Alpine Windharvest

WP 11: Legal, social, political and economic framework. Subpackage Cost Evaluation

Report 11.6

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Phase 1: Identify cost factors

A. Research objective

The objective of this research sub-package is to investigate the factors influencing production costs of wind electricity in Alpine countries and to formulate policy recommendations leading to the minimisation of total production costs per kWh.

B. Theoretical analysis of cost factors

Based on an in-depth analysis of the cost structure of wind energy projects, we identify four categories of factors affecting production costs (expresses as costs per kWh). Of these, some factors are liable to governmental influence by direct policy intervention or indirect policy effects. But others are out of policy reach as they depend on natural resource availability, quality and distribution, and its relation to the national energy infrastructure. The four categories of cost-factors and their sub-components are mentioned in Table 1.

As a general observation it can be mentioned that the anatomy of production costs for wind electricity is very complex and highly dynamic. During diffusion, some cost-components lower their weight in the total production costs, such as technology-specific costs, while other cost-components may inflate placing upward pressure on total costs per kWh. Column 3 of Table 1 presents the hypotheses regarding the evolution of cost-factors during diffusion.

Table 1. Categories of factors influencing production costs and evolution during diffusion

Categories of factors affecting production costs per kWh	at market introduction	after medium / long term diffusion	possible govern-mental influence
1. technology specific	high	decreasing	direct / indirect
2. technology complementary (influenced by resource location)	modest / possibly high (depending on plant size)		partially
3. context induced cost factors → financing / trade factors → project life-cycle stages → administrative(-social) consent / tax expenses	 high high uncertain	 possibly decreasing decreasing possibly sinuous evolution	 direct indirect direct / indirect
4. resource quality & availability	high	decreasing quality; increasing costs	no
overall production costs / kWh	high values	very wide range	limited

1. *Technology-specific* costs refer to technology costs per kW based on factory price, and to the technical characteristics that influence electricity generation such as availability and efficiency. Different wind power plants that were built with a technology with the same factory costs per installed kW may incur different production costs when they use technology designs with different annual availability and different levels of efficiency. During diffusion, as technological performances improve, competition intensifies, and economies of scale and learning are activated in the sector of renewable technology manufacturing, the weight of this component in production costs is likely to gradually decrease.

For example, in terms of efficiency, some studies mention a doubling of efficiency in 15 years, with increases from 600 kWh/m^2/year in 1985 to around 1150 kWh/m^2/year in 2000 (Energia, 2000:23). Higher levels of wind electricity production may imply lower overall production costs per kWh, provided that the technology-specific costs per kW are not too much higher than the less efficient models. There are still important efficiency differences among the many types of designs currently on the market and efficiency is still seen as a remaining technical challenge for wind technology - both by the industry and policy-makers supporting its development. The efficiency of wind turbines may be influenced by many technical and non-technical factors.

In Appendix 1 of Part 1 we explain – based on an overview of technical literature - the influence of three technical parameters on the production cost performances of wind technology: type of voltage, rotor speed and type of generator. These technical parameters will also be investigated empirically for the already commissioned projects in the Alpine countries.

2. *Technology-complementary* costs refer to infrastructure, civil works, construction, grid- connection, mechanical and electrical equipment costs. The equipment and services in this cost-category are generally conventional, and can be seen as accessories to wind electricity technology. They can be provided in principle by any company in related (long-established) industrial sectors, such as electricity companies, industrial-equipment companies, construction companies, etc. The location and accessibility of resources have a substantial influence on the weight of this cost-category. For wind technology these cost-factors may represent up to 30% - or more - of total investment costs per kW installed.

In countries where wind resources are scattered across the country in a way that does not match the distribution of the electricity grid infrastructure, the weight of technology complementary costs is likely to increase, as diffusion progresses. Besides, costs in this category may also increase because larger amounts of output are likely to need substantial grid reinforcement and back-up capacity from continuous resource power plants. However, these problems are not likely to affect wind projects in the Alpine countries since:

- there is a good coverage of high/medium voltage transmission lines in resource rich areas,
- wind projects are not likely to be large-size and to have high density, that would require grid reinforcement and back-up capacity; and even assuming that this happens,
- there is a good availability of continuous-resource power plants[1].

But technology-complementary costs are also influenced by project sizes, decreasing with the increase in plant size. In the Alpine regions, where project sizes are likely to be relatively small – i.e. perhaps frequently smaller than 5 MW and rarely larger than 10 MW – it is possible to observe a substantial share of technology-complementary costs in total costs, even when projects are located close to the electricity grid.

3. The category of *context induced cost factors* comprises a large variety of elements that may be grouped into three segments:

- monetary consequences of financing and trade arrangements;
- expenses in project life-cycle, and
- expenses incurred in relation to (local) administrative and social approval.

In the first segment: the interest rates, equity requirements (interest asked for cash down-payments), the debt maturity, the equity-to-debt ratio, insurance expenses, investment recovery term requirements, and electricity purchase contract length - all have impacts on the resulting production costs per kWh. Impacts related to financing may not be observed when financing schemes are used that do not involve 'project finance' loans. This appears to be the case in some Alpine countries, for example Austria, where there is a tradition of investments under the (local) cooperative approach (Lauber, personal communication 6.09.2003). However, the impact of trade arrangements cannot be avoided by the financing formula.

In the second segment the following factors should be placed: the costs for the numerous feasibility studies needed, costs for project design and management, engineering, construction, maintenance and operation. The costs for such services are a reflection of the level of competition in the industrial basis of wind technology.

In the third segment: wind developers incur also costs related to the social and administrative permit approval, taxes of different types for various administrative authorities, land rent payments and possibly even expenses for various local/regional social/economic benefits.

One can expect that in the first diffusion phases, all three segments would be inflated. For example, the novelty of technologies often requires caution from developers and financiers, manifested in the form of higher requirements for returns on equity, shorter period for investment recovery expected, and higher insurance fees. When loan financing is available, interest rates will be also higher in the beginning (caused mainly by high risk premiums) and the period for loan reimbursement required will be shorter. When an electricity purchase contract is available but the guaranteed contract length is short, the same amount of investment costs has to be recovered faster which raises sharply the requirements of price per kWh to be received. Similarly, when diffusion is in incipient phase and the industrial basis is in process of formation, it is likely that the costs of the various services needed along the life-cycle of renewable energy plants will be high. As the industrial basis grows, these costs are more likely to decrease especially under competitive pressure from developers who can become themselves specialised in such services.

4. *Resource quality and availability* is the fourth category influencing production costs for wind electricity. Resource quality is represented by the annual average wind speed [m/s] of available sites. Wind availability is expressed in terms of hours per year when the wind blows with speeds that allow the turbine to function at rated power.

Most turbine models start functioning at wind speeds of around 4 m/s, called the 'cut-in speed', and reach the maximum power for which they were designed only at wind speeds between 11 and 16 m/s. The maximum power is also called the 'rated power' of the turbine, and the specific wind speed at which this is reached is called the 'nominal wind speed' of the turbine. For wind speeds situated inside the interval defined by cut-in speed and nominal speed, the turbine functions at capacities below the rated power. When wind speeds increase above the nominal speed of the turbine, the conventional design technologies loose power and produce less kilowatt hours. More recently developed technologies are however able to continue functioning at the rated power at wind speeds above the nominal speed, being more efficient. But the

[1] Lauber, personal communication 6.09.2003.

efficiency of wind energy harnessing of a turbine is a more complex issue and it is influenced by more factors. For example the higher the hub height and rotor diameter are, the higher are the prospects that the efficiency of the turbine increases, provided that the rated power of the turbine is adequate for the annual average wind speeds of the site where the turbine is used.

We propose to conduct empirical research based on this differentiation of four categories of factors influencing production costs. The evolution of production costs per kilowatt-hour for wind electricity is influenced by the national resource potential and distribution, the support system put in place to help with market introduction, and a series of institutional and infrastructural national factors. Governmental influence on production costs may take place directly or indirectly - through the market and industrial developments stimulated by support systems. There could also be intentional and unintentional effects of governmental regulations. But some factors that are strongly affecting production costs are not liable for manipulation. They depend on resource availability, quality and distribution, being country specific and rigid variables. Table 2 presents a detailed overview of the cost factors to be empirically researched for each of the four categories. Comparing empirically found cost levels to those typical in other countries, policy recommendations can be made for measures and strategies towards cost minimization.

Categories of factors affecting production costs per kWh	Cost-factors
1. technology specific	Wind turbine and tower factory costs (€/kW) Turbine availability (in %) Turbine efficiency (kWh/m[2])
2. technology complementary (influenced by resource location) in (€/kW or %)	- Civil works (incl. construction of service roads) - Construction of foundations for wind turbines, pad mount transformers and substation - Transport of wind installation (turbine, tower, blades) and all necessary equipment - Electrical infrastructure[2] - Grid connection[3]
3. context induced cost factors → financing / trade factors * project life-cycle stages ~ administrative(-social) consent / tax expenses (in € per project or %)	→ Bank fees and Bank interest rates → Dependency on a certain investment recovery or loan reimbursement period * Wind resource assessment and analysis * Project development costs * Project management fees * Installation costs * Insurance costs * Maintenance and operation costs[4] * Transmission access and wheeling fees ~ Legal costs ~ Permit related costs (environmental studies, grid-approval etc) ~ Taxes ~ Land rent fees/costs
4. resource quality & availability	Wind speed average annual (m/s) Wind availability (h/year at nominal wind speed)
overall production costs / kWh	

Table 2. Detailed overview of cost factors for wind electricity production.

References

"Wind Energy - The facts" available at http://europa.eu.int/comm/energy/res/sectors/doc/wind_energy/ewea_the_facts.pdf

"Renewable Energy Sector in the EU: its Employment and Export Potential" by ECOTEC

[2] This includes: Construction and installation of wind speed and direction sensors together with communication capability to the associated wind turbines. Construction of operations and maintenance facilities. Construction and installation of a windfarm communication system supporting control commands and data flow from each wind turbine to a central operations facility. Provision of power measurement and wind turbine computer control, display and data archiving facilities. Integration and checkout of all systems for correct operation.

[3] This includes: Construction of power collection system including the power wiring from each wind turbine to the pad mount transformer and from the pad mount transformers to the substation. Reactive Power.

[4] Maintenance costs generally are grouped into three categories: 1. The costs of unscheduled but statistically-predictable, routine maintenance visits to cure wind turbine malfunctions. 2. The costs of scheduled preventive maintenance for the wind turbines and the power collection system. 3. The costs of scheduled major overhauls and subsystem replacements of the wind turbine.

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Information available at http://www.nationalwind.org/pubs/wes/wes11.htm.

European Commission (EC), Directorate of Energy, "Wind Energy - The Facts", Volume I – Technology", 1997, Brussels.

European Wind Energy Association, Information on wind technology available at the website http://www.ewea.org/scr/technology.htm in November 2001

V. Lauber, personal communication, 6.09.2003.

Appendix 1 (phase 1) –

The influence of three selected technical performances
on the production costs of wind technology

Based on an overview of technical literature we consider that three technical characteristics are relevant for the analysis of the influence of technology-specific factors on the production costs of wind energy systems[5]: the type of voltage regulation, rotor speed, and the type of generator. The voltage of the electricity that a wind turbine supplies can be regulated through two systems: pitch control and stall control. In pitch regulation the angle at which blades are positioned relative to the area described by the rotor's blades in their circular movement can be adjusted, either collectively or individually. But in a stall control system the angle is fixed during manufacturing.

The difference in performance is very important, as pitch control turbines are able to keep the voltage level stable when wind speed increases above the nominal level for which turbines are designed. In contrast, stall-controlled turbines experience reductions of voltage levels as wind speeds increase above the nominal speed, meaning that turbines will function below the nominal installed capacity for which they were designed. Under this design, "power is regulated by the progressive loss of rotor efficiency" (EC 1997), and the voltage control system is also referred to as 'control through aerodynamic losses'[6] (Avia Aranda, 2000: 24). The higher is the ability of wind turbines to stabiliz voltage, the higher the penetration of wind technologies in current grid electricity systems can be. In addition to this advantage, *pitch regulated machines are also able to generate more electricity in terms of kilowatts per square meter of rotor area*[7], since the voltage at which turbines generate power at winds above the nominal level does not decrease as in the case of stall regulated turbines[8].

The second technical characteristic that may influence cost performances is the speed of the rotor. At the end of 2000 there were three technological designs on the market: constant speed rotor, variable speed rotor and two-speed rotor. Technical literature indicates that the *most advantageous are the designs with variable-speed rotor and two-speed rotor because they are able to deliver power voltage of higher quality*[9]*, higher levels of electricity production, and to extract wind energy at lower wind speeds*[10].

[5] Besides they also influence the extent of micro- and macro-fluctuations brought by a wind energy system to the electricity grid to which it is connected.

[6] At the website of the European Wind Energy Association explanations are given over this alternative of power control. Stall control "is sometimes described as passive control, since it is the inherent aerodynamic properties of the blade which determine power output; there are no moving parts to adjust. The twist and thickness of the rotor blade vary along its lengths in such a way that turbulence occurs behind the blade whenever the wind speed becomes too high. This turbulence causes some of the wind's energy to be shed, minimising power output at higher speeds."
(http://www.ewea.org/scr/technology.htm available at 2.11.2001.

[7] Antonio Lara, MADE Spanish wind turbine manufacturing company, interview for "Las Energias Renovables", 4 November 2000, http://www.energias-renovables.com available at 31 October 2001).

[8] As the report of the European Commission mentions "Concern about power quality of stall regulated machines (also especially in the German market) has deterred some manufacturers, who supply medium size stall regulated machines, from continuing this design feature in their megawatt designs" (EC 1997).

[9] As a technical study explains (EC 1997), "Wind turbines result in fluctuations in real and reactive power, and hence in voltage level. Voltage fluctuations can cause consumer annoyance through the phenomenon of flicker where the light intensity from incandescent lighting fluctuates perceptibly. Variable-speed wind turbines generally produce significantly lower flicker than fixed-speed machines. Flicker can be an important issue for weak networks. Flickers and harmonics, and other related issues, come under the heading of power quality."

[10] Antonio Lara 2000; Menendez Perez 1998; EC 1997.

For variable-speed turbines, in order to maximise the benefits mentioned, a large range of variable speed is necessary, around a factor of 2,5 to 3.

In 1996, of all commercial wind turbine designs, 21 had variable-speed, 50 were based on two-speed rotors, and 40 models were relying on fixed-speed. In the first category, only about one-third of designs were using a wide range of variable speed, that is higher than 2,5. However, in terms of MW market share, constant rotor speed turbines were still dominating the market even in 2001. For the future, many manufacturers seem to continue favouring the two-speed option, since most of the large turbines with rated capacities above 1 MW are designed with two speeds for the rotor (EC 1997).

In terms of efficiency improvements, recent studies comparing the electricity output from three wind turbine designs reveal that "two-speed machines produce 6,4 % more energy per unit swept area at a wind speed of 6 m/s than a variable speed machine with similar ratings. At 10 m/s the two speed turbine produces only 1,6 % more" (Windpower Monthly, May 2000: 48). But, in its turn, the variable speed machine produces 10,5 % more energy at 6 m/s site, down to 5,2 % at 10 m/s than a constant speed turbine. Therefore, *at low wind speeds, the two-speed turbines have the best performances in terms of the capacity to harness wind energy (kWh/m^2), followed by variable-speed turbines. But at higher wind speeds the differences in efficiency performance are smaller.* Therefore it can be stated that two-speed and variable-speed turbines are able to generate slightly more electricity – all others equal – than turbines with constant speed design, improving the cost performances of wind energy systems.

The third technical characteristic relevant for cost performances is the type of generator that turbines are using. Two types have been used so far: the asynchronous and the synchronous generator. Asynchronous generators have the disadvantage that they need to consume electricity, especially at start and during low speed winds of low intensity (Menendez 1998: 92). For grid-connected installations this reactive energy comes from the grid itself and creates negative synergies with the impacts on grid management attracted by the intermittent and unpredictable nature of wind availability. But, still, asynchronous generators are a feasible option for grid-connected applications. Some manufacturers are even supplying their turbines together with compensation units, such as condensers, in order to minimise the effects of reactive energy demand (Lara, May 2001). However, when asynchronous turbines are used for stand-alone applications, it is necessary to accompany the wind installation by a special system that is able to generate electricity for the reactive demand of turbines. This system can be a diesel motor, an energy storage system or an accumulator, for example, but the economic disadvantage is that it can represent in the end 30 % of the total investment costs of a stand-alone wind-based electricity installation (Avia Aranda 2000), increasing significantly the production costs per kWh.

The best option for stand-alone applications is to use synchronous generators. In 1992, the German company Enercon launched its 500 kW E-40 synchronous model, which was also the first design to combine the variable rotor speed concept with the synchronous generator option, giving the company a strong international position. But, as De Vries (2001) explains "Enercon's success attracted a limited number of followers. To date, only one commercial competitor has emerged: Lagerway of the Netherlands. Other direct drive pioneers include Heidelberg Motor, Neptun, Genesys, and Siemens/Seewind, all from Germany. Newcomers to the field include Norwegian Swedish ScanWind, the Dutch H-Energiesystemen and the French Jeumount Industry." More recently, the Spanish Made manufacturer has also embarked in the use of this type of generator. Among the turbines with more than 1 MW commercialised around the world, synchronous-generator based wind turbines had a market share of 15 % (De Vries 2001).

In 1999, the first autonomous wind-park has been installed in Spain, through the cooperation of Enercon, the Canary Technological Institute and an industrial company of Las Palmas. The project consists of two Enercon generators of 240 kW each and proved to be able to maintain constant the voltage and frequency of electricity supplied to the isolated small grid, without need for additional load and for all wind speeds. But synchronous turbines are also better options for grid-connected applications than asynchronous turbines because, by avoiding the uptake of reactive energy from grid that causes voltage and frequency fluctuations, they avoid the disturbance of grid management. Consequently they deliver *higher levels of electricity production – all others equal – as compared to wind energy systems based on asynchronous generators.* An important note on this design is however that the equipment/technology specific costs are higher as compared to wind technology designs based on asynchronous generators (Ackermann and Soder 2002: 92; Kamp 2002). Their market adoption is therefore more likely in stand-alone application, as long as no technical specifications are made for the grid-connected wind systems.

Synchronous generators are also able to contribute to the lifting of the ceiling for grid-integration of wind technology that grid managers are so frequently warning about. The general director of the Spanish manufacturer Made argues[11], "Only the synchronous turbines are authentic generators, as a conventional power plants can be. (…) We believe that they are better options for the future because when the capacity of installed wind power increases considerably, distribution companies could place restrictions on the turbines that are not synchronous".

Consequently, wind technology designs with pitch control of voltage, and two-speed or variable speed rotor – all other things equal – are more likely to contribute to lowering the overall production costs per kWh of wind energy systems, compared to the other designs. Technology designs using synchronous generators are considered by many technical experts as superior from the standpoint of technical performances but they may have both increasing and decreasing effects on the overall production costs per kWh.

Phase 2 – Collection empirical data

Questions for data collection

Core questions

- What are the total production costs per kWh for the wind installation (€c/kWh)?
- What are the total investment costs for the wind installation (€/kW)?
- What is the annual electricity production of the wind installation (kWh/year)?

Questions investigating the influence of theoretically distinguished cost factors:

1. Questions investigating the weight of technology-specific factors in overall production costs:

a) What are the *factory costs per wind turbine* (including tower, turbine and blades) expressed as €/kW? Explanation: factory costs do not include transport costs and installation costs.
b) What is the technical *availability* of the turbine (in %)?
c) What is the *efficiency* of the wind turbine (kWh/m^2/year)?
d) What is the nominal wind speed of the turbines used (in m/s) - i.e the wind speed at which they reach their rated power? And what is the rated power of the turbine (i.e maximum power for which is it design)?
e) What is the cut-in speed of the turbine: i.e the wind speed at which the turbine starts to function?
f) What type of wind turbines are used:
- do they have constant speed rotor, variable speed rotor and two-speed rotor?
- do they have synchronous generators or asynchronous generators?
- do they have pitch control type of voltage regulation?

2. Questions investigating the weight of technology-complementary factors in the overall production costs.

These are influenced by resource location and are ideally expressed as % of total investment costs, or in €/kW installed. In the last resort the amount in € can also be helpful.

a) What is the percentage of the *civil works' costs* in the total investment costs per kW? (alternatively the costs in €/kW or € can be given). This should include: construction of service roads, the construction of foundations for wind turbines, of pad mount transformers and substations.
b) What is the percentage of the total *transport-related costs* in the total investment costs per kW? (alternatively the costs in €/kW or € can be given). This should include the transport of all elements for the wind power plant such as turbine, tower, blades and all necessary equipment.
c) What is the percentage of costs associated with the design, construction and installation of the *mechanical and electrical infrastructure*? This should include:
    - wind speed and direction sensors;
    - facilities for operations and maintenance;
    - systems for communication with the wind power plant, supporting control commands and data flow from each wind turbine to a central operations facility;
    - provision of power measurement; wind turbine computer control and data archiving facilities;
    - integration and checkout of all systems for correct operation

[11] Antonio de Lara, interview journal "Las Energias Renovables, 4 November 2000, on line at www.energias-renovables.com in November 2000.

d) What is the percentage of costs associated with the design, construction and installation of the *grid connection*? This should include the systems for reactive power, and the construction of power collection system (including the power wiring from each wind turbine to the pad mount transformer and from the pad mount transformers to the substation).

Observation: It is possible that interviewees have difficulties in reporting separately the costs of factors included in the mechanical and electrical infrastructure and of those considered as grid-connection costs (since the former may be seen as including the latter). In these case one cost figure can be reported for questions 2c and 2d.

3. Questions investigating the weight of context-induced factors in the overall production costs.

I. Details regarding financing costs:

a) Was a bank loan used to finance the project, or was the project financed only with equity by the owner(s), e.g. private finance, community finance, cash reserves of the company?
b) When a bank loan was used: was that a 'project finance loan' (loan guaranteed with the cash-flows from the wind installation, and or the wind installation itself)?
c) When a project finance loan was used:
  - what was/is the interest rate required by the bank (in %),
  - what is the debt maturity (deadline for paying the loan back to the bank entirely; in years),
  - what is the share of the loan in the total investment costs for the wind plant (in %, e.g. 80 % loan and 20 % equity), and
  - what were the banks fees required to analyze and approve and project loan (as % of total investment costs, or of total loan)
d) What is the price per kWh of wind electricity received for the wind plant?
e) Given the price per kWh of wind electricity the plant receives: what is the expected investment recovery period?

II. Costs incurred during different states of project life-cycle

a) What is the percentage of the *project development costs* in the total investment costs per kW? (alternatively the costs in €/kW or € can be given).
   This should include: wind resource assessment and analysis; costs for project feasibility analysis; project design costs; project management fees. Observation: this category does not include the costs for installation and construction of civil, mechanical, electrical infrastructures and grid connection because they have already been investigated under 'set 1' of questions.
b) What are the *insurance* costs (€/year or as % of total annual variable costs)
c) What are the annual *maintenance and operation* costs per wind power plant? (€/year or as % of total annual variable costs). Maintenance costs generally are grouped into three categories:
  - costs of unscheduled but statistically-predictable, routine maintenance visits to cure wind turbine malfunctions;
  - costs of scheduled preventive maintenance for wind turbines and the power collection system;
  - costs of scheduled major overhauls and subsystem replacements of the wind turbine
d) What are the costs related to access to the transmission (or distribution) *grid access and wheeling* the fees?

III. Costs related to the administrative(-social) consent and to tax expenses:

a) What are the costs incurred for getting the necessary *permits* to put the wind power plant into operation? (in % of total investment costs or €). This should include
  - environmental permit (studies, fees to the administration)
  - power generation permit (from the public authority in charge with approving generation capacity)
  - permit for grid-connection from the local utility
  - any other permits for national, regional or local public authorities
b) What is the level of total *taxes* paid by the wind plant owner (in % of annual income from wind electricity sale; or % from the price per kWh wind electricity received)
c) When land is rented: what is the level of the *land rent* costs (in % of annual income from wind electricity sale; or €/year per turbine)
d) What are the costs associated with the *legal procedures* for putting the wind installation into operation? (in % of total investment costs or €).

4. **Questions investigating the weight of resource quality and availability in the overall production costs.**
a) What is the average annual *wind speed* at the site of the wind installations in (m/s)?
b) What is the average annual *wind availability* (h/year at nominal wind speed)?

Comment for set questions (2) and (3.II): Whenever details on cost components included are mentioned (listed after 'should include'), these are mainly meant to make sure that data collection is uniform and comparable. Whenever it is possible to collect data also on the components of the cost factors, this is welcome. Ideally one should collect data with systematic measurements – for example only in terms of % of total investment costs, or only in terms of €/kW, unless another unit of measure is mentioned.

Phase 3: Analysis of collected data

The role of theoretically identified cost factors in the production costs of wind electricity in Austria, Italy, Slovenia, Switzerland and France

This chapter discusses the findings regarding the achieved and/or expected cost performances and factors influencing the production costs of wind electricity in four Alpine countries: Austria, Italy, Slovenia, and Switzerland. The key findings are summarized in Table 1. These findings are compared to data from a recent study of the European Wind Energy Association regarding the average costs in several European countries - Germany, Denmark, Spain and UK – in 2001/2. These are the countries were most of the European wind capacity has been installed so far.

Nevertheless, two important observations are necessary regarding the analysis performed for each of the four countries. Firstly, so far in the Alpine regions very few projects were realized. In mid 2004 there was yet no project in Slovenia, in Italy there were only two small projects, while in Austria only three projects were operating. In Switzerland, there were several very small projects and few small capacity wind power systems, but empirical data were only collected for three projects. The available cost data regarding these limited number of projects may not be representative for the projects that could/will be realized in these countries. Secondly, often, the first wind projects commissioned in a country have also important learning elements for many stakeholders interested in wind energy diffusion. Experiences with their development, construction and operation may have important lessons to teach to those that would be investing in wind power plants or in the industrial activities surrounding their functioning. Learning effects may have important consequences on the cost level of the different components discussed in this section. Therefore, these analyses should be rather seen as general orientation on the cost performances of wind projects in Alpine regions, and as points of departure for formulating expectations regarding how the various factors that may influence production costs are likely to de-facto affect the costs for generating wind electricity, for what reasons and what can be done to reduce their cost-increase influence.

Table 2 presents the average investment costs per kW in the four European countries with large wind capacity countries and the EU average costs. Table 3 gives the average percentage of various cost categories in the total investment costs as the EWEA study found for the same countries in the same years. In the third column of Table 3 we added up the cost categories according to the typology differentiated in the Research Methodology of Sub-package 9.2. This was meant to make easier a rough comparison of the situation in the four European countries of the EWEA study with the Alpine countries under the focus of this project. The chapter presents the findings per country in separate sections, which are each concluded with a series of policy recommendations to minimize production costs.

Categories of factors affecting production costs per kWh	Cost-factors Austria	Cost-factors Italy	Cost-factors Switzerland	Slovenia
Total investment costs €/kW	1160-1310 €/kW	1250 €/kW	Range 1200-1380;up to 2220 €/kW (1turb)	Expected low-moderate
1. technology specific	Range 845 - 1015 €/kW; 2 projects: 880 and 767 €/kW;	No data (demonstration technology)	721 €/kW; 1000 €/kW; 1513 €/kW;	Expected low

2. technology complementary (influenced by resource location)	Modest - high ~ 170 €/kW (Plankogel) & ~ 334 €/kW (Oberzeiering) i.e. 27 % and 17 % of IC	No data	Very high: 312,5 €/kW (26% IC); 313 €/kW (24,4 % IC); 494 €/kW (22,2% IC)	Expected low(er) 1st diffusion wave of 150 MW, and more expensive later
3. context induced cost factors → financing / trade factors → project life-cycle stages → administrative(-social) consent / tax expenses	 → ' business as usual' → typical / not inflated → high land rent and royaltee fees (expected)	 → possibly high → likely not inflated → not clear yet	 → high → high	 → likely normal → unclear → rents normal; royaltee unclear
4. resource quality & availability	High annual production	Wind resource still under mapping		Quality studies - questioned
Overall production costs €/kWh	No data	No data	8,5 - 13 - higher €c/kWh	No data

Table 1. The influence of cost factors of the production costs of wind electricity in four Alpine countries.

Countries	Total investment costs
Spain (850 kW turbines)	~ 990 (€/kW)
Denmark (1000 kW turbines)	~ 9100 (€/kW)
Germany (1280 kW turbines)	~ 1200 (€/kW)
United Kingdom (1300 kW turbines)	~ 1110 (€/kW)
United Kingdom (1750 kW turbines)	~ 1000 (€/kW)
Spain (1500 kW turbines)	~ 910 (€/kW)
EU-15 average	875 - 1250 (€/kW)[12]

Table 2. Total investment costs per kW in several European countries. Source: European Wind Energy Association, 2004, "Wind Energy: The facts, Volume 2 - Costs and Prices", page 99.

Cost components for investments costs/MW	Share of total costs, %	Share for cost-categories
Turbine (ex works)	74-82 %	Technology specific costs: 74 - 82 %
Foundation	1-6%	Technology-complementary costs: 5 - 29 %
Electric installation	1-9 %	
Grid-connection	2-9 %	
Road construction	1-5 %	
Consultancy	1-3 %	Context-induced costs: 3 - 11 %
Land costs	1-3 %	
Financial costs	1-5 %	

Table 3. Cost Structure for a Typical Medium Sized Wind Turbine (850 kW – 1500 kW). Based on data from Germany, Denmark, Spain and UK for 2001/02. Source: European Wind Energy Association, 2004, "Wind Energy: The facts, Volume 2 - Costs and Prices", page 98.

I. AUSTRIA

Wind electricity production in Austria reached 1 % in 2003[13]. However, in mid 2004 there were only three wind projects operational in the Austrian Alps:

- Oberzeiring: 11 Vestas turbines of 1,75 MW each (V66, with 66 m Diameter rotor; 60 m hub height) with total 19,25 MW, located at 1950 m altitude. Started operation September 2002. Operator/Owner: Tauernwind Windkraftanlagen GmbH. The annual production is reported to be 39.000 MWh by the state energy association LEV, supplying almost 10.000 households. The brochure of WEB Windenergie EG (holding 20 % ownership in Tauernwind Windkraftanlagen GmbH) reports in its brochure an annual production of 45.000 GWh/year, which represents 0,8 % of the electricity consumption of Styria (see www.tauernwind.com). In 2004 there were plans to expand the Oberzeining project with 2 new turbines.
- Prabichl: 1 turbine Enercon E40/6.44 of 600 kW with annual production of around 1200 MWh/yr production. Started production in December 2001. Individual owner Rudolf Schartner. Commercial project.
- Plankogel: 1 turbine Neg-Micon of 750 kW, D = 44 m, with around 1,50 GWh/yr annual production, started in May 1999. Operator/owner: ARGE Almwind GmbH.

[12] Source "POTENTIALS AND COSTS FOR RENEWABLE ELECTRICITY GENERATION A data overview", by M. de Noord, L.W.M. Beurskens, H.J. de Vries, ECN Raport ECN-C-03-006, February 2004.
[13] Brochure "Windenergie: Ja! Aber?".

There are four states in the Austrian Alpine region: Styria, Salzburg, Tyrol, Vorarlberg. All above-mentioned projects are located in Styria. In 2004 no new projects were put into operation in the Austrian Alpine region, while in the rest of country 140 MW were expected to be built (in mid 2004) by the end of the year. In Salzburg, it is expected that a three-turbine project will get permission by the end of 2004.

According to an industry insider, experience so far in Styria points to a range of total investment costs of (roughly) 1200 – 1300 €/kW for Austrian Alpine wind projects. According to IG Windkraft for the state of Styria, investment costs could range between 1160 €/kW and 1310 €/kW[14]. A study of the European Wind energy Association found out that in 2001/2 the average total investment costs per kW in several European countries - Germany, Denmark, Spain and UK, countries were most of the European wind capacitty is installed - ranged typically between 900-1200 €/kW (see Table 2). Therefore in Styria, total investment costs are - and expected to remain - considerably higher than the average costs in Europe. This is important to keep in mind as in the following sections the discussion is sometimes carried out in terms of percentages of various cost components in the total investments costs. As costs in Austria are compared to those in other European countries, a certain percentage of total investment costs in Austria is likely to imply a higher cost in Euro than the same percentage in another country.

No information was available regarding the average production costs per kWh for the three projects. Below, the cost aspects are discussed per category of factors affecting production costs per kWh, based on interviews with industry experts in Salzburg and Styria.

I.1. Technology-specific costs

The energy association LEV (Landsenergieverein Steiermark) offers potential wind investors cost guidelines to prepare their projects. LEV indicates that equipment costs can be procured in the range of *845 €/kW - 1015 €/kW for turbines* between 600 kW and 1500 kW (as orientative costs – this includes factory costs, transport, erection works and transformer). In the same time it is considered that in Styria investment costs could range between 1160 €/kW and 1310 €/kW, which means a share of 73 % - 78 % for technology-specific costs[15]. This spreads on a large part of the range considered typical in Spain, Denmark, Germany and United Kingdom by 2001/2 (74 % - 82 %) but as noted earlier the same percentages mean higher costs in €/kW. In the four EU countries the range of technology-specific costs is between 720 – 900 €/kW, with most of the recent turbine models (hence including turbines of > 1 MW) below 800 €/kW.

For the Oberzeiring project, the total investment costs were 23.864.166 € for the 19,25 MW, which means 1240 €/kW. Equipment costs represented around 71 %, that is around *880 €/kW* (WEB Windenergie EG brochure). The lower share in the total investment costs is mainly due to the higher-than typical technology-complementary costs, as a result of construction a 22 km grid line for connection. For the project Plankogel (1 turbine) the equipment cost had a higher share in the total investment costs, i.e. 78,3 %[16], which means 767 €/kW.

In the Research Methodology section it was considered that in the first stages of market introduction the technology-specific costs of wind projects are likely to be high. It appears that indeed, in Styria they have been so far quite high. In Table 4, we show some comparisons of turbine equipment cost ranges for several European countries based on a different study (Dinica 2003). It can be observed that the range of these costs is still higher in Styria, by 2004, as compared to Spain, United Kingdom in 2000, but they are comparable to those recorded in the Netherlands in 2000[17].

Country	Technology-specific costs
Netherlands	In 1990: on average 1100 €/kW In 2000: from 730 €/kW up to 900 €/kW
Spain	In 1990: on average 950 €/kW; In 2000: from typically 630 €/kW up to 750 €/kW [18]

[14] From brochure "Leitfaden zur Errichtung von Windkraftanlagen in der Steiermark" of the Landesevergieverrein Steiermark, 2004 (see also www.lev.at and www.ecowatt.at).
[15] Idem 3.
[16] Idem 3.
[17] In Austria wind technology is mainly bought from Germany where the wind turbine market has been slowing down in the last years (Winkelmeier, 2004).
[18] Lowest technology specific costs in Spain are 540 €/kW (Dinica 2003).

United Kingdom	In 1990: on average 1000 - 950 €/kW; In 2000: from 650 €/kW up to 770 €/kW
Styria	By 2004: 845 €/kW - 1015 €/kW (Oberzeiring project ~ 880 €/kW; Plankogel 767 €/kW)

Table 4. Comparing wind turbine equipment costs for several European countries.

As discussed in the Research Methodology section, certain technical characteristics of wind technology also influence the cost performances, in terms of production costs per kWh. There are three types of wind technology installed in Styria:

- 11 turbines Vestas with 2 speed rotor, pitch control of blades, asynchronous generator;
- 1 turbine Enercon with pitch control of blades, variable speed rotor, and multipol generator, i.e. neither synchronous nor asynchronous;
- 1 turbine Neg-Micon with 2 speed rotor, stall control of blades and asynchronous generator.

Experts consider that in mountain regions it is better to use technologies that have a pitch control design. In the Appendix 1 of the Research Methodology of Sub-package 9.2 it was concluded that wind technology designs with pitch control of voltage, and two-speed or variable speed rotor – all other things equal – are more likely to contribute to lowering the overall production costs per kWh of wind energy systems, compared to the other designs. Consequently, the technologies used so far in Styria belong to the category of designs able to deliver higher levels of wind electricity production.

However, this may not necessarily have been a deliberate choice. Unless previous/specific links exist between the manufacturer and the project developer, there is typically competition among manufacturers, that is, for each project a call of tender is organized. But the mountainous geographical conditions restrict the number of manufacturers that are technically able to install suitable technology at high altitude. Besides, bidding and technology selection are also influenced by hub height limits in permits.

So far, experts consider that the more suitable designs are Vestas and Enercon. Some potential developers have the intention to use in the future General Electric wind turbines, which are expected to assume lower technology-specific costs per kW. All three technologies have stronger generators able to face the strong wind speeds at high altitude. But for all designs, the altitude and icing problems remain technical challenges, potentially increasing the technology-specific costs considerably.

In conclusion:

- the technical characteristics of the turbines used and intended to be used are favorable to lowering the overall production costs, as they produce wind electricity more efficiently; however,
- the equipment costs are already higher than in other European countries and are likely to continue to increase due various adaptations to the wind technology so that optimal operation in Alpine wind regimes and icing conditions can be ensured.

I.2. Technology-complementary costs

In the Research Methodology section it was proposed to collect empirical data considering the following cost components as part of the technology-complementary cost component: civil works (incl. construction of service roads); electrical infrastructure; grid connection; construction of foundations for wind turbines, pad mount transformers and substation; as well as the transport of wind installation (turbine, tower, blades) and all necessary equipment. The relationship between resource location (considering the entire technically feasible potential that is environmentally-sound to harness) and the availability of road and grid infrastructure of corresponding quality. A study of wind energy experts and supporters of wind development in Styria indicated that the available technical potential would allow the construction of around 70 turbines (Fruhwald and Ulz interview May 2004), while the journal of LEV (spring 2004; see www.lev.at) published a list of planned projects that sum up to 59 turbines (hence 46 new turbines). The details regarding the planned project are reproduced in Table 5.

Location	Turbine size kW	Number	Total capacity MW	GWh Annual production	% Styria elec. consumption	CO_2 t/year substitution	Households supplied, no.
Plankogel	750	1	0,75	1,50	0,02	1290	375
Prabichl	600	1	0,6	1,08	0,01	929	270
Oberzeiring	1750	11	19,25	38,50	0,46	33110	9625
Spitaleralm	1750	2	3,5	6,65	0,08	5719	1663

Moschkogel	1800	5	9	17,10	0,21	14706	4275
Kreischberg	1750	5	8,75	16,63	0,20	14298	4156
Frauenalpe	1750	5	8,75	16,63	0,20	14298	4156
Rossalm	1750	6	10,5	21,00	0,25	18060	5250
Steinriegelalm	1300	10	13	23,40	0,28	20124	5850
Planneralm	600	2	1,2	2,16	0,03	1858	540
Hochwechesel	1650	6	9,9	19,80	0,24	17028	4950
Weinebene	1750	5	8,75	16,63	0,20	14298	4156
Summing up	-	59	93,95	181,07	2,17	155.716	45266

Table 5. Realized and planned wind projects in Styria (status end 2001 – reproduced from LEV Spring 2004, “Leitfaden zur Errichtung von Windkraftanlagen in der Steiermark”, page 12).

Technology-complementary costs depend on the distance from project site to the grid, the number of windmills in the project and the capacity of the grid to accept the wind electricity. When grid connection is far, the current (mid 2004) level of governmental price support in Austria implies that the project needs to have around 9 / 10 turbines in order to be economically interesting. However, if the available grid is weak, only a limited number of turbines may be attached to it. A project with a higher number would need to construct extra new grid infrastructure, which may add to the total investment costs to an extent that makes the wind project no more economically feasible (under the 2004 price support level). One project in Styria has already been affected in this way, as the quality of the existing grid only allowed for the connection of 2 turbines. However it is important to note that in Austria, when the electricity grid is weak, there is a limit of 12,5 MW per energy project.

In Styria the transport and construction costs are higher than in flat areas - and possibly even other mountain sites - because the good wind locations are especially in places where there are no roads that can be used to transport the technology and ensure maintenance of the plant. In some places there are some bad roads used to transport biomass but they are not adequate (wind towers parts may be even 30 m long and quite large diameter; blades are also long). At present the actors investigating the potential of wind power in Styria have only selected sites for possible new projects in places where there are already good roads available and an adequate electricity transport grid is in the neighborhood. Some sites with good wind potential have already been excluded from prospective studies because there is no/inappropriate road.

Experience so far shows that indeed the technology-complementary costs are high in Styria. For the Oberzeiring wind project, a 22 km long grid connection line had to be built, which has put quite some pressure on the investment. The costs for civil works (incl. construction of roads), electrical infrastructure and grid connection amounted to 6.434.000 €, that represents around 27 % of the total investment costs (WEB Windenergie brochure). This comes down to around 334 €/kW. For the project Plankogel (1 turbine), the technology complementary costs accounted for 17,3 %, that is 170 €/kW[19]. For comparison, the average technology complementary costs in Germany in 2001 were around 210-230 €/kW which includes foundation, grid-connection and infrastructure (EWEA 2004: 98&99). In Table 3 it can be observed that for the four countries of analysis selected in the cost report of the EWEA, the range of the technology-complementary cost category is very large (5 - 29 %). However the two projects in Styria for which data is available belong to the upper part of the European average range.

Consequently, a series of situations can be distinguished in the Alpine regions from the standpoint of the relationship between resource location and the availability of road and grid infrastructure, as mentioned in Table 6. The table gives also a quantitative estimation of the weight of technology-complementary costs in the overall production costs per kWh, with:

(*) suggesting low weight;
(**) suggesting moderate weight;
(***) suggesting high weight;
(****) suggesting very high weight.

Project size	Location relative to (adequate) grid and road infrastructure	Cost weight
Small project (< 5 MW)	Close to grid and adequate roads	(**-***)
	Far from grid (long grid lines needed)	(***-****)
Moderate size project (5 - 12,5 MW)	Close to adequate grid and roads	(**)

[19] This includes: fundament costs; **zuwegung (??);** network connection and transformer station; computer and telephone connection costs Source: brochure “Leitfaden zur Errichtung von Windkraftanlagen in der Steiermark” of the Landesevergieverrein Steiermark www.lev.at and www.ecowatt.at, page 12, Table 2.

	Far from grid (long grid lines needed[20])	(**-***)
Large size project (> 12,5 MW)	Close to adequate grid and roads	(*)
	Far from grid (long grid lines needed) and adequate roads	(**-***)

Table 6. Weight of technology complementary costs according to project sizes and location relative to (adequate) grid and road infrastructure

As an illustration to the qualitative estimations made in Table 6 it may be mentioned that the technology complementary costs of the Plankogel imply an approximate cost[21] of 0,85 €c/kWh, while for the Oberzeiring project of 19,25 MW this was in the range[22] 1,43-1,67 €c/kWh. Hence, it is apparent that in these cases the cost pressure posed by technology-complementary costs on production costs per kWh is larger for the large project Oberzeiring (high weight; location: far from grid) than for the small project Plankogel (moderate weight).

The projects mentioned in Table 5 are all in the range of 1,2 – 13 MW (or 2 to 10 turbines). Interviewed experts mentioned that the projects that are given priority for investments are those for which the technology complementary costs are lowest. This implies that the cost weight of this category is likely to be moderate for these projects. But if the social and political obstacles to investments are removed and more projects go ahead, the impact of this cost component in the overall production costs will continue to increase.

I.3. C*ontext-induced cost factors*

In the Research Methodology section, three categories of context-induced cost factors were differentiated:

- monetary consequences of financing and trade arrangements;
- expenses in project life-cycle, and
- expenses incurred in relation to (local) administrative and social approval.

For the project Plankogel (1 turbine) the following costs split corresponding to this category has been recorded: planning costs 3 %; other costs 1,4 %; variable costs are 4-5 % per year. (This is next to the equipment costs 78,3 % and infrastructure costs: 17,3 %.). For the other 2 projects in Styria such detailed information were not available. In the following three sub-sections we discuss the empirical information for the three categories of costs.

I.3.1. Monetary consequences of financing and trade arrangements

The Overzeiring wind project was based on the following financing arrangement:

- 15,29 % equity by community members;
- 75,55 % bank project finance loan;
- 5,94 % investment subsidy from Austrian government;
- 4,88 % investment subsidy EU; and
- 0,4 % regional government subsidy via Altener. (Source: WEB Windenergie brochure).

The financing of the Plankogel project took place as follows[23]:

- 19 % equity finance by community-based fund (Bürgerfinanzierungsmodell)
- 31 % bank project finance loan;
- 28 % investment subsidy from Austrian government;
- 22 % regional government subsidy - Land Steiermark.

The interviewed experts explained that, in Austria, banks are open to approve project finance loans for wind project but they ask also the financial contribution of people in the area of project location[24]. They should develop a bond system that can provide equity in the capital structure. This involvement is also seen as a guarantee of no/little obstacles from local opposition to the project proposal. But the equity requirement of banks is still quite high: the minimum may be between 20 % - 40 %. Nevertheless, as long as the equity

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[20] If a transformer station needed to connect to high voltage grid, this adds ~ 6 million € or more (anonymous investor). For projects > 5 MW, grid connection to medium / low voltage grid does not ensure proper functioning of the wind power systems.

[21] The 170 €/kW technology complementary costs of the Plankogel are associated with a one turbine of only 0,750 MW, which produces 1,50 GWh/yr wind electricity. The cost per kWh for this category was estimated as: technology complementary costs of 127.032 € divided by per annual electricity production and by assumed 10 year investment recovery period.

[22] The Oberzeiring project of 19,25 MW incurred 334 €/MW technology-complementary costs and generates between 39,00 - 45,00 GWh/yr. This implies a cost of 1,43-1,67 €c/kWh. The cost per kWh for this category was estimated as in the above footnote.

[23] Idem 3.

[24] Further, it appears that the availability of project finance loans in Austria is not constrained by the type of technology, like in Germany e.g. where it may be easier to finance projects using German technology than foreign technology plants.

providers do not require (very) high returns on the unit of equity investment this would not imply necessarily the increase of the calculated overall production costs per kWh[25]. The equity capital of the fund is split in shares and one can buy various numbers of shares. The equity return is 7 % pre tax. For good wind sites, 10 % equity return or higher is possible under the 2004 feed-in tariff.

The level of interest rate is considered 'normal' as for any other business area, while debt maturity is 13-15 years in Styria. This debt maturity length is typical of other business areas as well, such as investing in the construction of a building[26]. However the expectation for Salzburgerland – where there are no projects yet – is that this could be around 8 to 10 years, which may require higher governmental price support per kWh to pay the debt in a shorter time. It is expected that the interest rate in Salzburgerland will be around 4 %, which is considered 'business as usual'.

As regards the monetary consequences of trade arrangements, in Austria owners receive governmentally guaranteed contracts for 13 years for the feed-in tariff of 7,8 €c/kWh. There is confidence in politics that if regime changes this will not affect already made investments. After having benefited of that, wind projects will get the market price of 3,4 €c/kWh. But they may also be linked to the voluntary green electricity market where they may get a green premium that depends on the consumers' willingness to pay.

In the theoretical part of the project it was explained that there are three ways financing and trade arrangement have negatively impact on the overall production costs:

- too high interest rates on project finance loans, compared to other business opportunities; this proved not to be the case yet in Austria;
- the equity requirement of investors is too high because of increased equity contribution and/or too high project risks; for the time being the interested investors do not have high cut-off equity requirements, hence this does not yet have an impact on the calculated overall production costs per kWh; an equity range 7-10 % can be considered as 'normal' / typical for many other business options;
- the debt maturity period required by banks is too short as compared to the period of (governmentally guaranteed / privately ensured) contract for the sale of wind electricity; this has not been so far the case in Styria but it may happen in Salzburgerland or other Austrian states as long is there is no coordination with financing agents during policy implementation by public agents;

Consequently, although theoretically expected high, there appears to be no negative impacts on the overall production costs as consequence of the financing and trade arrangements concluded under the price support system applicable in 2004.

I.3.2. Expenses in project life-cycle

The energy association of Styria, LEV, gives potential wind investors cost guidelines to prepare their projects. As regards the expenses in project life-cycle, LEV (2004: 40) indicates that - as orientative costs - planning costs could be between 2 - 4 %, and project development costs between 1 - 1,5 % of total investment costs. Next to this, there are also management costs, of around 1 %. Separately, one needs also to calculate wind measurement costs. For measures up to 25 m, costs of 3640 € are usual. For measures up to 60 m, costs may climb to 18170 €/year[27]. From the LEV data it is not clear how much this would represent as percentage of investment costs per kW. Other costs associated with this category may account for 1 - 3 % of total investment costs. This implies a range of between *5 % and 9,5 % for the services of designing and putting into operation a wind project* (not including the percentage for wind measurement costs). This is a range found typical in the United Kingdom during the 1990s, while in Spain by 2000 this was around 5 % (Dinica 2003: 533).

Detailed information for the three projects operating in Styria were not available for all components of this cost-category. It is known only that for the Oberzeiring wind project, the planning and construction management assumed 2,15 % of investment costs (Tauerwind brochure), while for the Plankogel project wind measurements accounted for 0,5 % and project development costs accounted for 1,5 % of total investment costs (LEV 2004). The level of these components is comparable to that found in the United Kingdom, where the British Wind Energy Association estimates that for a project of 5 MW, the expenses for project management, development costs and installation are around 3 % (www.bwea.com). The EWEA study refers only to 'consultancy' in its cost analysis, which is considered to range between 1-3 % (see Table 3). It

[25] In Austria citizen participation is very good in equity pooling by means of limited liability company; this assumes the deposit by investors of a capital, while not participating in management.
[26] Arrangements can be done e.g. in the 2-3 years only the interest rate is paid (5 years for constructions) and after that the debt starts to be paid as well (Fruhwald 2004).
[27] Idem 3.

is not clear to what extent the services mentioned in the above paragraph have been included as ‘consultancy’, which makes comparisons difficult.

As regards, Maintenance and Operation costs, experience in European countries suggests that they are in the range of 2-4 % in the 1st year but they may go up to 5 % later. After 10 years these costs may increase to 6-7% (Fruhwald 2004, EWEA 2004). In alpine regions M&O costs are typically higher due to more difficulty in the accessibility of sites and frequent icing problems[28]. As for the insurance, for small projects such as those likely to emerge in the Austrian Alps, the insurance may be around 0,2 % of yearly project income, which is a typical share for projects in other European countries as well.

In the Research Methodology of Sub-package 9.2 it was hypothesized that the project life-cycle cost-category may have a higher than usual weight in the overall production costs per kWh in the early stages of market introduction of wind technology, with possible decreasing trend as diffusion continues. However it can be observed that the cost components in this category are comparable to those in other countries, which the exception of M&O costs – due to geographical conditions. The fact that services in this category have typical prices is also due to the fact that currently there are sufficient companies offering such services (see Table 1 in the Empirical Analysis Section of Sub-package 11.5). This creates some competition enabling (potential) investors to ‘shop around’ for good price services.

I.3.3. Administrative(-social) consent / tax expenses

We considered that this cost-category includes: land rent costs; permit-related costs (environmental studies, grid-approval etc); legal costs; taxes.

In the Eastern part of Austria, the Wind Energy Association WEA has recommended investors to offer 1,2 – 2,5 % of project income per year as land rent fees and, because there is sufficient competition between land owners, it has been possible to keep the fees in this range. Project owners pay a land rent fee based on the “per turbine formulas”. A 1,5 % rent per turbine may represent in upper Austria up to 5000 €/turbine. In Spain the typical practice is also 1,5 % of annual income, while in Colorado (United States) land rents are typically in the range of 2000-5000 $/turbine. For the Alpine regions, the Wind Energy Association WEA suggested investors to offer 1 – 1,5 % of project income per year, but in practice this has actually increased to 4 – 5 % because there are only few suitable sites at distance of each other and land owners can afford to keep prices high. In Styria, for land rent there is a combined formula: there is a fixed price per unit of land, which is combined with a value derived from the annual production and income from wind electricity calculated as €c/kWh produced (Fruhwald 2004). The interviewed experts mentioned that there is a clear trend of price increase for land rent in the Alpine region.

As regards permit-related costs, they can be divided in ‘official’ and ‘unofficial’ costs. Unofficially, in Styria the municipality gets royalties from the income of wind projects, in the form of cash payments for the local needs. In the flat areas of Austria, royalties are also given to local authorities. They are linked to changes in Regional Planning permits. These permits are crucial because only after they have been secured may all the other permits be asked: air impact, security issues, nature protection, utility grid connection etc. The royalties are considered as ‘voluntary contributions’ for ‘using local/regional roads/facilities’ or contributions for the lighting of the community. This is a practice applied for a longer time by Austrian energy utilities for the construction of regional power plants of any fuel/technology type. It is reported that royalties increase every year. Currently project owners pay between 1000-2000 €/turbine per year. In the Alpine areas, higher royalties are expected by municipalities given also the difficulty of finding techno-economically suitable sites and socially acceptable locations for wind harnessing. However, in other countries royalties are even higher, especially in Spain and increasingly frequent in the United Kingdom (Dinica 2003).

As regards the formal permit costs, the energy association of Styria, LEV, gives again potential investors price guidelines to prepare their projects. LEV indicates an orientative cost for nature and landscape permits of 5800 – 11.000 € per project. When the windpark is in a nature protection area and is larger than 5 turbines, a permit is necessary from the National Government of Syria[29]. This requires an Environmental Impact Assessment study which often adds substantially to project investment costs. This study is required also when the project is larger than 10 turbines or 20 MW, no matter its location. Further LEV indicates that the cost range for land investigation is 1820 – 3300 €, while for noise permits and analysis of shadow effects (Schattenwurfverträglichkeit) it is around 1240-2200 €. No indication is suggested for the costs for the

[28] Enercon has a subsidiary company only for maintenance in Lower Austria, and Vestas has one subsidiary in Styria to serve the Oberzeiring project.

[29] It is not allowed to commission wind projects in ‘ free areas’.

construction permit process. This leads to a range of 8900-16500 € plus the construction permit costs and eventually permit costs for a nature protected area.

Further, as regards the legal costs, these are considered as 'business as usual'. Investors so far have not encountered too high costs on legal documents and studies, as it happened for example in the United Kingdom where they often represent 1-2 % of total investment costs. Similarly, the tax regime is the same as for any other business option in the Alpine regions. Investors pay the typical company taxes and are not required by local authorities to pay supplementary taxes. The VAT for selling electricity to utility is 20 %. (Winkelmeier 2004). Consequently, Alpine sites are more expensive than flat areas of Austria because of higher royalties expected, higher land rent per turbine, possible higher permit costs when nature-protection permits are needed. The rest cost subcomponents are 'normal'.

I.4. Resource quality and availability

The cost components discussed above - technology-specific costs, technology complementary costs and context-induced costs - make up and can be discussed as percentage of the total investment costs per kW. However the influence of resource quality and availability on the overall production costs per kWh is of different nature. The higher the wind speeds and annual availability of wind speeds in the range cut-in speeds / cut-off speed, the lower the production costs per kWh - given wind projects of the same size, technology and investment costs per kW[30].

In Styria the best wind sites for projects are at 1500 m, 1800 m or higher – where wind potential is as good as in the Danish coast. However there is an important difference between the wind regimes in Alpine and flat areas. In Alpine areas, wind quality and availability differs very widely for nearby locations (complex wind patterns, in complex terrain). For example in Oberzeiring there are 11 turbines, but 2 turbines are in the best places from the standpoint of wind regime, while in few spots of the wind park there are constraints on wind speeds all year round. Although a wind map for Styria already exists, energy experts in the region are still learning from the currently running projects with regard to turbines locations and wind regimes in high mountain sites.

The wind electricity output in Alpine areas is approximately the same as in flat areas, but with very different distribution in terms of time availability of various speed ranges, as it can be observed in Table 7. This leads to situations were a project in the flat part of Austria produces at a mean annual speed of 6,3 m/s an amount of electricity around two thirds of what a project in the Alps yields for a mean annual speed of 6,2 m/s. This is because even if wind availability is smaller in terms of % of annual hours, when wind blows it is much stronger, with wind speeds that produce more electricity.

Examples wind speed availability [in % hours/year]	< 4 m/s	4 – 12 m/s	13 – 18 m/s	> 18 m/s
flat area	22 %	70 %	8 %	0
Alpine area	44,4 %	39 %	14 %	2,7 %

Table 7. Examples wind speed availability for two representative sites in Austria.

In Table 7, data translate in an annual availability of wind speeds that allow the operation of turbines at:
- installed capacity for around 1500 h/year (turbines with pitch control of blades[31] operate at installed capacity even when wind speeds increase above the nominal levels of typically 13-16 m/s, e.g max. 1 MW);
- below installed capacity for an average of 3416 h/year (at wind speeds below 4 and 12 m/s).

Consequently, in the Austrian Alps the wind quality is good which leads to high electricity production. However its distribution on an annual, monthly and daily basis is very different from that yielded in a flat site. When the governmental price support system rewards wind electricity production based on a price/time-

[30] At few locations in Europe, the combination of wind resource and availability, technology choice and project design has already led to production costs that are competitive with conventional electricity technologies without price support. For example in Spain, in 2000 wind projects using turbines of 600-660 kW rated power (in the lowest cost band), at sites with annual average wind speeds of at least 8- 9 m/s (at 10m height), and annual availability of nominal wind speeds above 2400 h/year could generate electricity at around 4 - 4,2 €c/kWh, when it was possible to minimize technology complementary costs and the impact of context induced factors. Having in view that the average cost of coal-based electricity in Spain and the average market pool price were around 4 €c/kWh, it can be therefore said that for specific resource-technology niches, cost-competitiveness was achieved in Spain in 2000. Beside this cost-competitive niche, there was also a chunk of potential that was economically feasible with the price support available in 2000. Taking into account that the legally guaranteed price in since 1995 was in the range of 6,3-7 €c/kWh, market experts mention that sites with wind speeds above 6 m/s and a minimum annual availability of 2000 hour per years were economically feasible in this period (Menendez 1998: 97; Cruz 2001; Lopez 2001). But this does not mean that automatically all sites with such characteristics could be developed into wind plants. Factors in the technology complementary category and/or context induced category were often making such sites not profitable.

[31] See Appendix 1 of Research Methodology Sub-package 9.2 for explanations.

of-(expected)delivery scheme that does not match the time-of-production scheme this may have negative impacts on the economics of a project, making it even unfeasible.

I.5. Financial public support[32]

Before making policy recommendations on price support it is necessary to understand the short history and current situation regarding the financial federal and state-level support for wind electricity.

2000-2002, 2003-

After a reform of the electricity sector, the use of renewable energy resources has become a subject matter for the nine provinces to regulate. However the price regulation has been very complex because of the differentiation for delivery moments (time-of-day and season), the renewable resource type, the size of installations etc. Many stakeholders considered it a deficient piece of regulation. In addition to feed-in tariffs, investment grants could be obtained from both the provinces and the federal government (Environment Ministry). For wind electricity, the feed-in-tariffs varied from one province to another. They have been considered as generous, leading to a wave of new plans for wind farms in the flat part of Austria. However, they have to go through a complex and time-consuming process of administrative permitting. Only those that have been accepted at the end of 2002 are eligible to get the old feed-in rates. The exact levels per state and time-of-delivery are mentioned in Table 8.

€c/kWh	S-HT	S-LT	W-HT	W-LT	average
Salzburg: < 2 MW	8,28	8,28	8,28	8,28	8,28
> 2 MW	3,71	3,06	5,23	4,72	4,22
Tirol	8,28				8,28
Vorarlberg	10,9				10,9
Steiermark	5,96	5,31	11,85	8,79	8,22

Table 8. Price support in the Alpine regions of Austria until the end of 2002. (Source LEV 2004)

After being strongly criticized as being too expensive, the support system suffered adjustments. The new energy authority E-Control - playing the role of regulator as a result of liberalization - and the Ministry of Economic Affairs supported a proposal for a lower price while the Environment Ministry claimed that innovative wind farms such as the one by Tauernwind in Oberzeiring need support anyhow. The compromise led to a uniform feed in tariff of 7.8 €c/kWh.

It was also decided that, there should not be any investment grants, but in practice this is sometimes bypassed. For example in Styria, some small subsidies may be given for wind measurement costs from the Regional/State Government (5000 €, which is around 50 % of wind measure costs for 1 year[33]). There are no tax reductions/exemptions for wind electricity generation.

2003-2004/5

During these years, very few wind farms were able to get the permits in time in order to secure the higher old tariffs. Nonetheless there was a strong wind boom in 2003 at country level. The installed capacity raised from 139 MW at the end of 2002 to 415 MW at the end of 2003. This has drawn an anti-wind reaction in some areas (especially in tourism areas). In Carinthia, near-Nazi populist Jörg Haider, governor of the province, vetoes a routine increase in compensation (he can do this as the conference of governors has certain functions in setting rates) and thus exposes many wind farms to commercial risks (the new ones could not get a commitment from the utilities). There is also a reaction from the Industrialists' Association, the Federal Chamber of Commerce and the Federal Chamber of Labor (among the most important corporatist institutions), who argue that consumers need to be protected and that the rates for wind energy are still excessive.

In mid 2004 it was widely expected that soon there will be another price reform at national level. This is likely to take the form of another rate reduction and possible an upper limit on new construction in terms of MW. The Ministry of Economic Affairs plans to give special prices only to the most efficient energy

[32] Information in this Section is based on Lauber, June 2004, personal communication.
[33] The regional energy authority has a small budget for wind energy from which it may cover: costs for wind conferences in Austria, part of consultancy costs, wind resource measuring costs.

projects. The change in price support approach has created a situation of insecurity, leading many investors to halt their investment plans for the time being.

I.6. Policy recommendations Austria (Alpine regions)

I.6.1. As regards the reduction of the influence of *technology-specific factors and costs*, public authorities could:

- Stimulate investors' choice for technological designs with:
    - Strong generators (able to face the Alpine wind regimes)
    - pitch control of blades;
    - variable / two-speed rotors;
    - adequate ice-removal devices.

These technical features are more likely to increase the electricity production of wind turbines compared to conventional models typically used in flat areas. This could be done by policy instruments such as:

- tax incentives: allowing the reduction of investment tax (or other taxes) for wind technological designs that have such technical features;
- technical standards for the manufacturers competing in the call for tenders in order to receive governmentally subsidized price support.
- financial support for Austria industrial companies working on R&D for ice removal systems.

- Revise the legal constraints on wind turbine maximum hub-heights in local permits that may work against the use of technological designs with superior technical features as described above.

- As indirect measure: provide more policy stability with regard to price support: adoption of one or two policy instruments with clear and simple design that should be maintained for a period of at least 10 years. This would attract more manufacturers of wind technology with desirable technical features to compete in Austria and reduce technology-specific costs. Interviewed experts explained that most of technologies are bought via German offices and representatives, which may be a cause of higher equipment costs in Austria. In order to create an attractive investment context, complex and versatile payment streams should be avoided. The operation of one or few clear support schemes increases the range of developers likely to understand and able to assess their financial impact. Transparency and stability in support system will increase the number of investors and industrial companies willing to contribute to the diffusion of wind technology.

I.6.2. As regards the *technology-complementary costs*, there is little public authorities may do to minimize them, because they are influenced by rigid factors, not liable for manipulation.
In Table 6 we presented a qualitative estimation of the weight that technology-complementary factors may have on production costs. If the political choice is to support first the projects with lower production costs and later the increase price support to enable also projects in more remote locations, then the government should:

- simulate first investments in larger-size projects (>15 MW) and moderate size project (5 - 12,5 MW) located *close* to adequate grid and road infrastructure;
- increase price support at a later stage to also enable:
    - larger-size projects (>15 MW) and moderate size project (5 - 12,5 MW) located *far away* from adequate grid and road infrastructure;
    - small size projects (< 5 MW, close/far from grid-road infrastructure).

If the political choice is to simultaneously support all types of projects (as differentiated in Table 6), the government should introduced a price support system that differentiates payment according to project size (as suggested above), and location relative to the grid-road infrastructure, while accounting for the need for clarity and simplicity in design.

I.6.3. As regards the reduction of the influence of *context-induced factors and costs*, public authorities could:

- Ensure that the governmentally guaranteed contract length is not shorter than 10 years since this may result in higher financing costs.
- Provide more policy stability with regard to price support: this may encourage even more industrial companies to offer services and product for wind power plants investors, increase competition and

lower the costs incurred by investors during the life-cycle of projects. Such stability may be achieved by a steady automatic decline of rates as it is practiced in Germany or France.
- Reduce the administrative bureaucracy around the Strategic Environmental Assessment studies that bring substantial costs to the project developers and contribute to the increase of overall production costs claimed. This may be done by providing technical support for the drawing up of such studies.

There are also factors whose influence on production costs cannot or should rather not be removed. What cannot be influenced by policy is that fact that Alpine wind projects incur higher Maintenance and Operation costs due to icing problems and difficulties in site accessibility. Public authorities involved in price design should take this into account when they set up prices. What should rather not be removed is the economic benefit that land owners and municipalities have when wind projects are located in their area. Land rents to owners and royalties to municipalities have positive spin off in terms of project acceptance and exposure to other citizens, communities, tourists etc. This contributes to the public acceptance of wind technology more widely. However, in order to keep these practices under control so that they do not endanger the economic feasibility of projects, the government should set ceilings on these fees, or facilitate a voluntary agreement between investors and stakeholders that may benefit of such payments.

I.6.4. As regards the influence of *resource quality and availability* on production costs, public authorities should rely on a price support system that rewards wind electricity also when it is produced and not only for the times when the general demand in the electricity system is high (as it does today). The Alps have good wind resources but with very large differences in wind speeds during the day and from month to month. This makes it desirable to tune price support with the technically possible timeline of wind electricity production.

Interviews in Austria

- Gerhard Ulz, LandesEnergieVerein Steiermark, Graz, 30 April 2004
- Wolfgang Jilek, Regional Government Styria, Graz, 30 April 2004
- Otmar Fruhwald, ECOWATT Sustainable Energy Solutions, Graz, 30 April 2004
- Gerd Gratzer, Styrian Government Department Economy and Labour, 30 April 2004
- Hans Winkelmeier, energy consultant, Salzburg, 29 April 2004.

II. ITALY

In 2003, the share of wind energy in the total electricity consumption of Italy was less than 0.5% (IEA 2003: 139). This came from 903 MW wind power capacity generating around 1,450 GWh/year. The main investors were ENEL Green Power (division of ENEL), the Italian Vento Power Corporation (IVPC) which is the largest private operator, and Edison (private company).

There are two regions in the Italian Alps on which this project is focused: Bolzano and Trento. At the end of 2002 there were 2 wind turbines connected to the grid in Trentino Alto Adige (Alpine Windharvest III: November 2003: 13):

1. Mals, Windkraft Marein: 1 turbine Leitwind (manufacturer Leitner AG Italien) of 1,2 MW at 1500 m above sea level, with D = 60 m, hub height 60 m, which started operation in 2003. Operator/owner: Windkraft Marein corporation.
2. Rein-Sand in Taufers at 1600 m altitude, one turbine Lagerwey LW 80/18 with 80 kW, annual yield of ~ 90.000 kWh, D = 18 m, which started production in 1996. Operator/owner: individual owner. In the autumn of 2003 the owner changed the turbine with a 300 kW Bonus windmill H=30m, D=30m.

The Mals Windkraft Marein project using the Leitwind turbine has received a temporary permit for two years (starting with the autumn of 2003). After two years it will be decided whether a permit for a wind park will be granted. A working group of civil servants from the regional government supervises the operation of the turbine and its environmental impacts. The Windkraft Marein is made up of a consortium of four communities - Glurns, Graun, Mals, and Schluderns - the utilities of Prad and Stilfs, the energy co-operative of Oberland, and the Vinschgauer Elektrizitätskonsortium (IEA 2003: 145). As regards the second project, given the fact the Rein-Sand project uses a very old design of small capacity turbine, which in not anymore in manufacture, it will not be discussed in this chapter.

In 2004 no new projects were made in the Italian Alpine region while in the rest of country 300 MW are expected to be built. (IEA 2003: 137). An interested local institutional investor has been attempting to start a new project in Bolzano, and has already installed a wind mast to measure wind quality at one location. Good quality wind resources were found but local opposition against the project emerged (anonymous investor) and its future is uncertain.

The total investment cost for the project in Mals of the Windkraft Marein corporation was 1250 €/kW. Comparing this with the EU-15 average levels in Table 2, it can be observed that this has been expensive project. This is however in the range of the investment costs in the Austrian Alps: 1160-1310 €/kW. No data are available regarding for the production costs (€c/kWh) of the two operating projects. Below the cost aspects are discussed per category of factors affecting production costs per kWh.

II.1. Technology-specific costs

No data are available regarding the equipment costs (€/kW) for the Mals project. However, having in view that it is using a technology design that is still under demonstration and development, equipment may change in future. The technical characteristics of the Leitwind turbine are:

- horizontal axis with three blades and rotor diameter of 62 m; and
- no gear box, resulting in more efficient wind generation (IEA 2003: 145).

The turbine is designed to operate in Alpine environments which makes it likely that the aim of the manufacturer is to adjust the technical characteristics so as to maximize wind electricity production in Alpine wind regimes. Next to Leitwind, the foreign manufacturers Vestas and Enercon try to promote their designs in the region. As discussed in the Sub-section for Austria, these designs have technical characteristics that favor higher levels of electricity production compared to other turbine designs on the market. Besides, the average annual availability of these turbines is very high - around 98-99%." (IEA 2003: 143)

II.2. Technology complementary costs

No data are available regarding the technology-complementary costs for the Mals project. Insight into the expected cost levels for new projects is difficult to develop because – in contrast to Styria – a map of wind energy resources was still under development for Bolzano and Trento. One map was being drawn up in the framework of the Alpine Windharvest project and another in the farmework of a research project at regional level in Bolzano. The results of mapping wind resources is important for deriving expectations for this cost-category as it would also reveal the availability and quality of road and electrical grid infrastructure in the vecinity of sites with high wind energy potential.

In 2003 a consortium of companies completed a three-year project that investigated wind energy potential in Italy. The project was based on grant from the Italian Ministry for Production Activities and the consortium was formed by the Enel Group, the Italian transmission operator, as well as several energy utilities and industrial companies (Pirazzi and Casale 2003: 146). This project also investigated the wind potential in mountain regions at altitudes between 1000m and 2000m. However a straightforward assessment of potential was not possible. It was argued that in mountain regions very many geographic and site-specific factors affect the economically feasible potential. Assumptions need to be made regarding factors such as, "terrain slope and roughness, soil use, distance from the electrical grid and roads, environmental, and other constraints) that can heavily affect the feasibility and production costs of a wind farm" (Pirazzi and Casale 2003: 147).

The issue of technology complementary costs is important for investors, from the standpoint of the likelihood of investment and project size. The mapping of resources is expected to shed light also regarding these cost components. The discussion made in the Sub-section for Austria regarding the relationship between resource location and the availability of road and grid infrastructure, as summarized in Table 6, applies also for the Italian Alps. The Table 6 gives also a quantitative estimation of the expected weight of technology-complementary costs in the overall production costs per kWh.

II.3. Context induced costs

In the Research Methodology section, three categories of context-induced cost factors were differentiated:

- monetary consequences of financing and trade arrangements;

- expenses in project life-cycle, and
- expenses incurred in relation to (local) administrative and social approval.

II.3.1. Monetary consequences of financing and trade arrangements

The project in Mals has not used a project finance loan so far (there are plans for the expansion of capacity, for which bank loans may be used). Financing took place in the form of equity and investment subsidies:
- the manufacturer Leitner AG Italien financed the technology-specific costs (the wind turbine system) and the construction of the wind project (civil and mechanical works);
- the community financed the grid-connection - which assumed 250.000 € equity by the community;
- EU and regional investment subsidies were available (Wunderer 2004).

The total investment costs were € 1,5 million for the 1,2 MW project, which means 1250 €/kW. The project was be estimated to have a 10 year return period. However the project is not part of the Italian Tradable Green Certificate system (TGC) or a system of guaranteed governmental tariffs, because wind electricity is used 100 % for self-consumption by communities that invested equity. Therefore the project saves the community electricity bills for 10 years.

Experiences in the rest of Italy may be seen as a basis for deriving expectations regarding the use of project finance in Alpine regions and consequences for investments. Interviews with energy experts and (potential) investors revealed that banks in Italy are interested in wind projects and allow project finance loans. Like in Austria, banks are especially interested to finance wind projects when there is the financial involvement of households / local community. But there are also (local) business people who have their own financial resources and banks and are interested to co-finance their commercial wind projects[34].

In the projects realized so far in Italy, loan contribution depends on the wind availability and quality at the proposed site. Private equity investments of between 20-50 % can be asked by banks. When the owners are institutional investors with high profit requirements – as it appears to be the case so far with many projects in Italy - this implies a *cost pressure on the overall production costs,* because equity is more expensive than interest rates (higher return expectations levels on a large share of capital structure).

The debt maturity has been on average 10 year, which can be considered as 'business as usual'. But 10 year loans are only available if the owner proves a purchase contract that is equally long. This is difficult to obtain under the Italian TGC system where obligees prefer to use short terms contracts or spot exchange, and wind has to compete with cheaper 'green' technologies. When contracts are shorter or not available this is reflected in a *higher than usual interest rate* that has direct impacts on the (increase of) overall production costs per kWh. In the Alpine regions, the fact that the regional government has not adopted yet by mid 2004 a energy plan with clear targets for wind energy harnessing and criteria for project development and approval (see Section 11.5 for more details), adds to the project risks and is highly likely to be reflected in higher interest rates, should the regional government delay its position.

Consequently, high equity requirements, large contributions of equity in the capital structures of projects and expected high interest rates may put pressure of the production costs of wind electricity in Alpine regions as well, when project finance schemes are used.

II.3.2. Expenses incurred in relation to (local) administrative and social approval

For the project in Mals, the land owner is a community, who is also member of the corporation that owns the project. The community considered the land as financial input in the project (non-profit, self-generation project). If the project is expanded with more turbines, land will be rented. The experience with land renting in the rest of Italy is that land owners require the use of formula 'amount cash per wind turbine'. An anonymous investor claims that land rent fees increase strongly from year to year, for which reason project developers prefer to buy land. This is presumably due to 'faking competition'[35]. As regards royalties, there is no information that this played a role in the Mals project – especially having in view that this is a self-

[34] However, the situation regarding the financing of wind projects in other regions of Italy warns towards a possible bias of bank agents against small developers – and hence the potential unavailability of project finance loans for them. In Italy, banks typically require the previous involvement of the (at least one of the) project developer(s) in other wind projects. This has already contributed to the domination of few large companies as project owners in Italy. Besides, there is the aspect of project size that limits the chances of small developers to develop wind plants. Project finance loans are given only for wind parks that are more expensive than € 30 million. For this, the private equity required can seldom be offered by small economic actors.

[35] There are 'one man companies' who propose wind projects but in the end it appears that they have no financial resources – or access hereto – to even start the projects. However by getting involved in the negotiations for land rent, they push rent prices 2 / 3 times above market prices, creating the false idea of high demand for land (many potential investors), helping land owners to drive rent prices up.

generation project with the involvement of several communities. As regards experiences in the rest of Italy, this is about 1% from annual turnover, but in an increasing trend (anonymous investor).

No information is available regarding the permit costs in Italy. It is known however that typically, it takes 3 to 5 years to have all necessary permits for a wind project. The rate of rejection is high: if 50 projects are proposed in a region, maybe 5 will go ahead (anonymous investor). This puts high stranded costs on investors, which fall into the calculation of permit costs of approved projects. For the time being it seems that many Italian regions will be soon stopping the issue of building license (e.g. Umbria, Campagña). For environmental permits, each region handles its own legal frame and there is a high heterogeneity of experiences.

As it will be explained in Section 11.5, in Bolzano and Trento the permit criteria are still awaited, Depending on their design and the efficiency of the regional authorities, the permit costs may be reasonable, or may place high cost pressure on the economics of projects if long procedural delays are allowed – as it happened in the other regions. Further, the regional energy policy and wind energy targets also expected to be adopted soon, should clarify the tax treatment for wind projects: tax reductions or – on the contrary – additional regional taxes.

II.3.3. Project life-cycle costs

No data are available regarding the technology-complementary costs for the Mals project. In principle, Maintenance and Operation costs are expected to be higher than in flat areas due to more difficulties in the accessibility of sites and icing problem. However, it is likely that if the regional investment framework clarifies and becomes attractive, investors are would not face inflated costs for the componenets in this category, because a good regional industrial potential already exists to innitiate competition for wind project services and products. South Tyrol industry has traditionally been strong in construction, mechanical engineering, metal processing and electro-materials processing, especially developed in small firms. But large firms have also been successful on both the domestic and foreign markets[36]. Currently, only few companies choose to specialise in wind technology profile because future demand for equipment and services is uncertain. At national level the industrial basis has already grown substantially after the installation of around 900 MW by the end of 2003, which means that potential investors may look for good cost-quality services also in other Italian regions.

II.4. Resource quality and availability

Although there are two projects running to map the wind energy potential in the Italian Alps (Windharvest and a regional project), there is already an idea that there is a low regional wind potential. However, the comment made in the sub-section for Austria still applies: in the Alps there are large differences in wind speeds and availability among adjacent sites. Thorough studies are necessary to locate the spots with the best wind-speed/availability values. Ideally the governmental price support system should reward wind electricity production based on a price/time-of-delivery scheme that matches the time-of-production scheme, supporting the economic feasibility of projects.

II.6. Policy recommendations Italy[37] (Bolzano and Trento)

II.6.1. As regards the reduction of the influence of *technology-specific factors and costs*, public authorities could:

- Support private initiatives for technological innovations in wind systems for mountain areas by means of R&D subsidies or tax incentives.
- In addition, as suggested in Section I.6.1, they could stimulate investors' choice for technological designs with:
    - strong generators (able to face the Alpine wind regimes)
    - pitch control of blades;
    - variable / two-speed rotors;
    - adequate ice-removal devices.

These technical features are more likely to increase the electricity production of wind turbines compared to

[36] Source: http://www.provincia.bz.it/english/overview/industry.htm.

[37] For a discussion of the price support system in Italy - Tradable Green Certificate system and other schemes - see Sub-package 9.1.

conventional models typically used in flat areas. This could be done by policy instruments such as:
- tax incentives: allowing the reduction of investment tax (or other taxes) for wind technological designs that have such technical features;
- technical standards for the manufacturers competing in the call for tenders in order to receive governmentally subsidized price support.
- financial support for Italy industrial companies working on R&D for ice removal systems.

- As indirect measure: provide more policy stability with regard to price support: adoption of one or two policy instruments with clear and simple design that should be maintained for a period of at least 10 years. This would attract more manufacturers of wind technology with desirable technical features to compete in Austria and reduce technology-specific costs.

II.6.2. As regards the *technology-complementary costs*, the comments and recommendations made in Section I.6.2. for Austria apply as well. There is little public authorities may do to minimize technology-complementary costs, because they are influenced by rigid factors, not liable for manipulation.

In Table 6 we presented a qualitative estimation of the weight that technology-complementary factors may have on production costs. If the political choice is to support first the projects with lower production costs and later the increase price support to enable also projects in more remote locations, then the government should:

- simulate first investments in larger-size projects (>15 MW) and moderate size project (5 - 12,5 MW) located *close* to adequate grid and road infrastructure;
- increase price support at a later stage to also enable:
    - larger-size projects (>15 MW) and moderate size project (5 - 12,5 MW) located *far(ther) away* from adequate grid and road infrastructure;
    - small size projects (< 5 MW, close/far from grid-road infrastructure).

If the political choice is to simultaneously support all types of projects (as differentiated in Table 6), the government should introduce a price support system that differentiates payment according to project size (as suggested above), and location relative to the grid-road infrastructure, while accounting for the need for clarity and simplicity in design.

II.6.3. As regards the reduction of the influence of *context-induced factors and costs*, (regional) public authorities could:
a) in order to contain the cost consequences of project financing arrangements, use policy instruments as:

- project aggregation schemes[38]
- governmentally subsidized soft loans[39] with
- workshops with financing agents to communicate the governmental energy policy and increase the confidence of financing agents in wind technology, and in the political support for wind energy;
- if Alpine wind projects are to get price support based on the existent scheme at national level, it would be desirable to revise the policy scheme of tradable green certificates so that it:
    - separates of obligation for renewable electricity purchase in technological bands with a special band for wind technology;
    - introduces a price floor (Ec/kWh) for trade with green certificates that is able to ensure the economic feasibility of the available Alpine wind resource potential.

b) In order to ensure low costs in project life cycle operations, public authorities should provide more policy stability with regard to the chosen price support scheme and its design details: this may encourage even more

[38] *Project aggregation or bundling* refers to a way of addressing the problems of financing availability and financing costs by aggregating more wind projects in order to secure a single large loan. This approach is generally used when sizes of projects are too small compared to the standards of the financing agent. After the loan is received the money is split among the developers whose projects were aggregated. Beside access to finance, this instrument also results in lower interest rates, because the transaction costs per project are reduced. The aggregation of wind projects can be done by any type of economic actor. But when a government agency takes the role of aggregator agent, this has higher chances to result in more attractive financing terms including lower interest rates. An example where this instrument was successfully used is the Autonomous Community of Catalonia in Spain, where the regional energy agency concluded agreements with regional banks for large and low interest rate loans that were consequently split to finance the installation of solar based energy systems by households and small companies.

[39] Soft loans assume the payment by the government of a percentage or the entire interest rate that project developers have to pay when loans are used to finance wind projects. This has similar effects to subsidies, but often assume a smaller extent of financial support. The loan could come from a financing institution or agency of the government, or from a commercial bank or other type of financing agent with who the government concluded an agreement to finance developers of wind projects. This instrument is very helpful to use in the first stages of market introduction to overcome the financing barrier.

industrial companies to offer services and product for wind power plants investors, increase competition and lower the costs incurred by investors during the life-cycle of projects.
c) fast adoption of regional regulations on permit criteria and time effective management of the approval procedures, to minimize costs related to administrative permits and social consent. As regards the cost components of land rent and royalties to municipalities, these expenses should not be necessarily minimized but ‘contained’, as they have positive spin off in terms of project acceptance and exposure to other citizens, communities, tourists etc. This contributes to the public acceptance of wind technology more widely. However, in order to keep these practices under control so that they do not endanger the economic feasibility of projects, the government should set ceilings on these fees, or facilitate a voluntary agreement between investors and stakeholders that may benefit of such payments.

II.6.4. As regards the influence of *resource quality and availability* on production costs, public authorities could design a price support system that rewards wind electricity also when it is produced and not only for the times when the general demand in the electricity system is high. The Alps have good wind resources but with very large differences in wind speeds during the day and from month to month. This makes it desirable to tune price support with the technically possible timeline of wind electricity production.

Under the current Tradable Green Certificate system, a policy design aspect that may help wind electricity get a more reasonable price would be to ensure that the period for obligees’ compliance proof is shorter than the period of trade validity of green certificates. This avoids the pressure on wind generators to lower the prices of green certificates when a high production period occurred (good wind speeds with long availability) and there is a high supply of certificates that have a short validity (e.g. 1 year) while the compliance period for obliges is longer (e.g. 2 years). Besides, this also is likely to lower price risks and reduce financing costs as compared to a policy design with reverse relationship between the two elements.

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III. SLOVENIA

In the (pre)Alpine region of Slovenia there are currently - mid 2004 - no wind projects running that use that use medium/large capacity turbines. Only a handful of very small wind generators are operating in isolated places for self-generation purposes.

The mapping of wind energy resources started in 1999 but so far the potential and its location is still a matter of public debate. Section 11.5 on Slovenia explains in detail the background and flow of events behind the current interest in wind energy. The first measurements of wind potential were made in 1999 at eight locations and a year later 4 other locations were examined. Technical experts assessed the exploitable potential at 300 MW, which would represent 12 % of total installed capacity in Slovenia and almost reach the 15% ceiling considered as technically feasible as "non-distributed generation capacity" given the intermittent nature of wind electricity.

1. Technology specific costs

In May 2004, no information was available regarding the technology to be used in the projects (co-)owned by the energy utility Elektro-Primorska. The company representative mentioned that a call for tender would be organized to select the manufacturer when projects receive the ‘go-ahead’ from municipalities. However given the long-standing cooperation with the Spanish EHN company that has had itself a long-standing ownership link with one of the largest manufacturers in the world, Gamesa, and has been starting manufacturing wind turbines itself since 1999, it would be surprising for EP not to use one of these Spanish turbines. Either because EHN would/might be involved in the ownership of Slovenia projects or/and because large orders are likely to be placed with a Spanish manufacturer, the technology-specific costs are likely to be low, so as to keep production costs low and increase the range of profits, given the governmental price per kWh guaranteed

Governmental estimations suggest that technology-specific costs would be low. There are already plans to install 383 wind turbines with an individual capacity of 750 kW[40]. and it is estimated that would assume – on average - a total investment costs of 645 €/kW. Comparing this with the costs in other European countries illustrated in Table 2, these are very low costs indeed suggesting also low technology-investment costs. This is understandable if: a) medium-size turbines are used – such as the 750 kW model – which have already enjoyed the benefits of large investments and economies of scale and are in the low(est) cost-band already; b) the technology is purchased in Spain, were technology costs were among the lowest already in 2000; a study documents that in 2000, in Spain, the typical costs for wind turbine equipment were 630 €/kW, but that were actually in the range of 540 - 750 €/kW, with lowest costs for the 600 kW; 660 kW; 750 kW; 800 kW models.

However, the EP mentioned that they would use 1,5 MW turbines (Persolja 2004). These are typically more expensive. The EWEA study (2004: 99) indicates that the 1,5 MW turbines has in Spain, in 2001, an average equipment costs of slightly above 900 €/kW. This is still in the lower part of the EU average costs (see Table 2). Consequently, there are reasons to assume that this cost category would not put pressure on production costs per kWh.

2. Technology complementary costs

Although there are no projects yet and investment plans are carefully guarded by potential investors, it may be expected that in the first wave of diffusion, this cost category will also not put pressure on production costs per kWh. Having in view the discussion made in the Section on Austria for the same cost component category, and the corresponding policy recommendations, there appears to be political awareness on the role of such factors on costs.

Governmental resource assessments took into account the aspects of transport access and grid access, and lowered the level of the technically found potential of 300 MW to the 'commercial potential' of around 150 MW. This was identified (cumulatively) at two locations: in Kokoš (30 MW) and Golič (120 MW)[41] (Klemenc 2004). There appears to be hence a political choice:

- to simulate first investments projects located *close* to adequate grid and road infrastructure, and to
- consider investment using the remaining potential seen now as 'not commercial' at a later stage – another 150 MW.

It appears that the developer EP has a preference for larger projects connected directly to the high voltage grid, which reduced the weight of technology-complementary costs when projects are located *close* to adequate grid and road infrastructure. But this implies that governmental price support needs to increase at a later stage to also enable:

  - larger-size projects (>15 MW) and moderate size project (5 - 12,5 MW) located *far away* from adequate grid and road infrastructure;
  - small size projects (< 5 MW, close/far from grid-road infrastructure).

However arguments of the opponents of wind energy (especially environmental NGOs) challenge the idea of lower technology-complementary costs in the first stage of diffusion. They argue that the best sites are located on top the ills and that 90 % of the roads would need to be purposefully built for the construction of wind power plants in Slovenia. If large 1,5 MW turbines are used - as the EP intends - this means that 4,5 m wide roads of total length of around 20 km needed to be built. Environmentalists also argue that this is another strong visual intrusion in the still 'wild' hilly landscape with large visibility. But from the standpoint of the analysis made here, the implication is that road construction will put indeed pressure on the total investment costs, hence on the public price support, to a larger extent than current government cost and potential estimations suggest.

3. Context-induced costs

In the Research Methodology section, three categories of context-induced cost factors were differentiated:

- monetary consequences of financing and trade arrangements;

[40] These would generate around 709.1 GWh/year.

[41] However the second location was challenged because of impacts on the rare lowland Karst grasslands and several rare flora and fauna species.

- expenses in project life-cycle, and
- expenses incurred in relation to (local) administrative and social approval

There are indications to believe that from the category ‘monetary consequences of financing and trade arrangements’ there will be no negative impacts on production costs. The interviewed (would-be) developer EP mentioned that banks are open and willing to finance wind energy projects – although no financing contract was concluded so far because projects are still under negotiation with municipalities for permits. It is estimated that given the level of promised governmental price support (still unknown) it would be possible to recover investment costs in 10 year. This is a good-length period for a project finance loan. Even if this would not be available, the EP (and eventually EHN) is a large corporation with financial credibility which is likely to be able to obtain loans at low financing costs.

As regards expenses in project life-cycle, the EP declared that for 60-70 % the equipment and services for project development and operation will be sub-contracted locally to contribute to regional industrial development. Opponents of wind projects are skeptical towards these statements. In any event it is difficult to predict to what extent – if at all – production costs would increase above what ca be described as ‘ typical for wind projects in other European countries.

Similarly, there is not enough basis to derive expectations regarding possible levels (%) of costs incurred in relation to (local) administrative and social approval. It is known that for one project the EP has already promised royalties – cash to the municipality, which the authority intends to use to build/finish a school, given the claim that the national education ministry allocates no money for such needs. But the financial impact of this cost on the production costs is far from clear. Further, EP will spend some money for renting land for wind projects whenever it is not possible to but land (which is the preferred option). Plans exist for paying 94.000 € per year for 47 wind turbines, each with a rated power of 1,5 MW, in Ilirska Bistrica. This amount will be paid in advance for 20 years by the investor in 2004 and 2005, in two installments. This equates with a payment of 2000 €/turbine/year, which cannot be sees as a high-impact cost. In the flat part of Austria, project owners pay up to 5000 €/turbine, while in Colorado (United States) land rents are typically in the range of 2000-5000 $/turbine.

4. Resource availability and quality

Information from the EP suggests that the selected sites have annual average wind speeds of 6 m/s for 1800 hours/year availability at full load. The EP estimated a potential of 200-250 MW in the Karsp and Primorska region. Such a wind regime can be seen as average quality in Europe, where sites have been first developed in regions with 8 m/s or higher average annual and > 2400 hours/year. However the different patterns of wind availability-speed may account for a difference, making such sites also attractive on an annual basis for electricity production.

As mentioned in Section 9.2 on Austria, the wind in Alpine regions blows with high speeds for shorter periods of time and there are periods with very low wind speeds. A similar phenomenon happens also in Slovenia, according to some interviewees. It is often argued that the western part of Slovenia is swept by the Buriana/Bora winds which are renown for blowing in very powerful gusts of 80 km/hour and higher, while for long periods of time they do not blow at all (Škulj 2004). Hence the period of time at which wind turbines can function at wind speeds between the cut-in and cut-off speeds (the technical start and stop of turbines) would be relatively small for projects to be economically attractive. If the time when wind blows at operational wind speeds is too short, this implies that only substantial governmental financial support - in terms here of contractual price per kWh - would make them sufficiently profitable to attract investors’ interest. However the impacts of Buriana winds on the economics of wind power plants need to be researched more closely with hard data on wind potential. These are currently available only in restricted circles - the governmental meteorological estimates are considered too old and the more recent data were done by interested investors privately are for commercial reasons are kept under control. Data on wind potential are only available on ‘capacity-potential’ or ‘generation-potential’ form. For example it is estimated that the total wind power capacity available is 287.25 MW (ISPO 1999):

- location Banjščica (73.5 MW with the annual power production of 137.6 GWh/year),
- location Gora (82.5 MW with 225.8 GWh/year),
- location Nanos (70.5 MW with 156.5 GWh/year), and
- location Volovja Reber (60.75 MW with 169.2 GWh/year).

Consequently, the potential influence of wind speeds levels and availability on production costs is still obscure in Slovenia due to the lack of transparency on resource potential across the region.

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IV. SWITZERLAND

In 2003, the wind turbines operating in Switzerland totalled 5,36 MW and generated 5,23 GWh (i.e. 0,01 % of electricity consumption). Most of these were single turbine projects of very small capacity. The national energy program Swiss Energy aims to increase wind electricity production at least 10 times by 2010, targeting a generation capacity able to deliver between 50-100 GWh/yr. This would represent around 0,1 % to 0.2% of the annual electricity consumption, although (environmentally and socially) suitable sites were identified that could contribute 3 % - 5 % to electricity demand (Horbaty 2003: 219). In 2003 the following wind projects were operating in Switzerland[42] (listing only projects with at least 30 kW capacity):

- single-turbine project of 30 kW capacity located at Simplon Pass, 2000 m altitude. Stating operation in 1990.
- single-turbine project of 30 kW capacity located on Chli Titlis, 3000 m altitude. Stating operation in 1997. Owned by Elektrizitätswerk Nidwalden.
- single-turbine project of 80 kW capacity located on Gabris, 1100 m altitude. Stating operation in 1995. Owned by Appenzellische Vereinigung zur Förderung umweltfreundlicher Energien. The electricity buyer is SAK. Production in 1997: 45,7 MWh/yr.
- *single-turbine project of 150 kW capacity located in Grenchenberg, 1300 m altitude.* Stating operation in 1994. Independent power producer ADEV Liestal cooperative society[43]. Electricity sold to City Utilities Grenchen and WWF Switzerland.

[42] Data on projects are based and http://www.suisse-eole.ch/power-sitessuisse-d.htm.

[43] Financial support was received from the Swiss Federal Office of Energy, the Swiss Office of Economics, the Canton of Solothurn and WWF Switzerland.

- *single-turbine project of 800 kW capacity located on Mount Gutsch, 2300 m altitude.* Stating operation in 2002, blade damage in December 2003. Utility owner (EW Ursern, Institution under public law). New machine:Enercon 40, 600kW, 1.5 GWh/a
- *six-turbine project of 4,16 MW capacity located on Mount Crosin at 1200 altitude.* Stating operation in stages: 1996 and 2002. Utility owner (Juvent SA).

During 2003, only one very small turbine was installed, due to the complexity of administrative processes and the increasing socio-environmental opposition. In 2004, two turbines of 1,75 MW each were under construction in Mont Crosin (Jura bernois), while projects totalling at least 35 MW were in administrative procedures for permitting (Horbaty 2003: 220).

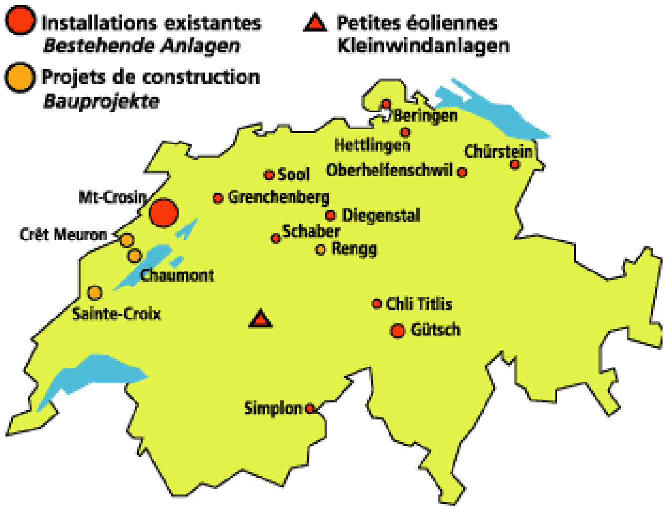

Figure 1 Realized and planned wind projects in Switzerland. Source: http://www.suisse-eole.ch/power-sitessuisse-d.htm

For the purpose of this research project, empirical data regarding cost performances were collected only for the three projects mentioned above in italics. The data are summarized in Table 9.

As mentioned in the introduction of the chapter, the available cost data regarding these limited number of projects may not be representative for the projects that could/will be realized in these countries. This is especially so in Switzerland, having in view that the projects that are planned based on the Swiss Concept for Wind Energy (see below) will use medium/large size turbines and medium-large power stations, while:

- one of the above projects uses a 10 year old 150 kW turbine, which is not likely to be used again (significantly);
- one project was confronted with technical problems that strongly effected its economics – the 800 kW pilot project;
- the 6 turbine wind park, owned by utility may well be representative for investments to be made, but the interviewee supplied less specific cost information to learn sufficiently from the experience.

Therefore, these analyses should be rather seen as general orientation on the cost performances of wind projects in Switzerland, and as points of departure for formulating expectations regarding how the various cost factors that may influence production costs.

The production costs of wind plants using 850 kW turbines are estimated to be around 8,5 €c/kWh. When new models of larger turbines are used, production costs are higher: even at locations with good wind speed and availability these goes up to around 13,5 €c/kWh. In the latter case, total investment costs are around 1380 €/kW (Horbaty 2003: 222).

However, information on the three projects mentioned in Table 9 suggests that these costs could have larger ranges. The one-turbine project of 150 kW commissioned in 1994 (independent power producer, column 2, Table 9) incurred total investment costs of 2220 €/kW and production costs of 35 €c/kWh. (Due to the receipt of 40 % investment subsidies, production costs were reduced to 22 €c/kWh). The one-turbine project of 800 kW commissioned in 2002 (utility owner, column 3, Table 9) incurred total investment costs of 1513 €/kW and calculated production costs of 12 €c/kWh. Due to technical problems, however, costs escalated to 35 €c/kWh. The 4,16 MW wind project commissioned in 2002 by an utility assumes much lower investment costs: 1202 €/kW, which is in the range of the investment costs in the Austrian Alps: 1160-1310 €/kW and the project in Mals, Italy (1250 €/kW). Data on production costs of this project were not available.

The study of the European Wind Energy Association found out that in 2001/2 the average total investment costs per kW in several European countries - Germany, Denmark, Spain and UK - ranged typically between 900-1200 €/kW (see Table 2). Therefore in Switzerland, total investment costs are considerably higher than the average costs in Europe and for single-turbine projects even higher than those in other parts of the European Alps. This is important to keep in mind, as in the following sections the discussion is sometimes carried out in terms of percentages of various cost components in the total investments costs.

Switzerland	1 turbine project, 150 kW. Independent power producer. 1994.	1 turbine project, 800 kW. Utility. 2002	6 turbine-project, total 4.160 kW. Utility. 2002.
Production costs €c/kWh	0,35 €/kWh but 40% investment subsidy => costs 0,22 €/kWh	Calculated: 0,12 €, Effectively: 0,35 €	No declaration
Total investment costs	333.000 € total cost 2.220 €/kW	1.210.000 € 1.513 €/kW	5 Mill. € total costs 1.202 €/kW
Annual electricity production	120.000 kWh/y	700.000 kWh; expected 1.600.000 kWh	5.000.000 kWh
Technology-specific costs			
Equipment costs	228.300 € 1.522 €/kW	800.000 € 1.000 €/kW	3.000.000 € (60% of IC) 721 €/kW
Technical availability	96%	50% caused by different technical problems	98-99%
Efficiency	265 kWh/m2/y 452 m2 Rotorfläche	336 kWh/m2/y, planned 768 kWh/m2/y	2002 = 608 kWh/m2/y, 2003 = 516 kWh/m2/y
Nominal wind speed	15 m/s	13 m/s	14 m/s
Cut-in speed	4 m/s	3,5 m/s	4 m/s
Type of wind turbines	Two-speed rotor; Asynchronus Stall-regulation	Variable speed rotor Synchronous generator Pitch control	3 Vestas V44; constant 1 Vestas V47; two-speed 2 Vestas V52; variable Asynchronus stall control & Optislip
Technology complementary costs			
Civil works' costs	3.400 € or 10% IC	200.000 €	10% of IC (500.000 €)
Transport costs	Part of total price	No info possible	1% of IC (50.000 €)
Mechanical and electrical infrastructure	52.000 €	37.000 € (3%)	15% of IC (750.000 €)
Grid connection	18.700 €	46.700 €	No declaration possible
Context induced costs			
Financing costs	Only equity	Only equity	Only equity
Received price / kWh	0,10 €c/kWh feed-in tariff + 0,15 €c/kWh green certificate => 0,25 €c/kWh	Customers pay 0,12 / 0,15 €c/kWh on top market price => 0,20 / 0,23 €c/kWh	0,12 €c/kWh on top of market price (~ 8 €c/kWh) => ~ 0,20 €c/kWh
Investment recovery	15 years	15-20 years	10 years
Project development costs	10.000 € (3 % of investment costs)	33.300 €[44] (2,75 % of investment costs)	50.000 € (1 % of investment costs)
Insurance costs	2.700 € (0,8 % of investment costs)	8.000 € (0,66 % of investment costs)	25.000 € (0,5% of investment costs)
Maintenance and operation costs	3.500 €/year (11,6 % of annual income)	No info – plant not working now	75.000 € (~ 1,5% of investment costs / kW)
Grid access and wheeling	1.500 €	Project owner owns the grid himself	No costs
Permits	300 €	500 €	No additional cost
Taxes paid	no taxes	No taxes	10.000 €
Land costs	3.500 € bought	Land bought for 2200 € (0.33 €/m2)	No declaration
Legal procedures	300 €	350 €	About 3.000 €
Resource quality and availability			
Average wind speed	4,9 m/s	7 m/s	6 m/s
Wind availability per year	850 hours/year	planned 2000 h/y effective 875 h/y	2002: 1'240 h 2003: 1'045 h

Table 9. Cost parameters for three wind projects in Switzerland

IV.1. Technology-specific costs

The three projects empirically analysed had largely different technology-specific costs:

[44] No costs on wind measurements because wind data were ready available.

- 1522 €/kW for the one turbine project of 150 kW (68,5 % of total investment costs);
- 1000 €/kW for the one turbine project of 800 kW (66 % of total investment costs);
- 721 €/kW for the wind park of 4,1 MW (60 % of total investment costs);

Comparing these with the typical range found in Spain, Denmark, Germany and United Kingdom by 2001/2 for recent turbine models (720 – 900 €/kW, with most turbines below 800 €/kW, including turbines of > 1 MW [EWEA 2004]), only the last project of 4,1 MW appears to have benefited of a good cost level.

Further, as discussed in the Research Methodology of Sub-package 9.2, certain technical characteristics of wind technology also influence the cost performances, in terms of production costs per kWh. The available empirical data indicate that the following designs were used in Switzerland (not considering the very small size turbines, which form another market segment):

- one-turbine project: Lagerwey 18/80, 80 kW, stall control of blades.
- one-turbine project: Bonus, 150 kW, stall control, two speed rotor, and asynchronous generator;
- one-turbine project: Lagerwey 800 kW turbine with variable speed rotor, pitch control of blades, synchronous generator; this was a new technological design based on the Dutch design of Lagerway but adapted with synchronous generator manufactured in Switzerland and variable speed; the turbine had substantial technical problems and the project has not been operational for some time; all involved manufacturers bankrupted in the meanwhile.
- six-turbine project: 3 Vestas turbines of 600 kW with constant rotor speed, 1 Vestas turbine of 660 kW with two-speed rotor, 2 Vestas turbines of 850 kW with variable speed rotor; all turbines with asynchronous generators, stall control of blades Optislip.

Experts consider that in mountain regions it is better to use technologies that have a pitch control design with strong generators able to face the strong wind speeds at high altitude. In the Appendix 1 of the Research Methodology of Sub-package 11.6 it was mentioned that wind technology designs with pitch control of voltage, and two-speed or variable speed rotor - all other things equal - are more likely to contribute to lowering the overall production costs per kWh of wind energy systems, compared to the other designs. The technologies used so far in Switzerland have quite diverse designs, but it is possible that the turbines that will be used for the new wind projects would have such technical features. In the multi-stakeholder Concept for Swiss Wind Energy assessing the economic and 'realizable' wind potential, the technology assumption was made that DeWind turbines will be used, with 80 m rotor diameter, 100 m height and 2 MW installed capacity. The models of DeWind turbines have pitch control of voltage and variable speed rotor (but they have asynchronous generators). Although in practice it is likely that some developers will have different preferences regarding the turbine manufacturer, it could be expected that many would prefer to use turbines of similar technical characteristics and capacity and/or that can generate wind electricity as comparable production costs to those resulting from the techno-economic models used to estimate the 'realizable potential'. But for all technology types, the altitude and icing problems remain serious technical challenges, potentially increasing the technology-specific costs considerably.

IV.2. Technology-complementary costs

The three projects empirically analysed had the following technology-complementary costs:

- 494 €/kW for the one turbine project of 150 kW (22,2 % of total investment costs);
- 313 €/kW for the one turbine project of 800 kW (24,4 % of total investment costs);
- 312,5 €/kW for the wind park of 4,1 MW (26 % of total investment costs).

For the last two projects (both utility owned, in Table 9), the costs in this category are comparable to those observed for the Oberzering project in Austria, estimated at about 334 €/kW (26 % of total investment costs). But they are higher then the average technology complementary costs in Germany in 2001: 210-230 €/kW[45], and they are much higher than for the project Plankogel (1 turbine of 750 kW) in Austria, for which these costs accounted for 17,3 %, that is 170 €/kW. For comparison with other European countries in terms of percentages of investment costs, in Table 3 it can be observed that the range of the technology-complementary cost category is very large: 5 - 29 %. However the three projects in Switzerland for which data is available belong to the upper part of the European range.

To ensure the achievement of the goals for wind electricity, consultations were initiated among various stakeholders resulting in the Swiss Concept for Wind Energy). This policy plan identifies locations where the erection of wind turbines is technically possible and acceptable from the standpoint of regional and local planning policies, nature and environmental protection and social preferences of turbines' location. Large

[45] This includes foundation, grid-connection and infrastructure (EWEA 2004: 98&99).

consensus was reached that wind energy in Switzerland should be harnessed by means of medium size wind farms, meaning 3 - 20 turbines, and using turbines not higher than 100m. The sites with projects using between 3 - 20 turbines, to be developed in short-medium term, were listed in the Swiss Concept for Wind Energy. Considering an average turbine size of 1,25 MW these projects may have between 3,75 MW and 25 MW or slightly higher[46]. However, this selection does not take into account the criteria of proximity to grid and road infrastructures. Looking at the categories differentiated in Table 6 (see Section on Austria) in terms of project sizes, it can be expected that technology complementary costs may be anywhere between low and high (* - ***), depending on the distance to infrastructures during the first wave of investments.

IV.3.Context-induced costs

In the Research Methodology section, three categories of context-induced cost factors were differentiated:

- monetary consequences of financing and trade arrangements;
- expenses in project life-cycle, and
- expenses incurred in relation to (local) administrative and social approval

IV.3.1. Monetary consequences of financing and trade arrangements

The trade arrangements in Switzerland attract very high financing risks. The three empirically investigated projects did not use project finance loans, being entirely financed with equity by project developer. However, when/if project finance loans are used this is highly likely to attract high interest rates[47]. According to the Energy Law in force since 1999, utilities are obliged to buy the electricity generated by independent power producers in their area of distribution and supply monopoly. The tariff generators get is fixed at about 10,5 €c/kWh, which regards only the physical streams of electricity. This is higher than the average electricity costs in Switzerland, which may vary around 5,5-8 €c/kWh.. Since 2005, this is paid out of a surcharge on thehigh voltage grid (see section 11.2).

Further, the 'greenness' of wind electricity is not financially rewarded by the federal government in terms of surplus price per kWh. Wind electricity producers need to find voluntary buyers of green energy through one of the accredited green certificate schemes available in various Cantons[48]. However, generally under this kind of scheme, there is high uncertainty regarding the reliability of green consumers' willingness to pay: the amounts of green electricity they may buy could change substantially during project life-time, or they may choose to shift at a later time to cheaper renewable technologies. This discourages many potential investors to build up new wind projects. When investment plans go ahead, this attracts high financing risks for investors and hence high financing costs, increasing the production costs per kWh as compared to a reliable price support system (ceteris paribus).

IV.3.2. Project life-cycle cost

The empirical data suggest that insurance for wind energy has normal levels. The levels encountered for the three projects - 0,5 %; 0,66 % and 0,8 % - are within the range of 0,2 % - 1 % of yearly project income observed in other European countries, including in other parts of the Alps (e.g. in Styria 0,2 %). As regards the maintenance and operation costs, there have been very expensive - 11,6 % - for the 150 kW project that encountered technical difficulties. The 4,1 MW project of utility owner has had so far low M&O expenses: 0,7 %[49]. As mentioned in the Section on Austria, maintenance and operation costs in European countries are in the range of 2-4 % in the 1st year but they may go up to 5 % later. After 10 years these costs may increase to 6-7 %. In alpine regions M&O costs are typically higher due to more difficulty in the accessibility of sites and frequent icing problems.

[46] There are plans that envisage the harnessing of around 500 GWh/yr by means of 300 wind power plants (Horbaty 2003: 219). This implies that, considering the production of around 1,7 GWh/turbine at an expected 1200 full load hours, the average turbine size would be around 1.4 MW / turbine.

[47] So far traditional financing agents (banks, insurance companies and pension funds) have not been interested in wind projects, but if projects are well developed it is no problem to find money among equity investors (Horbaty 01.09.2004, personal communication email).

[48] The federal government may offer investment subsidies up to 60 % of project development costs (such as feasibility studies, site and resource measurement) but other forms of price support were placed under the responsibility of state governments, where no additional support has been offered so far. See sub-package 9.1 on Switzerland for more details on the policy support system.

[49] Maintenance and operation costs are estimated at 75.000 € for the 10 year of investment recovery period, for a production of 5 million kWh paid with ~ 20 €c/kWh.

The project costs for the three analyzed projects are within the range of 1 % - 3 % of total investment costs. This includes planning costs, project management costs and wind measurement costs for which detailed data were not collected. In other European countries they are typically between 1 % - 3 %. However, for the two single turbine projects (see Table 9), the investment costs per kW are very high compared to other countries, meaning that these projects incurred higher than typical fees (for their size-band). Expert studies indicate that in Switzerland there are many industrial companies with highly qualified expertise in electrical-mechanical services, feasibility studies and project development in mountain conditions, but they are expensive (Horbaty 2003: 223). Typically, labor costs and engineering costs are higher in Switzerland than in many other European countries. Given also the fact that they operate in a niche market based on specialized knowledge[50], the costs for the products and services in the category of 'project life cycle' may be high in the future, not only for the single-turbine projects for which such costs are generally higher per kW investment, but also for larger size projects. Competition may eventually come from industrial companies in other Alpine countries but this depends on the extent to which the market develops in those countries to create sufficient demand.

IV.3.3. Administrative(-social) consent / tax expenses

We considered that this cost-category includes: land rent costs, permit-related costs (environmental studies, grid-approval etc), legal costs, and taxes. Based on the empirical data summarized in Table 9:

- for the 150 kW project, the above factors represented 1,7 % of total investment costs (i.e. 5600 €; no taxes paid);
- for the 800 kW project, these represented 0,25 % (i.e. 3.050 €; no taxes paid and no grid wheeling/access costs),
- for the 4,16 MW project, these costs represented 0,26 % (i.e. about 13.000 €; no grid wheeling/access costs and no permit costs; no declaration on land costs).

At these levels, the above cost factors do not put pressure on the production costs, so far. As regards welfare investments in the region (considered also as part of investment costs), only the owners of the 4,16 MW project made voluntary ecological investments and took care of the construction of a tourist infrastructure, but no information is available regarding their costs. No payments from have been made in the form of royalties so far.

IV.4. Resource quality and availability

Table 9 mentions the data regarding wind quality and availability for the three investigated projects. It can be observed that the average wind speed for the 150 kW project is quite low - 4,9 m/s - and the annual availability of wind speeds for rated power operation is also low - 850 hours per year. For the 4,16 MW project the annual availability of nominal winds was modest during 2002 and 2003 (1.240 hours, 1.045 hours). For comparison, in Spain most projects realized in early 1990s had annual availabilities of 3000h, many of those realized by mid 1990s had annual availabilities of around 2400 hours, while by 2001, many projects still could operate for around 1800 hours per year at rated power (Dinica 2003).

The technical potential of Switzerland, was estimated at 74 TWh/year, available on a total surface of 28 % of country surface[51]. This potential is mainly located in the North-East part of Switzerland. Based on this, Swiss experts estimated two options of the 'economic potential'. The first regards sites with at least 4,5 m/s annual average wind speed, with more than 800 full load hour per year, with a density of 5 turbines per km^2, for which production costs would be below 17 €c/kWh (nature protected areas were not excluded). These sites total 1.668 km^2 (4 % of country surface) and could accommodate 8.340 turbines. Assuming that these are DeWind turbines of 80 m rotor diameter, 100 m height and 2 MW installed capacity, they could generate 21.600 GWh/year. The second regards sites with at least 5 m/s annual average wind speed, with more than 1.100 full load hour per year, with a density of 5 turbines per km^2, for which production costs would be below 12 €c/kWh (nature protected areas were not excluded). These sites total 753 km^2 (1,8 % of country surface) and could accommodate 3765 turbines. Assuming that these are DeWind turbines of 80 m rotor diameter, 100 m height and 2 MW installed capacity, they could generate 12.000 GWh/year. For both variants a large part of the economic potential is located on a strip of land along the North-West border of Switzerland.

[50] Several Swiss companies focus their efforts in improving project design and technological performances of projects facing icing conditions and turbulences, located in areas of difficult accessibility for construction as well as maintenance/repairment of wind systems.
[51] This means 11.512 m^2 and it excludes areas with unstable ground, steep areas, inhabited areas, lake areas and not accessible areas.

The goal defined in the Swiss Energy national program[52] is the commissioning of turbines able to generate 100 GWh by 2010 (the BFE envisages 10 priority sites for investments, using 65 turbines). Wind electricity production should be later increased to 600 GWh by 2025 (320 GWh in wind farms and 280 GWh with single units) and 4.000 GWh by 2050. The target for 2050 is considered to come around finally with two-thirds from single-turbine wind projects (2.850 GWh/year) and one-third from wind parks (1.150 kWh/year). For these targets it is expected that production costs will be around 9 €c/kWh. On the short-term it is expected that for the 65 turbines that may be built at the selected 10 locations, production costs are would be on average 11 €c/kWh. This estimation took into account the available wind speeds and full load hours at the respective locations for turbines that have on average 1,25 MW installed capacity. However it is not clear to what extent cost estimations took into account the pressure on production costs due to the small size of projects – as agreed with many stakeholders - and the fact that many projects will be single-turbine projects, which increases production costs substantially[53]. Appendix 1 shows maps with the sites for wind parks as agreed upon in the framework of the Swiss concept for wind energy.

Policy recommendations - Switzerland

IV.6.1. As regards the reduction of the influence of *technology-specific factors and costs:*

- Public authorities could stimulate investors' choice for technological designs with:
    - Strong generators (able to face the Alpine wind regimes)
    - pitch control of blades;
    - variable / two-speed rotors;
    - adequate ice-removal devices
    - synchronous generators for stand alone applications.

  These technical features are more likely to increase the electricity production of wind turbines compared to conventional models typically used in flat areas. This could be done by policy instruments such as:

  - tax incentives: allowing the reduction of investment tax (or other taxes) for wind technological designs that have such technical features;
  - technical standards for the manufacturers competing in the call for tenders in order to receive governmentally subsidized price support.
  - financial support for Swiss industrial companies working on R&D for ice removal systems.
- Many projects are planned as single/two turbine plants - either connected to grid or (mostly) stand-alone. The turbine costs are often higher when single turbines are bought as compared to larger orders. Public energy agencies may support the purchase of single turbines by means of *project aggregation arrangements*. A series of project proposals may be brought together and orders can be made for larger numbers of wind turbines from selected manufacturers when the preference of project developers overlaps. This may reduce the equipment costs per kW.
- As indirect measure: provide price support that can make the 'realizable potential' found in the Concept Plan economically feasible and financeable. This should preferably be in the form of one or two policy instruments with clear and simple design that should be maintained for a period of at least 10 years. The operation of one or few clear support schemes increases the range of developers likely to understand and able to assess their financial impact. Transparency and stability in support system will increase the number of investors and industrial companies willing to contribute to the diffusion of wind technology. This may also attract more manufacturers of wind technology with desirable technical features to compete in Switzerland and reduce technology-specific costs.

IV.6.2. As regards the *technology-complementary costs*, the comments and recommendations made in Section I.6.2. for Austria apply as well. There is little public authorities may do to minimize technology-complementary costs, because they are influenced by rigid factors, not liable for manipulation.

In Table 6 we presented a qualitative estimation of the weight that technology-complementary factors may have on production costs. If the political choice is to support first the projects with lower production costs and later the increase price support to enable also projects in more remote locations, then the government should:

[52] The Swiss Energy national program is based on the provisions of the Energy Law, which became effective in 1999 and the Carbon Dioxide law adopted in 2000.
[53] When projects are stand-alone systems, production costs are even higher, being typically 30 % higher than for grid-connected systems (and they require synchronous generators for good operation which so far not too many manufacturers can provide).

- stimulate first investments in larger-size projects (>15 MW) and moderate size project (5 - 12,5 MW) located *close* to adequate grid and road infrastructure;
- increase price support at a later stage to also enable:
    - larger-size projects (>15 MW) and moderate size project (5 - 12,5 MW) located *far(ther) away* from adequate grid and road infrastructure;
    - small size projects (< 5 MW, close/far from grid-road infrastructure).

If the political choice is to simultaneously support all types of projects (as differentiated in Table 6), the government should introduce a price support system that differentiates payment according to project size (as suggested above), and location relative to the grid-road infrastructure, while accounting for the need for clarity and simplicity in design.

IV.6.3. As regards the reduction of the influence of *context-induced factors and costs:*
a) In order to contain the negative cost consequences of trade and financing arrangements, (Canton) public authorities may:

- Put in place a reliable financial support system that enables predictable payments for project owners and maintain them sufficiently long to enable banks loans at reasonable interest rates - desirable 10 years. This may imply a back-up price support system that enables projects to remain economically feasible in case the willingness to pay of voluntary consumers lowers too much, or a governmentally guaranteed purchase system with utilities, based on a cost-recovery mechanisms for buyers that reduces the current contract risks.
- Project aggregation schemes[54] could also help to contain the cost consequences of project financing arrangements especially for small and one-turbine projects, which appear likely to dominate future investments based on the Swiss Concept for Wind Energy (BFE) after 2025. These projects incur typically higher banking fees and interest rates than project larger than (around 5 MW). For the same purpose another policy instrument that may be used is that of:
- governmentally-subsidized soft loans[55].
- Workshops with financing agents to communicate the governmental energy policy may increase the confidence of financing agents in wind technology, and in the political support for wind energy, enabling more project financing loans and lower interest rates.

b) In order to ensure low costs in project life cycle operations, public authorities could provide more policy stability with regard to the chosen price support scheme and its design details: this may encourage even more industrial companies to offer services and product for wind power plants investors, increase competition and lower the costs incurred by investors during the life-cycle of projects.

II.6.4. As regards the influence of *resource quality and availability* on production costs, the same recommendations as in the case of Austria and Italy applies. Public authorities could design a price support system that rewards wind electricity also when it is produced and not only for the times when the general demand in the electricity system is high. The Alps have good wind resources but with very large differences in wind speeds during the day and from month to month. This makes it desirable to tune price support with the technically possible timeline of wind electricity production.

References

Personal communication with Horbaty R. from ENCO Energy Consulting AG, on 1 September 2004.
Website: http://www.suisse-eole.ch/power-sitessuisse-d.htm.

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[54] *Project aggregation or bundling* refers to a way of addressing the problems of financing availability and financing costs by aggregating more wind projects in order to secure a single large loan. This approach is generally used when sizes of projects are too small compared to the standards of the financing agent. After the loan is received the money is split among the developers whose projects were aggregated. Beside access to finance, this instrument also results in lower interest rates, because the transaction costs per project are reduced. The aggregation of wind projects can be done by any type of economic actor. But when a government agency takes the role of aggregator agent, this has higher chances to result in more attractive financing terms including lower interest rates. An example where this instrument was successfully used is the Autonomous Community of Catalonia in Spain, where the regional energy agency concluded agreements with regional banks for large and low interest rate loans that were consequently split to finance the installation of solar based energy systems by households and small companies.

[55] Soft loans assume the payment by the government of a percentage or the entire interest rate that project developers have to pay when loans are used to finance wind projects. This has similar effects to subsidies, but often assume a smaller extent of financial support. The loan could come from a financing institution or agency of the government, or from a commercial bank or other type of financing agent with who the government concluded an agreement to finance developers of wind projects. This instrument is very helpful to use in the first stages of market introduction to overcome the financing barrier.

Horbaty R. 2003, "Chapter 19 – Switzerland" in the *Wind Technology Annual Report* of the International Energy Agency available at www.ieawind.org
OFEN, OFEFP, ARE, August 2004, *Swiss Concept for Wind Energy – Basis for the Location of Wind Parks*, Berne
Dinica V., 2003, *Sustained diffusion of renewable energy*, PhD thesis, University of Twente, Enschede, The Netherlands.

V. FRANCE

(This section is based on the report by RAEE contained in 11.3.2)

The analysis of the questionnaires returned by wind farm developers makes it possible to indicate the differentiated production cost, on the basis of installed MW. Part of the operating costs (principally maintenance costs) is built into the production cost. Along with this, in order to reflect the commercial diversity of the wind generating business, costs will be expressed in price class / MW. They will show cost variations depending on parameters, like the size of the wind generators and power developed, or again, the professional status of the developers: constructors / developers, developers / operators, developers / project owners.

	Overall production cost of wind-generated electricity	850 to 1200 K€ / MW installed
	ALLOCATION OF COSTS PER POST:	
Investment	Cost of wind turbines (excluding transport and installation)	600 to 1000 K€ / MW installed
	Civil engineering	170 to 210 K€ / MW installed
	Transport	Priced per Km (from 5 to 8 % of the overall cost of the wind generator)
	Connection to grid	10 to 100 K€ / MW (10 to 100 K€/ Km)
	Development and study phase	30 to 100 K€ / MW installed
Opera tion	Supporting measures	Highly variable, but generally a low % of the overall cost
	Annual maintenance	20 K€ / MW for the first 10 years, then up to 30 K€ / MW installed depending on the level of maintenance.

Table 10. Estimation of the cost price per post of the wind-generated kW, on the basis of the results of the questionnaire sent to French wind farm developers.

The following observations can be made, based on the data in Table 10:
- The total investment costs range 850 – 1200 E/kW recorded so far in France is almost the same as the EU average (see Table 1 and 2). Compared to the already realized projects in the Alpine area of Austria, Italy and Switzerland, these costs are somewhat lower.
- Technology-specific costs: the lower range of this cost factor is also somewhat lower than for the other Alpine projects investigated and summarized in Table 1: starting from around 600 E//kW up to around 1000 E/kW. These represent between 70-83 % of total investment costs. This proportion is almost the same with that in Germany, UK Spain and Denmark (see Table 3).

Factors leading to higher overall production costs per kWh of wind electricity in the French Alps:

The discussion in this section is not based on a scrupulous economic analysis, in its scientific and analytic dimension. The amount of experience feedback from wind generating sites in mountain zones is too little to be significant and enable a reliable economic analysis. Therefore, the analysis here is mostly qualitative, based on the experience garnered by wind farm developers. Nevertheless, general trends have emerged, along with major priorities for consideration.

As the constraints of the mountain environment are passed on more or less directly to the cost of production of the wind farm, it is possible to confront the industry's development perspectives with the economic demands imposed by the mountain environment. The idea behind this is to assess specific needs and supply responses and recommendations optimising feasibility.

According to the answers given by the developers interviewed, the major constraints in terms of economic repercussions are:

→ *technology complementary factors*

• The accessibility of the wind generator site (cf. rapport WP 3 for details on the nature of the constraints),

• Accessibility of the electricity network,

→ *context induced factors:*

• The demands of "integrating" the landscape (cf. report WP 5),

• The low availability of land and the mechanisms associated with real estate speculation (cf. section I. C 3. a) 1.),

→ *resource availability and quality related factors*

• The impact of the constraints caused by weather conditions on the productivity of the installed machines,

• The impact of the constraints caused by weather conditions on conditions of maintenance (cf. report WP 3 for details on the nature of the constraints).

Although all of these factors are specific to mountain zones, we can make their constraint levels relative with regard to the variability of potential wind-farm sites. For example, for two sites that are close in terms of natural heritage and meteorological conditions, the economic feasibility of the wind-farm site will depend essentially on existing infrastructure (i.e. roads, electricity network, mechanical ski-lifts). Therefore the level of costs pressure of "technology complementary costs" is essential in the economic feasibility under existing price support mechanisms.

The generalisation of constraints throughout the Alpine zone would not be a good thing: certain zones of the mountains are already densely developed and have established network and service links, which makes it possible to considerably reduce constraints in terms of accessibility (to sites and networks) and impact on the landscape. However, these zones have considerable constraints in terms of land availability (i.e. lack of land available, speculation in tourist sites). At the other end of the scale, less developed zones offer interesting land acquisition perspectives, but the lack of networks is a drawback to an economically sustainable installation. This suggests the importance of the interplay between two cost categories differentiated in this project: technology-complementary costs and context induced costs. When one category increases, options need to be found to reduce cost pressure from the other cost-category (e.g lower interest rate level) in order to keep the overall production costs at a level that allows economic feasibility of the projects under existing governmental price support level.

Table 11 covers the specific constraints (cost pressure factors) most often referred to by developers. Details of their economic repercussions are given, but it is impossible to derive serious statistics from this.

CONSTRAINTS	ECONOMIC REPERCUSSIONS
Technology complementary costs	
Complicated access to site: bridges, tunnels and winding roads.	- Additional cost in developing or building roads. - Additional cost in an alternative transport solution (air transport).
The possibilities of connection and/or evacuation to networks are difficult: for reasons of distance and the complexity of the terrain to be connected; and for reasons of the capacity of a network that may already absorb hydro-electric production	- Additional connection costs relating to the number of kilometres of trench to be laid. -Additional cost if there is a long delay in reinforcing the network (investment costs to pay but still no operating revenue).
Context-induced cost factors	
Landscape requirements	- Additional cost in the site prospection and study phase. - Additional cost relating to the most probable abandon of project after planning applications. - Additional cost linked with compensatory measures or supporting measures.
Lack of land and high rental prices in certain tourist zones	- Additional cost in the study and prospection phase of the site. - Additional cost in fixed rental costs.
Resource-related cost factors	
Turbulence, ice and snow problems, low air density[19]	- Additional cost in terms of producible forecasting (continuity of wind measurement). - Additional cost linked to losses in productivity (wind generator productivity and difficulty of access for maintenance operations).

[19] The diminution of air density with growing altitude implies a lesser yield from wind generators.

Table 11. Résumé of the economic constraints on developing the wind generating industry in mountain zones.

As it can be seen, we can talk fairly seriously about the constraints and additional costs. However, it remains difficult to put a figure on additional cost, as the extra expenditure will depend on the characteristics of each site chosen (cf. annexe 3, the variability of additional cost estimates given by the developers).

In this context, the evaluation of additional costs relating to the constraints of mountain zones will be dealt with on a case-by-case basis. Developers will validate a mountain zone project by accepting the possible additional costs, only if the wind potential and the operating capacities prove profitable. The banks work on the basis of data on wind potential and producible forecasts before giving their approval, in around 80 % of investment (cf. finance section).

The additional costs mentioned above can be brought down. So, the question is to find the wind-farm structure best suited to the reduction of additional costs, by guaranteeing a profitable minimum of electrical producible. When one consider factors such as:

→ technology complementary costs:

- the problems of transporting wind generators to the site and
- the problems of capacity of the ARD and RTE networks;

→ factors possibly affecting both the level of technology complementary costs and context induced costs, due to the costs incurred for permits and studies:

- the problems of landscape impact
- the problem of land availability,

one can already envisage profitability difficulties for projects involving wind generators developing high power output[20] (> 850 KW).

Because transporting them is less complicated, their landscape impact is lower, their installation land requirements are less and their production is more compatible with the current electrical network, medium-sized wind generators (generally 750 and 850 kW, less than 70 metres high) involve lower additional costs in development. The land area required and the power developed also depend on the number of wind generators installed. This is why wind farms of modest proportions (< 10 MW developed), are a more realistic option.

Furthermore, the profitability of small to medium wind farms in mountain zones will also depend on the relative cost of wind turbines. It has been shown that developers who do not generate very large power output (< 2 MW), have a more interesting kW cost price on small wind generators compared with larger ones (cf. diagram 11). Small wind generators benefit from longer feedback experience and are, up to now and in most cases, less expensive to produce. In terms of economic and technical feasibility, medium power output wind generators are most adapted to the development of the industry in mountain zones.

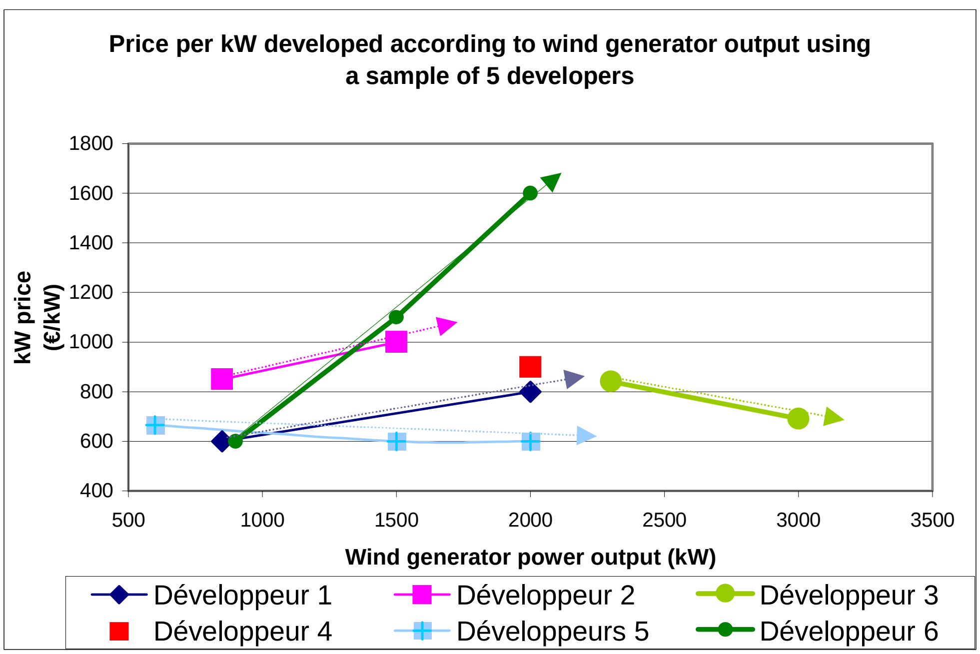


Figure 2: Prices of wind-generated kW (excluding turbine manufacturing, transport and installation costs) according to

[20] from 70 to 120 metres high excluding blade.

the power of the machines, for six French developers. Short of output power of 2 MW, the production cost of small wind generators is lower than (developers 1, 2 & 6) or equal to (developer 5) the cost of the largest machines.

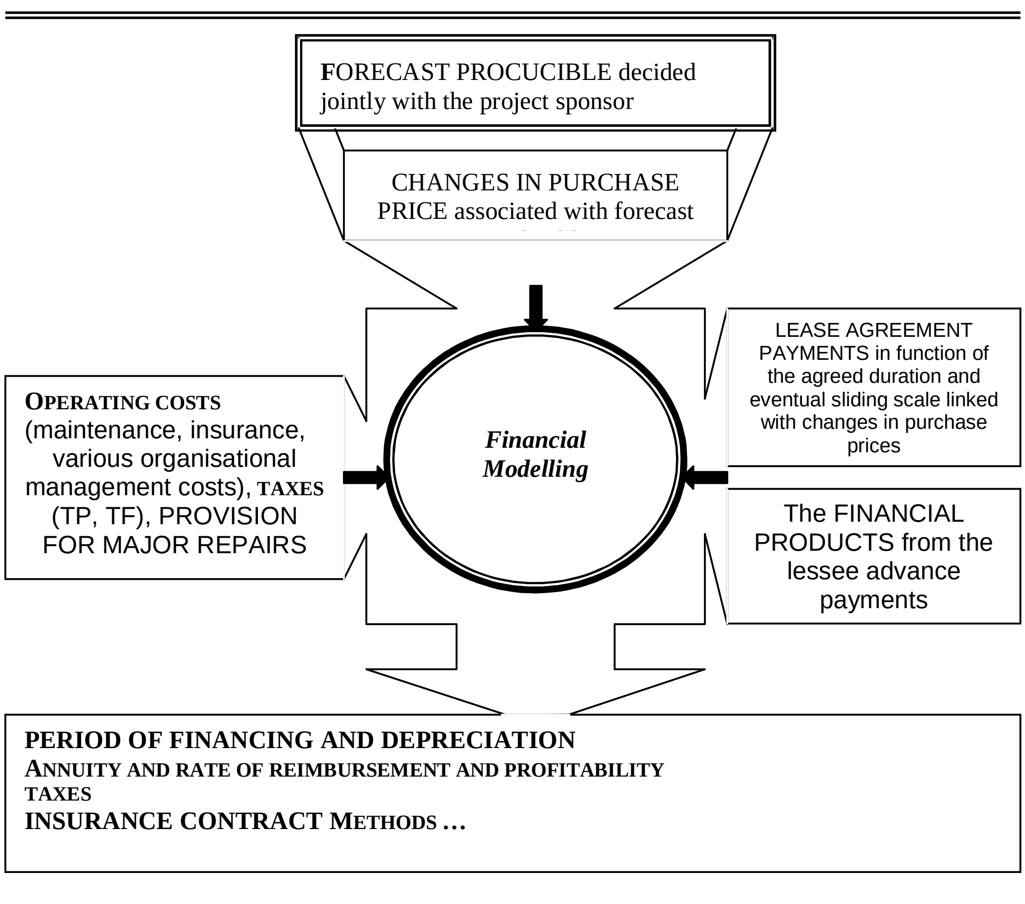
Therefore, the following observations could be made:
→ The topographic, meteorological, landscape and land availability conditions in mountain zones represent additional cost factors.
→ The costs of connection to the electricity network and developing the road network increase exponentially with the complexity of the terrain, and the development of wind farms will be facilitated in zones that have already been developed.

Context-induced costs - monetary consequences of financing and trade arrangements

In this section we address the questions: Who are the financial players in a wind generating project and what parameters do they use for deciding whether or not to invest? Is the development of wind farms in mountain zones inseparable from specific incentive measures?

The financing of wind projects depends on:
- the cost price of the investment per installed kW,
- the number of operational hours per year (2,200 to 2,300 hours per year minimum).
On the basis of these factors and the owners equity / bank debt ratio, the bank will create a financial development model for the wind farm project (see Figure 3) and will use it to decide whether it will participate in the project and, where this applies, set the conditions for the loan or the SOFERGIE leasing (see below) arrangement to the project's sponsors.

Figure 3: Summary of the financial approach of banks in the context of a wind farm project. (Source: Arno Houllière, 2004)



The following forms of financing have been observed

1. Banks / private funds: 80 % / 20 %.

Typically, the financing of a wind generating project relies on the participation of private investors and banks. With participation of 20-25 % and 75-80 % respectively. The private investors can be autonomous producers with solid experience in other energy sectors (hydraulic, thermal), major operators, French or foreign electricity producers (energy subsidiaries of major industrial or service groups) or independent developers (design consultants, small operators) who have developed projects in which they want to remain at least partially involved. The developers (or operators) are in charge of setting up the financial aspect of wind generating projects and ask the banks for loans. Within the framework of this type of financing, the structure of wind generating projects can fall into several different legal forms, which are detailed in annex 4. The banks offer their participation in the following ways:

→ a loan:

- Financed over 5 to 15 years.
- Variable or fixed rate.
- Repayment at constant rate (linear) or constant capital (sliding scale).
- Possibility of capital exemption in one or two repayments.

→ SOFERGIE[21] leasing:

Specific financing by property and equipment leasing or simply renting installations intended for energy control and protection of the environment.

- Financed over 5 to 15 years.
- Rental rates adapted to the growing scale of investment and the project's own economy (progressive, by stages, seasonal), and taking into account the price scale or the nature o the producible.
- Fiscal depreciation allowance on the property element over the same duration as the equipment element, without fiscal reintegration at the end of the leasing agreement.
- At the end of the leasing agreement, the lessee can return the property to the lessor or purchase it for the amount of its residual value (fixed at the beginning of the operation).

The BDPME (Small and Medium Business Development bank), a limited company where the State and the Caisse des dépôts et consignations (deposit and consignment office) are the majority stakeholders, is often the main financial partner in setting up wind generating projects. When the risk of a wind generating project is acceptable, it allows the financing of the project by calling on its international network of financial partners. Private investors finance up to 15-20 % depending on the quality of the project, either in the form of a current account with withdrawals possible to meet the debt repayments, or as a security deposit.

2. Alternative financing

→ The FIDEME

Beyond loans and SOFERGIE leasing arrangements offered by a pool of financial players, there is also the FIDEME (Environment and energy control investment fund). The fund is managed by a subsidiary of the Caisse des Dépôts group investment bank, Iéna Environnement. It allows a partial substitution for promoters and credit establishments, through an action in quasi-equity. This means the FIDEME provides an additional financial resource (and intermediary between promoter's owners equity and classic bank debt), where the finance costs and guarantees are competitive, with regard to those required for owner's equity, in the framework of a wind generating project. The sectors eligible for FIDEME involvement are renewable energy sources (wind generating, hydraulic, geothermal and biomass), waste upgrading, and equipment manufacturers in energy control and waste upgrading in Metropolitan France and in French overseas territories. The FIDEME's aims do not include financing companies in the start-up phase, or the development of technological innovation. For further information about the FIDEME, readers are invited to consult the fact-sheet in annex 5.

→ Local investment (in line with WELFI[22])

German and Danish experience in the subject of financing wind generating projects show that local investment, by individuals or co-operatives, can play a decisive role in matters of appropriation and acceptance (see Figure 4). In Germany, 90% of wind generators are owned by private individuals. In Denmark, 26% of wind generators belong to co-operatives.

These methods of financing are not common in France. However, there are several legal forms that allow numerous individuals to set up in assocation and investors to limit their liability to the value of their stake.

[21] Created by the law of July 18th 1980.

[22] WELFI: Wind Energy Local Financing (http://www.etd-energies.fr/welfi/fr/).

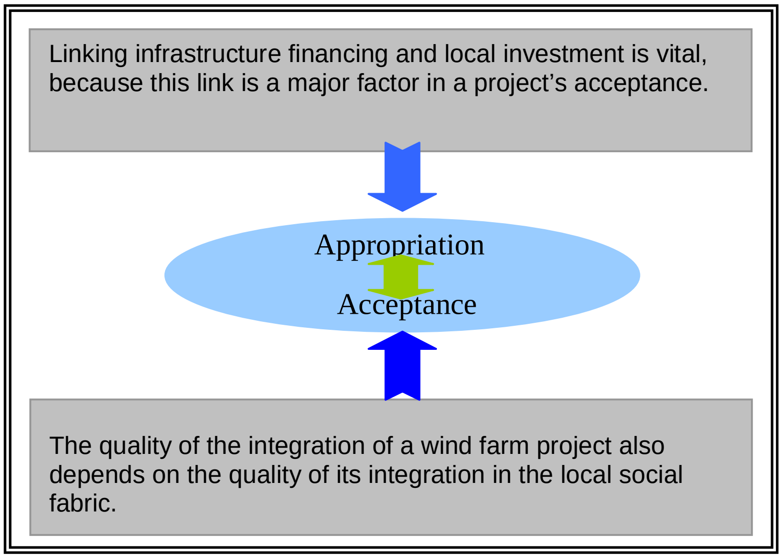


Figure 4: Schema resuming the interactivity between local financing and the acceptance and social integration of wind generator projects. (Source : Arno Houlliere, 2004).

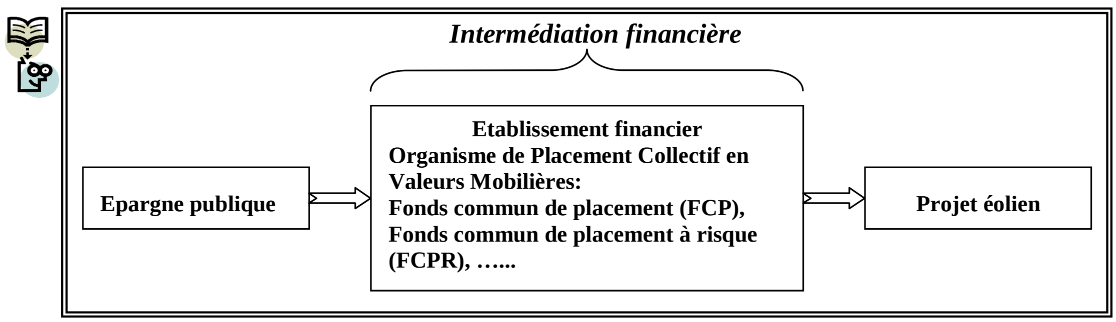


Figure 5 : Summary of financial intermediation mechanisms in financing wind generator projects. (Source, Reynald Bavay, ADEME, 2004).

i: Via direct investment:
The French system allows direct local investment by calling on public savings schemes, for the following types of legal status:

- Société en commandite par actions (Partnership companies limited by shares);
- SEM's (Mixed Economy Companies);
- SCOP's (Co-operative production companies);
- SCA's (Co-operative agricultural companies);
- SCIC (Collective interest co-operative companies).

ii: Via indirect investment:
Indirect investment via adapted financial tools would enable a better mobilisation of public savings schemes and encourage local investment.

→ Proposed legislation relating to local investment
The procedure of a public call for savings schemes is very cumbersome to set up (application file sent to the COB) and, because of this, represents a major constraint to indirect local investment. So, this type of financial deal is only appropriate for major projects.

A new, particularly interesting, financial tool has been announced: the FIP (local investment fund –the "Dutreil" 1 bill – accepted on its first reading in 2003). The bill provides for the creation of a new sub-category of FCPR (common funds for risk investment) called FIP (local investment fund), which will provide local financing solutions allowing mandated organisations to collect regional public and private savings in the form of minority stake-holding in the region's small to medium businesses. Subscribers to these FIP's are entitled to an income tax reduction of 25% of the amount subscribed, with a €10,000 ceiling for a single person and €20,000 for married couples returning a joint declaration. The initiative for these new funds will be in the hands of the regions, which will participate in defining their investment rules. They will be able to participate in financing the fund management structure. Subscribers can be private individuals or institutional investors. This will allow investors to make investments voluntarily dedicated to economic activities, where localisation is an additional motivation to the prospect of profit. Consequently, indirect and local investment in France is encouraged by collective investment schemes which:

- offer investors the means of making an investment of an economic type,
- mutualise risks,
- offer the possibility of contributing to the economic development of their territory, beyond profit considerations.

It should be noted that the financial analysis carried out by the bank represents a 1 to 2% share of the total investment costs. According to the results from the questionnaires sent back by the developers, the following general financial trends can be underlined:

- Project sponsors turn principally towards finance lessors in financing wind farms.
- The repayment deadlines stretch from periods of 12 to 20 years, depending on the availability of the resource and the relative share of owner's equity in the total investment.
- The internal profitability rate after tax varies from 6 to 10 % according to the availability of the resource and the project sponsors.

Consequently, it can be concluded that under the dominating financing options, the financing costs (as one of the sub-categories of context induced costs) do not put cost pressure on (leading to increase in) the overall production costs of wind electricity per kWh. However, bank loan financing remains an obstacle for many project developers. The explanation for this financial constraint lies in the notion of financial risk, fed by uncertainties concerning profitability that essentially affect the forecast of producible and maintenance guarantees.

1. Forecasting the producible:

There are 3 major problems in estimating the producible:

- The continuity of wind measurement: anemometers encounter operating problems in extreme weather conditions. Yet the banks demand continuous wind measurement over a period of at least 6 months.
- The correlation of wind measurements with the nearest Météo France meteorological stations: the complexity of mountain meteorological phenomena confronted with the insufficient number of exploitable weather stations (for wind data) in most mountain ranges makes it difficult to obtain the 95 % correlation coefficient demanded by the banks.
- Wind prediction models (WASP, MESO NH) are less accurate, particularly in taking topographical variations into account. The banks often consider this bias in prediction as a supplementary risk.

With regard to uncertainties over forecasting and estimating wind potential, the banks extract safety margins of the producible. These margins of around 10 % on the annual duration of the wind, for example, modify the estimated profitability of wind farms and very often compromise their financing.

2. The operating and maintenance guarantees:

The risk of operating loss linked to the impossibility of maintenance operations because of weather conditions will be increased in mountain zones. There are two risk factors:

- access to the site,
- and the safety and efficiency of maintenance operations.

3. The decreasing level of purchase prices which affects project profitability and risks. This is explained in the section below.

Financial public support

Investment in a wind farm project is directly dependent on the profitability prospect of the electricity producing structure. The revenue of the industrial wind farm is completely ensured by the purchase of electricity. The purchase price is comfortable, as it aims to encourage the expansion of the industry with a view to meeting France's Community requirements. In France, an agreement[23] sets an average purchase price of 7.3 c€ per kWh (Teq) for 15 years. EDF and the non-nationalised distributors (Inter-communal syndicates, SEM's or private distributors) are obliged to buy the electricity at the high price for the first 5 years: 8,38

[23] The decree of June 8th 2001, setting *the purchase conditions for electricity produced by installations using the wind's mechanical energy* and the decree of March 7th 2003 relating to *the multi-annual programming of investments in electricity production*.

c€/kWh (T1); then, for the next ten years, the purchase price varies from 3.05 to 8.38 c€/kWh (T2) according to the duration of operation noted over the first period (5 years). The maximum remuneration concerns the sites with the least wind, so, the more wind there is, the lower the purchase price.

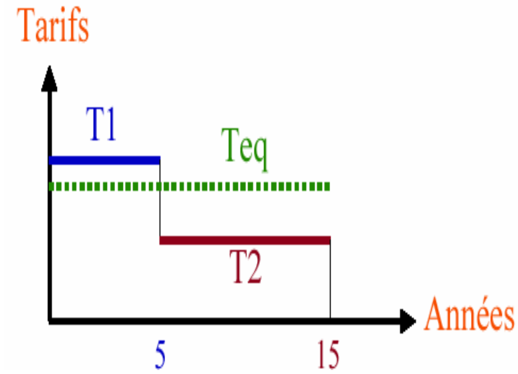


Figure 6: Purchase prices for wind-generated electricity (Source, Bernard Chabot, 2003).

	For the first 1,500 MW installed			For the following MW		
Annual operating period (hours)	Years 1 to 5	years 6 to 15	Above this	years1 to 5	years 6 to 15	Above this
	price c€/kWh	price c€/kWh	price c€/kWh	price c€/kWh	price c€/kWh	price c€/kWh
1900 and less	8.38	8.38	4.42	8.38	8.38	4.42
2000	8.38	8.38	4.42	8.38	7.89	4.42
2100	8.38	7.98	4.42	8.38	7.41	4.42
2200	8.38	7.57	4.42	8.38	6.92	4.42
2300	8.38	7.17	4.42	8.38	6.44	4.42
2400	8.38	6.76	4.42	8.38	5.95	4.42
2500	8.38	6.36	4.42	8.38	5.63	4.42
2600	8.38	5.95	4.42	8.38	5.31	4.42
2700	8.38	5.66	4.42	8.38	4.98	4.42
2800	8.38	5.37	4.42	8.38	4.66	4.42
2900	8.38	5.08	4.42	8.38	4.34	4.42
3000	8.38	4.79	4.42	8.38	4.02	4.42
3100	8.38	4.50	4.42	8.38	3.69	4.42
3200	8.38	4.21	4.42	8.38	3.37	4.42
3300	8.38	3.92	4.42	8.38	3.05	4.42
3400	8.38	3.63	4.42	8.38	3.05	4.42
3500	8.38	3.34	4.42	8.38	3.05	4.42
3600	8.38	3.05	4.42	8.38	3.05	4.42

Table 12 : Table summarising the interpolation of purchase prices for wind-generated electricity as a function of the power developed (threshold of 1,500 MW) and the number of hours of operation on site. This price grid is only valid for projects that came into operation before June 2002.

The variation of purchase prices according to the availability of the resource should allow widespread installation of wind generators throughout the country, in order to avoid the concentration of wind farms in the zones with the highest wind potential. The basic price grid is effective for projects that came into being in 2001 and 2002 (from June 2001 to December 2002). Since 2003, prices have come down by an annual 3.3 % in order to take into account the improvement in productivity and the principles of competition between different electricity producing installations. The prices are calculated on the basis of the prices announced for the first 1,500 MW installed. Beyond the first 1,500 MW, the basis for calculating prices should be lowered by around 10 % for operating duration of > 5 years, in addition to the annual reduction of 3.3 %.

The purchase prices represent additional costs for EDF. These costs are compensated by a surcharge on the consumer's bill, collected by the FCSPE (Public service electricity compensation fund). According to the estimate of public service costs made by the CRE (Energy regulation commission) at the end of 2002, the preferential prices for wind-generated electricity induce an additional cost of around € 30M for 2003, an annual additional cost of € 0.18€ for a household with average consumption (3,000 kWh).

The "purchase price" variable is decisive in the forecast profitability analysis. The gradual decrease of prices will complicate the achievement of less productive projects. The fact that France lags considerably behind in the development of wind farms has major economic implications. Although there have been technical improvements in productivity, the absence of a national network of production and operation (dependence in relation to the Spanish, Danish and German industries) cannot be compensated by constantly decreasing purchase prices (Boston Consulting Group, 2004).

Resource quality and availability factors

The system of purchase prices is not necessarily favourable to investment in wind farm projects in mountain zones. Amongst other things, *the profitability of mountain zone wind farms requires good wind conditions (≥ 3000 hours of operation per year) to offset essentially the additional technical costs (hence the higher costs in the category 'technology specific costs').* An optimistic scenario of the development of the industry in the zones in question, could forecast the wind farms being operational by 2007-2010. In terms of purchase prices, this implies an accumulated drop of 9 to 15 % of price bases that are already diminishing, beyond 5 years of operation. The drop in the guaranteed contractual prices means that even some sites with high quality resources and high wind availability may not be able to accommodated economically profitable wind projects.

To deal with the risks, in terms of investment, imposed by the specific features of mountain zones, wind farm developers propose several development scenarios for the wind generating industry in mountain zones:

• Either an incentive scenario, based on specific changes in prices or the administrative facilitation of projects,

• Or a wait-and-see scenario, based on the development of R&D in terms of productivity and wind potential forecasting in extreme conditions.

Others think that the potentially profitable wind generating potential of mountain sites should be exploited rapidly, in order to take advantage of current purchase prices, sufficient to ensure a good level of profitability for installations. In the main, they call for a facilitation of projects or, at least, a reduction of administrative hindrances and obstacles.

Policy recommendations

The above empirical analyses lead to the formulation of the following policy recommendations for wind energy expansion in the French mountain zones:

As regards the reduction of the influence of *technology-specific factors and costs*, public authorities could:

- Stimulate investors' choice for technological designs with:
    - Strong generators (able to face the Alpine wind regimes)
    - pitch control of blades;
    - variable / two-speed rotors;
    - adequate ice-removal devices.

These technical features are more likely to increase the electricity production of wind turbines compared to conventional models typically used in flat areas. This could be done by policy instruments such as:

- tax incentives: allowing the reduction of investment tax (or other taxes) for wind technological designs that have such technical features;
- technical standards for the manufacturers competing in the call for tenders in order to receive governmentally subsidized price support.
- financial support for French industrial companies working on R&D for ice removal systems.

As indirect measure: improve the economic attractiveness for the economic support systems by means of additional instruments (such as investment subsidies) able to give compensation for the higher investment and production costs for projects in Alpine environments. Bringing the profitability of wind projects in the range typical for projects in other landscapes may increase the number of manufacturers, investors and industrial companies involved in wind projects in French Alps and competition may reduce technology-specific costs (or rather said help with a lower rate of cost increase, when additional devices and technical measures need to be incorporate to deal with the aspects of icing and other alpine-whether impacts).

Further, public energy agencies may support the purchase of single turbines by means of *project aggregation arrangements*. A series of project proposals may be brought together and orders can be made for larger numbers of wind turbines from selected manufacturers when the preference of project developers overlaps. This may reduce the equipment costs per kW.

As regards the *technology-complementary costs*, there is little public authorities may do to minimize them, because they are influenced by rigid factors, not liable for manipulation.
In Table 6 of Report 11.6 we presented a qualitative estimation of the weight that technology-complementary factors may have on production costs. If the political choice is to support first the projects with lower production costs and later the increase price support to enable also projects in more remote locations, then the government should:

- stimulate first investments in larger-size projects (>15 MW) and moderate size project (5 - 12,5 MW) located *close* to adequate grid and road infrastructure;
- increase price support at a later stage to also enable:
  - larger-size projects (>15 MW) and moderate size project (5 - 12,5 MW) located *far away* from adequate grid and road infrastructure;
  - small size projects (< 5 MW, close/far from grid-road infrastructure).

If the political choice is to simultaneously support all types of projects (as differentiated in Table 6), the government should introduced a price support system that differentiates payment according to project size (as suggested above), and location relative to the grid-road infrastructure, while accounting for the need for clarity and simplicity in design.

As regards the reduction of the influence of *context-induced factors and costs*, public authorities could:

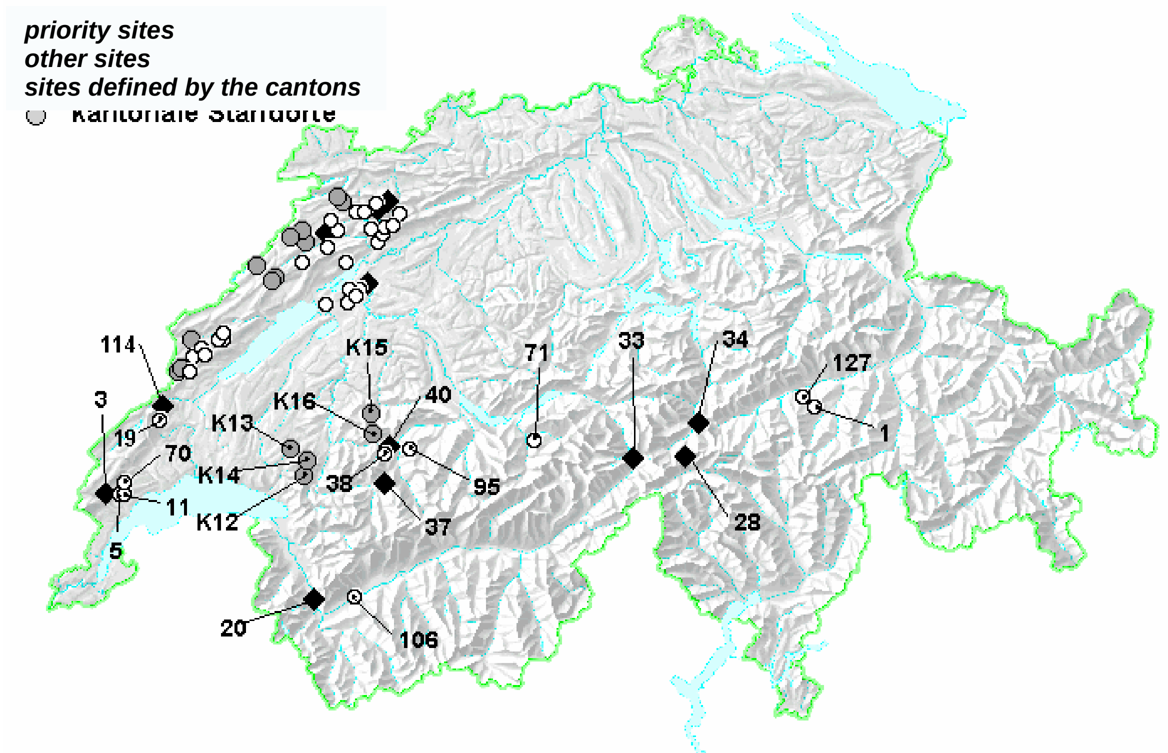
- Reduce the administrative bureaucracy around the studies that need to be done for the issue of permits. These studies need to be well-founded but organizational inefficiencies may bring substantial costs to the project developers and contribute to the increase of overall production costs claimed. Support might be offered in the form of technical assistance for the drawing up of such studies.
- Public authorities involved in price design should take into account the additional maintenance and operation costs due to icing problems and difficulties in site accessibility, when they set up price support.
- Allow for a certain level of economic benefit for land owners and municipalities in the area where wind projects are developed. Land rents to owners and royalties to municipalities have positive spin off in terms of project acceptance and exposure to other citizens, communities, tourists etc. This contributes to the public acceptance of wind technology more widely. However, in order to keep these practices under control so that they do not endanger the economic feasibility of projects, the government should set ceilings on these fees, or facilitate a voluntary agreement between investors and stakeholders that may benefit of such payments. This should also be taken into account when the level of price support is calculated for Alpine projects.

As regards the influence of *resource quality and availability* on production costs, public authorities could design a price support system for the Alpine projects that enables a profitability in the same range as in the other regions – 6 to 10 %, for a period of time at least as long as the period of debt maturity. This would enable bank financing and more types of project owners to enter the market, including the small economic actors.

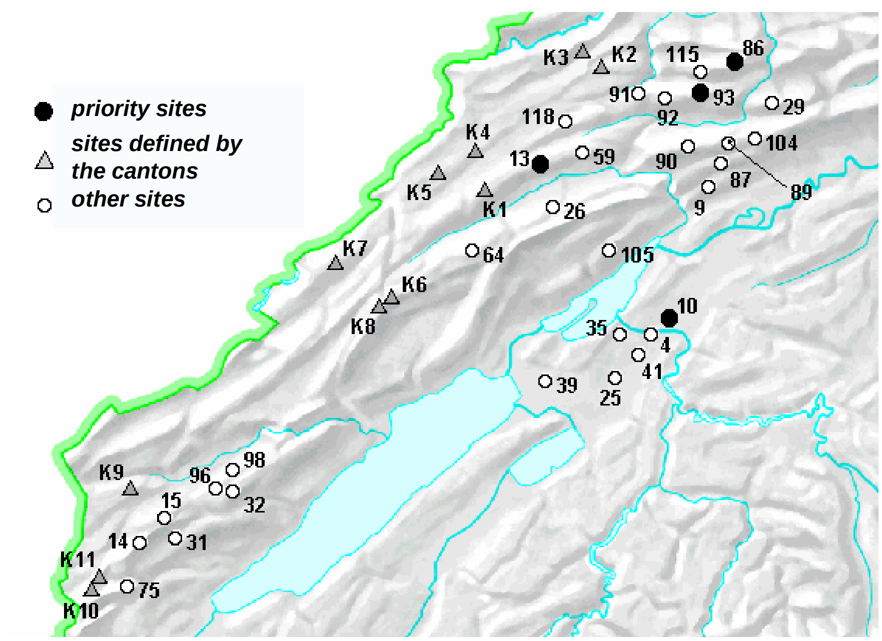
Appendix I (of Phase 3) –
Sites selected for wind project investments, based on the Swiss Concept for Wind Energy

The BFE considers all exclusion criteria such as landscape protection and statements from stakeholder groups and the cantons. The locations for single turbines are not specified here.

a) All of Switzerland



b) Details for "Arc jurassien"



Appendix II (of Phase 3) –
Guarantee requirements for investments in wind energy projects in France

The investment of private parties and banks in wind generating schemes is strongly influenced by the existence of preferential purchase prices. But the turnover attained will be subject to the good operating capacity of the wind farm site. The parameters of good operating capacity are the "risk" parameters, about which investors demand guarantees.

a) Guarantees
In order to judge the guarantee of profitability, banks and private investors demand information and guarantees about the following parameters (source: information documents from the Natexis Banques Populaires group):

- The professional experience and technical competence of the project sponsor,
- The legal form of the company sponsoring the project and its financial solidity, ,
- The real estate foundation:

- Contract to acquire the land,
- Perpetual lease contract or construction lease with substitution of the lessor (in the case of a SOFERGIE lease),
- Signature of a temporary occupation agreement for public land (in cases of land belonging to the state),
- Price, rights of way, access.

- Wind potential:

- 12-month measurement campaign, with 40 metre mast and certified equipment and recognised methodology,
- Correlation of measurements with data from the nearest Météo France meteorological stations :
COEFFICIENT ACCEPTED WITHOUT RISK = 95 %,
- Forecast of producible by processing the measurements obtained with a recognised software programme, with possible second assessment for larger projects: the producible must be between at least 2,200 and 2,300 hours of nominal wind per year.
- Matching of measurements obtained with the characteristics of the machine obtained.

- Planning permission

- Planning permission application to open the financing procedure,
- Any potential prescriptions with the granting of planning permission,
- Any potential appeal,
- Cessation of all appeals (certificate of non-appeal) and issue of Planning Consent with bailiff affidavit of publication at local town hall and on site before passing to the credit committee,
- Public availability of the entire planning consent application.

- Other administrative authorisations (to supply before planning consent)

- Wind farm authorisation supplied by the DIDEME to the Industry Ministry,
- Certification of purchase obligation supplied by the DRIRE.

- The machine

- Reputation of the manufacturer: financial extent, number and type of machine installed in France and throughout the world, experience feedback…
- Guarantees and commitment concerning data availability,
- Supply and maintenance contract.

Phase 4: Final reflections - changes in the categories of factors influencing the production costs during the diffusion process

In the market introduction phase, technology-specific costs of innovative systems such as wind technology are likely to be high. In the long-term, the general expectation is that these costs would decrease. The rate of reduction could be influenced by direct governmental support for research development and demonstration. But it could also be indirectly influenced by the government, by means of the price support system put in place to address the economic and financing obstacles for the market adoption of the respective technology. Depending on the size and dynamics of the domestic manufacturing industry the support system is able to stimulate, as well as the (allowed) industry openness towards technology imports, the extent to which technology specific costs decrease in a certain period of time can be different.

Technology-complementary costs can vary strongly among countries. But they could also vary inside countries, since not all types of developers would be to the same degree successful in finding and getting administrative permits for good-resource locations. As diffusion progresses, this cost category is likely to exert an upward pressure on production costs. The rate of cost increase from these sources is outside the scope of policy influence, being determined by the geographic conditions and resource distribution inside countries.

Context-induced cost factors are a more complex category. The segment defined by monetary consequences of financing and trade arrangements is likely to be inflated in the stage of market introduction. The length of time during which such costs remain inflated, and the extent to which they decrease depend on the risk-profitability characteristics of economic-policy support systems. But these can also be influenced by a series of country specific factors such as: business requirements on profitability from financing agents and project developers, their willingness to accept economic and/or technology risks, or their environmental sensitivity and green image concerns which could be translated into lower financing costs and/or profitability expectations. The data collected so far seem to suggest that indeed the design of support instruments can have negative impacts on economic performances of wind installation by placing too high risks on the cash flows of projects.

High risks on price support are sometimes unintended, and other times considered unavoidable, acceptable or even desirable, in order to stimulate competition and production costs reduction. But while reducing for example technology-specific costs to the same extent, context-induced costs in the project life cycle staged, the monetary consequences of financing and trade arrangements could increase to the point that all those cost reductions are being cancelled. Hence, assuming a constant low risk investment environment, it is quite likely that the factors influencing production costs in this category will decrease their weight after a longer period of diffusion. But this is no guarantee that when the investment risks increase again, the monetary consequences of these cost factors will remain the same low in the overall production costs per kilowatt-hour.

Further, the costs incurred during the various stages of projects' life-cycle are likely to decrease in time. The rate of their decrease could be influenced by government policy indirectly. We assume that the characteristics of the price support mechanism put in place for market introduction and diffusion will be reflected in the size of and competition within the industrial basis emerging to serve the demand for renewable electricity plants. The extent to which the industry grows will be reflected in the costs for services such as project feasibility analyses and management, plant construction and maintenance-operation works. These costs are more likely to decrease when the industrial basis and dynamics are large.

As regards the expenses related to administrative and local social consent, their level in the market introduction phase is uncertain and their evolution after a longer period of diffusion as well. In some national contexts, it is possible that regional/local authorities or local people will be very cautious in grating consent for location of power plants using technologies new to them. When long delays are created in the approval processes or numerous and expensive studies are required regarding the technical, environmental, or economic plant performances, developers might incur high costs in this segment, in the market introduction phase. As administrative bodies and local populations become accustomed to that technology, these costs could decrease in time. But another scenario is also possible - alternatively or simultaneously to that just described - whereby developers have to accept higher local taxes and/or supplementary investments for regional development and social welfare in order to have their projects approved. This could be a way to win site locations in market environments with tough competition to invest. But it can also be a unique option to deal with local opposition to wind plants' construction. In any case, this will increase the costs in the segment of 'context-induced' expenses.

The government could influence the evolution of these costs directly, by halting such practices or approval blockades that create financial leakages. The policy instruments for such intervention would be though outside the package used as price support mechanism. But governmental intervention could also have an indirect influence, when the institutional framework stimulates or tolerates additional expenses compared to investments in other business areas or other locations. We argue, however, that the allowance of attractive local benefits from the profits of renewable plants is actually desirable in the stage of market introduction. When more actors are able to reap economic benefits from the new business coming in the region, this can only help acceptance of the new technology by a wider category of actors and speed up diffusion. But it is possible that as diffusion progresses this component of context-induced costs does not deflate. Communities and authorities in new areas might need similarly attractive offers to accept projects locally. Consequently, one can hardly make statements on the likely evolution of this group of context-induced cost factors - both for the market introduction phase and for the longer-term diffusion period.

Finally, resource availability and quality are of great influence for production costs. It is commonplace to expect that in the market introduction phase project developers will pursue the locations with best resources, and optimize the relationship resource location - resource quality and availability. As diffusion progresses, sites with lower resources will be also exploited until the remaining sites are no more economically feasible with the available price support or for the market price, in case support instruments are no longer applicable. This category of factors influencing production costs is outside the scope of policy intervention.

Consequently, the following conclusions can be drawn based on these analyses. Firstly, only technology-specific cost factors and context-induced cost factors could be influenced by governmental policy in order to improve cost performances. The design of price support systems could indirectly influence the following factors: *technology-specific* cost factors; and expenses in the *life-cycle stages* of projects. Besides, support systems have a direct influence on cost performances by means of the monetary consequences of *financing and trade arrangements* that can be settled under the respective support system.

In addition to these, the government has also leverage on technology-specific cost factors (such as efficiency, availability of technologies), potentially, by means of direct support in research, development and demonstration. The expenses related to administrative and social consent could also be influenced by means of intervention in the institutional framework governing the relationships between investors, and local authorities or communities. But these intervention points are outside the scope of price support mechanism design. The technology-complementary costs and the factors associated with resource quality and availability are outside the scope of governmental influence. As technology-specific costs decrease with the increase in wind installed capacity, the weight of these two groups of cost factors in overall production costs increases, up to a point that production costs could increase again. For these reasons we argue that while policy matters, the scope of policy design for the influence of wind cost performances is limited, while the influence of support instruments addressing exclusively the economic and financing obstacles of wind is even narrower.

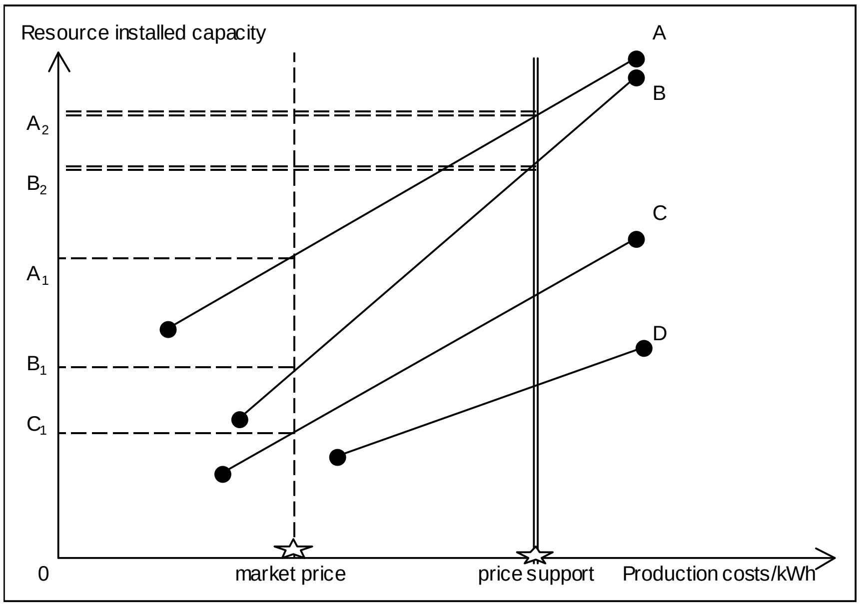
Secondly, this approach on cost analysis indicates that the use of production costs per kWh as indicator for cost performance improvements of renewable technologies and for comparisons with conventional electricity technologies is misleading. It indicates an insufficient understanding of the economies of wind systems, which need a different analytical approach given the particularities of the resource, compared to fossil fuels. We propose to use as reference for cost performance improvements the indicator of technology-specific costs in terms of factory costs per kW. This is also the only indicator that enables fair international comparisons. The indicators currently used - of overall investment costs per kW and production costs per kWh - are contaminated by the influence of factors from the other two, respectively three categories, and hence inconclusive.

Thirdly, due to the multitude and complex interaction of factors influencing production costs, combined with the fact that some factors depend on the national geographic conditions and natural resource potential, it is not likely that expectations on production costs evolution can be more precisely formulated than we attempted in Table 1 of Part 1 of Sub-package 11.6. But one thing can be ascertained, namely that as diffusion takes place production costs expand from '(very) high' levels to a *range that can be very wide*. For the sites with high quality and availability of wind resources, and provided that the interaction of factors in the other three categories can keep the various cost components at low expenses, cost competitiveness could be reached with conventional electricity technologies. But the installed capacity of the wind technology that can generate at competitive prices will depend on how abundant and how accessible the high quality resources are in that country, and whether low costs can be maintained in the other three cost categories. Different countries will have different ceilings of (maximum possible) installed capacity for wind technology at competitive / market prices.

Figure 7 offers examples of installed capacity - production costs per kWh situations that could be encountered in different countries. For example, country A could be able to install a larger capacity that can generate wind electricity at or below market price, represented here by A_1. Countries B and C will have lower ceilings of price-competitive wind capacity, represented with B_1 and C_1. But country D has so poor resources that with all cost reductions in the categories of technology specific, technology complementary and context induced costs, developers will not be able to generate wind electricity at market prices.

When in a country, technology-specific costs cannot be lowered any further and context-induced costs have deflated to normal business terms and also cannot be lowered further, the production costs for remaining resource sites will only depend on geographical conditions and resource potential. The further capacity increase will then be defined by the extent of price support the government is willing to accept. There would be no more scope of policy intervention for price reduction. At that moment, the situation for wind energy' role on electricity supply systems becomes one of political acceptance of price increase. This price support will have to be sustained as long as the contribution of the wind resource in the electricity supply system is viewed necessary or desirable for reasons such as security or diversity of supply, climate change policy, or jobs and industrial activities preservation. In Figure 7 we suggested how the installed capacity could increase when the political decision is taken to allow and sustain price support at a level that is double to the market price[56]. For example, country A could increase its economically feasible wind resource potential, with an increase of installed capacity from level A_1 to level A_2. Similarly, country B will be able to almost double its installed capacity when price support is allowed up to double the market price level.

Figure 7. Examples of country situations for the relationship: installed capacity - production costs



Renewable energy policies that fail to recognize the importance of the profitability in support system design and the risks attached to it are by essence problematic. Profitability is a crucial driver for stimulating large developers to join the renewables' market and lend their financial weight and influential presence to break through the economic and financial obstacles to diffusion. The level of risks associated with support instruments and legal framework should also become a constant concern for the policy design agenda. Providing for public financial support while introducing investment risks is a self-defeating approach.

[56] These are imaginary cases for which the capacity-cost relationships were represented as straight lines purely for reasons of simplification.