

Technical University of Denmark



Best practice guidelines for the development of wind energy projects

Cronin, Tom; Clausen, Niels-Erik; Frydenberg, B.; Huard, E.; Tuan, N.; Hernando, S.; Lien, T.T.

Publication date:
2007

Document Version
Publisher's PDF, also known as Version of record

[Link back to DTU Orbit](#)

Citation (APA):

Cronin, T., Clausen, N-E., Frydenberg, B., Huard, E., Tuan, N., Hernando, S., & Lien, T. T. (2007). Best practice guidelines for the development of wind energy projects. EC-ASEAN Energy Facility.

DTU Library

Technical Information Center of Denmark

General rights

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.



ASEAN Wind 2005

Feasibility Assessment and Capacity Building
for Wind Energy Development
in Cambodia, Philippines and Vietnam

Best practice guidelines for the development of wind energy projects

January 2007

Project reference: EuropeAid/119920/C/SV

Document reference: ASEAN Wind guideline_Task8_Final

Version: Final Document

RISØ

IED

Mercapto

PNOC-
EDC

IE

MIME

ASEAN Wind 2005 - Fact Sheet

Main project data

Full project title: Feasibility Assessment and Capacity Building for Wind Energy Development in Cambodia, The Philippines and Vietnam

Objective: The main objective of the project is to promote wind energy development and facilitate investments on wind energy projects in The Philippines, Vietnam and Cambodia through feasibility assessment and capacity building.

Start: February 2005 End: December 2006

Total effort: 64.5 man-month

Contracting Authority: EC-ASEAN Energy Facility (www.aseanenergy.org/eaef)

Budget / Support: €1 000 000 / €500 000 by European Community

Tasks

Task 1: Wind Resource Assessments	RISO + IED; PNOC-EDC; IE	(10.5 MM)
Task 2: Power System Analyses	RISO + PNOC-EDC; IE	(7.5 MM)
Task 3: Policy & Market Studies	RISO + IED; Mercapto; PNOC-EDC; IE	(9.5 MM)
Task 4: Technical Feasibility Studies	RISO + PNOC-EDC; IE	(10 MM)
Task 5: Economic Feasibility Studies	IED + RISO; PNOC-EDC; IE	(7 MM)
Task 6: CDM Project Studies	Mercapto + All	(5.5 MM)
Task 7: Financial Framework	IED + All	(5.5 MM)
Task 8: Dissemination	RISO + All	(4.5 MM)

Project partners

RISO	RISØ National Laboratory	Denmark	Niels-Erik Clausen	niels-erik.clausen@risoe.dk
IED	Innovation Energie Développement	France	Anjali Shanker	a.shanker@ied-sa.fr
Mercapto	Mercapto Consult	Denmark	Bernt Frydenberg	bernt@frydenberg.dk
PNOC-EDC	PNOC Energy Development Corporation	Philippines	Samuel Hernando	hernando@energy.com.ph
IoE	Institute of Energy	Vietnam	Pham Khanh Toan	toanpk@fpt.vn
MIME	Ministry of Industry, Mines & Energy	Cambodia	Sovanna Toch	mimedet@forum.org.kh

Table of Contents

- 1 Planning for wind energy 5**
 - 1.1 Purpose of planning 5
 - 1.2 The use of software tools and GIS for wind energy planning 6
- 2 Project development 8**
 - 2.1 Wind farm site selection 8
 - 2.2 Wind resource assessment 9
 - 2.3 Grid connection analysis 10
 - 2.4 Permitting and right-of-way issues 12
 - 2.5 Feasibility analysis 14
 - 2.6 International standards 20
- 3 Financing – General issues of wind projects 22**
 - 3.1 Ownership options, financing instruments and financial terms differences 22
 - 3.2 Project / corporate finance 24
 - 3.3 Various contractual schemes 26
 - 3.4 Risk analysis and mitigation instruments 27
- 4 Lessons learned 30**
 - 4.1 Long-time measurements of wind – what to look for? 30
 - 4.2 Good practice for measurement heights 30
 - 4.3 Good practice for met station O&M 30
 - 4.4 Management of data gaps 31
 - 4.5 Overview of lessons learned from site selection in the Philippines 32
 - 4.6 Design of wind farms in typhoon areas 32
 - 4.7 Electrical design 33
 - 4.8 Planning, policy and institutional issues 34
 - 4.9 CDM Lessons Learnt 37
 - 4.10 Economic and financing issues 39

Preface

This report is intended as a summary of the recommended methods for the feasibility analysis of wind energy projects in Cambodia, the Philippines and Vietnam. Some background description is also given to introduce the various topics. The methods were generally employed during the project and, indeed, improved upon and customised for the countries involved. To try to document these, a section is also included on the lessons learned during the project. The case studies chosen in the project were located in the Philippines and Vietnam and so, naturally, there is more detail on developments in these two countries.

The report has had contributions from all the project members to try to get as wide a view as possible on the feasibility processes and maximise the capacity building effort. Editorial input was by Tom Cronin, Risø National Laboratory, Denmark.

1 Planning for wind energy

1.1 Purpose of planning

The purpose of planning or zoning for different land use may seem obvious but because wind energy impacts on so many different interests at all levels in society, it deserves a closer look and this is perhaps best illustrated by briefly following what has happened in Denmark over the last 20 to 25 years. Looking back at this period of wind turbine planning in Denmark, it becomes clear that the interaction between national goals, economic incentives and physical planning has had a considerable impact on wind farm development.

Just as in most countries when a new activity starts, there was no overall, coordinated planning in Denmark at the beginning of the 1990s. Until then, the common principle was more or less that an individual wanting to erect a wind turbine should find their site and then start looking around for who to apply to for permission. But the need for systematic planning increased with growing political ambitions, as did the uneasiness caused by a growing number of apparently randomly sited wind turbines scattered across the landscape. When wind power was first introduced, the domestic – or household – wind turbine was the dominating feature. Furthermore, an application to erect a wind turbine would be processed by the local municipality, which would tend to treat every application individually and without the support of an overall goal or plan.

The first real change to this approach was motivated by the launching of an energy plan for Denmark in 1990 which, for the first time, put up a national target for the installation of 1500MW of wind power capacity by 2005. Following this, the city municipalities were named as responsible for the planning of wind turbine siting, and this actually resulted in sufficient allocations for a potential total capacity of 2,500 MW. In practice, the county would point to suitable areas for wind turbine siting at the regional level – or to areas where they definitely did not want wind turbines – and the city municipalities would process applications and make the final decisions as to the exact siting of a project. This was the start of wind energy planning.

In the long run, however, it proved counterproductive to leave this responsibility at the local level. Wind turbines grew considerably in size and capacity during these years, making the prospect of a wind farm still more attractive in the eyes of potential investors, and at the same time turning the wind turbines into much more dominating features of the landscape. Wind turbines had also become so big that the visual disturbance now crossed the municipality borders and the wind farm concept grew simultaneously. A further complication with leaving the decisions with a relatively small, local, group was that it made it difficult to make the unpopular decisions concerning the environment.

So, by 1990 the responsibility for the allocation of wind turbine zones was raised to the higher level of the county authorities. At this point, the growing awareness of the environment's vulnerability was also enacted in legislation. The mandatory environmental impact assessment (EIA) was introduced for the erection of more than three wind turbines or wind turbines exceeding a height of 80 m.

By the time the government's next call for a revision of regional planning came in 2002, it was realised that the original goal of 1,500 MW had been reached years previously. In this way the purpose of zone planning by identifying and labelling areas of intended use has been fulfilled.

1.2 The use of software tools and GIS for wind energy planning

The aim of planning or “territorial planning” (TP), that is the exercise of identifying zones of land for a particular use, is to evaluate the potential of developing projects and the associated constraints, not on a site by site approach, but at a larger, territorial, scale. For wind energy planning it is, therefore, required to identify and interpret the main parameters for wind project development using a spatial dimension. This means that techno-economic, environmental and socio-economic data all need to be translated into data that can be mapped to give an overview of the main stakes, opportunities and barriers over a wide area.

The territorial planning is closely connected to the use of the Geographic Information System (GIS), offering powerful capabilities of processing and analyzing data whilst integrating their spatial value.

The main steps in this planning methodology are:

- Identification of criteria and defining their interpretation (grading, weighting between them, etc.)
- Data collection
- GIS data integration and processing in order to translate the main issues into spatial criteria: maximum distances (“buffer zones”), exclusion or preferred areas, classifications, areas, etc.
- GIS multi-criteria analysis: thematic analysis, multi-criteria analysis and calculations.
- Interpretation: map representations, results calculation and potential ranking of sites.

1.2.1 The GIS multi-criteria analysis

The territorial planning process integrates numerous information sets (constraints, possibilities, etc.) which all need to be combined and interpreted together. The GIS multi-criteria analysis is based on the traditional multi-criteria analysis (MCA), incorporating a spatial dimension to the data.

The GIS approach enables the integration of various “layers” (criteria or thematic maps) within a synthetic representation, i.e. the superposition of geographical information. Various methodologies of ranking are available: total aggregation (with risk of “compensation effect”) or partial aggregation (such as the “Electre” methodology, for instance) including preference relations, thresholds, etc. Figure 1 presents the GIS MCA approach.

It is important to underline that GIS territorial planning is not an optimization, nor does it give a final decision. It is rather a decision assistance tool within a complex and multi-criteria environment. In the planning for wind energy, the results can lead to various presentation formats:

- synthesis map of potential / exclusion areas for wind projects
- estimation of potential power capacity installed
- evaluation of grid reinforcement requirements
- agreement of local stakeholders and further participatory work taking into account their concerns

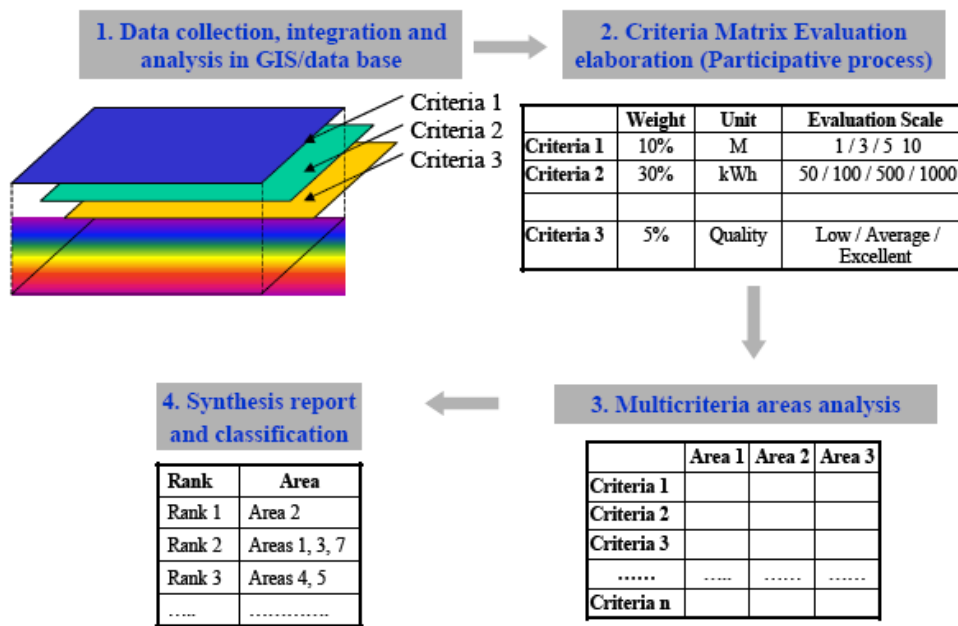


Figure 1 Illustration of GIS multi-criteria analysis process

Developing a wind project is dependent on the wind resource, but not only this. An excellent wind resource might lead to a non-feasible project (due to poor access or low grid connection capacity, for instance) or a bad project (too costly due to grid connection costs, negative impacts on the environment or the local population). Conversely, a project located in a medium wind resource area could turn out to be an excellent project (short period to develop, limited cost, good local acceptance, etc...). Thus, it is important to incorporate as early as possible in the development stage the integration of other various criteria (see Figure 2 for examples) within the site identification process. This is the main aim of the territorial planning approach.

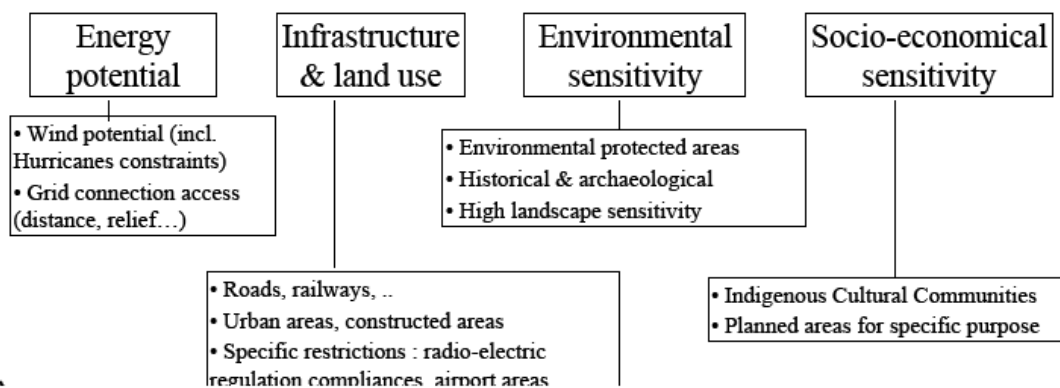


Figure 2 Main parameters affecting a wind project

2 Project development

2.1 Wind farm site selection

Once the more promising areas for wind farm development have been identified then the process of selecting a site for actual development starts. This is a procedure which most commonly comes down to a comparison of candidate sites selected with respect to, among other issues, the following:

- compatibility with project objectives and development plans, which may involve other than economic drivers
- potential wind energy production
- environmental “costs and benefits”
- sustainability, assumptions, uncertainties and risks
 - production estimation
 - availability of land, infrastructure (e.g. for access), institutional framework, human resources, equipment
 - community and power system development as well as authorities’ attention and priority
 - investments, investors, economic and financial data and assumptions
 - design safety, interference, reliability and lifetime
 - wind farm and power system operation and maintenance
- economic and financial viability and attractiveness

The initial phase of the subsequent planning process of a wind farm project involves the determination of the size of the possible wind farm in view of constraints with respect to many aspects, including:

- planning act and other legislation
- local and national development plans and policies
- land availability, access and transport infrastructure
- power system – present situation and expansion plans
- wind turbine technology
- financing/funding
- electricity market and PPA
- environmental impacts
- institutional capacity

The economic and financially optimum size for society and investors at the given conditions may vary for different sites, so sizing and siting should be seen as integrated activities. Furthermore, sizing certainly involves aspects that may not easily be quantified in monetary terms.

In practical terms, the siting and sizing exercise is carried out through implementation of a pre-feasibility study, which at an early stage in the project cycle analyses all essential feasibility aspects as indicated above – with the main purposes of serving as input to:

1. initiation of the negotiation of financial arrangements,
2. the local scoping process and hearings
3. obtaining planning authorisation and approvals, including nature conservation – i.e. Environmental Impact, etc

Some definitions are given here to help distinguish some similar activities:

- **Siting:** Investigation of an area/region/district with the purpose of selection of the location (site) for a wind farm
- **Sizing:** Decision on the size of wind farm in terms of land area and installed capacity
- **Wind farm layout:** The configuration and arrangement of the individual wind turbines' locations within the selected site – as a result of an optimisation at given assumptions and constraints using agreed criteria
- **Micro-siting:** Determination of exact position of each wind turbine in a wind farm; coordinates (x, y down to 1 m) on a detailed map as well as survey and marking in the ground on-site

2.2 Wind resource assessment

The approach to wind resource assessment will depend on many factors but not least is the particular stage of the project development. Three stages can easily be identified:

- **Initial large-area assessment**
At this stage, the identification of regions with the potential of an acceptable wind resource (as used in the GIS mapping activity described in Section 1.2) can use existing data from a variety of resources, e.g. wind atlases, meteorological stations, etc. This could provide information for the selection of new wind measurement sites.
- **Evaluation of a specific resource**
This is the stage where a specific area, or even a specific site, has been identified for consideration for development of a wind farm. Some of the aims could be to:
 - Compare the resource with other areas
 - Confirm that further investigations of sites within the area are justifiable
 - Produce estimated production data for further analysis (e.g. economic)
- **Micrositing**
This looks at a selected site in specific detail to analyse the particulars of the wind flow over the terrain so that individual wind turbines can be placed to maximise the energy production of the wind farm.

2.2.1 General good practice for site-specific measurement campaigns

The main reason for carrying out a wind resource campaign is to provide input data for an analysis of the potential energy generation from a proposed wind turbine site. The following are some of the points that should be considered so as to obtain the data best suited to this objective.

- The measurement campaign should be of sufficient length to give the seasonal pattern of the wind, i.e. longer than 12 months.
- Location of the mast needs to be chosen so as to give the best data to allow calculations to be made for the whole wind farm. The mast site and height should be as similar as possible to the wind turbine sites, i.e. with respect to elevation, exposure, ground cover, terrain ruggedness, etc. In practice, there are also other constraints such as planning permission, ground conditions, etc.
- The location of the mast should be accurately known, determined by GPS readings or by surveying. The instrument levels should also be accurately recorded, determined by a measuring tape when mounted on the mast.
- The wind speed should be measured at no less than two heights, preferably three. The lowest should be 10m as this corresponds to the most common meteorological mast measurement height. The others should be placed to best give information about the nature of the wind

profile and may not necessarily be at a wind turbine hub-height. Therefore, for a 50m mast, suitable measurement heights would be 10, 30 and 50m.

- Other measurements are required in addition to wind speed: wind direction, ambient air temperature and air pressure. If at all possible, there should be two wind vanes on the mast so as to have redundant data if one sensor fails.
- Wind vanes are usually placed as high up as possible on the mast, but a little below the highest anemometer. It is particularly important that the wind vane is aligned correctly in relation to the north direction.
- Anemometers and wind vanes should be mounted sufficiently far from the mast itself, on booms or otherwise, so as not to be aerodynamically affected by the mast itself. The highest anemometer should preferably be mounted on a vertical, slender top pole of sufficient length in order to avoid flow distortion from the mast top itself. This anemometer is the reference anemometer and it should be of the highest quality possible. It is particularly important that this anemometer is well maintained and calibrated.
- The booms should be positioned so that they are at an approximate 45° angle to the prevailing wind direction, if there is one. This gives the least distortion of the air flow for the majority of the time. Wind sensors mounted on booms should be at least 12 boom diameters away from the boom, i.e. the vertical distance from the boom to the rotor of the anemometer should be at least $12 \times D$, where D is the boom diameter.
- The measuring equipment should be of good quality, maintained and calibrated at the correct intervals.
- The wind speed and direction should be logged as averages over a ten minute period.
- The data logging should be checked regularly for quality, as holes in the data or erroneous records have a large effect on the accuracy and reliability of the final predictions. If remote monitoring is not available, the mast and data logger should be visited and checked at intervals of about a month or even more frequently.

Good planning and methodical procedures are needed in a wind measurement campaign as they can be costly and, more importantly, time consuming. Time lost in recording poor or unrepresentative data is very difficult to recover within a project's budget.

2.3 Grid connection analysis

The main objective of a good grid connection is to deliver the active power produced by the wind farm to the grid. It also needs to fulfil other objectives (for instance providing the reactive power required by the wind farm) and be able to accomplish these without affecting the power quality at the connection point. The ultimate measure of power quality is a continuous and sinusoidal voltage with an invariant amplitude and frequency but this is not achievable in practice, as all wind turbines will (at the very least) cause voltage variations, and so acceptable limits are used. These are generally set by standards (within Europe EN 50160 is applicable) and by the transmission operators. The standard practice for analysing grid connection possibilities is to start with the most basic of connections and then build up both the connection and the wind farm capacity until an acceptable result is achieved. In the first instance, the impact on the voltage amplitude and on the variation in amplitude is assessed as these are often the limiting factor in a grid connection. The voltage level is an essential aspect of the connection and finding the optimum level is an integral part of the analysis. All this is briefly described below together with the information required about the grid for this analysis.

This section is intended to give a general qualitative background to power systems, the particular aspects that are important when injecting wind power, and the common scope of feasibility studies.

2.3.1 Grid Connected Systems

The objective of injecting wind power into a grid is to deliver power whilst maintaining the power quality as seen by the consumer. With this in mind, the following are some power quality aspects that are important to the consumer:

- **Stable system voltage** – the voltage at the point of common coupling (“PCC”, i.e. where the power enters the grid network) must remain within a stable region at the maximum power input.
- **Consistent voltage amplitude (long term)** – the voltage must remain within acceptable limits throughout the range of powers delivered.
- **Voltage fluctuations (short term)** – the voltage amplitude must not vary too much from cycle to cycle, otherwise flicker (i.e. annoying variations in the output of incandescent lighting) can occur.
- **Sinusoidal wave form** – the wave form of the resulting voltage must not be distorted beyond set limits (i.e. contain excessive harmonics).
- **Power delivery** – the system connection must be able to handle the power delivery from the wind farm.

A number of the quality issues are not, however, specific to the injection of wind power in particular and many of the aspects involved have to be considered in one way or another with “conventional” power delivery. Some important characteristics of power systems and their analysis are given below.

- **Standard transmission and distribution systems** – most modern grid systems are based on the same concept of a few large central generating units feeding into a high voltage transmission network which is then distributed out to the consumers and delivered at a lower voltage.
- **Thévenin equivalent and network impedance** – for the first stage analysis, the complicated transmission and distribution system can be conveniently reduced to a single network impedance as seen from the point in the network where the power quality is assessed. This is called the Thévenin equivalent and can generally be obtained from system operators who have a model of their whole system. Most importantly, this impedance has both a magnitude and an angle.
- **Voltage drop and power drawn** – a fundamental characteristic is that as power (particularly reactive power) is drawn from a system the voltage of the system drops.
- **Loading and voltage instability** – a phenomenon that power engineers have always had to deal with is that as a system is loaded then there is a point at which, if loaded further, the voltage drops faster than the current can increase to provide the power. This is termed voltage instability and is a region that must be avoided. (Note that it does not refer to the stability or otherwise of the voltage sine wave.)
- **Load power factor and network impedance angle** – the voltage instability described above sets in earlier when the load draws reactive power because the network impedance always has a significant reactive part. This is indicated by the network impedance angle which can usually be obtained from the power system operators.
- **Short circuit power and grid strength** – the power that would be dissipated in the network impedance if there were a short circuit is called the short circuit power and this varies from point to point on a network. It gives a measure of the grid strength and determines how much voltage drop there is when power is drawn and how robust the system is against instability. Once again, the value of short circuit power can usually be obtained from system operators.
- **Voltage fluctuations** – power systems have always had to ensure that the voltage is steady and does not fluctuate too rapidly, both for the correct functioning of consumers’ equipment and, most noticeably, the constant output of light from incandescent filaments. This is known as flicker and it is important to keep within certain limits.

- **Harmonics** - this are an issue that has only really become prominent since the introduction of power electronic equipment that operates by chopping up the voltage waveform. This can result in an injection of voltage waveforms many times the system frequency – something that can cause overheating in certain equipment and malfunctioning in others.

When considering the injection of wind power, there are some aspects of the items described above that have a particular importance:

- **Wind farms are often connected to weak(ish) grids** – good wind resources are often found in under-populated areas and thus are not close to points in the existing power grids that were designed to deliver large amounts of power. Wind farm connection points are, therefore, often quite weak and this provides power quality challenges.
- **Power flow is in the “wrong” direction** – power grids were built to deliver power from high voltages to low voltages, and not to take in power injected at lower voltages. This reversal of flow direction can have an adverse effect on the power system protection coordination.
- **Voltage increase and voltage instability** – the phenomenon of voltage instability also occurs with power injection (as opposed the convention of drawing power) but depending on the network impedance and the power factor of the power injected there is, initially, a voltage rise.
- **Voltage flicker** – the short term power production from a wind turbine can vary causing voltage flicker. Flicker is emitted both during switching operations such as start up and shutdown and during normal, continuous operation. Two common sources of the latter are the power variation experienced as each blade passes the turbine tower, and the power variation in the wind that inevitably exists over the swept area of the blades.
- **Harmonics** – in practice harmonics need only be considered from turbines that use power converters.
- **Thermal considerations** – the power cables/lines must be able to handle the active power production. This is a thermal consideration and depends on the current carried.

The task of grid connection analysis is a reiterative one and must always be carried out with the economics of the project in mind. It is generally possible to reinforce a grid to accept a sizeable wind farm but the economics of it may make the project unfeasible. This balance should be struck at the feasibility stage.

2.3.2 Island systems

In general, island systems tend to operate with lower power quality than national grid systems and, at present, are characterised by higher wind penetration levels than grid connected cases. This brings particular challenges in keeping the system balanced. However, the following are fundamentals when integrating wind power into island systems with existing diesel generation:

- The amount of wind power is determined by the minimum consumer load and the technical minimum part load of the diesel generator(s).
- The installed diesel generator capacity is determined by the maximum consumer load.
- The necessary spinning capacity is determined by the variations in consumer load and wind power.

It is then advisable to use a system simulation package to assess the details of the integration of wind energy. The power obtained from a wind farm can be simulated and the resulting operation of the diesel generators can be predicted, together with their fuel consumption.

2.4 Permitting and right-of-way issues

The process of obtaining the necessary permits and approvals for the building and operation of a wind farm will vary widely from country to country because many of the requirements will depend on the

local planning authorities and the legal framework. In some countries the process is quite developed with a central body having responsibility for the co-ordination of applications but in others the process is more disparate. Most likely, it will not be a straightforward exercise, so it is of the utmost importance to start early on in the project. Some common aspects are given below:

- Permits may not only be required for the wind farm itself. Other important aspects are:
- Construction permits
- Environmental permits
- Access and access road permission
- Permits for any buildings associated with the building
- Grid connection and power purchase agreements
- Power line “right-of-way” and construction

The overall process can be lengthy, not least because there may be many bodies to consult. This is particularly the case if there are many private landowners involved along the route of the power line.

2.4.1 Environmental assessment

One of the most important documents for the permitting process will be the Environmental Impact Assessment report. The contents will vary from country to country and location to location but the following issues could be covered together with any measures planned for mitigation.

- *Site selection*
- *Impact on any areas with special designations*
- *Visual and landscape assessment*
- *Noise assessment*
- *Ecological assessment (fauna and flora)*
- *Archaeological and historical finds*
- *Hydrological impact (e.g. water courses)*
- *Interference with telecommunications*
- *Aircraft safety*
- *Safety assessment*
- *Traffic management and construction period*
- *Electrical connection and route of cables/lines*
- *Economic effects on the local community*
- *Global environmental effects*
- *Tourism and recreational effects*
- *Decommissioning*

Over the years the main environmental concerns when developing wind farms have been visual impact, noise and the risk of bird-collisions.

Today, noise is dealt with in the planning phase and normally it possesses little problems to build wind turbines close to human settlements. The visual effects of wind turbine may, however, create some controversy, as some people believe wind farms have a severe negative visual impact on the landscape. Experience shows that it often pays to invest some effort in designing a good layout of the wind farm using well defined geometrical patterns while taking into consideration the specific landscape features.

The impact on plants and animals is not very well established despite a sizable number of studies, but as with all power generation a certain amount of disturbance to plants, birds and mammals is

inevitable. With respect to wind energy the largest concern concerns bird strikes and the possible associated effects on both the resident bird population and those migrating through the area.

All the experience with environmental impacts shows that dealing with them early and openly and entering into dialogues with the relevant stakeholders will normally facilitate a solution satisfying all parties. Software tools (e.g. WindPro, www.emd.dk) for analysis of the environmental impact of wind farms are available, which include noise calculation, visualization and photomontage for illustration of visual impact as well as calculation of shadow flickering.

2.5 Feasibility analysis

The project feasibility study forms part of the decision basis for the initiation and implementation of the project. In general, it is common practice to divide up a feasibility analysis into technical and economic appraisals. Naturally, the economic assessment requires data that come out of the technical study so there should be close co-ordination between the two exercises.

2.5.1 Technical feasibility

A technical feasibility study of a wind power project typically includes assessment of the following issues:

- Wind conditions
- Power system
- Land issues
- The proposed wind farm
- Organisational issues
- An environmental impact assessment
- The costs and benefits

Wind conditions

Information about the wind conditions is obviously crucial for the feasibility study. The information should include details about:

- the geographical distribution of the wind resources;
- the expected annual energy in the wind;
- the variation of the wind energy from year to year;
- the variation of the wind energy over the year;
- the variation of the wind speed over the day;
- the fluctuation of the wind speed within minutes and seconds; and
- the maximum wind speed.

The geographical distribution of the wind resources should identify the most promising areas. The mapping of the wind resources may either indicate the overall wind resources under uniform conditions or indicate the actual local wind resources, taking local effects into account – such as orography and surface roughness.

The evaluation of the wind resources at a given site must be based on at least one full year of wind data. If only one year's worth of data is available, then this data must be evaluated by correlation to long term reference wind data representative for the site and with data overlapping the actual measuring period. There may be large variation in the wind energy from year to year.

The value of the wind power depends on the correlation of the variations of the wind power to the power needs, both variations over the day and over the year. In the case where hydro power is part of

the power generation mix, the power needs is a combination of the power loads and the hydro power available. The hydro power may be restricted during some parts of the year due to lack of water inflow and limited dam capacity.

For a given area, the wind resources may vary greatly within the actual site due to local effects. Micro siting is therefore important.

The expected maximum wind speed in combination with the turbulence intensity determines the design wind speed for the wind turbine construction. For areas outside of hurricane/typhoon regions, the methodologies to determine the design wind conditions are described in international standards such as the IEC 61400-1 where standard classes for the wind conditions are defined. (See section 2.6 on international standards.)

The power system – integration of wind power

The stochastic and fluctuating nature of the wind and therefore the variations in the wind power generated are a major challenge for the integration of a significant amount of wind power in a power supply system. The power system must have the capability and flexibility to handle the fluctuating wind power and constantly maintain the power balance between the actual production and consumption – both if the system is a small isolated system or if it is a large national/international system. Stand alone wind power systems are not part of the present report.

The actual available wind power cannot be controlled and may not be well correlated to the demand. The value of the wind power produced is therefore highly dependent on the design of the power system. In the case of low wind, the system must still be able to maintain the power balance – either by control of the consumption or by alternative power generation. The control of the consumption may have an impact on the quality, and thereby the value, of the power supply. The alternative generation capability may require investment and operation of additional production capacity, and thereby additional costs. In the case of high wind, the system may not be able to utilise all of the available wind power which will reduce the actual capacity factor of the wind power capacity installed and thereby have an impact of the benefit of the wind power investment.

Wind power and hydro power may form a very good combination because hydro power can easily be regulated very quickly and because the water reservoirs may form excellent seasonal energy storage.

The benefit from wind power in combination with diesel power generation in isolated power supply systems is the savings in diesel fuel that should have been used to produce the electricity that the wind turbines provided. However, the benefit of the wind power in such a combined wind and diesel power supply system cannot be measured directly, but has to be calculated by use of a model analysis. The benefits are, to a high degree, dependent on the characteristics of the diesel engines.

Land issues and site access

The wind turbine units themselves do not occupy much land, around 10 × 10 m, but there must be an access road to each wind turbine unit for service and maintenance. The land between the wind turbine units may still be utilised for agriculture. However, mainly due to the visual impact no buildings should be closer than approximately 1 km from the wind turbines.

The best site according to the wind resources may be very difficult to access or may be very expensive to acquire, thus a compromise must be found.

Wind farm design

The siting, design and layout of the wind farm should always be an optimisation between the investment costs on the one hand and power generation on the other hand. Issues to take into consideration include

- land availability and cost of land;
- site accessibility;
- wind power generation;
- cost of the wind turbine units;
- cost of the connection of the wind farm to the power system.

The wind resource will change depending on various aspects of the actual sites. For instance, turbines that are in the wake of other turbines will have a lower production. The severity of this wake effect is dependent on the distance between the turbines and the alignment with respect to the prevailing wind direction. Increasing the distance between the wind turbine units does, however, increase the cost of the cabling between them.

Wind turbine units

The characteristics of the proposed wind turbine must be suitable for the actual characteristics of the wind at the specific site. The wind turbine must be designed to withstand the expected maximum wind speed at the site as specified in the Wind Turbine Class. Likewise, the wind turbine must be designed for a specified lifetime under the actual wind conditions, including the wind fluctuations (expressed by the wind turbulence intensity). This is taken care of by the national and international certification schemes established for wind turbine units and wind power projects.

In addition, the wind turbine should be optimised for the actual conditions. In general, the following three parameters may vary:

- the rated (maximum) (generator) power capacity
- the rotor diameter (or rotor swept area)
- the height of the tower (the hub height)

The wind turbine's rotor-to-power factor is the ratio between the rotor swept area and the generator capacity. The wind turbine's capacity factor is defined as the actual annual production relative to the maximum potential production (full time at maximum production).

The annual expected energy production (AEP) from a given wind turbine unit at a given site is influenced by the wind resource and a combination of the wind turbine's hub height, the rotor diameter and the rated power.

Organisational issues

The operation and maintenance of wind turbines requires dedicated skills, and an organisation with the sufficient skills must be established. The related cost of the operation and maintenance is highly dependent of the number of wind turbines that the organisation services.

Environmental impact assessment

The most crucial environmental impact of wind power is the visual impact. It is also the most difficult to solve. Wind turbines must be located in the open landscape, and they will necessarily always be very visible and dominating in the landscape. The best solution is to install wind turbines at a distance from residential areas and other human activities to reduce their visual impact.

Noise is not considered a problem for modern wind turbines because if the other environmental considerations are duly accounted for then, in general, the noise criteria will also be met.

Costs and benefits

The cost of a wind power project may be estimated with relatively little uncertainty. The world market prices of large scale wind turbines designed for grid connection and operation under the wind conditions of Class I-III are in the range of 1.0-1.5 USD/W, depending on the total capacity of the order (100..10 MW). Recently, wind turbine prices have increased due to higher demand than supply. Also delivery times have increased. The price for the civil and electrical works varies according to the location.

The difficult parameter is the value of the wind power – specifically the capacity value of the installed wind power. In small wind-diesel systems, the wind power capacity will not substitute the diesel power capacity needed, and the capacity value of the wind power is zero. In large power supply systems the installed wind power will have a capacity value, and in systems with hydro power the capacity value of the wind power may be close to 100 %.

2.5.2 Economic feasibility

Introduction to economic and financial analysis

Following on from the technical feasibility study, this section describes the common concepts used and definitions of the main parameters evaluated in economic terms: discount rate selection, IRR calculation, simulation in nominal or real terms, etc.

Economic versus financial analysis

The distinction between economic and financial analysis is not always clearly defined.

An **economic analysis** of wind energy project will mainly check the general value of a project, i.e. will the revenues generated cover the initial investment and annual costs?

This level of analysis is good for comparing various energy production solutions against each other or for comparison with a national marginal production cost for instance. It demonstrates the “first level” profitability. It can also take into account global economic inputs, like the cost of externalities and local development impact, although not from an individual project point of view but from a society’s viewpoint.

A **financial analysis** will basically incorporate the costs and impact of financing the project together with any taxation implications.

This analysis is able to take into account financing conditions and impacts from an investor’s viewpoint (debt payment, real return on investment on equity, accounting optimization, etc.). It will also be based on market prices.

Thus, it is important to keep in mind that economic and financial analyses are different and complementary.

Economic and financial analysis inputs

Economic and financial analysis is strongly linked to the other investigations that are carried out in a feasibility study. Figure 3 presents the main links between the various tasks within the ASEAN Wind project.

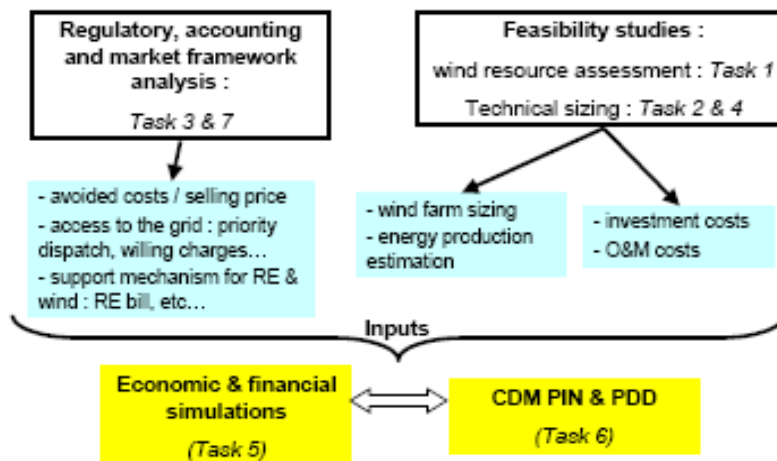


Figure 3 ASEAN Wind project tasks and inputs to the Economic and Financial analysis

The main inputs for **economic analysis** are the following:

- Macro-economic : duration of project life, discount rate
- Technical data : power installed (in MW), Annual Energy Production (AEP in GWh)
- Cost inputs: initial investment costs (development, construction, contingencies...), Operation & Maintenance (O&M) costs and residual value
- Possible revenues: electricity sales, capacity sales, Green credit, CO₂ credit, etc.

From a utility or government point of view, this economic analysis can also integrate hidden costs (tax relief, incentives, etc.), together with other community benefits from the project (local development, road/grid extension construction, revenues from taxation, etc.) as well as externalities.

Additional inputs for **financial analysis** will take into account:

- Financial package: sharing out among equity/loans or grant financing, with specific characteristics of each (rates, grace period, term of loan or take over period of some sponsors, local or foreign currency, etc.)
- Cash flow balance : working capital financing, possible bank overdraft conditions
- Escalation rates for calculation in current currency: inflation, local and foreign currencies rates, energy prices escalation, CO₂ Certified Emission Reduction (CER) escalation, etc.
- Taxes : VAT, asset depreciation method & income tax

Financial analyses will go in to more detail establishing the real project cash flow with debt payment, provisions, dividend, taxes, working capital needed, bank overdraft, etc.

Main outputs of economic and financial analyses

The main **economic analysis** outputs are the following:

- Benefit / Cost ratio
- Economic Internal Rate of Return (IRRe)
- Net Present Value (NPV) for a given discount rate
- Simple payback time
- Levelised production costs

- Externalities: GHG emission reduction cost, etc.
- Other economic indicators : equivalent annual life cycle savings

Outputs from the **financial analysis** focus on the various investors' point of views, by providing ratios for the capital investor, the debtor, etc., depending on the complexity of the financial package. Specific financial ratios are also elaborated to evaluate some specific kinds of risks and profitability:

- Dividend payment cash flow and financial IRR (IRRf or ROE, Return On Equity)
- Equity pay back period
- Debt payment & debt service coverage (DSR) (and evaluation of financial leverage)
- Profit & loss account (and possible tax optimization)
- Balance sheet
- Many other financial indicators: WACC, EBIPTA, etc.

It should be remembered that an economically viable project can be financially unviable, and vice-versa.

Particulars of investment in wind energy projects

Wind energy projects are not mainstream investments. It is important to take into account some particulars when evaluating a wind project investment. The following are issues from different phases:

(i) The technical study needs careful examination:

- Optimisation of wind turbine design for energy production : micro-sitting optimization, hub height and selection of turbines
- Survivability: extreme wind events, land slides, etc., should be taken into account as far as possible in the design and cost (equipment and construction costs)
- Careful estimation of losses: atmospheric losses, array losses, scheduled maintenance, turbine failure, forced outage (power plant or substation/transmission line), transmission line losses, etc.
- Impact of wind fluctuations:
 - annual fluctuations in energy production: impact on the cash flow and sensitivity & risk analysis
 - short term fluctuations require good prediction ability for grid balance/stability and capacity charge or incomes on spot market

Figure 4 shows an example of the variation of the annual average wind speed recorded on a site in Morocco monitored over 5 years. The average wind speed varies from -2.2% to +2.2%, leading to a variation in the annual energy production and incomes ranging between -4.3% to +3.9%. Such income variations will impact on the cash flow of the wind project, and sufficient capitalization and minimum DSCR are required.

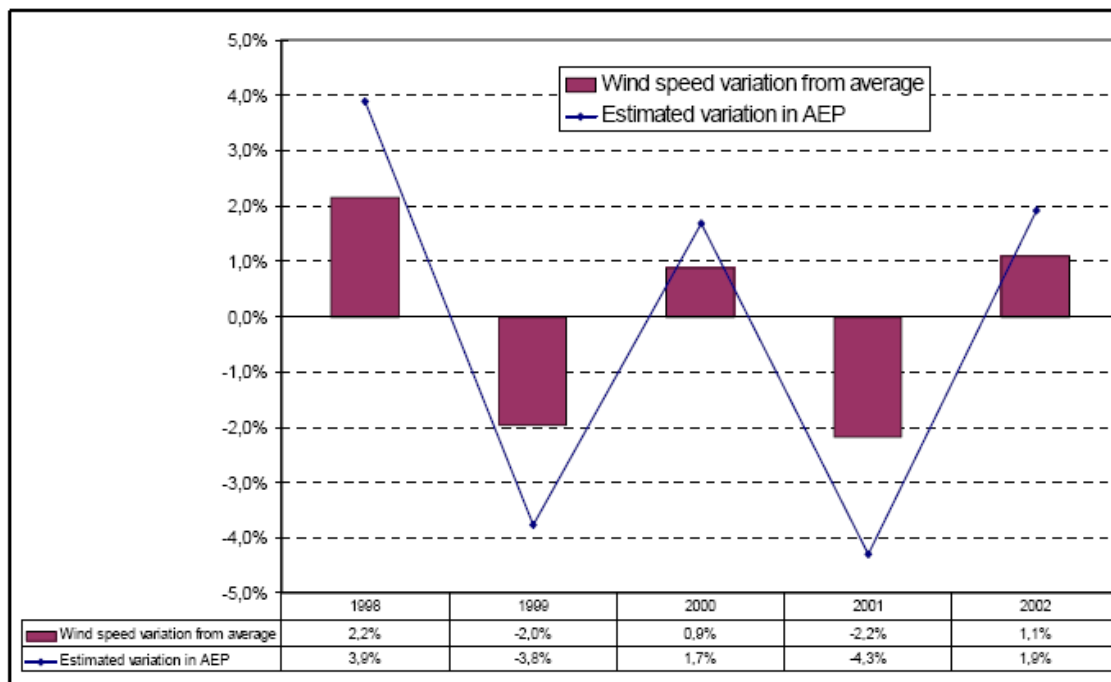


Figure 4 Example of annual wind speed variation for a Moroccan wind farm and AEP variation.

(ii) Project development costs:

- High up-front costs and long processes: wind assessment, Environmental Impact Assessment including bird campaign survey, land lease, grid connection study with grid operator, local acceptance, PPA negotiation, etc. All these various steps involve some risk in final permit approvals at the end of project development
- Investment costs might vary widely from one project to another: specific turbines, transport costs, civil works constraints, transmission lines, etc.
- O&M needs to take into account all issues: land lease, insurances, maintenance and periodic replacement costs, transmission costs, etc.,

2.6 International standards

The use of internationally agreed standards assists in ensuring a certain standard of work within a project. It has the additional advantage that it can help make sure that important items are not left out, which can happen if specifications are put together on an ad-hoc basis. The International Electrotechnical Commission (IEC) has undertaken to develop international standards for wind power.

A standard often referred to is the IEC61400-12 Power Performance Verification, specifying wind and performance measurement requirements. The general standard for wind turbine design and safety is IEC61400-1 ed. 2.

IEC61400-1, main contents:

- Structural design
 - Design methodology
 - Loads: stochastic, deterministic, extremes, calculations
 - Design situations and load cases
- Design methods
- Safety classes

- Quality assurance
- Wind turbine markings
- External conditions - "Design climate" in wind farms (Turbulence and wind speed)
- Control and protection system
- Mechanical systems
- Electrical system
- Compatibility for site-specific conditions
- Assembly, installation and erection
- Commissioning, operation and maintenance

Central to the IEC61400-1 standard is the specification of characteristics of wind turbine classes, as shown in Table 1 below. Finally, please note the IEC WT 01 (2001-04) IEC System for Conformity Testing and Certification of Wind Turbines - Rules and procedures.

Table 1 Basic parameters for wind turbine classes

Wind Turbine Class		I	II	III	S
V_{ref}	(m/s)	50	42,5	37.5	Values
A	I_{ref} (-)	0,16			Specified by the Designer
B	I_{ref} (-)	0,14			
C	I_{ref} (-)	0,12			

3 Financing – General issues of wind projects

3.1 Ownership options, financing instruments and financial terms differences

Wind power projects have many differences from conventional energy systems: scale, capacity, resources, output, technology, etc. The list below highlights the main differences which can have impacts on the financing of wind power projects:

- Bankers' & financiers' lack of information about wind power technology
- Capital intensive and low operation cost
- High transaction costs in relative values
- Relatively unproven technologies when compared to conventional technologies
- Supply concerns (varying output, very dependent on natural conditions)
- Not always commercially viable

3.1.1 Financing instruments

Financing is the process of securing funds via loans, grants, equity investment, or other instruments. Financiers in general are concerned with making a return on their investment and will finance projects that meet their fiscal, geographical and ethical guidelines. They will assess the risks related to individual projects and may demand security or guarantees to ensure the desired return on investment.

Financing for wind power projects can come from international development banks in the form of Official Development Assistance (ODA) or concessionary finance. Government ministers can procure large loans – and in some cases grants – from multilateral development banks and bilateral agencies. Private foundations can also provide grants or soft-loans. "Green" market mechanisms like Certified Emissions Reductions produced through the Clean Development Mechanism, can further augment project funding. Finally, guarantees from development banks can play an important role in facilitating financing.

Basic types of financing

- Grants – do not require repayment but have specific terms for use attached
- Loans – “debt” financing requires repayment (principal + interest): commercial loans and soft loans
- Equity – selling an ownership interest in the project to investors
- Semi-equity or "mezzanine" fund
- In-kind contributions – non-cash to alleviate the financing burden
- Guarantees – a contractual promise to provide back-up to a loan
- Others – technical assistance, CDM or JI

Financing sources

- Multilateral Development Banks (MDB) – cooperation between several developed countries to fund development projects with specific goals; large loans with low interest rate, grace periods
- Bilateral – Close and direct partnership, usually historical and political reasons
- Funds, Foundations – Often provide grants or soft loans. Low limits and short funding time-frames
- National development incentives – National funds, subsidies, tax & duties relieves
- Commercial banks – profit seeking but have some advantages
- Green investment – CDM, JI

Developers need to consider a number of variables as they plan their financing packages, often including financing from a mix of sources to maximize flexibility. Each type of financing source may have different requirements for ROI (return on investment) and different levels of flexibility for dealing with the length, uncertainties, and risks of a given program.

3.1.2 Ownerships

Due to the high capital costs associated with wind power plants and their inherent and perceived resource and technology risks, finance costs are of significant importance to wind power facilities.

With the financial constraints of state-owned utilities, governments recognize the important role of non-utility investors, which includes the public sectors (national and local level) and private sectors, in speeding up investment in energy services using wind power.

Fundamentally, we can distinguish three mainstream ownerships associated with different financial options that can have various impacts on wind power project financing due to perception, risks and guarantees.

a) Private ownership investment: this ownership form is a relatively new progression in developing countries, particularly with renewable energy projects. Private investors are tapping into wind power investment for its potentially high return on investment. The private power producers have generally financed projects on a stand-alone basis. In these project finance arrangements, the lender looks primarily to the cash-flow and assets of a specific project for repayment rather than the assets or credit of the promoter of the facility. The strength of the underlying contractual relationship between different parties is essential. Credit support for project finance comes in large part from the revenues associated with the power purchase agreement.

b) Utility ownership investment: Utilities can borrow money from public markets; the support for their credit comes from the income of their entire asset base, not an individual project. Debt and equity investors in the ownership scheme generally require lower returns than in individual projects due to the large asset base of the utility, the increased liquidity, the franchise monopoly provided to the utility, the extreme-event risks covered by the implicit social contract with public authorities. Compared to private ownership investment, the advantages of utility ownership are:

- Lower interest rate debt
- Longer debt amortisation
- Lower cost equity
- Debt service coverage ratio (DSCR) requirement close to 1

c) Public ownership investment: This scheme of investment will have much lower costs than for private ownership investment. The expected economies are due to the franchise monopoly provided to public bodies, monopoly in the setting of rates, the tax-exempt nature of public debt, and lower perceived associated risks. These benefits can be the follows:

- Debt is tax exempt
- Longer debt amortisation
- Debt percentage in capital structure can be up to 100%
- No specific DSCR
- No income taxes

3.1.3 Financial terms differences under various ownership schemes

a) Capital structure: In terms of financial capital structure, private ownership can try to optimize the capital structure to reduce the equity charge, often only subject to the regulatory constraints imposed by regulatory bodies. Because the debt interest rate is usually lower than equity cost, private developers generally have an interest to maximise the debt but this maximisation should comply with the minimum debt service coverage ratio (DSCR) which is the limiting factor to maximise debt leverage. For private ownership investment, debt fractions of around 60%-80% are common in energy projects.

Utility ownership investment projects have significantly less free choice in optimisation of the capital structure. The utility capital structure is determined by regulators and shareholders because additional debt can reduce the ability of the firm to pay interest on existing debt, so electrical utilities typically maintain conservative debt-equity ratios. Public ownership investment projects also do not have much flexibility in determining capital structure, but it generally can obtain the bulk of their funds through tax-exempt borrowing, and therefore effectively have capital structures consisting of 100% debt, thereby reducing its cost.

b) Loan maturity (or loan term): Due to the high risks in wind power investment, private ownership investment project usually have shorter loan term. A debt term is often assumed between 7 to 15 years in the analysis for private and utility ownership schemes. For public ownership, the maximum debt term is equivalent to the project analysis period, which is 20 years. Debt payments include interest and principal.

c) Debt interest rate: The interest rate changes depending on both the maturity and risk of the loan. Interest rates typically rise with loan maturity and higher risks. It is therefore expected that private ownership will have a higher interest rate due to the increased investor risk associated with project finance. Utility ownership can finance projects with corporate debt which generally depends on bond credit rating and maturity but typically lower than private ownership scheme. Public ownership can avail themselves of significantly lower cost debt due to the tax-exempt nature of the bonds to the holders and due to low perceived risks.

d) Debt Service Coverage Ratio (DSCR): To reduce the risk associated with a project defaulting, lenders require that a project maintains a minimum ratio of the available cash (operating revenues less expenses) to total yearly debt service (includes both principal and interest payments). The constraint is expressed as a minimum acceptable value for the DSCR. For a private owned wind power project, this ratio ranges from 1.2 to 2. For utility and public owned wind power projects using corporate finance, there are generally no project-specific requirements for DSCR, but they must maintain the utility-wide DSCR requirements.

e) Equity cost: Required equity returns for private owned, project-financed wind power projects depends on perceived technology maturity and the resource's risks. It is assumed that these returns must be higher than for utility owned projects, because under these schemes, company-wide ROE is typically used and set by state public commission. The capital structure of public ownership projects does not contain equity in the traditional sense.

3.2 Project / corporate finance

3.2.1 Definitions

A common distinction is made between corporate finance and project finance:

- Within corporate finance, debt is provided by banks to companies that have a proven track record. This type of financing is mainly based using "on-balance sheet" assets as collateral. Most mature companies have access to corporate finance, but have limited total debt loads and therefore must rationalise each additional loan with other capital needs.
- Project finance (or "off-balance" sheet or non-recourse finance), on the other hand, is evaluated only based on the cash flow of a specific project, which should enable it to pay back loans by itself. Thus, a creditor's return and risk is largely dependent on the project's cash flows and assets. The project has an identity distinct from the company that sponsors the project and creditors have limited recourse against the sponsor. Project finance refers to innovative methods of financing large, complex projects. This type of finance has been, however, largely used in many countries for energy resource development, power generation, telecoms, transportation, water, and other utilities.

3.2.2 Key players in project financing

Figure 5 indicates the main stakeholders in project financing. Each stakeholder's intervention is detailed below.

Sponsors / investors: Provide equity financing or subordinated loans

- Usually in place, even partially, before any other funding
- May issue limited guarantees, provide additional funds for cost overruns, etc.
- Bear the greatest risk

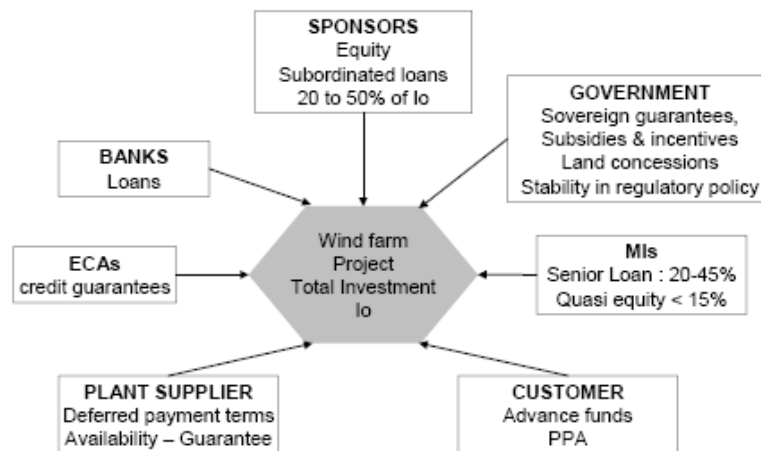


Figure 5 Key players in project financing

Banks: Major source of project finance

- Advantages of commercial bank borrowing: availability, fewer conditions (e.g. not tied to procurement from specific source), terms may be tailored to needs of project
- Disadvantages: floating interest rate, substantial front-end fees, shorter maturity than other sources

ECAs: Export Credit Agencies

These agencies grant credit or credit guarantees to stimulate foreign sales and investments. Most industrialized countries have their own ECA, e.g. US EIB, OPIC, Japan EIB, Export Credit Guarantee Department, COFACE (France), KF.

- Support in the form of direct loans, insurance, interest rate subsidy, etc.
- Main advantages: availability, fixed interest rate, high degree of subsidy

- Main disadvantage: procurement is tied to the credit

MIIs: Multilateral Institutions

These international institutions provide soft loans, hard loans and even in some case some equity participation. The main ones are the following: WB, IFC, MIGA, ADB, etc.

- Main advantages: can provide very low cost of capital. May also give outright grants to fund feasibility studies, technical assistance, etc.
- Main disadvantages: mainly available for large utility / government projects (or through specific credit facilities managed by local banks, raising cost of fund by adding their own management fees). Most of the time for large amount of investment, not necessarily adapted to decentralized electrification project like small or medium wind farm

Vendor / customers financing

- Vendor financing = vendors of capital equipment may grant deferred payment terms or assist in arranging financing with their country's ECAs or KBs
- Customers' advances = customers may advance funds for a project or enter into long term purchase agreements that enhance a project's viability
- Rationale: to assure supply of a key material (minerals, metals, oil & gas, steam) or availability of a service facility (oil pipeline)

Governments

- Host country government may provide local currency counterpart funding, guarantees, subsidies & incentives, land, mineral concessions, etc.
- More important than financial/material contribution is the maintenance of an environment that is conducive to the project (stability in regulatory policy, peace & order, provision of basic infrastructure, etc.).

All these investors will raise the following questions:

- What will they put into the project?
- When and under what conditions will they do it?
- What return will they get? In what form? When?
- What risks will they bear?
- What participation will they have in running the project?

3.3 Various contractual schemes

The contractual arrangement with the buyer is a key issue for project financing. Depending on the certainty of the revenues, some specific arrangement could be set up in order to share the various risks. In that view, financial engineering will not only consider the various financial instruments opportunities, but will also need to look at the contractual arrangements.

Various types of contractual schemes are presented below:

TAKE OR PAY AGREEMENT

- Long-term purchase agreement with fixed or minimum prices/volumes
- Buyer guarantees a certain cash flow to the project that allows the latter to service its debts.

DEFICIENCY AGREEMENT

- Another party (guarantor) covers shortfall in revenues to ensure that the project can service its debts

PAYMENT TRUST

- Involves trust account to ensure that the creditor is repaid
- Trustee receives payments from customers and pays the amount for debt service directly. Only the excess is remitted to the project.
- Could be further enhanced by a deficiency agreement

PRODUCTION PAYMENTS

- Involves segregating or assigning part of the project's output to a creditor : Creditor sells output used to service debt
- If demand for output is weak, lender is exposed to market risk.
- Could be further enhanced by a deficiency Agreement

A mix of these schemes might be required. For instance, the take or pay agreement is one of the most well know and preferred for energy production project, but the buyer's creditworthiness must be carefully evaluated. In some cases, the take-or-pay contract will need to be mixed with other risk management instruments.

3.4 Risk analysis and mitigation instruments

Investors and lenders are averse to risks that can lead to unexpected fluctuations of project cash flow. To attract financing, there is fundamental requirement to manage risk. Several options to decrease the risk:

- Find the perfect project, no risk & highly profitable (not so common)
- Carry out risk allocation and due diligence studies to anticipate and mitigate some risks: this can be costly and difficult for short background history technologies
- Transfer / share part of the risks : role of risk management instruments

3.4.1 Wind project risk evaluation

Investors make investment decisions based on their estimation of both the risk and returns of a project. In considering a project, an investor will usually prepare a risk/return profile, based on an approach similar to that shown in Figure 6.

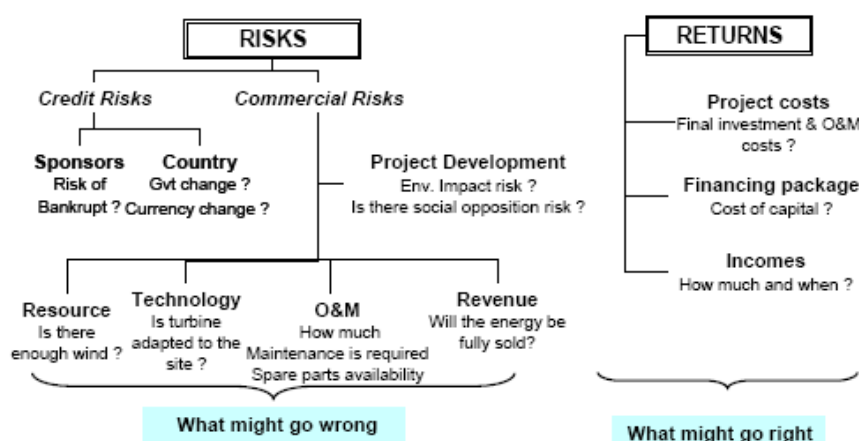


Figure 6 Project's risk and return profile tree

Some contractual arrangements presented above can turn out to be difficult to implement in some countries, or too costly for low or medium profit wind projects in countries where exploitation of wind

energy is only starting. In any case, risk is a key issue to be addressed when considering financing. The first stage will be to carefully assess the risk of various issues within a wind project. Then, selection of a particular contractual arrangement and also other risk mitigation instruments might be required to enable fund raising.

Below are some specific risks associated with wind project development:

1. At the development stage:

- Long development process & up-front costs (wind study, permission, etc.,)
- Incertitude in the final permits approval and wind resource

2. During construction:

- Delay in equipment supply, financial failure of the contractor
- Increased price or shortages of raw materials
- Difficulties encountered during civil work / turbine erection
- Consequential increase in interest expense on construction financing & delay in contemplated revenue flow

3. During operation:

- Poor wind resource assessment and/or unexpectedly strong fluctuation
- Non-guaranteed or uninsured critical component failure (gear train/box, bearings, blades) or destruction (lightning or typhoons for instance)
- Grid connection outage (substation, transmission line, security eqpt), or grid dispatch
- PPA price not correctly indexed, currency depreciation, etc.,

Other common causes for project failures include: government interference, poor management, technical obsolescence of the plant, expropriation

3.4.2 Risk management instruments

There exist many risk management instruments, conceived to address the many types of risks identified previously. Some of them are summarised below, focusing on the most appropriate ones identified for wind projects:

1. Due diligence, certification & equipment guarantees:

- Due diligence on wind assessment and use of P(90) or P(95) value of AEP instead of the median P(50) value
- Certification : IEC standards requirements
- Guarantee of manufacturer, including machine breakage confirmed under possible specific site conditions

2. Insurance / guarantee products:

- Based on conventional energy or infrastructure projects : commissioning delay, operating all risks, property damage, machinery breakdown, business interruption
 - But wind energy project might find difficulties to find all this type of insurance covers at reasonable price (or with high deductibles)
- Contractual Service Agreement with a large turbine manufacturer, which can guarantee the technical availability of a system over the term of the financing agreement (based on fees /kWh generated)
 - NB: creditworthiness of the manufacturer to be considered!

3. Credit enhancements, partial credit guarantees:

- Guarantees from multilateral funding agencies : partial risk/credit guarantee (specific political risk most of the time)
- Contingent capital: support/replace debt (in some case equity) in case of inability to meet debt service
- Semi-equity / mezzanine funds: buy down the risk, with a leverage effect for raising capital.
- Export Credit Agencies, through direct financing/credit, re-financing, interest rate support, insurance or guarantees for some commercial & political risks
- National guarantee funds
 - Can help in raising capital at lower cost

4. Price support mechanism and ROI improvement

- fixed-price system (feed-in tariff in Europe)
- Green certificate or premium prices
- ROI improvement :
 - subsidies (on development or investment costs, loan rate, etc.)
 - tax holidays, etc.
- improving the profitability of a project make the risk more acceptable for investors

Other emerging risk management instruments are appearing, for example: credit derivatives, alternative risk transfer, and weather insurance/derivatives. The risks are transferred from project investors to the market through trading companies, banks or re-insurers (but this does require high quality and robust data to be available).

4 Lessons learned

The following sections are intended to summarise some of the most important aspects of the lessons learned during this project. Some of them are, naturally, specific for the sites that were used as case studies in the project whilst others are more general in nature.

4.1 Long-time measurements of wind – what to look for?

The reason for having historical wind data is that the wind measurements made on a chosen site will, by necessity, be shorter than the lifetime of a wind farm, and therefore may not be representative of the wind conditions that the wind farm will experience during its period of operation. One therefore looks for data measured in the surrounding area that can be used to adjust the data measured on the site so that it is more likely to represent what the wind farm will experience. This technique is commonly called MCP: Measure (on site), Correlate (with historic data) and Predict (what the wind farm will experience in the future).

There are, therefore, some requirements that this historical data should meet and which should be borne in mind when looking for suitable data.

- The data should overlap time-wise with the site measured data.
- The data need to have been measured at a location that experiences the same wind systems to ensure that it will be representative for the wind farm site. In practice, this means that the distance between it and the chosen site should not be too great (50-100km) but this is highly dependant on the terrain. The WASP software, for example, calculates a “correlation coefficient” with which one can assess how representative the two data sets are.
- The met mast for the historical data should preferably have a wind exposure similar to the chosen site’s met mast. This means that there should be as little directional bias between the two data sets as possible.
- The long time series data should be long enough, preferably greater than 10 years. A met mast with a longer time series but a little further away is preferable to a mast with shorter time series but closer to the site.
- The historical data needs to be of good quality, recorded with well maintained instruments and data loggers. A check should be made for data gaps, replacement of equipment during the measurement period and even changes in location (even though the name of the source stays the same) and surroundings.
- The historical data should have both wind speed and direction, so that a correlation on a sector-wise basis can be carried out.

4.2 Good practice for measurement heights

Use several heights for wind measurement chosen to give information about the wind profile, rather than trying to replicate hub-height. For example, anemometers at 10, 30 and 50m for a 50m mast is better than 30, 40 and 50 m. The 10m height is also very useful because it is the most common height for meteorological measurements and can thus be used for direct comparison with other non site-specific data. In addition, the wind vane should be duplicated to better understand the air flow at different heights (and to provide redundancy).

4.3 Good practice for met station O&M

If the data obtained from a measuring station are to be accurate and complete then a good operations and maintenance regime is essential. There should be a comprehensive, but simple, plan that includes

the quality control and assurance measures necessary to ensure that the smooth and continuous collection of data. The following are some important measures:

- Ensure anemometers are calibrated at correct intervals
- Visit mast regularly or use GSM or satellite transfer of data
- A preparation plan, as well as an on-site procedure plan, is necessary so that nothing is forgotten, as equipment is often in remote locations.
- A site visit should include a check of the tower components as well as measuring equipment.
- Downloading data should be the first activity upon arrival. This will minimise any data loss should a fault occur during subsequent activities.
- An adequate spare parts record must be maintained and included with all visits to site.
- An early assessment should be made of the necessity for securing the mast site as equipment theft can produce long gaps in data records, as happened on the Dinagat site in The Philippines.
- Local residents should be made aware of the reason behind the erection of a mast, possibly with an information campaign, so that a) complaints can be minimised, and b) through their involvement, people could act as unofficial guards.

A visit to a mast should be seen primarily as a check on its proper operation and the collection of data viewed as a secondary objective. The temptation to postpone a visit knowing that the logger still has capacity for data should be avoided as this prevents the correct operation from being checked. If the data transfer is automatic, then the value is more in the ability to assess the quality of the data than in being able to use it directly. A regular remote quality check can highlight problems quickly so that a solution can be implemented early rather than continuing to collect erroneous or less-than-useful data.

4.4 Management of data gaps

The case studies within the project provided some good opportunities for the management of data gaps. The data records for the island of Dinagat in The Philippines contained a gap of nearly one and a half months because of equipment vandalism. The data for December 2005 and half of January 2006 were thus not recorded.

The overall philosophy for the repair of the data is to be able to use the 11 (or approx 10.5) months worth of data that is available as input to a WAsP calculation and obtain a good estimate of the annual production from a wind farm/wind turbine. In the following exercise, it is assumed that the entire month of December 2005 is missing. The objective is to avoid a seasonal bias due to the fact that the missing data are not randomly distributed but are all from the same month. So, in this case the summer period would have too much weighting because December's data (and some January data) is missing.

The recommended action for "repairing" the hole should be done at the time of performing the WAsP calculation, as a possible correction to the result, i.e. to the annual energy production (AEP). It is not recommended to modify the data or fill in any "surrogate" data.

Steps to be taken:

A) The data as recorded should be filtered through the OWC (Observed Wind Climate) wizard of WAsP as usual and the AEP calculated. This is called AEP(11).

B1) The measured data from Dinagat should be used to establish a yearly profile, calculating 11 monthly mean values which are then plotted. This annual profile is then compared with a similar profile established by plotting monthly means from a nearby PAGASA (Philippine meteorological organisation) station or other measured data nearby. Judging from the photos available, the PAGASA station in Surigao City is not too well located and surrounded by high vegetation, but nevertheless it

may be possible to establish a yearly profile. If the annual profile correlates reasonably with the profile from the Dinagat mast then a correction to the AEP(11) already calculated could be carried out. This is done by calculating the ratio $[\text{Annual mean wind speed (12 months)} / \text{annual mean wind speed (11 months)}]^2$ for the relevant PAGASA station and multiplying the AEP (11) by this ratio.

If, however, there is not a good correlation using the ground data then step B2) should be followed.

B2) The same analysis and possible correction should be carried out using NCEP/NCAR re-analysis data from a nearby node(s).

If there is still no good correlation using NCEP/NCAR data or the ground data then step B3) is next.

B3) An inspection should be made of the monthly means from the Dinagat dataset. An attempt should be made to try to compare this with some generic knowledge of the seasonal variation that may be present from other sources (for example, PAGASA). By geographical comparison, a reasonable annual profile of the monthly means may be able to be established, following which the ratio can be calculated as above (see B1).

4.5 Overview of lessons learned from site selection in the Philippines

The following are some notable points that have contributed to the positive experience gained during the site selection process:

- Permission is required for the erection of a meteorological mast and even this can take time, so a parallel permitting process may have to be done on a number of sites to increase the chances of keeping to the project programme.
- The installation of the met mast should be properly co-ordinated with the local authority and the local population to increase the likelihood of acceptance.
- Choice of island site should include an analysis of the ability of the islanders to pay, as many of the existing island supplies are subsidised by central government.
- There are a number of factors that influence the choice of turbine: wind resource, access, grid connection, soil bearing capacity, etc. Therefore, the annual energy production calculation should be carried out with a range of turbines. Banks are also keen on seeing a range of alternatives.
- If existing port facilities are insufficient then a beach landing technique can be considered, although this is even more weather dependent. It could also be that a choice of smaller turbines may ease the civil infrastructure constraints.
- The chosen wind turbine contractor should be required to guarantee a power curve for use in analysis and also approve the turbine siting (e.g. minimum turbine spacing)
- In terms of project selection, the conditions attached to any finding available should be carefully reviewed. The nature of tied loans may mean reduced competition and increase costs.
- The long-term sustainability of a project would be improved with a closer participation between the public and private sectors in renewable energy developments. This may best be done in rural and off-grid situations where private applications with an element of storage can help integrate wind into a public system, and reduce the overall cost.

4.6 Design of wind farms in typhoon areas

In this project a re-evaluation of safety levels of turbines designed according to existing IEC (International Electrotechnical Commission) standards was carried out but with the specific situation when they are exposed to typhoons. Using Zone 1 in The Philippines as the specific study area, has resulted in the following remarks:

- An indicative load safety factor of 1.7 for The Philippines would be more appropriate if the same level of structural reliability as intended as the IEC61400-1 is desired, where a factor of 1.35 is used.
- Based on a very crude cost model setup as part of the work reported here, the higher mean wind speed (Zone 1 60-70m/s) and safety factor of The Philippines indicates that the construction costs would increase by about 20-30% relative to turbines designed according to IEC 61400-1 with a reference wind speed of 50m/s.
- The demand on the yaw system in the instance of the eye of a typhoon passing over the turbine location has been the subject of a preliminary investigation. It turns out that modern turbines can cope with the demand as long as they are powered up. However, because the grid connection is almost inevitably lost during a typhoon, power back-up is required.

4.7 Electrical design

4.7.1 Grid connection

- It is essential to obtain information from the grid operator (or the entity that has responsibility for the electrical network at the point of common coupling (PCC)). At the very least, this should be the impedance (and impedance angle) of the grid at the PCC, together with the short circuit fault level at the PCC.
- The voltage stability at the PCC is not only affected by the active power injected by the wind farm but also the reactive power consumed (or produced). This includes all the equipment (cables, lines, transformers, etc.) and therefore the wind turbines, wind farm internal network, sub-station and delivery lines all need to be considered when analysing the grid connection.
- The strength of power systems are traditionally built to deliver power according to the predicted load. Thus, the network away from major load centres is likely to be weak. Unfortunately, this is often where the better wind resources are and this presents a major challenge for the grid connection design.

4.7.2 Island systems

- One of the most important aspects to assess when considering to introduce wind power to an island system (powered by diesel generators) is the load curve of the existing system. The minimum load is the main figure that dictates the maximum wind power that can be assimilated. If there is insufficient load then there can quite possibly be loads that can be transferred onto the system that will help with wind power integration. A good example has been the ice making processes found on the Vietnamese island of Ly Son. These provide an excellent 24-hour load.
- The collection of data can be a time-consuming task. When simulating a system, it is important to get the basic data correct: generator sizes, fuel consumption, voltage levels, transformer sizes, transmission lengths, etc. Some data may well not be fully documented, for example, the engine droop curve or maximum overload. The best chance of obtaining this kind of data is by making a visit to the power plant, which will also enable the operating procedure to be ascertained. Some data, such as transmission losses can be estimated to a sufficient degree of accuracy.
- It is important to look at the whole wind regime over a year so that equipment is not over- or under-sized.
- A dump load in the system appears to waste power but can be very useful in balancing a system and actually increase the wind energy used if properly designed.
- A system that has a number of smaller diesel generator units can more easily integrate wind power than one with a few large units. The age of the units is also crucial as newer designs can

operate at lower part loads and have more flexible control systems, two aspects that help when trying to balance the variability of wind power.

- When considering the wind farm size, a number of smaller turbines are better than one large turbine for the quality of power production.

4.8 Planning, policy and institutional issues

In this section some of the lessons learned are presented together with some recommendations as to how the development of wind energy projects can benefit from them. Issues with the GIS planning tools are presented first, followed by a look at some of the barriers presented by policies (or the lack of them) and how institutional frameworks can be improved.

4.8.1 GIS territorial wind planning

- A wind assessment campaign is a long and costly exercise but this does not mean that it is the only (or even major) aspect to consider in developing a wind. Over-emphasis on an excellent wind resource could lead to a project that is unfeasible due to a different, but very hard, constraint (for example, the adjacent grid may be too weak). Of course, it could also merely lead to a bad project (where, for example, the cost of reinforcing the grid is very high. On the other hand, a project with a relatively mediocre wind resource may be very successful because the various other factors are favourable (short development period, easy access, low cost, etc.). The incorporation and integration, as early as possible, of all the various criteria is very important and underpins the use of territorial planning.
- Site selection should take into account as much information as possible, which means that all the economic results arising from the technical analysis, environmental data and socio-economic data should be rendered into a form that can be mapped in order to give an overview of the main issues, opportunities or barriers over a wide area.
- Care should be taken when using a "national atlas" as it provides data for only a very first level assessment.
- The project came up against two limitations with respect to the GIS territorial planning exercise. The first one was, most importantly, the restricted availability and accuracy of GIS data: reliable wind data, land cover, administrative/physical/environmental constraints, etc. The second one was the time consuming process for data collection, importation and analysis under the GIS.
- Conversely, the result of the territorial planning turned out to be a very powerful tool for investigation over a wide area once the GIS database had been created. It enabled various constraints to be assessed at a very early stage and ensured a much more reliable pre-selection of areas suitable for wind energy projects. The multi-criteria site information quickly led to a better understanding of the constraints with a territorial overview. This can facilitate communication with all the stakeholders, mainly due to clear visual outputs.
- Various improvements to the methodology could be envisaged, including carrying out sensitivity analyses for certain criteria (for example, wind data, distance to substations, etc.). The integration of additional GIS data would also be of great interest (for example, urbanized areas, airport clearance areas, piers/harbour facilities, military facilities, ornithological corridors, etc.). Additional technical data such as grid connection capacity can also be computed, leading to a major improvement for planning purposes.

Recommendations:

Territorial planning of wind energy should be of interest at various levels:

- Planning authorities/grid operators: by improving the future possibilities of wind integration into the grid, evaluating the impact on the grid, and possible reinforcement/grid operation adjustments required in the medium or long term
- Wind developers: help to identify priority development areas and facilitate integration of the numerous criteria to take into account for site development at earlier stage
- Local communities: participatory approach with local stakeholders assists in taking into account their concern, and wind project territorial integration

4.8.2 Policy and institutional observations and issues

This section identifies some of the lessons learned with respect to the barriers preventing, and the policies developing, the exploitation of renewable energy in Vietnam and the Philippines, but many of them apply to other situations equally well. The paradox of only a small share of electricity coming from renewable sources whilst the electricity demand of the country is growing strongly is quite widespread.

Approval procedures are complex and not adapted for RE in general

The procedures to obtain approval of investments into wind power development are, in general, still complex. The level of state intervention and the length and complexity of the process depend on the ownership of the funding and the scale of the project. The existing legal framework is more likely to have been designed to accommodate larger (conventional) power projects but not small-scale projects such as renewable energy (RE). All this translates into high development costs (compliance documentation, negotiation, long-waiting time, etc.) for small RE projects.

Difficulty in securing power purchase from small producers

There is a lack of adequate policies and regulations to purchase power from small power producers. The barriers at present are the lack of a national energy policy and a legal framework strong enough for promoting exploitation and use of renewable energy, especially production of electricity from renewable energies. This means there is little support for negotiating power purchase agreements and electricity tariffs.

The RE policy frameworks are establishing

- More developed in the Philippines than in Vietnam, but none existing in Cambodia. There is an absence of definite government policy on renewable energy overall and no specific policy and implementation measures for wind power. The RE Bill in The Philippines is still not finally approved, there are many uncertainties on the final content and time taken to come into force
- There are, as yet, no clear mechanisms for implementation (tariffs, RE funds, etc.).
- No measures to cover RE-related specific risks for private investment (relatively unproven technology, uncertainty in long term supply, capital intensive investment, small current market, etc.)

Lack of R&D on local specificities

- At present there is only small scale R&D
- There is a general lack of R&D, and of experience in wind power development.
- Local conditions are quite different from other regions so special conditions need to be taken into account (high typhoon, corrosive tropical conditions, etc.)
- Lack of comprehensive data
- No indigenous technologies - all equipment has to be imported which is expensive.

Financing barriers

- Limited access to financial sources for investment. Without policy and subsidy, wind power cannot develop.
- No private funds for user access, no bank-assisted schemes.
- The market for private users is limited due to the low income of the villagers and the absence of any subsidy or institutional financing.
- Carbon credit and incentive for cleaner production can help the wind power to have a more significant role.

Wind energy can play a bigger, but yet limited role

Following the analysis of the power development strategies in the Philippines, Vietnam and Cambodia, the wind power development can play certain roles in the future to:

- Diversify the supply sources but will have a limited impact on global power supply
- The most promising trend is to supply electricity to mountainous regions, islands and remote areas
- There is a bigger role for some coastal provinces in the Philippines and Vietnam, and to a lesser extent in Cambodia.

Recommendations

Introduce various mechanisms to enhance the development of wind

These incentive mechanisms can be classified into:

- Pricing incentives: Feed-in tariffs for wind power, standardized PPAs with preference for RE.
- Financing incentives: create special RE funds, exemptions of taxes, duties and other charges for wind power
- Legal incentives: Simplify procedures (a “one-stop shop”), private-oriented incentives for investors and developers.
- Wind measurement and assessment should be publicly financed.

Capacity building

- Public investment in R&D in RE.
- Human resources development: technical & managerial skills development, financial engineering training, etc.
- Dissemination and awareness for wider acceptance and understanding of the problems.
- Enhance and separate regulatory role from utilities: regulatory process and decision must be independent.

Recommendations for off-grid and small scale wind power

- Off-grid wind power development can contribute to improve the economic situation and to supply electricity in remote area. However, the largest potential development is in island systems where a grid connection cannot be constructed and there are no other options of power supply apart expensive diesel gensets. The government should elaborate a specific policy and regulation for those areas: subsidy and tax exemption, removal of duty for wind equipment imported.
- Wind measurements which are costly for small off-grid projects, should be subsidised and technical assistance must come from the government.

Recommendations for grid-connected and large scale wind power development

- Identify the support mechanism that could be used.
- Standardisation of PPAs to lower transaction costs must be implemented.

- Without preferential and incentive policy, it is difficult for wind power development to take-off. Clear objectives for power development must be set with incentive tools (financial, regulatory, fiscal, etc.). Select a supporting scheme that stimulates the development.
- Given the present conditions (no local references, high uncertainties and risk, tariffs on LRMC is not yet established), elaborate regulation modes which are most suitable for wind power development are very important. They should differentiate the supporting model used.
- Full transparency and true prices are important
- Grid connection policies and data accessibilities: a minimum transparency on grid connection capacities is required to enable developers and planning institutions to work more efficiently for the development of wind energy
- Make detail analyses estimating the true (national) value of wind power in the power system.

4.9 CDM Lessons Learnt

4.9.1 Island systems: The Philippines and Vietnam

- For small scale wind projects (with a capacity installed below 15 MW) the small scale project baseline and monitoring methodology “1 D” is valid. According to this the avoided CO₂ emission is the emission from a diesel generator which would otherwise have had to be used for producing the electricity supplied to the mini-grid. Two possibilities exist for calculating the avoided emissions: either the UNFCCC default of 0.8 t CO₂e/MWh can be used or the actual amount in tons of diesel used multiplied with the emission per ton diesel (UNFCCC default value of 20.2 tC/TJ) divided by the electricity delivered to the grid in MWh. As the first is conservative it is recommended to make use of the actual figures (registered and audited).
- The economic viability depends on the obligation imposed by the Ministry on the power supply companies EVN and NPC respectively to provide electricity to consumers 24 hours a day. Given such an obligation the energy produced by wind turbines can replace the diesel whenever produced. The electricity produced and not used but dumped depends on how well the diesel engines are suited to operating at low load and if the wind turbine capacity exceeds the low demand (lowest hour on lowest day). Since the configuration of the power system will have to include a dump load, the avoided CO₂ emission to the atmosphere is the power production from the wind turbines minus the power consumed by the dump-load in the same period.
- The two Island systems studied in the Philippines and Vietnam both have an estimated net wind power production too low for making a CDM project viable bearing in mind the cost incurred for PDD development, independent validation by DOE, registration and negotiation of an Emission Reduction Purchase Agreement (ERPA). It is consequently recommended to bundle the project with other small scale island CDM projects respecting the total limit of installed capacity of 15 MW. In Vietnam this can be done by letting EVN install wind turbines at the islands of Phu Fui and Phu Quoc at the same time as installing a hybrid system at Ly Son. The total capacity may reach between 5 and 10 MW. For the Philippines the option of using the wind farm to supply the nickel mine situated in the south east end of the island of Dinagat has been recommended increasing the possible capacity to 5 MW or above, is the most obvious since a farm situated next to the mine will, due to more favourable wind conditions there, have twice the output per MW installed capacity.
- The contribution from the sale of CER to the economic viability ERR may not be important, however, the leverage on FRR securing soft financing may be very important, and the cash

flow from the CER in foreign currency during the repayment of such a loan and later in the 3x7 years period may secure funds for maintenance and repair of the imported components.

4.9.2 Main grid connected: The Philippines and Vietnam

- For wind farms with a capacity above 15 MW the Approved Consolidated Methodology ACM0002 applies. This methodology is valid for Renewable Energy Production to the Grid and specifies how the baseline is to be calculated and how the avoided CO₂ emission is to be monitored. It is, for both countries, permitted to leave out the “Low Cost Must Run” plants when calculating the emission from the present power plants supplying to the grid. The low cost must run power plants are the hydro power and geothermal power plants as well as other wind farms. The criteria to be fulfilled is that in none of the last 5 years must the electricity supplied from these sources to the grid surpass 50 % of the total. The avoided emission is what the wind farm has pushed out at the margin, it is called the Operational Margin (OM). Since the low cost must run plants constitute less than 50 % it is permitted to calculate it in the simple way only taking the CO₂ emission from the fossil fuel consumed in each of the last 3 years year divided by the electricity produced from these plants the corresponding year.
- As the emission avoided is calculated ex-ante, the development in new capacity influences the baseline. Here the methodology given in ACM0002 states the margin will change in the 7 years period and that is allowed to maintain this as a fixed margin for the 7 years if the emission at the margin from the last 5 constructed power plants or the 20% last constructed is used to adjust the operation margin OM. This is called the build margin (BM) and is calculated as the CO₂ emission from the last power plants divided by the electricity produced the last year before requesting the CDM project for registration. It shall be noted the electricity produced in the BM calculation comes from all kinds of power plants and reflects the trend in the utilisation of fuels and renewable resources. The ACM 0002 defines the avoided CO₂ emission as the Combined Margin of the OM and the BM as $CM = 75\%OM + 25\%BM$ for wind and solar power production.
- For both Vietnam and the Philippines no detailed information is available on the fuel consumption and the actual annual efficiency of each power plant and hence the emissions per MW for each power plant cannot be calculated based on measured values. The calculation of the OM and BM has been based on the aggregated figures for the production of electricity for all plants using the same type of fossil fuel and the efficiencies has conservatively been set at 50% for natural gas fired power plants, 36 % for oil fired, and 33 % for coal fired power plants. Further standard emission figures using the UNFCCC default values have been established. The estimates are probably 10 % on the low side and can, as CDM project numbers peaks up, represent a value far above the cost of maintaining a register on the efficiencies of the individual power plants.
- Provided realistic tariffs are valid for the power production from wind farms and priority of access to the grid is given without penalties for not being able to announce the exact expected production from a wind farm 24 hours ahead the CDM may lift a project IRR by 1-2% and may prove useful as the tool for providing access to soft financing. It shall be emphasised, however, that the revenue from CER can not turn a bad project into a good project and will, during the 21 years valid for a wind CDM project, contribute to the financing with 15-20 %.

4.10 Economic and financing issues

The following difficulties have been identified while carrying out the economic and financial studies within this project:

Peculiarities of wind project development

- Up front costs : the project development process is long and risky
- Technical issues have a big impact on financial analysis. For example, careful design of wind turbines (possible overrun of costs for Class S wind turbines under typhoon areas, optimization of energy production and costs, etc.) and grid connection facilities.

Uncertainties

- Lack of suitable cost benchmarks: WTG costs are varying in a moving market, uncertainty over costs for a special class turbine, plus transportation, erection, logistic and worksite risks. This highlights the necessity of carrying out sensitivity and risk analysis
- Risk analysis and mitigation: there is no local due diligence expertise for wind project assessment and no specific financial instruments (maybe for RE Bill RES funding)
- Uncertain inflation rates.

Financial framework

- Existing financial instruments not adapted to wind energy projects on a standard commercial basis. The loan term is too short (7 to 10 years) for wind projects, most banks do not accept wind farms as collateral, requiring specific other collateral, resulting in costly guarantees that are difficult to obtain.

Methodological recommendations

- Avoid confusion between economic analysis carried out in real term or nominal term
- Impact of foreign currency depreciation on economic analysis should be carefully assessed: hard currency loan / equity payment for instance
- For a hybrid diesel/wind system on a small grid, the economic analysis should not consider the wind farm alone, but the whole energy system "diesel / wind", so as to evaluate the savings in diesel costs
- Choice of discounting rate for economic studies to be carefully discussed with local authorities: high discount rate minimizes the impact of the future on present choice, which is not necessarily a sustainable development approach. In any case, comparison between RE and fossil fuel production costs should include a risk factor for fossil fuel cost uncertainties (and long term increase)
- National policy and purchasing price for wind projects should be at least based on real avoided costs, including the risk factor for fossil fuels price variations as well as external costs
- Syndicate loans can mitigate single lender risk
- Take advantage of CDM

Wind energy lacks a track record in Vietnam and the Philippines and the regulatory frameworks do not facilitate the development of projects. Table 2 presents the criteria identified for developing a successful wind project in these two countries. Note that the global national framework is separated from the project development point of view.

In conclusion, there is a need to increase the expertise in developing good wind projects in order to build up the confidence of potential investors and lenders. Currently, financing a wind project might be a challenge at a reasonable cost, as the existing funding products are not adapted to the specificities of wind projects. The barriers identified for the financing and contractual issues are summarised in Annex 1, where proposed activities or possible solutions are also included.

Table 2 Criteria for successful development of wind projects

Global framework issues	Project development
<ul style="list-style-type: none"> - Stable & friendly political environment; available licenses & permits; enforceable contracts; existing legal remedies - No risk of expropriation - Satisfactory country risk - Satisfactory sovereign risk - Currency and foreign exchange risks to be addressed - Key promoters have made adequate equity contribution - Project has value as collateral - Satisfactory appraisals of resources and assets - Adequate insurance coverage - Force majeure risk has been addressed - Cost over-run risk has been addressed 	<ul style="list-style-type: none"> - Satisfactory feasibility study and financial plan - Assured cost of product or raw material - Market exists for output : secured PPA contract - Available grid access - Adequate communication - Reliable and experienced contractor - Reliable and experienced operator - Reliable and experienced management - Satisfactory contractual agreement among JV partners

Annex 1 Barriers and recommendations

Identified financial barriers	Activities to be undertaken/possible solution
1. Cost of capital : wind power projects not financially viable if funded substantially by commercial funds	Ideal funding mix that may make it financially viable, cocktail of ODA loans, grants and equity Ensure that the benefits of gearing are not out weighted by the cost Carefully consider the costs and benefits of fixing rates at financial close. Examine the effects of financial covenants on projects to ensure breaches do not occur (through a range of sensitivities). In particular, examine the cost of unwinding financial structure so that refinancing is possible if there are large scale changes in economic circumstances.
2. Risk on capital cost overrun	Use fixed price turnkey contract, proven technologies and experienced contractors Ensure penalties for late completion properly compensate for lost profits Ensure where possible that output warranties are given by manufacturer
3. Risk on operating costs	Ensure critical resource inputs are obtained if possible on the basis of fixed price or known variation contracts If not possible, consider the option of -Contractual Service Agreement with large turbine manufacturer for the first years of operation, where cash flow is critical
4. Taxes and fiscal optimization	Take appropriate professional advice to maximize capital allowances (but wind energy project are likely to benefit already for taxes and fiscal advantages)
5. Careful timing of project	If possible, ensure that turbines are erected at the start of windy seasons Possibly purchase turbines from manufacturer from off peak production schedule to negotiate possible discounts (difficult in the current market of high demand and low offer)
6. Consider additional sources of revenue	Green certificate if existing on national market (in project under the RE bill in the Philippines) Consider CDM to enhance the revenue streams through carbon credits
7. Joint Several Signatures (JSS)	Risk sharing through JSS likely to be imperative. However, it can be waived, on certain conditions: strong balance sheet, strong cash flows, quality of collateral and track record
8. Lack of financing for Wind Power Project Preparatory Activities. This results to very few projects that are ready for financing.	Potential funding sources available (GEF, WB, EC-ASEAN), need to be secured by local investors with the help of local banks