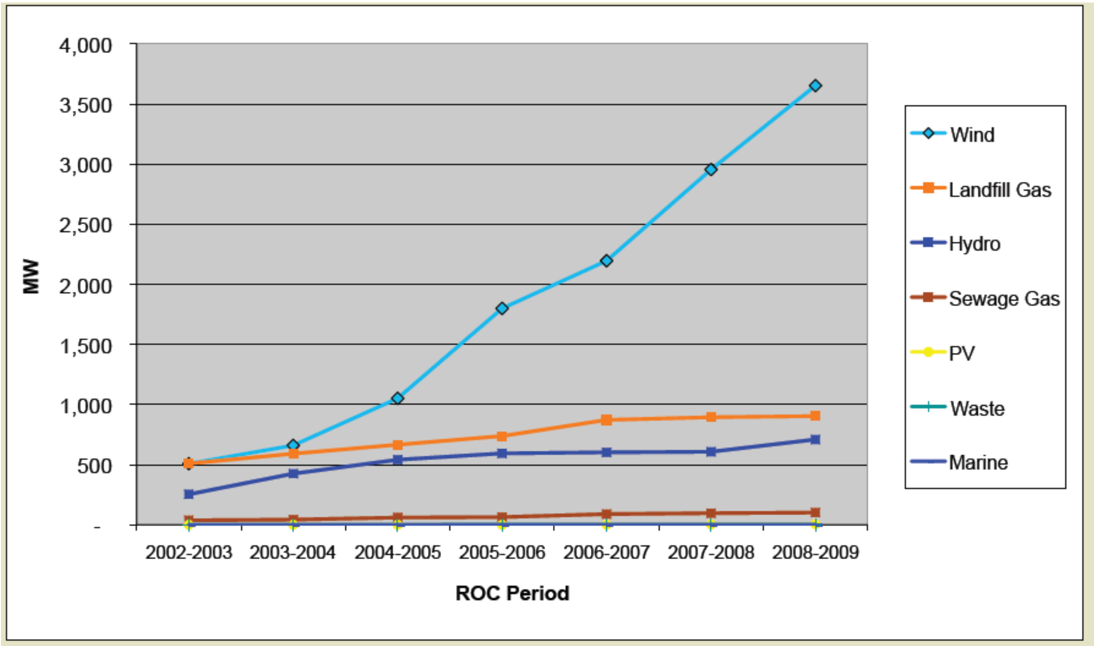


**Figure 18: ROCs by technology (as % of all ROCs p.a.)**

Source: Constable (2009)

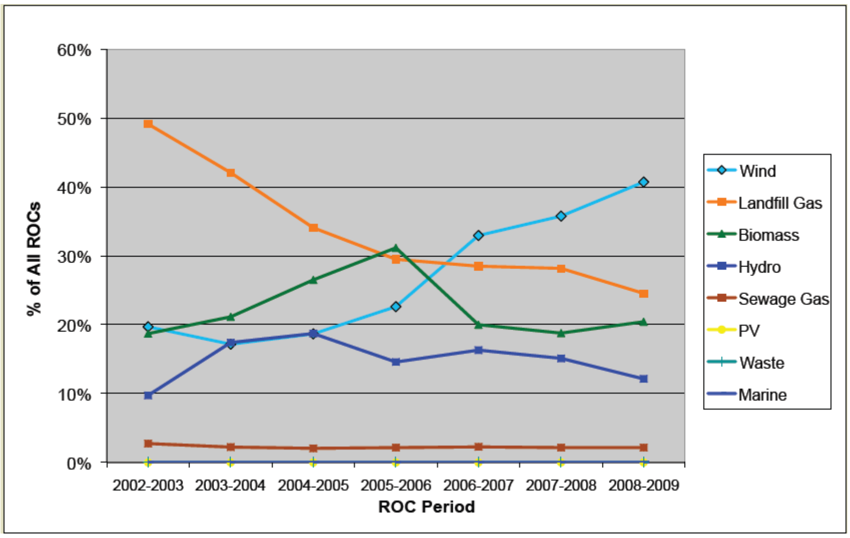


**Figure 19: ROCs by technology (as % of all ROCs p.a.)**

Source: Constable (2009)

To make the scheme more technology inclusive, the concept of banding was introduced in April 2009. ROC-Banding discriminates between technologies by offering different levels of support:

**Table 46: ROC-banding**[45]

| ROCs/MWh | Band | Generation Type |
|---|---|---|
| **0.25 ROCs/MWh** | Established Band | Landfill gas |
| **0.5 ROC/MWh** | | Sewage gas, co-firing and non-energy crop (regular) biomass |
| **1 ROC/MWh** | Reference Band | Onshore wind; hydro-electric; co-firing of energy crops, wind with combined heat and power; geo-pressure; other not specified |
| **1.5 ROCs/MWh** | Post-Demonstration Band | Offshore wind; dedicated regular biomass |
| **2 ROCs/MWh** | Emerging Technologies | Wave; tidal stream; advanced conversion technologies (anaerobic digestion; gasification and pyrolysis); dedicated biomass burning energy crops; microgeneration |

Source: DECC http://chp.decc.gov.uk/cms/roc-banding/

#### *6.6.3.1.2 Climate Change Levy*

Renewable Electricity is exempt from the climate change levy (CCL) on electricity (GBP 4.3/MWh). The levy is a measure designed to help the UK meet its legally binding commitment to reduce greenhouse gas emissions. It is chargeable on the industrial and commercial supply of taxable commodities for lighting, heating and power by consumers in industry, commerce, agriculture, public administration and other services. In relation to electricity, this means that the suppliers have to charge commercial customers an extra 0.43 GBP per kWh. RES-E, however, is issued with exemption certificates and allows the renewable generator to charge a premium price for renewable power.

#### *6.6.3.1.3 Feed-In Tariffs*[46]

As part of the Renewable Energy Strategy, the British government introduced feed-in tariffs (FiTs) which guarantee those who produce their own renewable energy a fixed payment per kWh generated and a guaranteed payment of 5p/kWh per kWh exported to the market for a 20-year period.

FiTs are set at levels that should offer projects a 5%-8% return on their investment, providing enough incentive to for e.g. a small-scale solar PV to stimulate domestic demand. The tariffs are however insufficient to promote larger commercial-scale installations. The tariff for some technologies will decrease over time and support levels will be reviewed periodically to factor in learning, technology and factory

[45] Separate enhanced banding levels operate under the Scottish Renewables Obligation where tidal energy technologies are banded at 3 ROCs and wave energy technologies at 5 ROCs per MWh.
[46] http://www.fitariffs.co.uk

capacities that might drive the price of technology down. The tariffs are index-linked for inflation.

The aim is to achieve a delivery of 2% of UK's energy from small-scale projects by 2020. Projects of up to 5 MW across all technologies (wind, solar PV, hydro, anaerobic digestion, biomass and biomass CHP, non-renewable micro-CHP) are eligible.

From 1 April 2010 onwards, only installations of less than 50 kW capacity which are eligible for FiTs will get the option to participate in the FiT-scheme. Certain pre-conditions have to be met, for example the installation needs to be carried out by an installer certified under the Microgeneration Certification Scheme. Larger installations between 50 kW and 5 kW can make a one-off choice between receiving the RO or the FiT.

#### *6.6.3.2 Support for Renewable Heat*

The deployment of renewable heat production from biomass is incentivized by a 66 mn GBP Bioenergy Capital Grants Scheme, which supports biomass-fuelled heat and combined heat and power projects in the industrial, commercial and community sectors.

However, the government came to realize that currently existing incentive schemes are not sufficient to deliver the 12% renewable heat target by 2020. In 2009, RES-H accounted for only 1% of total heat demand. It was argued that expansion of renewable heat was not possible without some form of financial assistance because other forms of heat were cheaper. Therefore, the government published a consultation scheme on the proposed design of the Renewable Heat Incentive (RHI) scheme, which should come into force in April 2011.

The Renewable Heat Incentive is very similar to the FiTs and is for households, landlords, businesses, schools, hospitals etc. Most forms of renewable heat generation will be eligible for the RHI and there is no upper limit to capacity (this differs to the 5 MW cap for the feed-in tariffs). The RHI is currently under consultation.

#### *6.6.3.3 Support for Biofuels*

The Renewable Fuel Obligations places an obligation on fuel suppliers, who supply in excess of 450,000 litres per year, to ensure that a certain share of their aggregate sales is made up from biofuels. 5% of all fuel sold (on a volume basis) in the UK must come from a renewable source by 2010. Certificates can be claimed when renewable fuels are supplied and fuel duty is paid on them. Fuel suppliers who fail to meet their obligation have to pay a buy-out price.

Further grants, schemes and subsidies for renewable fuels and materials are in place[47]:

- the Energy Crops Scheme: Grants for establishing short rotation coppice (willow, poplar, ash, alder, hazel, silver birch, sycamore, sweet chestnut and lime) and miscanthus.
- the Bio-energy Infrastructure Scheme supports growers and other businesses to process and supply biomass to heat and electricity end users.
- the Bio-energy Capital Grants Scheme stimulates the installation of biomass-fuelled heat and combined heat and power (CHP) projects in the industrial, commercial and community sectors in England.
- Relief from excise duty: No duty is paid on the use of bioliquids as a heating fuel or for the generation of electricity.
- Support for building biofuel-processing plants: Regional Development Agencies provide capital support for building biofuel-processing plants.

## 6.7 Future Developments

In its Renewable Energy Strategy, the British government set out ambitious plans for the future development of RES. The goal is to achieve a 15% market share of renewable energies by 2020. Compared to 2008-levels (2.3%), this goal would require a growth of the use of renewables by a factor of almost seven.

47 http://www.decc.gov.uk/en/content/cms/what_we_do/uk_supply/energy_mix/renewable/explained/bioenergy/grants_subsidy/grants_subsidy.aspx

**Table 47: Final energy consumption in 2008 and projected for 2020**

| | 2008 | | | 2020 | | |
|---|---|---|---|---|---|---|
| | All Energy (TWh) | RE (TWh) | Share of RE | All Energy (TWh) | RE (TWh) | Share RE |
| **Electricity** | 387 | 22 | 5.7% | 386 | 117 | 30.3% |
| **Heat** | 711 | 7 | 0.98% | 599 | 72 | 12.02% |
| **Transport** | 598 | 9 | 1.5% | 605 | 49 | 8.09% |
| **Total final energy consumption** | 1,695 | 39 | 2.3% | 1,590 | 239 | 15.03% |

Source: DECC (2009)

The Renewables Advisory Board (RAB (2008)), an advisor to the government on policy issues, identified bulk electricity from renewables and efficiency savings by the built environment as the main potential providers of the 15% target.

In the electricity sector, RAB identified three technologies that will dominate the RES-E market: Onshore and offshore wind with a total share of 5% of UK energy production (1.8% and 3.2% respectively), followed by biomass and solid recovery fuel waste with a 1.3%-share. RAB expects other RES-E technologies (landfill gas, hydro, smaller barrages, wave and tidal) to provide 0.6% of UK's energy. Prerequisite for achieving this size of contribution is the removal of obstacles to rapid growth: Development of large capacities of onshore wind requires substantial grid enforcement. Bureaucracy around planning consents particularly for wind farms has to be reduced. Reliable long-term policies, commitments and financial support systems have to be in place to guarantee investors' confidence.

Improvements in energy efficiency and the uptake of renewable energy by the built environment depend on individuals, households and companies. Recent developments in policy have stimulated the demand of entities that had been slow to embrace energy efficiency measure. FiTs provide an incentive to install renewable energy technologies. The Renewable Heat Incentive will increase demand further. The government also introduced building regulations with minimum energy efficiency standards that any newly constructed home must achieve. Under the zero carbon building standards all news homes have to be sustainable and energy efficient from 2016 onwards. The same applies for non-domestic buildings from 2019 onwards. On-site renewables will count towards the zero carbon standard (and receive financial rewards through FiTs and the RHI).

Bulk heat is - according to RAB - limited to burning of biomass and solid recovery fuels preferably in CHPs associated with heat networks and industrial loads. It could potentially contribute 0.9% points of the 15% target.

The National Audit Office (NAO (2005)) defined five key factors for future success in increasing renewable energy generation:

- Clear guidance for planning installations: The Planning System can impose difficulties for developers with significant differences in duration and success rates of planning applications.
- Timely reinforcement of grid network: Parts of the network need to be enhanced and upgraded to cope with the connection of large capacities of renewable energy, often in new places affecting the flow of electricity across the system.
- Market value of electricity: Wholesale electricity prices are a determinant of investor confidence. They have risen recently and are likely to remain high due to higher fuel costs, higher dependence on fuel imports and $CO_2$-pricing introduced by the EU Emissions Trading Scheme.
- Stable policy framework: Rapid growth in RES-capacity depends on the investors' confidence in the government's policies and long-term goals that provide a reliable environment for investment and secure returns.
- Additional support for renewable technologies that are not commercially viable under the Renewable Obligation alone, for e.g. capital grants for bioenergy or offshore wind power.

The British government has acknowledged these concerns in its latest Energy Strategy, which includes

- a review of the Renewables Obligation
- a commitment to stronger supply chains and the planning system, quicker grid connections and sustainable bioenergy supplies
- higher investment in emerging technologies like wind and tidal generation, improvements to offshore wind technologies and the development of more sustainable advanced fuel
- new mechanisms to support investments by businesses, communities and households in small-scale RES-E and RES-H generation
- a commitment to long-term support by extending the RO until 2037.

The NAO concludes that the Renewable Obligation is a very expensive way to save $CO_2$. By 2010 it will have cost consumers and taxpayers over 1 bn GBP yearly. As a means of reducing $CO_2$-emissions, it is several times more expensive than other measures. The British government nevertheless sees it as a necessary component of its Climate Change Program. It is unlikely that policy tools focusing directly on emission reduction like a carbon tax would have resulted in the same level of renewable energy generation that exists now. Moreover, the Obligation assists in other aims such as security of energy supply and creating business opportunities and jobs for the domestic economy.

## 6.8 Possible Implications for Poland

Like the United Kingdom, Poland supports its renewable energy sector with a combination of tradeable certificates and an obligation for enterprises - which sell electricity to end-users - to purchase electricity produced from renewable sources. It also provides direct incentives for specified investment intensive technologies.

The UK is recognized as a country with strong support for renewables. It began much earlier than Poland to formulate and implement a renewable energy policy and is a few considerable steps ahead of the ex-Communist country. British experience could serve as a good point of reference for future policy considerations by the Polish government. An analysis of the UK's renewable energy support scheme, its developments and adjustments over the years, (in)efficiencies and effectiveness should provide valuable information for Poland's renewable energy policy.

It has, for example, been argued in this thesis that the current Polish GC-system oversubsidizes onshore wind power and creates a situation where developers collect windfall profits. Wind farms are erected in areas where conditions are less than ideal. On the other hand, technologies with a higher intrinsic merit but higher investment costs are less attractive for investors and starved off investment due to a lack of discrimination between technologies in the Polish system. Emerging technologies are often neglected as they are not viable under the Green Certificate system alone. British experiences could motivate the Polish government to introduce a banding of the various technologies: It could grant more commercially viable ones with a lower level of support (say 0.25 or 0.5 of a GC per MWh) while rewarding emerging technologies with more than one certificate per MWh.

The qualification of co-firing for certificates has been scrutinized in both countries. In 2006, the United Kingdom put a 10% limit on the proportion of co-firing-ROCs, which generators can count towards their obligation. This cap increased to 12.5% in 2010. However, to encourage the development of energy crops, the UK has extended the eligibility of co-firing within the RO to 2016 and excluded fuels like miscanthus and short rotation coppice willow and poplar. This might be an interesting move for Poland, where a number of energy generators are currently vertically integrating their supply chain by investing in their own energy crop plantations; the Polish Government has stipulated that a large part of biomass should come from sources other than forestry or the wood processing industry (20% in 2010 and 60% in 2014). Nevertheless, the concern that some of the environmental benefits of co-firing may be lost because it increases the commercial life of coal-fired power stations is just as valid for Poland as it is for the United Kingdom.

The British government concluded that small-scale generation should play an important part in achieving the 15%-target (RES-share in final energy consumption in 2020). By introducing low carbon standards for the built environment, feed-in tariffs and the RHI, it placed an emphasis on the uptake by individuals, communities and businesses. Poland, on the other hand, is still concentrating on large-scale developments, especially wind farms and biomass burnt in CHPs. Support for households is very limited and available only on a regional level. An evaluation of the effects of recent UK policy on the deployment of small-scale installations and their contribution to achieving the UK's RES-targets could encourage Poland to follow the same path and extend support to entities like households, companies, schools and hospitals.

Poland is currently looking into extending the certificate scheme to renewable heat projects by introducing tradeable RES-H certificates. This measure would mainly concern large-scale installations, especially co-firing CHPs. However, biomass has traditionally been used by a large number of Polish households to heat their houses; a Renewable Heat Incentive for small-scale installations could encourage households to invest in new equipment and help Poland to achieve its RES-goals.

To put it in a nutshell: Even though Poland and the United Kingdom differ in their renewable energy endowments and stand at different stages of economic development, the renewable energy support schemes of both countries are comparable. British policies are, however, a few steps ahead of Polish regulations. Consequently, it should prove interesting for Polish policy makers to observe and evaluate the latest developments in the United Kingdom. British experiences might offer valuable conclusions and could even prevent a duplication of policy failures and research efforts.

# 7 CONCLUSION

Renewable energy policies must support the fast expansion of the most effective renewable technologies as needed for fulfilling given climate or renewable commitments. At the same time, they have to guarantee competition, a project's feasibility and the production of reasonably priced energy.

A wide range of incentive schemes is available for the policy makers. They should be applied effectively and need to be tailored to a country's national circumstances and the respective technology.

However, non-economic barriers can significantly drive up costs and slow down the effectiveness of support policies for renewable energies, irrespective of the type of support. Accordingly, besides offering financial support, an overall renewable energy policy package has to dedicate attention also to the removal of non-economic barriers such as administrative red tape, obstacles to grid access, poor electricity market design, and lack of social acceptance.

Policies should provide a predictable and transparent support framework to attract investment. Incentives should be formulated and implemented to exploit the potential of different renewable energy technologies over time. They need to be based on an understanding of the implications and differences of large-scale and small-scale renewable energy technologies on the overall energy system.

The reduction of risk is an important element of an effective and efficient support mechanism. Risk reduction also lowers the cost of capital and therefore increases the mechanism's efficiency.

Poland is a country with considerable natural endowment for energy production from renewable sources. However, renewables have traditionally played a less important role in energy production due to the importance and availability of fossil fuels, particularly coal.

The deployment of renewable energy has gained momentum in Poland since its entry into the European Union. First indicative and later binding targets on the deployment of RES imposed by the EU on individual member states came into force. Poland had to translate the targets into national law and had to start implementing and enforcing national policies that support the promotion of renewable energy sources.

Major barriers and obstacles decrease the effectiveness of Poland's renewable energy policies. Among the most pressing ones are the problems of integrating RES into the power grid. The overall energy infrastructure is in bad shape and needs urgent upgrading.

Since effective support mechanisms should also contribute to the removal of non-economic barriers to improve policy and market functioning, upgrading of the grid and improvement of grid integration deserve special attention from the policy makers. If policies are well formulated and enforced, they will maximize long-term cost efficiency while respecting national circumstances.

Support schemes should be a result of constant re-evaluation, adaptation, improvement and the permanent strife to learn from experiences and good practices, including those of other countries. Poland could highly profit from observing past and current developments in countries that have a longer history of renewable energies and their support mechanisms. For Poland, the United Kingdom may serve as such an example due to the similarities in the overall policy selection (i.e. both countries make use of the quota obligation accompanied by a trading scheme to support renewables) and the "lessons learnt" in the UK.

Effectiveness and efficiency of support schemes also depend on the risk investors face when they finance a project. Well-formulated policy schemes decrease the investors' perceived risk. In Poland, the renewable obligation is currently guaranteed until 2017. This leaves uncertainty for investors about the shape of the scheme after 2017 and provides a barrier for entry. A RES investment process takes about five years. In order to attract investors, the energy law needs to be adapted so that income from the sale of RES-E is guaranteed for a period of a minimum of 15 years.

Changes in the pricing structure could also prove beneficiary for Poland's renewable energy policy scheme. Currently, RES power generators sell the energy at an average price of electricity based on the previous year. However, electricity markets are very dynamic and a steady growth of energy prices can be observed.

Calculating the sale price of RES-E in any given quarter of a year based on the average price from the previous quarter would add additional dynamism to the pricing structure and would reflect current price developments more accurately[48].

The current support scheme (GC) over-incentivizes certain technologies (e.g. wind onshore, biomass co-firing), but does not provide enough support for others (e.g. wind offshore, dedicated biomass plants, PV). An introduction of banding could introduce the discrimination necessary to encourage the development of ALL renewable energy technologies (as required for RES-target fulfillment), not only those championed by government. The experiences of the United Kingdom with banding could be a useful reference point for Poland.

The UK's new feed-in tariff scheme for small-scale installations could provide Poland with further expertise for future policy formulation. Poland's current policies (GC-scheme, direct subsidies and preferential debt) favor large-scale projects. This is effective to guarantee a fast increase of capacity within a relatively short period of time. In the medium-run however, small-scale installations should be promoted to win the acceptance of private customers (companies, public sector, households), which is essential to reach the overall renewable energy targets. Feed-in tariffs for small-scale-systems could trigger this crucial uptake by individuals.

[48] However, this would have consequences for investor's risk.

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# APPENDIX: CALCULATIONS FOR A WIND POWER PROJECT

The following pages contain the calculations for the case study discussed in Chapter 5.2. “Efficiency of Polish RES-E Policy Measures: Case Study of Onshore Wind Power”.

- Spreadsheet 1:

Project Appraisal without a policy mechanism.

- Spreadsheet 2:

Project Appraisal with policy mechanism (GC scheme).

- RetScreen© Calculation 1:

Project Appraisal with credit on preferential terms and GC.

- RetScreen© Calculation 2:

Project Appraisal with credit on preferential terms, no GC.

- RetScreen© Calculation 3:

Project Appraisal with a direct subsidy covering part of the initial outlays and GC.

- RetScreen© Calculation 4:

Project Appraisal with a direct subsidy covering part of the initial outlays, no GC.

## Case Study Onshore Windpower / No Policy Mechanism

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **EUR per MWh (average p.a.)** | **48,33** | | | | | | | | | | | | | | | | | | | | |
| **Income per MWh growth p.a.** | **0,03** | | | | | | | | | | | | | | | | | | | | |
| **Net initial investment:** | | | | | | | | | | | | | | | | | | | | | |
| Machinery | -18.000.000 | | Maintenance cost p.a. | | 1,80% | | | | | | | | | | | | | | | | |
| Development and Design | -1.800.000 | | | | | | | | | | | | | | | | | | | | |
| Infrastructure and Connection to Mains | -9.800.000 | | | | | | | | | | | | | | | | | | | | |
| EUR per MWh (average p.a.) | | **48,33** | **49,78** | **51,27** | **52,81** | **54,40** | **56,03** | **57,71** | **59,44** | **61,22** | **63,06** | **64,95** | **66,90** | **68,91** | **70,97** | **73,10** | **75,30** | **77,56** | **79,88** | **82,28** | **84,75** |
| MWh (average p.a.) | | 47.304 | 47.304 | 47.304 | 47.304 | 47.304 | 47.304 | 47.304 | 47.304 | 47.304 | 47.304 | 47.304 | 47.304 | 47.305 | 47.306 | 47.307 | 47.308 | 47.309 | 47.310 | 47.311 | 47.312 |
| Revenues | | 2.286.202 | 2.354.788 | 2.425.432 | 2.498.195 | 2.573.141 | 2.650.335 | 2.729.845 | 2.811.740 | 2.896.093 | 2.982.975 | 3.072.465 | 3.164.639 | 3.259.647 | 3.357.507 | 3.458.305 | 3.562.130 | 3.669.071 | 3.779.223 | 3.892.682 | 4.009.548 |
| Maintenance costs | | -324.000 | -324.000 | -324.000 | -324.000 | -324.000 | -324.000 | -324.000 | -324.000 | -324.000 | -324.000 | -324.000 | -324.000 | -324.000 | -324.000 | -324.000 | -324.000 | -324.000 | -324.000 | -324.000 | -324.000 |
| Depreciation | | -1.480.000 | -1.480.000 | -1.480.000 | -1.480.000 | -1.480.000 | -1.480.000 | -1.480.000 | -1.480.000 | -1.480.000 | -1.480.000 | -1.480.000 | -1.480.000 | -1.480.000 | -1.480.000 | -1.480.000 | -1.480.000 | -1.480.000 | -1.480.000 | -1.480.000 | -1.480.000 |
| Tax base | | 482.202 | 550.788 | 621.432 | 694.195 | 769.141 | 846.335 | 925.845 | 1.007.740 | 1.092.093 | 1.178.975 | 1.268.465 | 1.360.639 | 1.455.647 | 1.553.507 | 1.654.305 | 1.758.130 | 1.865.071 | 1.975.223 | 2.088.682 | 2.205.548 |
| Tax | 0 | -91.618 | -104.650 | -118.072 | -131.897 | -146.137 | -160.804 | -175.911 | -191.471 | -207.498 | -224.005 | -241.008 | -258.521 | -276.573 | -295.166 | -314.318 | -334.045 | -354.364 | -375.292 | -396.850 | -419.054 |
| **(a) NII, NOCF (€)** | **-29.600.000** | **1.870.584** | **1.926.139** | **1.983.360** | **2.042.298** | **2.103.004** | **2.165.531** | **2.229.935** | **2.296.270** | **2.364.595** | **2.434.970** | **2.507.456** | **2.582.117** | **2.659.074** | **2.738.341** | **2.819.987** | **2.904.085** | **2.990.708** | **3.079.931** | **3.171.833** | **3.266.494** |
| Discount Rate | 0,12 | | | | | | | | | | | | | | | | | | | | |
| **Present Values (PV)** | | 1.670.164 | 1.535.506 | 1.411.716 | 1.297.917 | 1.193.301 | 1.097.126 | 1.008.709 | 927.425 | 852.697 | 783.995 | 720.834 | 662.765 | 609.391 | 560.319 | 515.201 | 473.719 | 435.580 | 400.513 | 368.271 | 338.627 |
| **Sum PV** | **16.863.776** | 1.670.164 | 3.205.670 | 4.617.387 | 5.915.304 | 7.108.605 | 8.205.730 | 9.214.440 | 10.141.864 | 10.994.561 | 11.778.556 | 12.499.390 | 13.162.155 | 13.771.546 | 14.331.865 | 14.847.066 | 15.320.786 | 15.756.365 | 16.156.878 | 16.525.149 | 16.863.776 |

| | |
|---|---|
| **(b) NPV (€)** | **-12.736.224** |
| PVIFA | 7,02 |
| **(c) Ann (€)** | **-1.813.352** |
| **(d) IRR** | **0,05** |

| Total income of green electricity per MWh on July 8th, 2010 | Price in PLN/MWh | Price in EUR/MWh |
|---|---|---|
| Average price for electricity in 2009 | 197,21 | 48,33 |
| Market price for Green Certificates | 274,00 | 67,15 |
| Expected total income | 471,21 | 115,49 |

## Case Study Onshore Windpower / Project Appraisal with Policy Mechanism (Green Certificates)

| | |
|---|---|
| **EUR per MWh (average p.a.)** | **115,49** |
| **Income per MWh growth p.a.** | **0,03** |

**Net initial investment:**

| | | | |
|---|---|---|---|
| Machinery | -18.000.000 | Maintenance cost p.a. | 1,80% |
| Development and Design | -1.800.000 | | |
| Infrastructure and Connection to Mains | -9.800.000 | | |

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EUR per MWh (average p.a.) | | **115,49** | **118,95** | **122,52** | **126,20** | **129,99** | **133,88** | **137,90** | **142,04** | **146,30** | **150,69** | **155,21** | **159,87** | **164,66** | **169,60** | **174,69** | **179,93** | **185,33** | **190,89** | **196,61** | **202,51** |
| MWh (average p.a.) | | 47.304 | 47.304 | 47.304 | 47.304 | 47.304 | 47.304 | 47.304 | 47.304 | 47.304 | 47.304 | 47.304 | 47.304 | 47.305 | 47.306 | 47.307 | 47.308 | 47.309 | 47.310 | 47.311 | 47.312 |
| Revenues | | 5.463.139 | 5.627.033 | 5.795.844 | 5.969.719 | 6.148.811 | 6.333.275 | 6.523.274 | 6.718.972 | 6.920.541 | 7.128.157 | 7.342.002 | 7.562.262 | 7.789.295 | 8.023.143 | 8.264.012 | 8.512.112 | 8.767.661 | 9.030.882 | 9.302.005 | 9.581.267 |
| Maintenance costs | | -324.000 | -324.000 | -324.000 | -324.000 | -324.000 | -324.000 | -324.000 | -324.000 | -324.000 | -324.000 | -324.000 | -324.000 | -324.000 | -324.000 | -324.000 | -324.000 | -324.000 | -324.000 | -324.000 | -324.000 |
| Depreciation | | -1.480.000 | -1.480.000 | -1.480.000 | -1.480.000 | -1.480.000 | -1.480.000 | -1.480.000 | -1.480.000 | -1.480.000 | -1.480.000 | -1.480.000 | -1.480.000 | -1.480.000 | -1.480.000 | -1.480.000 | -1.480.000 | -1.480.000 | -1.480.000 | -1.480.000 | -1.480.000 |
| Tax base | | 3.659.139 | 3.823.033 | 3.991.844 | 4.165.719 | 4.344.811 | 4.529.275 | 4.719.274 | 4.914.972 | 5.116.541 | 5.324.157 | 5.538.002 | 5.758.262 | 5.985.295 | 6.219.143 | 6.460.012 | 6.708.112 | 6.963.661 | 7.226.882 | 7.498.005 | 7.777.267 |
| Tax | 0 | -695.236 | -726.376 | -758.450 | -791.487 | -825.514 | -860.562 | -896.662 | -933.845 | -972.143 | -1.011.590 | -1.052.220 | -1.094.070 | -1.137.206 | -1.181.637 | -1.227.402 | -1.274.541 | -1.323.096 | -1.373.108 | -1.424.621 | -1.477.681 |
| **(a) NII, NOCF (€)** | **-29.600.000** | **4.443.903** | **4.576.657** | **4.713.394** | **4.854.233** | **4.999.297** | **5.148.713** | **5.302.612** | **5.461.127** | **5.624.398** | **5.792.567** | **5.965.782** | **6.144.192** | **6.328.089** | **6.517.506** | **6.712.610** | **6.913.571** | **7.120.565** | **7.333.774** | **7.553.384** | **7.779.587** |
| Discount Rate | 0,12 | | | | | | | | | | | | | | | | | | | | |
| **Present Values (PV)** | | 3.967.770 | 3.648.483 | 3.354.901 | 3.084.953 | 2.836.735 | 2.608.498 | 2.398.632 | 2.205.658 | 2.028.214 | 1.865.052 | 1.715.020 | 1.577.061 | 1.450.235 | 1.333.611 | 1.226.369 | 1.127.753 | 1.037.070 | 953.681 | 876.999 | 806.485 |
| **Sum PV** | **40.103.178** | 3.967.770 | 7.616.253 | 10.971.154 | 14.056.106 | 16.892.842 | 19.501.340 | 21.899.972 | 24.105.630 | 26.133.844 | 27.998.896 | 29.713.915 | 31.290.976 | 32.741.211 | 34.074.822 | 35.301.191 | 36.428.944 | 37.466.014 | 38.419.695 | 39.296.694 | 40.103.178 |

| | |
|---|---|
| **(b) NPV (€)** | **10.503.178** |

| | |
|---|---|
| PVIFA | 7,02 |
| **(c) Ann (€)** | **1.495.416** |

| | |
|---|---|
| **(d) IRR** | **0,17** |

| Total income of green electricity per MWh on July 8th, 2010 | Price in PLN/MWh | Price in EUR/MWh |
|---|---|---|
| Average price for electricity in 2009 | 197,21 | 48,33 |
| Market price for Green Certificates | 274,00 | 67,15 |
| Expected total income | 471,21 | 115,49 |

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# RETScreen® International

www.retscreen.net

*Clean Energy Project Analysis Software*

## Project information

*See project database*

| | |
|---|---|
| Project name | Wind Power Project: Credit / GC |
| Project location | Poland |
| Prepared for | MSc - CEE |
| Prepared by | Cosima Steiner |
| Project type | Power |
| Technology | Wind turbine |
| Grid type | Central-grid |
| Analysis type | Method 2 |
| Heating value reference | Higher heating value (HHV) |
| Show settings | ☑ |
| Language - Langue | English - Anglais |
| User manual | English - Anglais |
| Currency | Euro |
| Units | Metric units |

## Site reference conditions

*Select climate data location*

| | |
|---|---|
| Climate data location | Poland, Warminsko Mazurskie |
| Show data | ☐ |

*Complete Energy Model sheet*

RETScreen4 2010-02-26



NRCan/CanmetENERGY

**RETScreen Energy Model - Power project**

☐ Show alternative units

**Proposed case power system**

| | | | |
|---|---|---|---|
| Technology | | Wind turbine | |
| Analysis type | ◉ | Method 1 | |
| | ○ | Method 2 | |
| | ○ | Method 3 | |
| **Wind turbine** | | | |
| Power capacity | kW | 18.000,0 | *See product database* |
| Manufacturer | | | |
| Model | | | |
| Capacity factor | % | 30,0% | |
| Electricity exported to grid | MWh | 47.304 | |
| Electricity export rate | €/MWh | 115,49 | |

## RETScreen Cost Analysis - Power project

| Settings | | | |
|---|---|---|---|
| ◉ Method 1 | ○ Notes/Range | Second currency | Poland |
| ○ Method 2 | ◉ Second currency | | |
| | ○ Cost allocation | Rate: €/PLN | 4,08000 |

| Initial costs (credits) | Unit | Quantity | Unit cost | Amount | Relative costs | % | Amount |
|---|---|---|---|---|---|---|---|
| **Feasibility study** | | | | | | | |
| | cost | | | € - | | | PLN - |
| Sub-total: | | | | **€ -** | 0,0% | 0% | PLN - |
| **Development** | | | | | | | |
| Development and Design | cost | 1 | € 1.800.000 | € 1.800.000 | | | PLN - |
| Sub-total: | | | | **€ 1.800.000** | 6,1% | 0% | PLN - |
| **Engineering** | | | | | | | |
| | cost | | | € - | | | PLN - |
| Sub-total: | | | | **€ -** | 0,0% | 0% | PLN - |
| **Power system** | | | | | | | |
| Wind turbine | kW | 18.000,00 | € 1.000 | € 18.000.000 | | | PLN - |
| Road construction | km | | | € - | | | PLN - |
| Transmission line | km | | | € - | | | PLN - |
| Substation | project | | | € - | | | PLN - |
| Energy efficiency measures | project | | | € - | | | PLN - |
| Infrastructure and Connection to Mains | cost | 1 | € 9.800.000 | € 9.800.000 | | | PLN - |
| | | | | € - | | | PLN - |
| Sub-total: | | | | **€ 27.800.000** | 93,9% | 0% | PLN - |
| **Balance of system & miscellaneous** | | | | | | | |
| Spare parts | % | | | € - | | | PLN - |
| Transportation | project | | | € - | | | PLN - |
| Training & commissioning | p-d | | | € - | | | PLN - |
| User-defined | cost | | | € - | | | PLN - |
| Contingencies | % | | € 29.600.000 | € - | | | PLN - |
| Interest during construction | | | € 29.600.000 | € - | | | PLN - |
| Sub-total: | | Enter number of months | | **€ -** | 0,0% | 0% | PLN - |
| **Total initial costs** | | | | **€ 29.600.000** | 100,0% | 0% | PLN - |

| Annual costs (credits) | Unit | Quantity | Unit cost | Amount | | % | Amount |
|---|---|---|---|---|---|---|---|
| **O&M** | | | | | | | |
| Parts & labour | project | 1 | € 324.000 | € 324.000 | | | PLN - |
| | cost | | | € - | | | PLN - |
| Contingencies | % | | € 324.000 | € - | | | PLN - |
| Sub-total: | | | | **€ 324.000** | | 0% | PLN - |

| Periodic costs (credits) | Unit | Year | Unit cost | Amount | | % | Amount |
|---|---|---|---|---|---|---|---|
| User-defined | cost | | | € - | | | PLN - |
| | | | | € - | | | PLN - |
| End of project life | cost | | | € - | | | |

## RETScreen Financial Analysis - Power project

### Financial parameters

| | | |
|---|---|---|
| **General** | | |
| Fuel cost escalation rate | % | |
| Inflation rate | % | 2,5% |
| Discount rate | % | 12,0% |
| Project life | yr | 20 |
| **Finance** | | |
| Incentives and grants | € | 0 |
| Debt ratio | % | 41,0% |
| Debt | € | 12.136.000 |
| Equity | € | 17.464.000 |
| Debt interest rate | % | 6,00% |
| Debt term | yr | 15 |
| Debt payments | €/yr | 1.249.556 |
| **Income tax analysis** | ☑ | |
| Effective income tax rate | % | 19,0% |
| Loss carryforward? | | Yes |
| Depreciation method | | Straight-line |
| Depreciation tax basis | % | 90,0% |
| Depreciation period | yr | 20 |
| Tax holiday available? | yes/no | No |

### Annual income

| | | |
|---|---|---|
| **Electricity export income** | | |
| Electricity exported to grid | MWh | 47.304 |
| Electricity export rate | €/MWh | 115,49 |
| Electricity export income | € | 5.463.139 |
| Electricity export escalation rate | % | 3,0% |
| **GHG reduction income** | ☐ | |
| **Customer premium income (rebate)** | ☐ | |
| **Other income (cost)** | ☐ | |
| **Clean Energy (CE) production income** | ☐ | |

### Project costs and savings/income summary

| | | | |
|---|---|---|---|
| **Initial costs** | | | |
| Development | 6,1% | € | 1.800.000 |
| Power system | 93,9% | € | 27.800.000 |
| Balance of system & misc. | 0,0% | € | 0 |
| **Total initial costs** | **100,0%** | **€** | **29.600.000** |
| **Annual costs and debt payments** | | | |
| O&M | | € | 324.000 |
| Fuel cost - proposed case | | € | 0 |
| Debt payments - 15 yrs | | € | 1.249.556 |
| **Total annual costs** | | **€** | **1.573.556** |
| **Periodic costs (credits)** | | | |
| **Annual savings and income** | | | |
| Fuel cost - base case | | € | 0 |
| Electricity export income | | € | 5.463.139 |
| **Total annual savings and income** | | **€** | **5.463.139** |

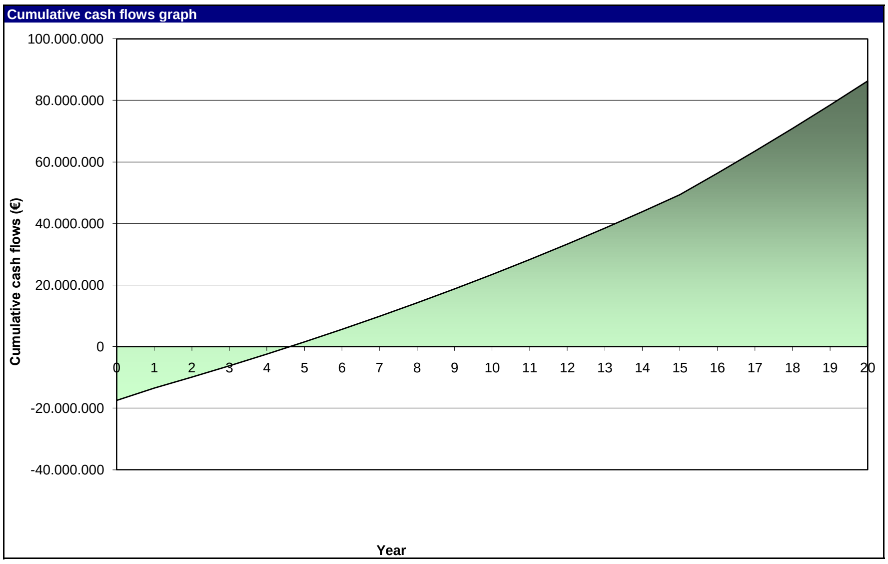
### Financial viability

| | | |
|---|---|---|
| Pre-tax IRR - equity | % | 26,7% |
| Pre-tax IRR - assets | % | 16,2% |
| After-tax IRR - equity | % | 23,3% |
| After-tax IRR - assets | % | 13,7% |
| Simple payback | yr | 5,8 |
| Equity payback | yr | 4,6 |
| Net Present Value (NPV) | € | 15.917.365 |
| Annual life cycle savings | €/yr | 2.130.997 |
| Benefit-Cost (B-C) ratio | | 1,91 |
| Debt service coverage | | 4,24 |
| Energy production cost | €/MWh | 70,96 |

### Yearly cash flows

| Year | Pre-tax | After-tax | Cumulative |
|---|---|---|---|
| # | € | € | € |
| 0 | -17.464.000 | -17.464.000 | -17.464.000 |
| 1 | 4.045.377 | 3.993.170 | -13.470.830 |
| 2 | 4.205.886 | 3.554.838 | -9.915.992 |
| 3 | 4.371.251 | 3.682.483 | -6.233.508 |
| 4 | 4.541.620 | 3.813.804 | -2.419.705 |
| 5 | 4.717.143 | 3.948.898 | 1.529.193 |
| 6 | 4.897.977 | 4.087.870 | 5.617.063 |
| 7 | 5.084.282 | 4.230.822 | 9.847.885 |
| 8 | 5.276.222 | 4.377.863 | 14.225.748 |
| 9 | 5.473.970 | 4.529.100 | 18.754.848 |
| 10 | 5.677.698 | 4.684.647 | 23.439.495 |
| 11 | 5.887.590 | 4.844.617 | 28.284.112 |
| 12 | 6.103.830 | 5.009.127 | 33.293.239 |
| 13 | 6.326.610 | 5.178.295 | 38.471.534 |
| 14 | 6.556.128 | 5.352.245 | 43.823.779 |
| 15 | 6.792.588 | 5.531.099 | 49.354.878 |
| 16 | 8.285.754 | 6.964.541 | 56.319.419 |
| 17 | 8.536.732 | 7.167.833 | 63.487.252 |
| 18 | 8.795.299 | 7.377.272 | 70.864.524 |
| 19 | 9.061.685 | 7.593.045 | 78.457.569 |
| 20 | 9.336.125 | 7.815.341 | 86.272.910 |

### Cumulative cash flows graph



## RETScreen Sensitivity and Risk Analysis - Power project

### Sensitivity analysis

| | |
|---|---|
| Perform analysis on | Net Present Value (NPV) |
| Sensitivity range | 20% |
| Threshold | 10 € |

| Initial costs | | Electricity export rate | | | | €/MWh |
|---|---|---|---|---|---|---|
| | | 92,39 | 103,94 | 115,49 | 127,04 | 138,59 |
| € | | -20% | -10% | 0% | 10% | 20% |
| 23.680.000 | -20% | 12.263.774 | 16.379.891 | 20.496.008 | 24.612.124 | 28.728.241 |
| 26.640.000 | -10% | 9.968.117 | 14.090.570 | 18.206.686 | 22.322.803 | 26.438.919 |
| 29.600.000 | 0% | 7.669.671 | 11.796.015 | **15.917.365** | 20.033.481 | 24.149.598 |
| 32.560.000 | 10% | 5.371.225 | 9.497.569 | 13.623.913 | 17.744.160 | 21.860.277 |
| 35.520.000 | 20% | 3.072.779 | 7.199.123 | 11.325.467 | 15.451.811 | 19.570.955 |

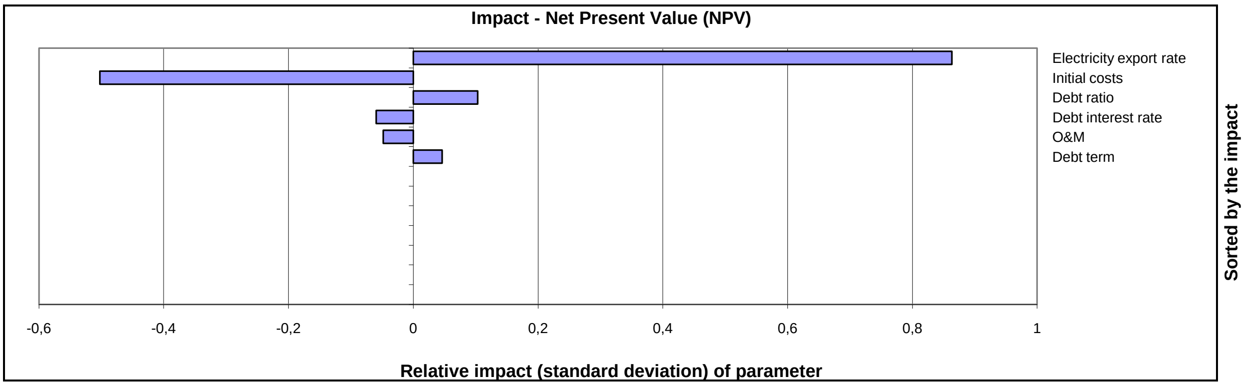
| Debt interest rate | | Debt ratio | | | | % |
|---|---|---|---|---|---|---|
| | | 33% | 37% | 41% | 45% | 49% |
| % | | -20% | -10% | 0% | 10% | 20% |
| 4,80% | -20% | 15.460.758 | 15.942.967 | 16.425.176 | 16.907.385 | 17.389.593 |
| 5,40% | -10% | 15.259.795 | 15.716.883 | 16.173.971 | 16.631.060 | 17.088.148 |
| 6,00% | 0% | 15.054.510 | 15.485.937 | **15.917.365** | 16.348.793 | 16.780.220 |
| 6,60% | 10% | 14.844.993 | 15.250.231 | 15.655.469 | 16.060.707 | 16.465.945 |
| 7,20% | 20% | 14.631.337 | 15.009.868 | 15.388.399 | 15.766.931 | 16.144.633 |

| Debt interest rate | | Debt term | | | | yr |
|---|---|---|---|---|---|---|
| | | 12 | 14 | 15 | 17 | 18 |
| % | | -20% | -10% | 0% | 10% | 20% |
| 4,80% | -20% | 15.827.819 | 16.269.187 | 16.425.176 | 16.767.978 | 16.928.417 |
| 5,40% | -10% | 15.603.210 | 16.035.411 | 16.173.971 | 16.508.826 | 16.655.267 |
| 6,00% | 0% | 15.374.624 | 15.797.028 | **15.917.365** | 16.243.643 | 16.375.330 |
| 6,60% | 10% | 15.142.127 | 15.554.121 | 15.655.469 | 15.972.569 | 16.088.783 |
| 7,20% | 20% | 14.905.785 | 15.306.778 | 15.388.399 | 15.695.750 | 15.795.811 |

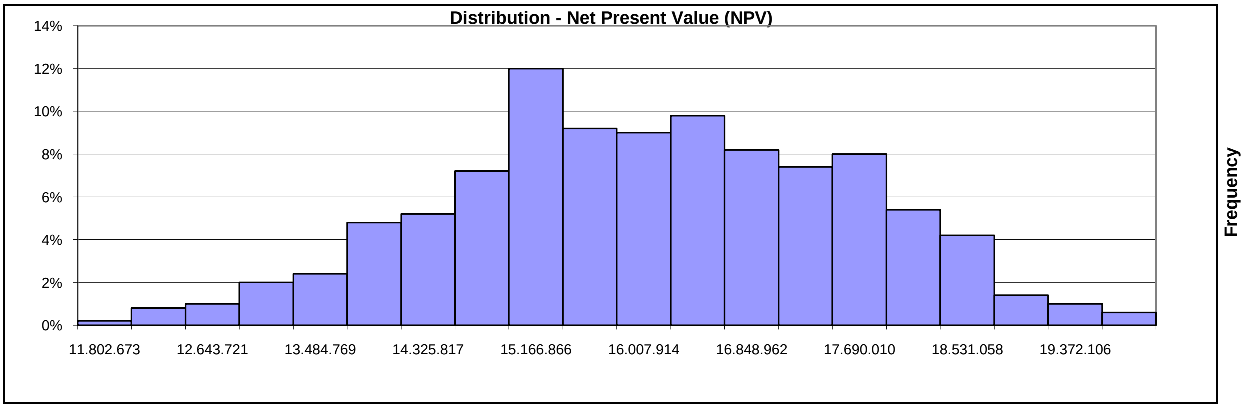
### Risk analysis

| | |
|---|---|
| Perform analysis on | Net Present Value (NPV) |

| Parameter | Unit | Value | Range (+/-) | Minimum | Maximum |
|---|---|---|---|---|---|
| Initial costs | € | 29.600.000 | 10% | 26.640.000 | 32.560.000 |
| O&M | € | 324.000 | 10% | 291.600 | 356.400 |
| Electricity export rate | €/MWh | 115,49 | 10% | 103,94 | 127,04 |
| Debt ratio | % | 41% | 10% | 37% | 45% |
| Debt interest rate | % | 6,00% | 10% | 5,40% | 6,60% |
| Debt term | yr | 15 | 10% | 13,5 | 16,5 |




| | | |
|---|---|---|
| Median | € | 16.049.430 |
| Level of risk | % | 10,0% |
| Minimum within level of confidence | € | 13.509.444 |
| Maximum within level of confidence | € | 18.488.826 |



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# RETScreen® International
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*Clean Energy Project Analysis Software*

## Project information

*See project database*

| | |
|---|---|
| Project name | Wind Power Project: Credit / No GC |
| Project location | Poland |
| Prepared for | MSc - CEE |
| Prepared by | Cosima Steiner |
| Project type | Power |
| Technology | Wind turbine |
| Grid type | Central-grid |
| Analysis type | Method 2 |
| Heating value reference | Higher heating value (HHV) |
| Show settings | ☑ |
| Language - Langue | English - Anglais |
| User manual | English - Anglais |
| Currency | Euro |
| Units | Metric units |

## Site reference conditions

*Select climate data location*

| | |
|---|---|
| Climate data location | Poland, Warminsko Mazurskie |
| Show data | ☐ |

NASA · UNEP · GEF · reeep

*Complete Energy Model sheet*

RETScreen4 2010-02-26



NRCan/CanmetENERGY

**RETScreen Energy Model - Power project**

☐ Show alternative units

| Proposed case power system | | | |
|---|---|---|---|
| Technology | | Wind turbine | |
| Analysis type | ◉ | Method 1 | |
| | ○ | Method 2 | |
| | ○ | Method 3 | |
| **Wind turbine** | | | |
| Power capacity | kW | 18.000,0 | *See product database* |
| Manufacturer | | | |
| Model | | | |
| Capacity factor | % | 30,0% | |
| Electricity exported to grid | MWh | 47.304 | |
| Electricity export rate | €/MWh | 48,33 | |

## RETScreen Cost Analysis - Power project

| Settings | | | |
|---|---|---|---|
| ◉ Method 1 | ○ Notes/Range | Second currency | Poland |
| ○ Method 2 | ◉ Second currency | | |
| | ○ Cost allocation | Rate: €/PLN | 4,08000 |

| Initial costs (credits) | Unit | Quantity | Unit cost | Amount | Relative costs | % | Amount |
|---|---|---|---|---|---|---|---|
| **Feasibility study** | | | | | | | |
| | cost | | | € - | | | PLN - |
| Sub-total: | | | | € - | 0,0% | 0% | PLN - |
| **Development** | | | | | | | |
| Development and Design | cost | 1 | € 1.800.000 | € 1.800.000 | | | PLN - |
| Sub-total: | | | | € 1.800.000 | 6,1% | 0% | PLN - |
| **Engineering** | | | | | | | |
| | cost | | | € - | | | PLN - |
| Sub-total: | | | | € - | 0,0% | 0% | PLN - |
| **Power system** | | | | | | | |
| Wind turbine | kW | 18.000,00 | € 1.000 | € 18.000.000 | | | PLN - |
| Road construction | km | | | € - | | | PLN - |
| Transmission line | km | | | € - | | | PLN - |
| Substation | project | | | € - | | | PLN - |
| Energy efficiency measures | project | | | € - | | | PLN - |
| Infrastructure and Connection to Mains | cost | 1 | € 9.800.000 | € 9.800.000 | | | PLN - |
| | | | | € - | | | PLN - |
| Sub-total: | | | | € 27.800.000 | 93,9% | 0% | PLN - |
| **Balance of system & miscellaneous** | | | | | | | |
| Spare parts | % | | | € - | | | PLN - |
| Transportation | project | | | € - | | | PLN - |
| Training & commissioning | p-d | | | € - | | | PLN - |
| User-defined | cost | | | € - | | | PLN - |
| Contingencies | % | | € 29.600.000 | € - | | | PLN - |
| Interest during construction | | | € 29.600.000 | € - | | | PLN - |
| Sub-total: | | Enter number of months | | € - | 0,0% | 0% | PLN - |
| **Total initial costs** | | | | € 29.600.000 | 100,0% | 0% | PLN - |

| Annual costs (credits) | Unit | Quantity | Unit cost | Amount | % | Amount |
|---|---|---|---|---|---|---|
| **O&M** | | | | | | |
| Parts & labour | project | 1 | € 324.000 | € 324.000 | | PLN - |
| | cost | | | € - | | PLN - |
| Contingencies | % | | € 324.000 | € - | | PLN - |
| Sub-total: | | | | € 324.000 | 0% | PLN - |

| Periodic costs (credits) | Unit | Year | Unit cost | Amount | % | Amount |
|---|---|---|---|---|---|---|
| User-defined | cost | | | € - | | PLN - |
| | | | | € - | | PLN - |
| End of project life | cost | | | € - | | |

## RETScreen Financial Analysis - Power project

### Financial parameters

| | | |
|---|---|---|
| **General** | | |
| Fuel cost escalation rate | % | |
| Inflation rate | % | 2,5% |
| Discount rate | % | 12,0% |
| Project life | yr | 20 |
| **Finance** | | |
| Incentives and grants | € | 0 |
| Debt ratio | % | 41,0% |
| Debt | € | 12.136.000 |
| Equity | € | 17.464.000 |
| Debt interest rate | % | 6,00% |
| Debt term | yr | 15 |
| Debt payments | €/yr | 1.249.556 |
| **Income tax analysis** | ☑ | |
| Effective income tax rate | % | 19,0% |
| Loss carryforward? | | Yes |
| Depreciation method | | Straight-line |
| Depreciation tax basis | % | 90,0% |
| Depreciation period | yr | 20 |
| Tax holiday available? | yes/no | No |

### Annual income

| | | |
|---|---|---|
| **Electricity export income** | | |
| Electricity exported to grid | MWh | 47.304 |
| Electricity export rate | €/MWh | 48,33 |
| Electricity export income | € | 2.286.202 |
| Electricity export escalation rate | % | 3,0% |
| **GHG reduction income** | ☐ | |
| **Customer premium income (rebate)** | ☐ | |
| **Other income (cost)** | ☐ | |
| **Clean Energy (CE) production income** | ☐ | |

### Project costs and savings/income summary

| | | | |
|---|---|---|---|
| **Initial costs** | | | |
| Development | 6,1% | € | 1.800.000 |
| Power system | 93,9% | € | 27.800.000 |
| Balance of system & misc. | 0,0% | € | 0 |
| **Total initial costs** | **100,0%** | **€** | **29.600.000** |
| **Annual costs and debt payments** | | | |
| O&M | | € | 324.000 |
| Fuel cost - proposed case | | € | 0 |
| Debt payments - 15 yrs | | € | 1.249.556 |
| **Total annual costs** | | **€** | **1.573.556** |
| **Periodic costs (credits)** | | | |
| **Annual savings and income** | | | |
| Fuel cost - base case | | € | 0 |
| Electricity export income | | € | 2.286.202 |
| **Total annual savings and income** | | **€** | **2.286.202** |

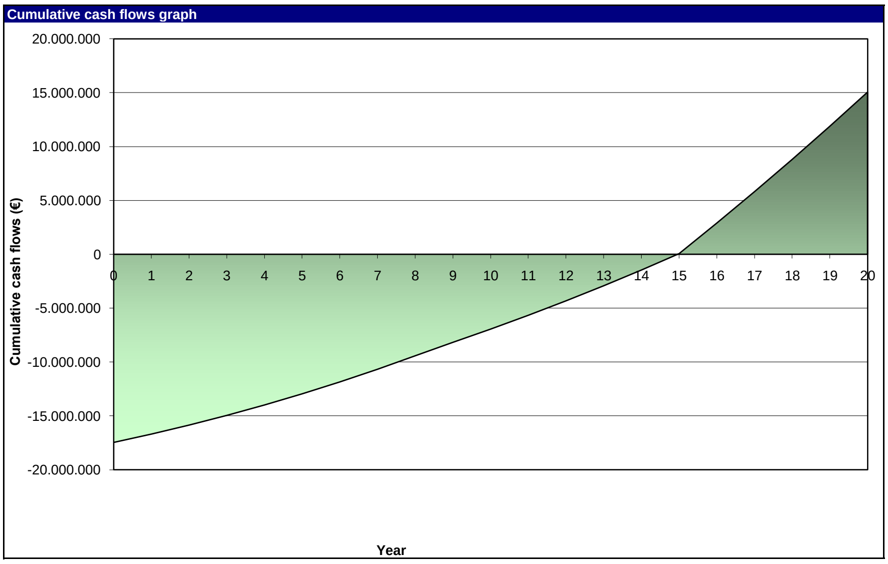
### Financial viability

| | | |
|---|---|---|
| Pre-tax IRR - equity | % | 6,0% |
| Pre-tax IRR - assets | % | 1,5% |
| After-tax IRR - equity | % | 5,2% |
| After-tax IRR - assets | % | 0,7% |
| Simple payback | yr | 15,1 |
| Equity payback | yr | 15,0 |
| Net Present Value (NPV) | € | -8.250.483 |
| Annual life cycle savings | €/yr | -1.104.565 |
| Benefit-Cost (B-C) ratio | | 0,53 |
| Debt service coverage | | 1,62 |
| Energy production cost | €/MWh | 70,96 |

### Yearly cash flows

| Year | Pre-tax | After-tax | Cumulative |
|---|---|---|---|
| # | € | € | € |
| 0 | -17.464.000 | -17.464.000 | -17.464.000 |
| 1 | 773.132 | 773.132 | -16.690.868 |
| 2 | 835.473 | 835.473 | -15.855.394 |
| 3 | 899.726 | 899.726 | -14.955.668 |
| 4 | 965.949 | 965.949 | -13.989.719 |
| 5 | 1.034.203 | 1.034.203 | -12.955.516 |
| 6 | 1.104.548 | 1.104.548 | -11.850.967 |
| 7 | 1.177.050 | 1.177.050 | -10.673.917 |
| 8 | 1.251.774 | 1.251.774 | -9.422.143 |
| 9 | 1.328.788 | 1.250.095 | -8.172.048 |
| 10 | 1.408.161 | 1.226.322 | -6.945.726 |
| 11 | 1.489.967 | 1.282.542 | -5.663.184 |
| 12 | 1.574.278 | 1.340.190 | -4.322.995 |
| 13 | 1.661.172 | 1.399.290 | -2.923.704 |
| 14 | 1.750.727 | 1.459.869 | -1.463.835 |
| 15 | 1.843.024 | 1.521.952 | 58.117 |
| 16 | 3.187.704 | 2.835.120 | 2.893.237 |
| 17 | 3.285.740 | 2.914.529 | 5.807.767 |
| 18 | 3.386.777 | 2.996.369 | 8.804.136 |
| 19 | 3.490.907 | 3.080.715 | 11.884.851 |
| 20 | 3.598.224 | 3.167.641 | 15.052.492 |

### Cumulative cash flows graph



## RETScreen Sensitivity and Risk Analysis - Power project

### Sensitivity analysis

| | | |
|---|---|---|
| Perform analysis on | Net Present Value (NPV) | |
| Sensitivity range | 20% | |
| Threshold | 10 | € |

| Initial costs | | Electricity export rate | | | | €/MWh |
|---|---|---|---|---|---|---|
| € | | 38,66 | 43,50 | 48,33 | 53,16 | 58,00 |
| | | -20% | -10% | 0% | 10% | 20% |
| 23.680.000 | -20% | -7.100.639 | -5.289.895 | -3.519.686 | -1.770.307 | -32.129 |
| 26.640.000 | -10% | -9.535.044 | -7.674.350 | -5.869.352 | -4.099.083 | -2.348.211 |
| 29.600.000 | 0% | -12.007.486 | -10.098.761 | **-8.250.483** | -6.448.809 | -4.678.479 |
| 32.560.000 | 10% | -14.509.414 | -12.557.879 | -10.665.589 | -8.826.615 | -7.028.266 |
| 35.520.000 | 20% | -17.059.049 | -15.046.088 | -13.114.064 | -11.235.653 | -9.403.438 |

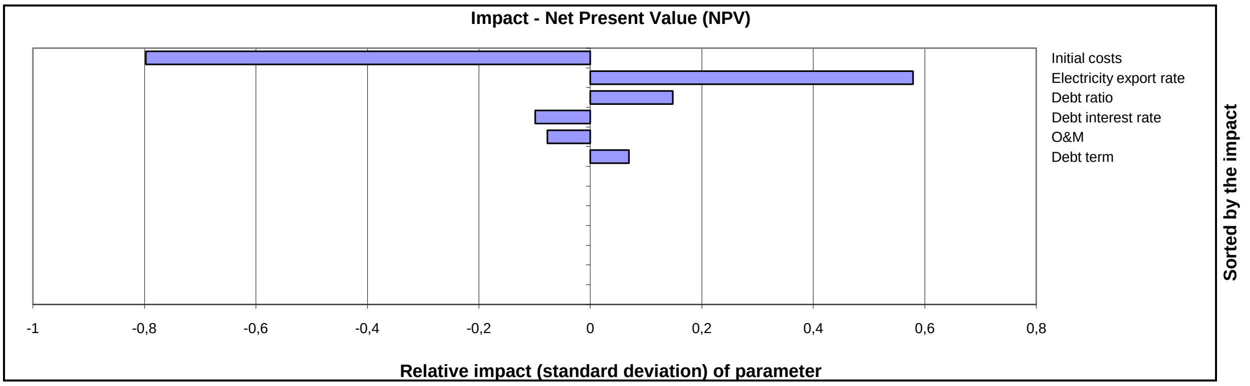
| Debt interest rate | | Debt ratio | | | | % |
|---|---|---|---|---|---|---|
| % | | 33% | 37% | 41% | 45% | 49% |
| | | -20% | -10% | 0% | 10% | 20% |
| 4,80% | -20% | -8.627.953 | -8.160.040 | -7.693.978 | -7.229.246 | -6.765.790 |
| 5,40% | -10% | -8.843.620 | -8.405.113 | -7.967.759 | -7.533.137 | -7.099.337 |
| 6,00% | 0% | -9.065.925 | -8.656.503 | **-8.250.483** | -7.845.854 | -7.444.266 |
| 6,60% | 10% | -9.293.720 | -8.916.041 | -8.540.637 | -8.168.369 | -7.799.317 |
| 7,20% | 20% | -9.528.072 | -9.181.636 | -8.839.226 | -8.500.436 | -8.164.316 |

| Debt interest rate | | Debt term | | | | yr |
|---|---|---|---|---|---|---|
| % | | 12 | 14 | 15 | 17 | 18 |
| | | -20% | -10% | 0% | 10% | 20% |
| 4,80% | -20% | -8.285.381 | -7.847.258 | -7.693.978 | -7.353.374 | -7.194.750 |
| 5,40% | -10% | -8.531.624 | -8.103.270 | -7.967.759 | -7.635.542 | -7.491.951 |
| 6,00% | 0% | -8.782.466 | -8.366.069 | **-8.250.483** | -7.928.044 | -7.799.512 |
| 6,60% | 10% | -9.040.990 | -8.635.618 | -8.540.637 | -8.229.176 | -8.117.583 |
| 7,20% | 20% | -9.304.503 | -8.913.210 | -8.839.226 | -8.538.923 | -8.445.337 |

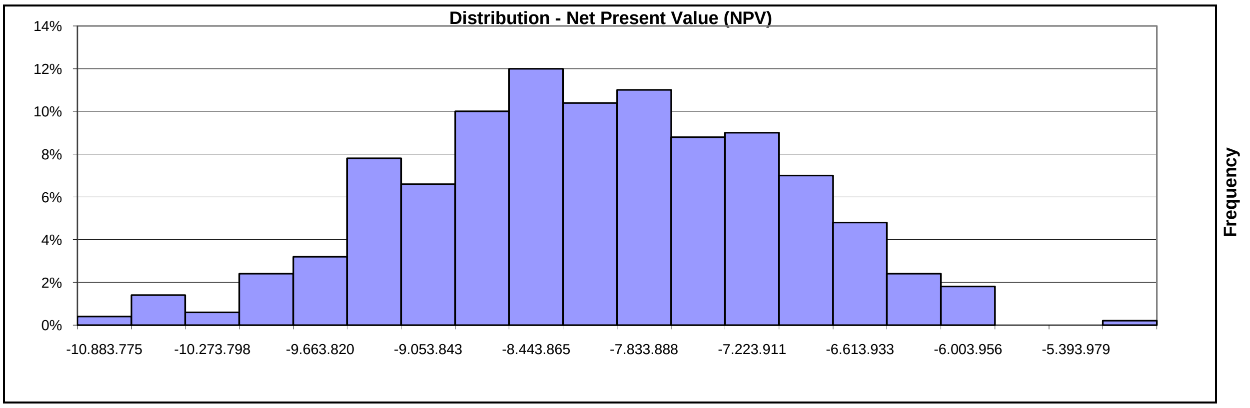
### Risk analysis

Perform analysis on: Net Present Value (NPV)

| Parameter | Unit | Value | Range (+/-) | Minimum | Maximum |
|---|---|---|---|---|---|
| Initial costs | € | 29.600.000 | 10% | 26.640.000 | 32.560.000 |
| O&M | € | 324.000 | 10% | 291.600 | 356.400 |
| Electricity export rate | €/MWh | 48,33 | 10% | 43,50 | 53,16 |
| Debt ratio | % | 41% | 10% | 37% | 45% |
| Debt interest rate | % | 6,00% | 10% | 5,40% | 6,60% |
| Debt term | yr | 15 | 10% | 13,5 | 16,5 |




| | | |
|---|---|---|
| Median | € | -8.107.436 |
| Level of risk | % | 10,0% |
| Minimum within level of confidence | € | -9.799.867 |
| Maximum within level of confidence | € | -6.508.290 |



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## Clean Energy Project Analysis Software

### Project information

See project database

| | |
|---|---|
| Project name | Wind Power Project: Direct Subsidy / GC |
| Project location | Poland |
| Prepared for | MSc - CEE |
| Prepared by | Cosima Steiner |
| Project type | Power |
| Technology | Wind turbine |
| Grid type | Central-grid |
| Analysis type | Method 2 |
| Heating value reference | Higher heating value (HHV) |
| Show settings | ☑ |
| Language - Langue | English - Anglais |
| User manual | English - Anglais |
| Currency | Euro |
| Units | Metric units |

### Site reference conditions

Select climate data location

| | |
|---|---|
| Climate data location | Poland, Warminsko Mazurskie |
| Show data | ☐ |

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Complete Energy Model sheet

RETScreen4 2010-02-26  NRCan/CanmetENERGY

**RETScreen Energy Model - Power project**

☐ Show alternative units

| Proposed case power system | | | |
|---|---|---|---|
| Technology | | Wind turbine | |
| Analysis type | ◉ | Method 1 | |
| | ○ | Method 2 | |
| | ○ | Method 3 | |
| **Wind turbine** | | | |
| Power capacity | kW | 18.000,0 | *See product database* |
| Manufacturer | | | |
| Model | | | |
| Capacity factor | % | 30,0% | |
| Electricity exported to grid | MWh | 47.304 | |
| Electricity export rate | €/MWh | 115,49 | |

## RETScreen Cost Analysis - Power project

| Settings | | | |
|---|---|---|---|
| (•) Method 1 | ( ) Notes/Range | Second currency | Poland |
| ( ) Method 2 | (•) Second currency | | |
| | ( ) Cost allocation | Rate: €/PLN | 4,08000 |

| Initial costs (credits) | Unit | Quantity | Unit cost | Amount | Relative costs | % | Amount |
|---|---|---|---|---|---|---|---|
| **Feasibility study** | | | | | | | |
| | cost | | | € - | | | PLN - |
| Sub-total: | | | | € - | 0,0% | 0% | PLN - |
| **Development** | | | | | | | |
| Development and Design | cost | 1 | € 1.800.000 | € 1.800.000 | | | PLN - |
| Sub-total: | | | | € 1.800.000 | 6,1% | 0% | PLN - |
| **Engineering** | | | | | | | |
| | cost | | | € - | | | PLN - |
| Sub-total: | | | | € - | 0,0% | 0% | PLN - |
| **Power system** | | | | | | | |
| Wind turbine | kW | 18.000,00 | € 1.000 | € 18.000.000 | | | PLN - |
| Road construction | km | | | € - | | | PLN - |
| Transmission line | km | | | € - | | | PLN - |
| Substation | project | | | € - | | | PLN - |
| Energy efficiency measures | project | | | € - | | | PLN - |
| Infrastructure and Connection to Mains | cost | 1 | € 9.800.000 | € 9.800.000 | | | PLN - |
| | | | | € - | | | PLN - |
| Sub-total: | | | | € 27.800.000 | 93,9% | 0% | PLN - |
| **Balance of system & miscellaneous** | | | | | | | |
| Spare parts | % | | | € - | | | PLN - |
| Transportation | project | | | € - | | | PLN - |
| Training & commissioning | p-d | | | € - | | | PLN - |
| User-defined | cost | | | € - | | | PLN - |
| Contingencies | % | | € 29.600.000 | € - | | | PLN - |
| Interest during construction | | | € 29.600.000 | € - | | | PLN - |
| Sub-total: | | Enter number of months | | € - | 0,0% | 0% | PLN - |
| **Total initial costs** | | | | € 29.600.000 | 100,0% | 0% | PLN - |

| Annual costs (credits) | Unit | Quantity | Unit cost | Amount | % | Amount |
|---|---|---|---|---|---|---|
| **O&M** | | | | | | |
| Parts & labour | project | 1 | € 324.000 | € 324.000 | | PLN - |
| | cost | | | € - | | PLN - |
| Contingencies | % | | € 324.000 | € - | | PLN - |
| Sub-total: | | | | € 324.000 | 0% | PLN - |

| Periodic costs (credits) | Unit | Year | Unit cost | Amount | % | Amount |
|---|---|---|---|---|---|---|
| User-defined | cost | | | € - | | PLN - |
| | | | | € - | | PLN - |
| End of project life | cost | | | € - | | |

## RETScreen Financial Analysis - Power project

### Financial parameters

| | | |
|---|---|---|
| **General** | | |
| Fuel cost escalation rate | % | |
| Inflation rate | % | 2,5% |
| Discount rate | % | 12,0% |
| Project life | yr | 20 |
| **Finance** | | |
| Incentives and grants | € | 8.880.000 |
| Debt ratio | % | 0,0% |
| **Income tax analysis** | | ☑ |
| Effective income tax rate | % | 19,0% |
| Loss carryforward? | | Yes |
| Depreciation method | | Straight-line |
| Depreciation tax basis | % | 90,0% |
| Depreciation period | yr | 20 |
| Tax holiday available? | yes/no | No |

### Annual income

| | | |
|---|---|---|
| **Electricity export income** | | |
| Electricity exported to grid | MWh | 47.304 |
| Electricity export rate | €/MWh | 115,49 |
| Electricity export income | € | 5.463.139 |
| Electricity export escalation rate | % | 3,0% |
| **GHG reduction income** | | ☐ |
| **Customer premium income (rebate)** | | ☐ |
| **Other income (cost)** | | ☐ |
| **Clean Energy (CE) production income** | | ☐ |

### Project costs and savings/income summary

| | | | |
|---|---|---|---|
| **Initial costs** | | | |
| Development | 6,1% | € | 1.800.000 |
| Power system | 93,9% | € | 27.800.000 |
| Balance of system & misc. | 0,0% | € | 0 |
| **Total initial costs** | **100,0%** | **€** | **29.600.000** |
| Incentives and grants | | € | 8.880.000 |
| **Annual costs and debt payments** | | | |
| O&M | | € | 324.000 |
| Fuel cost - proposed case | | € | 0 |
| **Total annual costs** | | **€** | **324.000** |
| **Periodic costs (credits)** | | | |
| **Annual savings and income** | | | |
| Fuel cost - base case | | € | 0 |
| Electricity export income | | € | 5.463.139 |
| **Total annual savings and income** | | **€** | **5.463.139** |

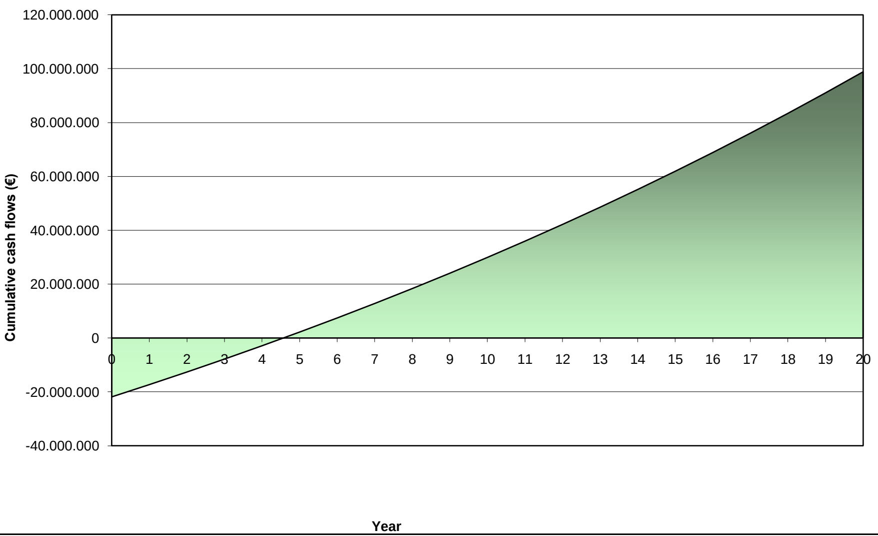
### Financial viability

| | | |
|---|---|---|
| Pre-tax IRR - equity | % | 28,3% |
| Pre-tax IRR - assets | % | 28,3% |
| After-tax IRR - equity | % | 23,1% |
| After-tax IRR - assets | % | 25,6% |
| Simple payback | yr | 4,0 |
| Equity payback | yr | 4,6 |
| Net Present Value (NPV) | € | 18.856.145 |
| Annual life cycle savings | €/yr | 2.524.438 |
| Benefit-Cost (B-C) ratio | | 1,64 |
| Energy production cost | €/MWh | 62,58 |

### Yearly cash flows

| Year | Pre-tax | After-tax | Cumulative |
|---|---|---|---|
| # | € | € | € |
| 0 | -20.720.000 | -21.844.800 | -21.844.800 |
| 1 | 5.294.933 | 4.541.976 | -17.302.824 |
| 2 | 5.455.442 | 4.671.988 | -12.630.836 |
| 3 | 5.620.807 | 4.805.934 | -7.824.903 |
| 4 | 5.791.176 | 4.943.932 | -2.880.971 |
| 5 | 5.966.699 | 5.086.106 | 2.205.136 |
| 6 | 6.147.533 | 5.232.582 | 7.437.717 |
| 7 | 6.333.838 | 5.383.488 | 12.821.206 |
| 8 | 6.525.778 | 5.538.961 | 18.360.166 |
| 9 | 6.723.526 | 5.699.136 | 24.059.302 |
| 10 | 6.927.255 | 5.864.156 | 29.923.458 |
| 11 | 7.137.146 | 6.034.168 | 35.957.627 |
| 12 | 7.353.386 | 6.209.323 | 42.166.949 |
| 13 | 7.576.166 | 6.389.775 | 48.556.724 |
| 14 | 7.805.684 | 6.575.684 | 55.132.408 |
| 15 | 8.042.144 | 6.767.217 | 61.899.625 |
| 16 | 8.285.754 | 6.964.541 | 68.864.166 |
| 17 | 8.536.732 | 7.167.833 | 76.031.999 |
| 18 | 8.795.299 | 7.377.272 | 83.409.271 |
| 19 | 9.061.685 | 7.593.045 | 91.002.315 |
| 20 | 9.336.125 | 7.815.341 | 98.817.656 |

### Cumulative cash flows graph



## RETScreen Sensitivity and Risk Analysis - Power project

### Sensitivity analysis

| | | |
|---|---|---|
| Perform analysis on | Net Present Value (NPV) | |
| Sensitivity range | 20% | |
| Threshold | 10 | € |

| Initial costs | | Electricity export rate (€/MWh) | | | | |
|---|---|---|---|---|---|---|
| | | 92,39 | 103,94 | 115,49 | 127,04 | 138,59 |
| € | | -20% | -10% | 0% | 10% | 20% |
| 23.680.000 | -20% | 16.053.359 | 20.169.475 | 24.285.592 | 28.401.708 | 32.517.825 |
| 26.640.000 | -10% | 13.338.635 | 17.454.752 | 21.570.869 | 25.686.985 | 29.803.102 |
| 29.600.000 | 0% | 10.623.912 | 14.740.029 | **18.856.145** | 22.972.262 | 27.088.378 |
| 32.560.000 | 10% | 7.909.189 | 12.025.305 | 16.141.422 | 20.257.538 | 24.373.655 |
| 35.520.000 | 20% | 5.194.465 | 9.310.582 | 13.426.699 | 17.542.815 | 21.658.932 |

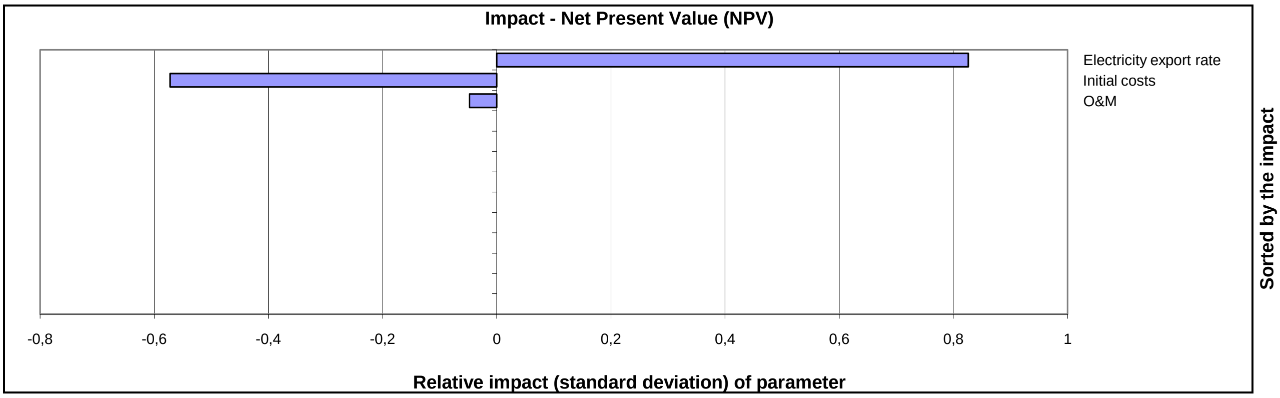
| Debt interest rate | | Debt ratio (%) | | | | |
|---|---|---|---|---|---|---|
| | | 0% | 0% | 0% | 0% | 0% |
| % | | -20% | -10% | 0% | 10% | 20% |
| 0,00% | -20% | 18.856.145 | 18.856.145 | 18.856.145 | 18.856.145 | 18.856.145 |
| 0,00% | -10% | 18.856.145 | 18.856.145 | 18.856.145 | 18.856.145 | 18.856.145 |
| 0,00% | 0% | 18.856.145 | 18.856.145 | **18.856.145** | 18.856.145 | 18.856.145 |
| 0,00% | 10% | 18.856.145 | 18.856.145 | 18.856.145 | 18.856.145 | 18.856.145 |
| 0,00% | 20% | 18.856.145 | 18.856.145 | 18.856.145 | 18.856.145 | 18.856.145 |

| Debt interest rate | | Debt term (yr) | | | | |
|---|---|---|---|---|---|---|
| | | 0 | 0 | 0 | 0 | 0 |
| % | | -20% | -10% | 0% | 10% | 20% |
| 0,00% | -20% | 18.856.145 | 18.856.145 | 18.856.145 | 18.856.145 | 18.856.145 |
| 0,00% | -10% | 18.856.145 | 18.856.145 | 18.856.145 | 18.856.145 | 18.856.145 |
| 0,00% | 0% | 18.856.145 | 18.856.145 | **18.856.145** | 18.856.145 | 18.856.145 |
| 0,00% | 10% | 18.856.145 | 18.856.145 | 18.856.145 | 18.856.145 | 18.856.145 |
| 0,00% | 20% | 18.856.145 | 18.856.145 | 18.856.145 | 18.856.145 | 18.856.145 |

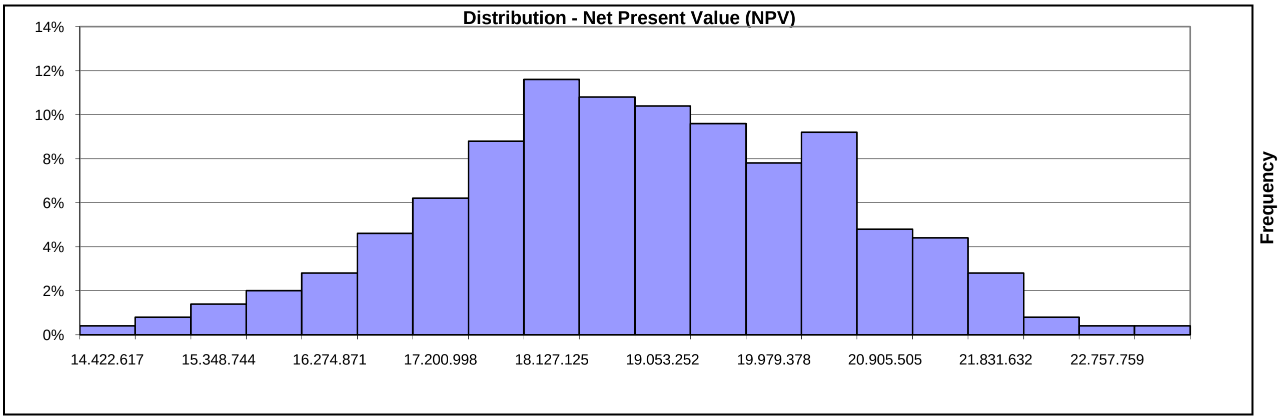
### Risk analysis

Perform analysis on: Net Present Value (NPV)

| Parameter | Unit | Value | Range (+/-) | Minimum | Maximum |
|---|---|---|---|---|---|
| Initial costs | € | 29.600.000 | 10% | 26.640.000 | 32.560.000 |
| O&M | € | 324.000 | 10% | 291.600 | 356.400 |
| Electricity export rate | €/MWh | 115,49 | 10% | 103,94 | 127,04 |
| Debt term | yr | 0 | 10% | 0 | 0 |




| | | |
|---|---|---|
| Median | € | 18.846.063 |
| Level of risk | % | 10,0% |
| Minimum within level of confidence | € | 16.101.117 |
| Maximum within level of confidence | € | 21.520.315 |



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*Clean Energy Project Analysis Software*

## Project information

*See project database*

| | |
|---|---|
| Project name | Wind Power Project: Direct Subsidy / No GC |
| Project location | Poland |
| Prepared for | MSc - CEE |
| Prepared by | Cosima Steiner |
| Project type | Power |
| Technology | Wind turbine |
| Grid type | Central-grid |
| Analysis type | Method 2 |
| Heating value reference | Higher heating value (HHV) |
| Show settings | ☑ |
| Language - Langue | English - Anglais |
| User manual | English - Anglais |
| Currency | Euro |
| Units | Metric units |

## Site reference conditions

*Select climate data location*

| | |
|---|---|
| Climate data location | Poland, Warminsko Mazurskie |
| Show data | ☐ |

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*Complete Energy Model sheet*

RETScreen4 2010-02-26



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**RETScreen Energy Model - Power project**

☐ Show alternative units

**Proposed case power system**

| | | |
|---|---|---|
| Technology | | Wind turbine |
| Analysis type | ◉ | Method 1 |
| | ○ | Method 2 |
| | ○ | Method 3 |
| **Wind turbine** | | |
| Power capacity | kW | 18.000,0 |
| Manufacturer | | |
| Model | | |
| Capacity factor | % | 30,0% |
| Electricity exported to grid | MWh | 47.304 |
| Electricity export rate | €/MWh | 48,33 |

*See product database*

## RETScreen Cost Analysis - Power project

| Settings | | | |
|---|---|---|---|
| ◉ Method 1 | ○ Notes/Range | Second currency | Poland |
| ○ Method 2 | ◉ Second currency | | |
| | ○ Cost allocation | Rate: €/PLN | 4,08000 |

| Initial costs (credits) | Unit | Quantity | Unit cost | Amount | Relative costs | % | Amount |
|---|---|---|---|---|---|---|---|
| **Feasibility study** | | | | | | | |
| | cost | | | € - | | | PLN - |
| Sub-total: | | | | **€ -** | 0,0% | 0% | PLN - |
| **Development** | | | | | | | |
| Development and Design | cost | 1 | € 1.800.000 | € 1.800.000 | | | PLN - |
| Sub-total: | | | | **€ 1.800.000** | 6,1% | 0% | PLN - |
| **Engineering** | | | | | | | |
| | cost | | | € - | | | PLN - |
| Sub-total: | | | | **€ -** | 0,0% | 0% | PLN - |
| **Power system** | | | | | | | |
| Wind turbine | kW | 18.000,00 | € 1.000 | € 18.000.000 | | | PLN - |
| Road construction | km | | | € - | | | PLN - |
| Transmission line | km | | | € - | | | PLN - |
| Substation | project | | | € - | | | PLN - |
| Energy efficiency measures | project | | | € - | | | PLN - |
| Infrastructure and Connection to Mains | cost | 1 | € 9.800.000 | € 9.800.000 | | | PLN - |
| | | | | € - | | | PLN - |
| Sub-total: | | | | **€ 27.800.000** | 93,9% | 0% | PLN - |
| **Balance of system & miscellaneous** | | | | | | | |
| Spare parts | % | | | € - | | | PLN - |
| Transportation | project | | | € - | | | PLN - |
| Training & commissioning | p-d | | | € - | | | PLN - |
| User-defined | cost | | | € - | | | PLN - |
| Contingencies | % | | € 29.600.000 | € - | | | PLN - |
| Interest during construction | | | € 29.600.000 | € - | | | PLN - |
| Sub-total: | | Enter number of months | | **€ -** | 0,0% | 0% | PLN - |
| **Total initial costs** | | | | **€ 29.600.000** | 100,0% | 0% | PLN - |

| Annual costs (credits) | Unit | Quantity | Unit cost | Amount | % | Amount |
|---|---|---|---|---|---|---|
| **O&M** | | | | | | |
| Parts & labour | project | 1 | € 324.000 | € 324.000 | | PLN - |
| | cost | | | € - | | PLN - |
| Contingencies | % | | € 324.000 | € - | | PLN - |
| Sub-total: | | | | **€ 324.000** | 0% | PLN - |

| Periodic costs (credits) | Unit | Year | Unit cost | Amount | % | Amount |
|---|---|---|---|---|---|---|
| User-defined | cost | | | € - | | PLN - |
| | | | | € - | | PLN - |
| End of project life | cost | | | € - | | |

## RETScreen Financial Analysis - Power project

### Financial parameters

| | | |
|---|---|---|
| **General** | | |
| Fuel cost escalation rate | % | |
| Inflation rate | % | 2,5% |
| Discount rate | % | 12,0% |
| Project life | yr | 20 |
| **Finance** | | |
| Incentives and grants | € | 8.880.000 |
| Debt ratio | % | 0,0% |
| **Income tax analysis** | | ☑ |
| Effective income tax rate | % | 19,0% |
| Loss carryforward? | | Yes |
| Depreciation method | | Straight-line |
| Depreciation tax basis | % | 90,0% |
| Depreciation period | yr | 20 |
| Tax holiday available? | yes/no | No |

### Annual income

| | | |
|---|---|---|
| **Electricity export income** | | |
| Electricity exported to grid | MWh | 47.304 |
| Electricity export rate | €/MWh | 48,33 |
| Electricity export income | € | 2.286.202 |
| Electricity export escalation rate | % | 3,0% |
| **GHG reduction income** | | ☐ |
| **Customer premium income (rebate)** | | ☐ |
| **Other income (cost)** | | ☐ |
| **Clean Energy (CE) production income** | | ☐ |

### Project costs and savings/income summary

| | | | |
|---|---|---|---|
| **Initial costs** | | | |
| Development | 6,1% | € | 1.800.000 |
| Power system | 93,9% | € | 27.800.000 |
| Balance of system & misc. | 0,0% | € | 0 |
| **Total initial costs** | **100,0%** | **€** | **29.600.000** |
| Incentives and grants | | € | 8.880.000 |
| **Annual costs and debt payments** | | | |
| O&M | | € | 324.000 |
| Fuel cost - proposed case | | € | 0 |
| **Total annual costs** | | **€** | **324.000** |
| **Periodic costs (credits)** | | | |
| **Annual savings and income** | | | |
| Fuel cost - base case | | € | 0 |
| Electricity export income | | € | 2.286.202 |
| **Total annual savings and income** | | **€** | **2.286.202** |

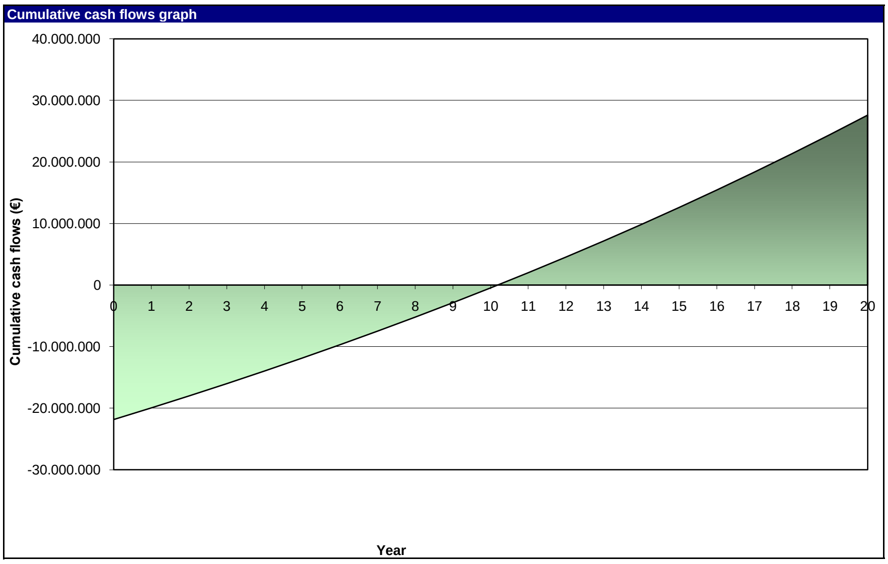
### Financial viability

| | | |
|---|---|---|
| Pre-tax IRR - equity | % | 10,3% |
| Pre-tax IRR - assets | % | 10,3% |
| After-tax IRR - equity | % | 8,5% |
| After-tax IRR - assets | % | 9,9% |
| Simple payback | yr | 10,6 |
| Equity payback | yr | 10,2 |
| Net Present Value (NPV) | € | -5.079.987 |
| Annual life cycle savings | €/yr | -680.102 |
| Benefit-Cost (B-C) ratio | | 0,83 |
| Energy production cost | €/MWh | 62,58 |

### Yearly cash flows

| Year | Pre-tax | After-tax | Cumulative |
|---|---|---|---|
| # | € | € | € |
| 0 | -20.720.000 | -21.844.800 | -21.844.800 |
| 1 | 2.022.688 | 1.891.458 | -19.953.342 |
| 2 | 2.085.030 | 1.941.954 | -18.011.388 |
| 3 | 2.149.282 | 1.993.999 | -16.017.390 |
| 4 | 2.215.505 | 2.047.639 | -13.969.750 |
| 5 | 2.283.759 | 2.102.925 | -11.866.826 |
| 6 | 2.354.104 | 2.159.905 | -9.706.921 |
| 7 | 2.426.606 | 2.218.631 | -7.488.290 |
| 8 | 2.501.330 | 2.279.157 | -5.209.132 |
| 9 | 2.578.344 | 2.341.539 | -2.867.594 |
| 10 | 2.657.717 | 2.405.831 | -461.763 |
| 11 | 2.739.523 | 2.472.093 | 2.010.330 |
| 12 | 2.823.834 | 2.540.385 | 4.550.716 |
| 13 | 2.910.728 | 2.610.769 | 7.161.485 |
| 14 | 3.000.283 | 2.683.309 | 9.844.794 |
| 15 | 3.092.580 | 2.758.070 | 12.602.864 |
| 16 | 3.187.704 | 2.835.120 | 15.437.984 |
| 17 | 3.285.740 | 2.914.529 | 18.352.513 |
| 18 | 3.386.777 | 2.996.369 | 21.348.883 |
| 19 | 3.490.907 | 3.080.715 | 24.429.597 |
| 20 | 3.598.224 | 3.167.641 | 27.597.239 |

### Cumulative cash flows graph



## RETScreen Sensitivity and Risk Analysis - Power project

### Sensitivity analysis

| | | |
|---|---|---|
| Perform analysis on | Net Present Value (NPV) | |
| Sensitivity range | 20% | |
| Threshold | 10 | € |

| Initial costs | | Electricity export rate | | | | €/MWh |
|---|---|---|---|---|---|---|
| | | 38,66 | 43,50 | 48,33 | 53,16 | 58,00 |
| € | | -20% | -10% | 0% | 10% | 20% |
| 23.680.000 | -20% | -3.095.547 | -1.373.043 | 349.460 | 2.071.963 | 3.794.467 |
| 26.640.000 | -10% | -5.810.270 | -4.087.767 | -2.365.263 | -642.760 | 1.079.743 |
| 29.600.000 | 0% | -8.524.993 | -6.802.490 | **-5.079.987** | -3.357.483 | -1.634.980 |
| 32.560.000 | 10% | -11.239.717 | -9.517.213 | -7.794.710 | -6.072.207 | -4.349.703 |
| 35.520.000 | 20% | -13.956.021 | -12.231.937 | -10.509.433 | -8.786.930 | -7.064.427 |

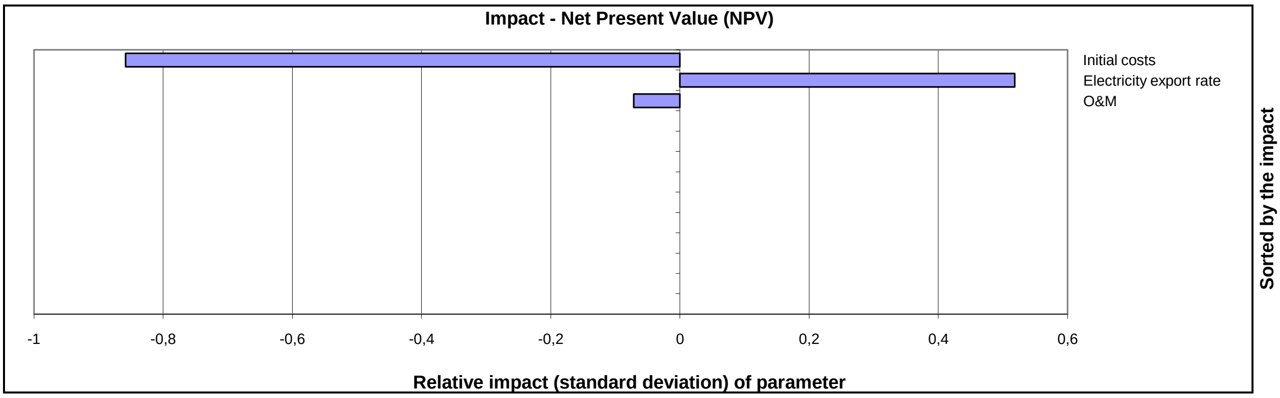
| Debt interest rate | | Debt ratio | | | | % |
|---|---|---|---|---|---|---|
| | | 0% | 0% | 0% | 0% | 0% |
| % | | -20% | -10% | 0% | 10% | 20% |
| 0,00% | -20% | -5.079.987 | -5.079.987 | -5.079.987 | -5.079.987 | -5.079.987 |
| 0,00% | -10% | -5.079.987 | -5.079.987 | -5.079.987 | -5.079.987 | -5.079.987 |
| 0,00% | 0% | -5.079.987 | -5.079.987 | **-5.079.987** | -5.079.987 | -5.079.987 |
| 0,00% | 10% | -5.079.987 | -5.079.987 | -5.079.987 | -5.079.987 | -5.079.987 |
| 0,00% | 20% | -5.079.987 | -5.079.987 | -5.079.987 | -5.079.987 | -5.079.987 |

| Debt interest rate | | Debt term | | | | yr |
|---|---|---|---|---|---|---|
| | | 0 | 0 | 0 | 0 | 0 |
| % | | -20% | -10% | 0% | 10% | 20% |
| 0,00% | -20% | -5.079.987 | -5.079.987 | -5.079.987 | -5.079.987 | -5.079.987 |
| 0,00% | -10% | -5.079.987 | -5.079.987 | -5.079.987 | -5.079.987 | -5.079.987 |
| 0,00% | 0% | -5.079.987 | -5.079.987 | **-5.079.987** | -5.079.987 | -5.079.987 |
| 0,00% | 10% | -5.079.987 | -5.079.987 | -5.079.987 | -5.079.987 | -5.079.987 |
| 0,00% | 20% | -5.079.987 | -5.079.987 | -5.079.987 | -5.079.987 | -5.079.987 |

### Risk analysis

Perform analysis on: Net Present Value (NPV)

| Parameter | Unit | Value | Range (+/-) | Minimum | Maximum |
|---|---|---|---|---|---|
| Initial costs | € | 29.600.000 | 10% | 26.640.000 | 32.560.000 |
| O&M | € | 324.000 | 10% | 291.600 | 356.400 |
| Electricity export rate | €/MWh | 48,33 | 10% | 43,50 | 53,16 |
| Debt term | yr | 0 | 10% | 0 | 0 |




| | | |
|---|---|---|
| Median | € | -5.094.445 |
| Level of risk | % | 10,0% |
| Minimum within level of confidence | € | -6.743.874 |
| Maximum within level of confidence | € | -3.364.014 |