Technical Feasibility Studies Philippines

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ASEAN Wind 2005

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

Technical Feasibility Studies
Philippines

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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)
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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)

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Preface

This report documents part of the work and the output of the activities under the Projects Task 4: Technical Feasibility Studies and forms the Project Deliverables no. 14.

As part of the present Project, technical wind power feasibility studies and analyses have been performed for four selected sites – two in Vietnam (one grid connected and one island system) and two in the Philippines (one grid connected and one island system).

The cases form the basis for the studies and have been selected by the local partners (IE and PNOC-EDC respectively) in the very beginning of the project in order to be able to collect one year of local wind data. For various reasons, some of the original selected sites have been changed. The four sites have been all visited by project teams for site inspection and data collection.

The technical feasibility studies have been presented and discussed at the 2-day workshop 24-25 July 2006 in Hanoi with participation of stakeholders from the countries. The present Report presents the studies and the results. The outcome of the technical analyses forms the input for the economic and financial feasibility studies for the same cases within the Project.

The four very different cases illustrate various typical issues for the introduction and integration of wind power. Large scale integration of wind power into a national grid dominated by hydro power generation is illustrated by the Phuoc Minh case in central Vietnam. The integration of wind power into the national grid at the outer end of a relative weak transmission / distribution line is illustrated by the Sta. Ana case in the north of the Philippines. The integration of wind power into an isolated power supply system, mainly intended for supporting a local mining industry is illustrated by the Dinagat Island case in the Philippines. And the integration of wind power into a small, electrically isolated island power system with a potential for growing consumption is illustrated by the Ly Son Island case in Vietnam.

The present report presents the two feasibility studies in the Philippines, while the two cases in Vietnam are presented in a separate report (deliverable no. 15).

The report has been edited by Niels-Erik Clausen, Risø National Laboratory, with input from all Project Partners.

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Executive summary

As part of the present Project, technical wind power feasibility studies and analyses have been performed for four selected sites – two in Vietnam (one grid connected and one island system) and two in the Philippines (one grid connected and one island system).

These cases form the basis for the studies and have been selected by the local partners in the project (IE and PNOC-EDC respectively) in the very beginning of the project in order to be able to collect one year of local wind data. Due to lack of permit to install a meteorological mast the island based site in Vietnam had to be changed, and the Project did not get access to one full year of high quality wind data. The sites have all been visited by mixed teams for site inspection and data collection.

The four very different cases illustrate various typical issues for the introduction of and integration of wind power. Large scale integration of wind power into a national grid dominated by hydro power generation is illustrated by the Phouc Minh case in central Vietnam. The integration of wind power into the national grid at the outer end of a relative weak transmission / distribution line is illustrated by the Sta. Ana case in the north of Luzon in the Philippines. The integration of wind power into an isolated power supply system, with a possibility for supporting a local mining industry is illustrated by the Dinagat Island case in the Philippines. And the integration of wind power into a small island power system with a potential for growing electricity consumption is illustrated by the Ly Son Island case in Vietnam.

In the following we will summarise the findings of the two cases in the Philippines.

Sta. Ana is a municipality located in the province of Cagayan Valley, NE Luzon on the northeast tip of the province. The town's population is 22,000 and is politically subdivided into 16 barangays. This area was chosen by the Project Partners for the Philippine Grid-connected Case.

Data Collection. PNOC-EDC erected a 27 meter meteorological mast for data gathering in Barangay Diora near Sta. Ana on September 12, 2005 equipped with 2 anemometers, a wind vane and a data logger. In the course of data collection, 35 days worth of data were lost due to equipment malfunction. An average wind speed of 5 m/s in 27 m height was found. This is considered a moderate to low wind resource. However, modelling by means of WaSP showed that relocation of the wind farm site to an area further east in the mountains (150 to 250 above sea level) would yield a better annual energy production. However, at the same time the wind farm would be completely exposed to the typhoons, normally approaching the country from the Pacific from the eastern direction and moving across the country in a western or north-western direction.

Accessibility and Land Area. Sta. Ana is both accessible by land and air through a national road (12 hour trip from Manila) or through Tuguegarao Airport (1 hour from site). Furthermore Sta. Ana is very close (12 km) to a suitable port where the wind turbines may be offloaded at Port Irene, which is soon to be developed into an international port. It is not recommended that the wind turbines be transported from Manila as the roads to the site are

narrow with several obstructions such as Welcome Arches, unsupported bridges, hairpin turns, etc.

Power System / Grid Connection. An assessment of the power system and the requirements yielded that the proposed 30 MW wind farm can be connected to the nearest substation at the existing 5 MVA installation at the nearby export processing zone (CEZA) which also serves the Sta. Ana town load through a 13.8 kV line. A power factor compensation at the substation is recommended.

Dinagat Island is a big, seven-town island lying between Southern Leyte and Surigao del Norte. The island is about an hour's boat ride from Surigao City's port. It has a total population of 107,000 with an annual growth rate of 1.55%. The island has a total land area of 80,200 hectares. Around 54,200 hectares are considered mineral lands. Among the minerals found abundantly are nickel silicate ores, saprolite, limonite, metallurgical chronomite, gold and silver.

Data Collection. Data collection commenced on August 12, 2005 using a 30 m meteo-rological mast equipped with an anemometer and a wind vane at 30-meter level, another anemometer at 10-meter level. Similar to the Sta. Ana case, data gaps were experienced for more than one month during December 2005 – January 2006 due to vandalism. The measurements indicated an average wind speed of 5 m/s.

Dinagat Power System. The Dinagat power distribution system runs from north to south on the island using 13.8 KV transmission lines. The island is powered by a total of 1783 KW diesel generators. The island's average load is 400 KW with a peak load of 1 MW. The domestic load is thus too low in itself to justify the construction of a wind farm. An alternative is to sell the wind farm's output to the mining (PhilNico), which has recently obtained permits to resume the mining operations. PhilNico plans to erect a 30 MW diesel generator to provide its power requirements and with that load (24hrs a day) a 5 MW wind farm might be financially attractive to the mining company.

Alternative wind sites closer to the mining company were identified during the site visit. Initial WaSP runs indicated a significantly better wind resource here.

1 Technical wind power feasibility studies

The project feasibility study forms part of the decision basis for the initiation and implementation of the project. The results of the study are presented in findings and recommendations. Typically, the feasibility study is divided into a technical feasibility study and an economic & financial feasibility study.

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

- The wind conditions
- The power system
- The land issues
- The proposed wind farm
- The organisational issues
- An environmental impact assessment
- The costs and benefits

1.1 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.

Determination 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.

Wind turbine class	I	II	III	S
Vref	50 m/s	42.5 m/s	37.5 m/s	Values specified by the designer
A	$I_{15} = 0.16$			
B	$I_{15} = 0.14$			
C	$I_{15} = 0.12$			

Table 1: Wind turbine classes as defined in the international standard for design of wind turbine constructions, IEC 61400-1, valid only out of typhoon areas. I_{15} is the turbulence intensity @ 15 m/s wind speed. V_{ref} is 5× mean wind speed.

1.2 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.

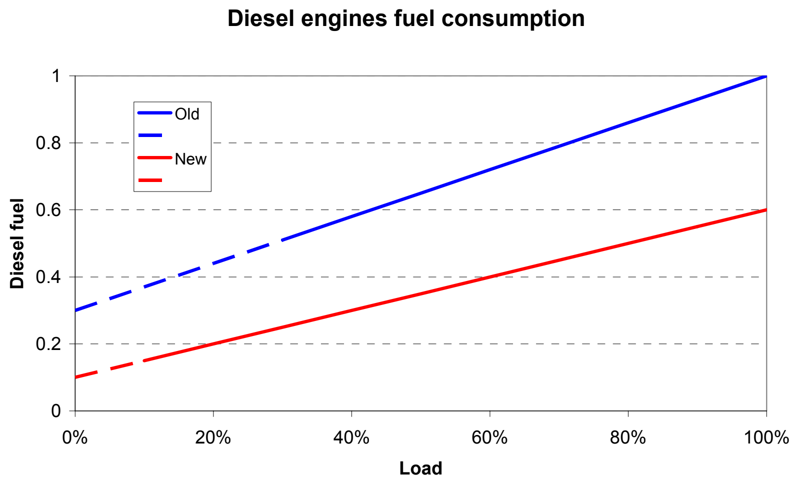


Figure 1: Typical relative diesel fuel consumption for an old and a new diesel engine. The fuel consumption at 'no-load', the slope and the technical minimum load differs. The benefits in terms of 'saved fuel' are highly dependent of the diesel engines efficiency at low load and therefore also of the technical minimum load of the diesel engine.

1.3 Land issues and site access

The wind turbine units 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.

1.4 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.

1.4.1 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 influnced by the wind resource and a combination of the wind turbine's hub height, the rotor diameter and the rated power.

1.4.1.1 The hub height

The larger the surface roughness at the site, the more will be gained in production by increasing the hub height of the wind turbine, although the costs of the wind turbine and the wind turbine foundation will also increase. In general, the larger the surface roughness, the higher the optimal hub height relative to the rotor diameter. For wind turbines designed for off-shore applications, the hub height will typically be less than the rotor diameter. For wind turbines designed for in-land applications, the hub height will typically be greater than the rotor diameter.

1.4.1.2 The rotor-to-power factor

The cost of the wind turbine is highly dependent on the rated power and on the rotor diameter. The revenue is dependent on the annual production, while the capacity factor expresses the utilisation of the wind turbine. Wind turbines designed for low wind applications (average wind speed < 5 m/s) will therefore typically have a relatively high rotor-to-power factor (typically 3 m^2/kW), while wind turbines designed for high wind application (average wind speed > 8 m/s) will have a lower rotor-to-power factor (typically 2 m^2/kW) for cost reasons.

1.5 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. Wind power should therefore be considered only if there is a sufficient large wind power potential – at least 5-10 % of the total power generation capacity in the power supply system.

1.6 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.

For countries like the Philippines, however, wind farms can currently be considered as attractions. It is still not known whether the visual impact will become a big issue in the near future as this industry is still in its infant stage. It is advantageous, however, that the most promising sites for wind farm development in this country are generally far from residential areas.

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.

1.7 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 and transport prices depend on the access roads, harbours etc. available.

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 Technical feasibility case studies

Feasibility studies have been performed within the Project for four cases – two in Vietnam (one grid connected and one island system), and two in the Philippines (one grid connected and one island system). Two of the cases (one grid connected in the Philippines and one island system in Vietnam) have been analysed in more detail.

An additional aim of the technical feasibility studies in the Project has been to strengthen the local capability in performing the relevant technical wind power feasibility analyses. This has been done through illustrative examples, demonstrating methodologies, tools, analyses and evaluations. The specific aims have been to evaluate the technical feasibility of wind power for the region in general and for the site in specific, and to provide economic figures to be used as input for the economic and financial feasibility analyses to follow.

The issues have been studied in various details in the 4 case studies.

Site	**Phouc Minh**	**Ly Son**	**Sta. Ana**	**Dinagat**
Country	Vietnam	Vietnam	Philippines	Philippines
System	Grid	Island	Grid	Island
Wind power	50-100 MW	1 MW	30 MW	180 kW or 5 MW

Table 2: An overview of the cases in the study.

3 Philippines case studies

3.1.1 Philippines energy situation

As in most countries, The Philippines are facing an increasing demand for energy from around 215 million barrels of fuel oil equivalent (MMBFOE) in 2005 to an estimated 335 MMBFOE in 2014. All sectors are expected to contribute to this growth in demand but it will be petroleum products used mainly by the transport sector that will be the single largest source with an average share of around 40% of total demand. The corresponding share for electricity is about 15%.

The Philippines has many indigenous energy sources and these were projected to give the country a self-sufficiency level of about 57% in 2005.

For the production of electricity, The Philippines uses a mix of energy sources with coal and oil fired power stations making up 50% of the capacity share with hydro, natural gas, geothermal and diesel providing the majority of the remaining capacity. In 2005, other renewable sources accounted for approximately 0.1% of the installed capacity.

3.1.2 Philippines energy policy

The Philippines energy policy is based on the 2004-2010 Medium Term Philippine Development Plan, and as part of this The Philippine Energy Plan 2005 Update has most recently outlined the options to secure sufficient supplies of various energy sources. The two main aims are to move towards energy independence and to instigate reforms of the electrical power sector. The Department of Energy (DOE) has set a target of 60% self-sufficiency by 2010 and one of the mechanisms to achieve this is the development of renewable energy sources.

The peak demand on the country’s electricity system is expected to more than double from 2004 to 2014 to around 19 000 MW. Fossil fuels will be used to meet some of the growing demand but expansion of the renewables’ sector includes increased generation from geothermal and hydro power. Wind power projects of approximately 425MW installed capacity of are being made available to add to the contribution from renewable energies.

3.1.3 Philippines power sector

The Philippines power sector is currently moving through a transitional period from a government operated system (the National Power Corporation or NPC) towards a market driven, competitive, system called the Wholesale Electricity Spot Market (or WESM). This serves as a pool for selling and buying electricity on an hour-by-hour basis, with a key aspect of WESM being to balance supply and demand. Long-term contracts will still cover much of the electrical energy supplied/consumed and the transmission grid operator (TRANSCO) retains the obligation for the acquisition of adequate ancillary services.

Along with reforms of the power market, there is a move to privatise the government owned generating assets of NPC and transmission assets of TRANSCO.

3.1.3.1 Wind power potential

An assessment of the wind power potential in The Philippines was carried out by the US National Renewable Energy Laboratory (NREL) in the late 1990s, which has been used by the University of The Philippines Solar Laboratory (UPSL) as a basis for a medium to long term study of the economic potential of wind power. Using constraints on the wind resource and power transmission, the study identified just over one thousand sites with excellent wind potential with a possible installed capacity of nearly 7 500 MW.

3.1.3.2 Wind power integration

With a current peak demand on the system of around 9GW, the assimilation into the grid of the identified 425MW of wind power should not pose a problem to the system as a whole but limitations are more likely to come from constraints due to the properties of the local transmission and distribution equipment. To this end, developers are obligated to obtain a grid system impact study from TRANSCO based on the particular wind farm design.

3.1.3.3 Regulatory framework

Private developers have been legally authorised to participate in the exploitation of (the publicly owned) natural energy resources (among them wind energy) by an executive order issued in 1997. This was amended by a further executive order that sought to increase the incentives for private developments by easing the government share (tax) levied on the production.

Wind farm projects are legally bound to conform to the requirements of the Grid Connection Requirement of the Grid/Distribution code.

Since the power sector is undergoing the process of transformation into a market based entity, wind farm developers now have a variety of legally permissible buyers for their production. First among these are the distribution companies which are a mixture of local cooperatives, private companies and local government units. Then there are also the possibilities of direct sales on the WESM market, sales to the Small Utilities Group of the National Power Corporation (covering remote and isolated areas), and operation as a Qualified third Party distributing power directly to un-energised villages.

3.2 The two sites of the case studies

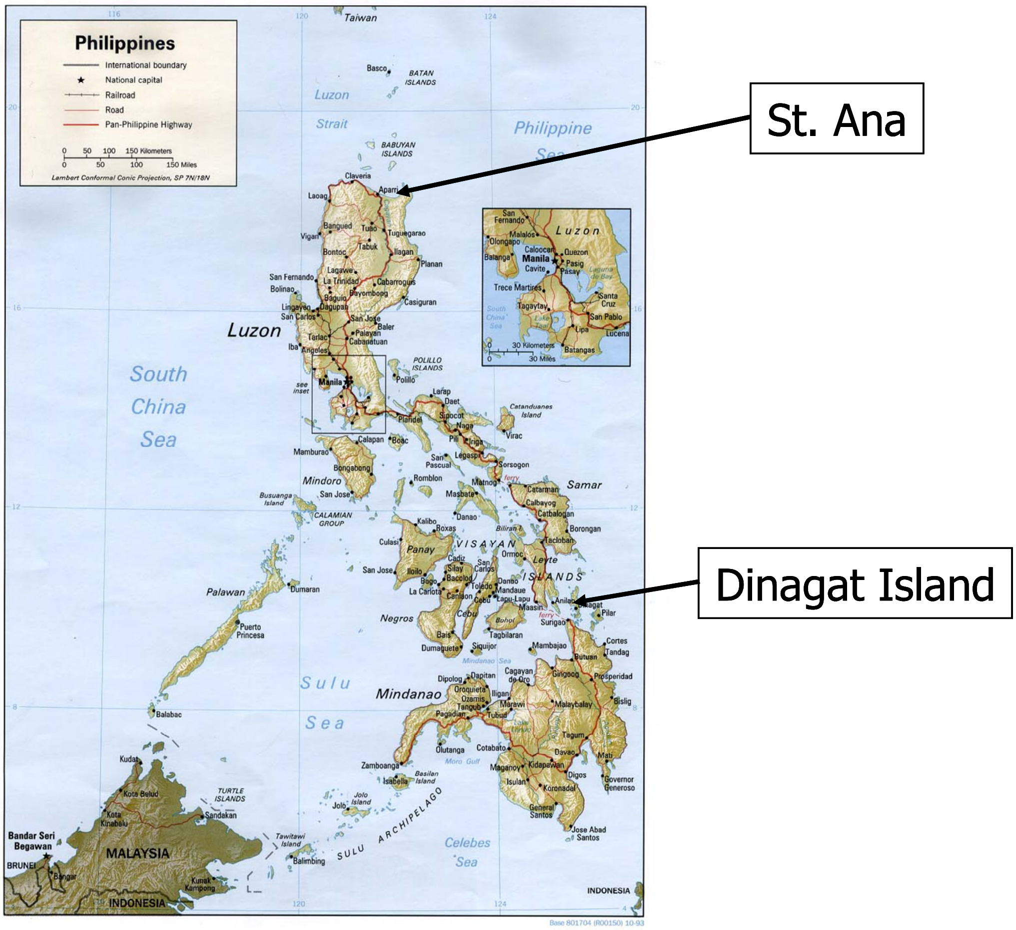


Figure 2: Location of the two sites for the case studies in the Philippines

Sta. Ana Case – 30 MW grid connected wind farm

PNOC EDC will be developing its first wind farm on the north-western part of Luzon island. This 30MW wind power project includes the construction of a transmission line to connect to the end of the national grid 42 km south of this project. They are also looking at other wind power projects on this part of Luzon with an aggregate capacity of 116 MW, including the first 30MW.

PNOC EDC believes that the northern part of Luzon is the most promising site for wind power development. However, the eastern part of the said island is frequently hit by typhoons. Even though PNOC EDC wants to consider developing similar wind farms on the north-eastern part of Luzon to extend the transmission line loop north of the Philippines from the west end to the east end of the national grid, the available wind turbine generators in the market would not pass the design survival wind speed criteria of the National Structural Code of the Philippines.

For the purpose of the case study, the site in Sta. Ana, Cagayan (close to Aparri) was chosen primarily because it is located in Zone I as described in the National Structural Code of the Philippines, where the extreme wind speed design criteria for infrastructure starts from 70 meters per second and higher (see Figure 3). In addition, the area being on the eastern side of the Philippines is on the typhoon path. It should be noted that the Philippines experiences about 20 typhoons per year on average.

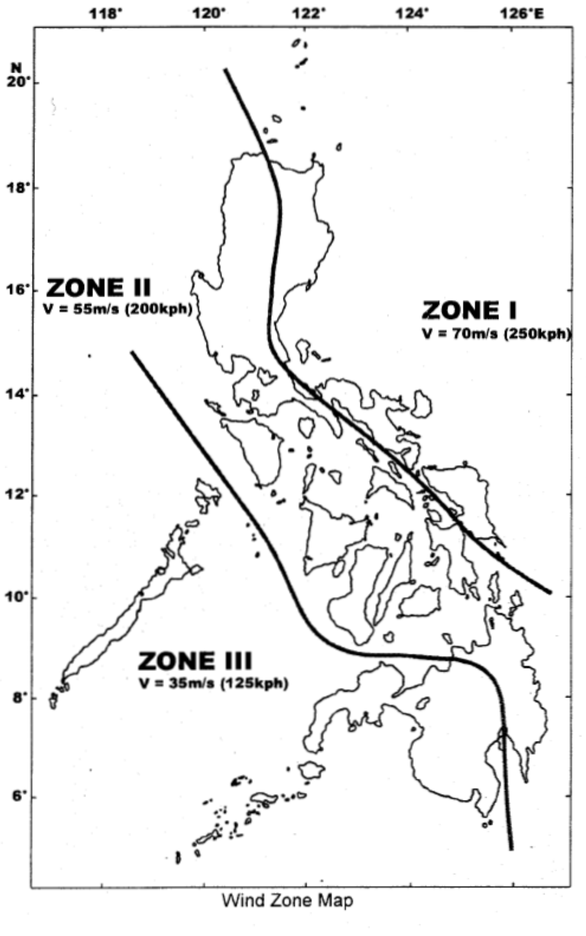


Figure 3: Map of zones from the National Structural Code of the Philippines 5th ed,. 2001

3.2.1 Wind conditions

3.2.1.1 Wind resources

In order to assess the wind resource PNOC-EDC has conducted a one-year measurement program from September 2005 to August 2006. A 27 m meteorological tower was raised with cup anemometers in 27 and 10 m height and a wind vane in 27 m height.

The collection efficiency for the period is about 85%. This is considered rather low.
The annual average wind speed in 27 m height for the year September 2005 to August 2006 is around 5 m/s, and the prevailing wind direction is due east or south-east (see Figure 4).

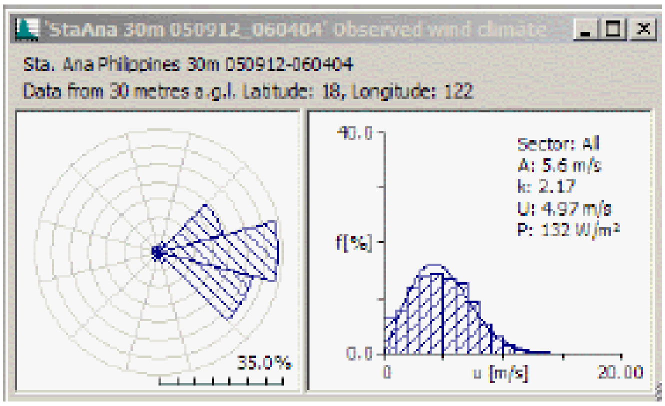


Figure 4: Sta. Ana observed wind climate September 2005 to August 2006.

3.2.1.2 Design wind conditions

Overall the Philippines faces about 20 tropical cyclones or typhoons annually, with four to five of them expected to cause major damages to life and property. The Sta. Ana site is located in typhoon area, zone I (the most severe) according to National structural code of the Philippines (Figure 3). Wind turbines according to IEC class S are expected due to the high extreme wind speeds (50-year wind extreme wind > 50 m/s) experienced in this zone. In task 1.6 of the present project the 50-year wind is estimated at 65-75 m/s in this part of Luzon from analysis of 28 years of typhoon tracks (see deliverable no. 1 of the project).

3.2.2 The power system

The nearby town of Sta Ana is supplied by the CEZA sub-station (Figure 5) which is at the end of a 69kV feeder from the Tuguegarao sub-station approximately 140km away. The CEZA sub-station operates a 5MVA transformer which supplies the town at 13.8kV.

Figure 5 CEZA sub-station feeding the town of Sta Ana

In 2005, the peak load on the transformer was 2.2MVA with a power factor of 0.99.The load is almost entirely residential (i.e. domestic).

Plans by TransCo to create a 220kV ring around the north part of Luzon (which would end up at Tuguegarao sub-station and thereby strengthen the feed to Sta Ana) have been put on hold. There are, at present, no further plans for upgrading the supply system in this area. Therefore, any wind farm would have to be designed to connect into the voltage levels available at present.

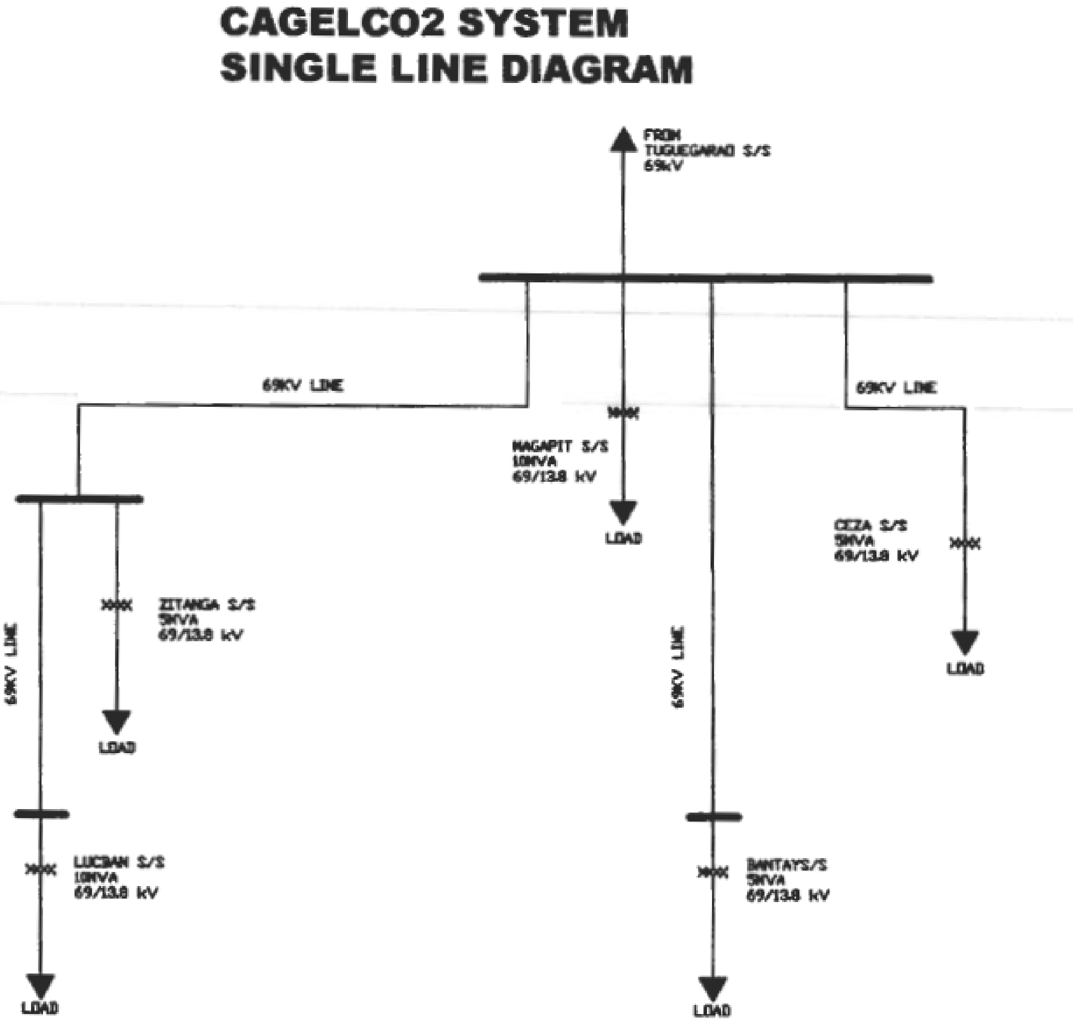


Figure 6 Single line diagram of 69kV network in north east Cagayan

3.2.2.1 Grid access

Access to the grid at 69 kV level can be gained at the CEZA Sta. Ana sub-station.

3.2.2.2 Grid connection

A schematic of the grid connection is shown in Figure 7 below. The connection from the wind farm is at 69kV using overhead line for approximately 12 km to the existing Sta Ana sub-station. Here, the connection to the 69kV network is made and a power factor control unit installed to regulate the voltage at the PCC (point of common coupling) according to the power injected by the wind farm.

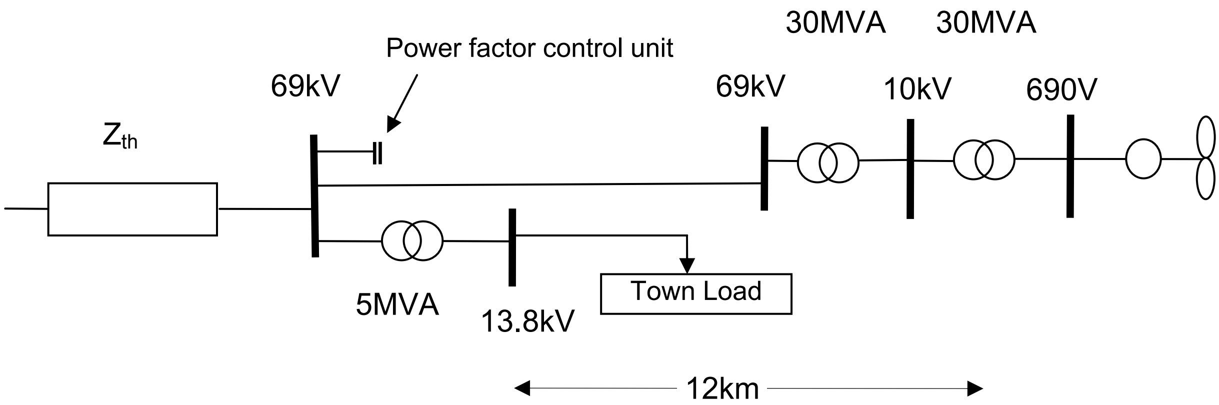


Figure 7 Schematic of grid connection for Sta Ana wind farm

3.2.3 Land issues

Land in the Philippines is classified as either Public (government-owned) or privately owned. The proposed location of the wind farm in Sta. Ana, Cagayan is a mixture of both.
The area in Barangay Diora, where the mast is located is owned by the Municipal Government of Sta. Ana.

For government lands, a Special Land Use Permit (SLUP) is secured from the Department of Environment and Natural Resources (DENR). Application fees and annual rental fee apply if the SLUP is granted. However, if the public land has been entrusted to non-government organizations or individuals for productive use, the consent of these entities is required. Negotiations as to the areas to use and some compensation (on top of the SLUP fees) are also expected. Agreements sometimes include joint use of facilities, like the constructed roads, lightings and fencing of the properties.

There are also instances where public lands are further classified as protected areas. If it would be possible to look for other sites, PNOC EDC would do that. However, there are cases where PNOC EDC would seek for limited access through legislative means. But these are on special occasions. It is not expected that wind development will be considered on protected areas as these areas are normally forested areas.

On the other hand, private lands are usually secured through long-term lease agreement with the owner or through purchase. In the case of PNOC EDC, long-term lease agreements are preferred with the option to pre-terminate if the project is found to be not viable, or to purchase if otherwise.

3.2.4 Site accessibility

The site at Sta. Ana is both accessible by land and air through a national road (12 hour trip from Manila) or through Tuguegarao Airport (1 hour from site). Sta. Ana is located close (12 km) to a suitable port where the wind turbines may be offloaded at Port Irene, which is soon to be transformed into an international port. Due to roads conditions in the Philippines it is not recommended that the wind turbines are transported from Manila as the roads to the site are narrow with several obstructions such as Welcome Arches at the barangays, unsupported bridges, hairpin turns, etc. In case of the NorthWind project at Bangui Bay, Illocos Norte, the wind turbines was transported directly to the site at the beach by barges capable of offloading at the beach.

PNOC-EDC initially recommended siting a the wind farm close to the Sta. Ana town in available A&D lands; discussions among the workshop participants however resulted in an agreement that siting the wind farm close to Sta. Ana would prove disadvantageous since the development of the nearby Port Irene might catalyze a development of Sta. Ana town and it would not be unreasonable to conclude that the town development would encroach on the wind in the future and such development would significantly impact on the wind farm's output. The land surrounding Sta. Ana towns are classified as Alienable and Disposable and therefore would be available for lease or purchase from private persons (1000 – 3000 pesos / hectare per year) or the government under Special Land Use Permits.

3.2.5 Wind farm

3.2.5.1 Wind turbine

For the case study a 2 MW Vestas V80 with a rotor diameter of 80 m and a hub height of 67 m is suggested. The power curve of this wind turbine is shown in Figure 8 below.

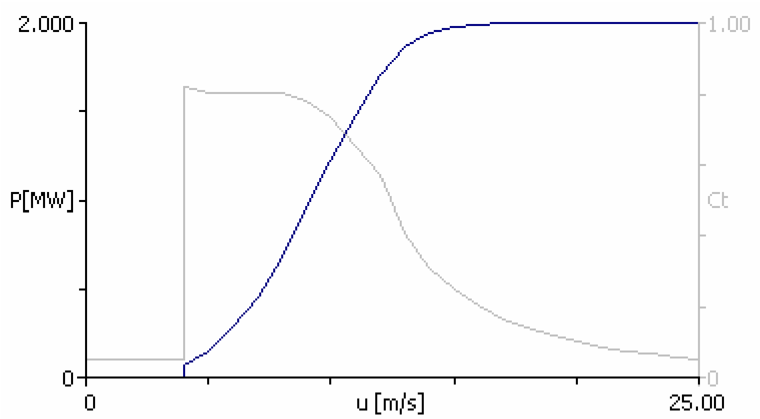


Figure 8: Sta Ana: Power curve of the V80 2MW wind turbine

3.2.5.2 Wind farm physical layout

Two different layouts are considered which will take advantage of the landscape features (the small hills near the mast). A layout running north-south and located on a small ridge is called wind farm no. 1, while a layout running mostly east-west is called wind farm no 2. See Figure 9 for a general overview and Figure 10 for more details below.

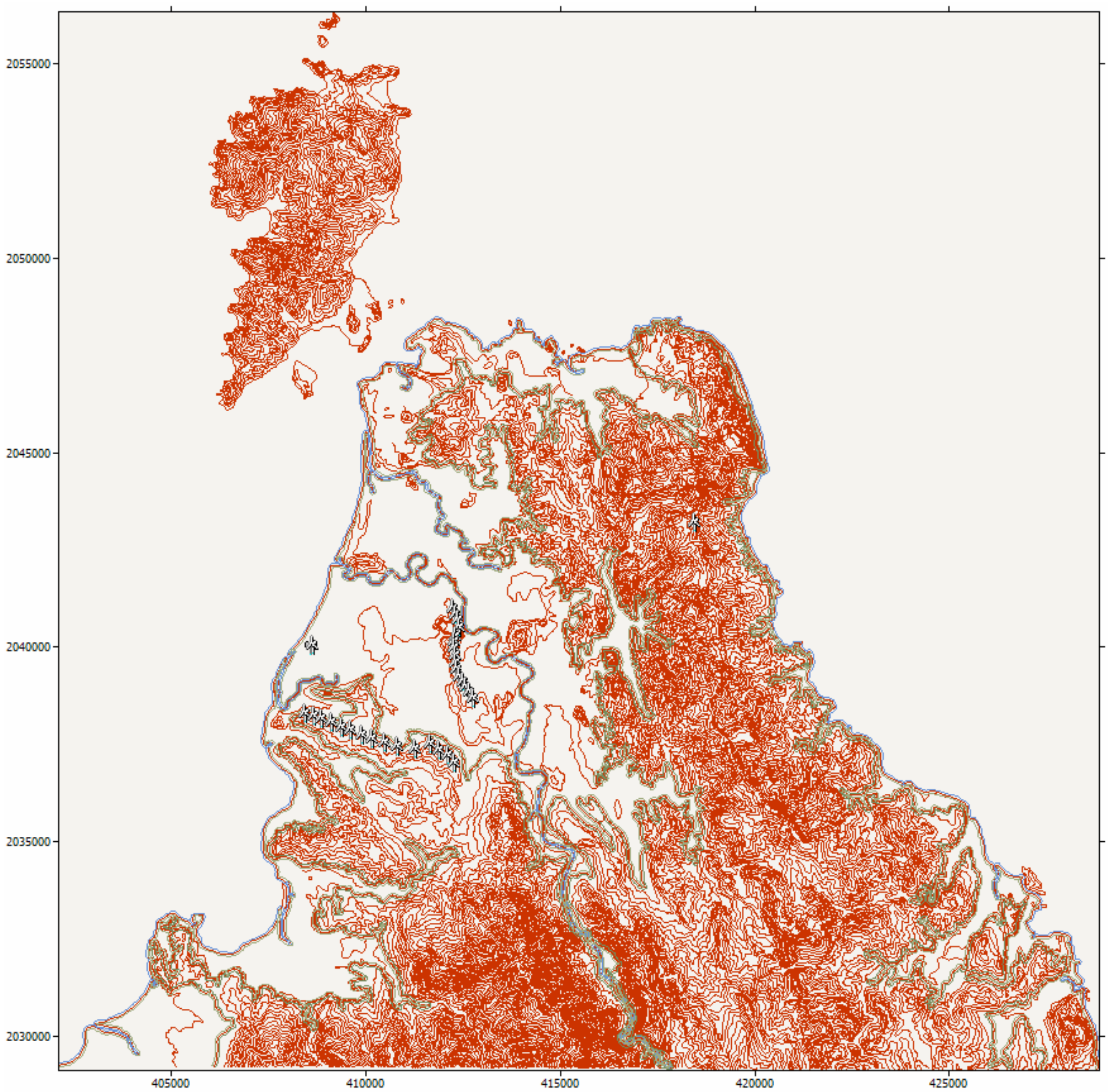


Figure 9: Location of the two alternative wind farm layouts at Sta Ana, North Cagayan. Note the prospective wind turbine location to the NE of the two wind farms in the hills.

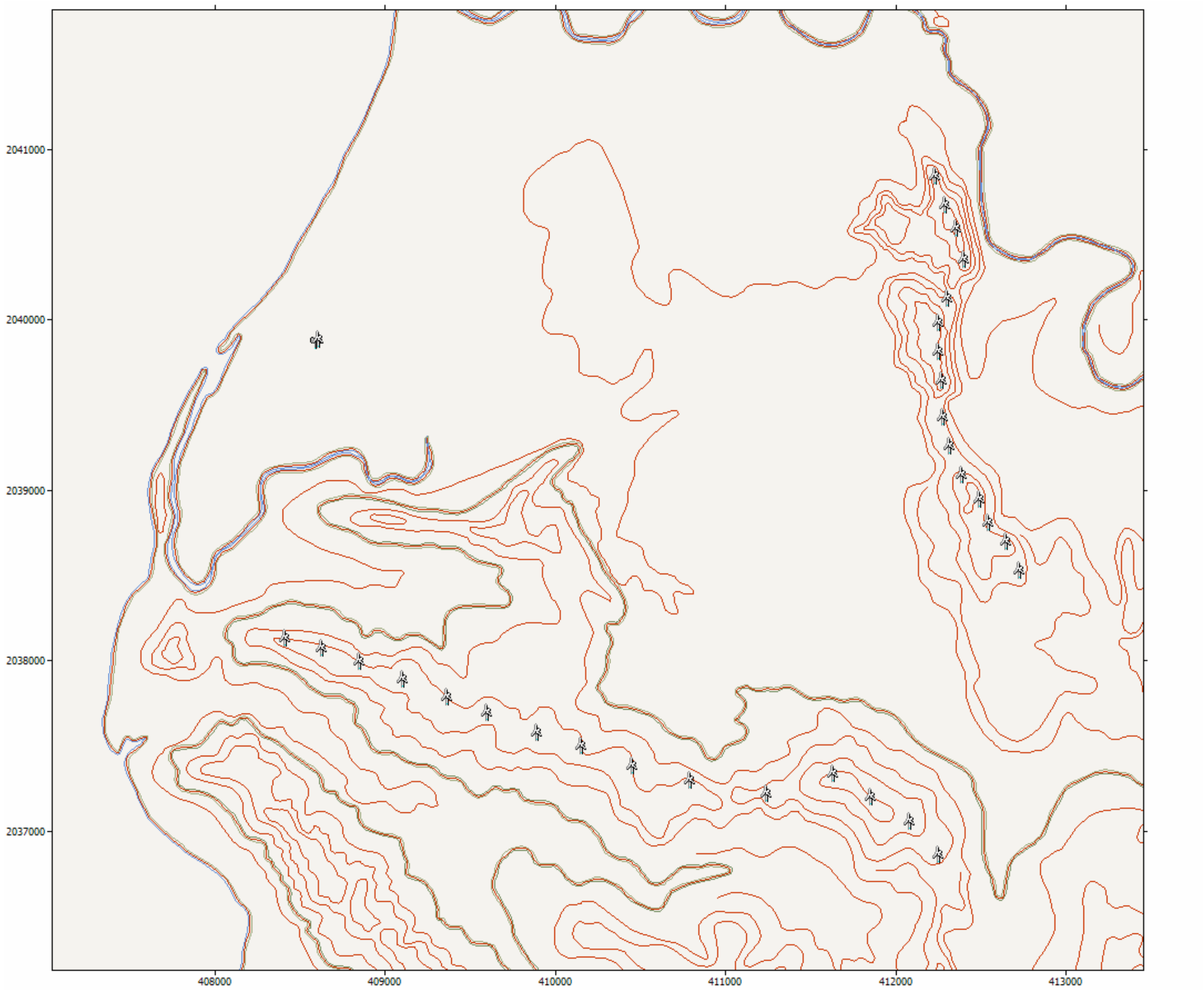


Figure 10: A closer look at the two wind farm layouts and the location of the meteorological mast at Sta Ana. Wind farm no 1 to the right is running north-south and wind no 2 oriented east west is to the left.

3.2.5.3 Wind farm electrical layout

The precise electrical layout of the wind farm depends on the physical siting of the wind turbines, their rating and the local topography. However, the general principle is that the turbines are connected, electrically, in groups of three or four with one radial cable serving each group from the wind farm substation. Each wind turbine has its own transformer to convert to the wind farm grid medium voltage level, probably 10 or 20kV. Each turbine also has its own isolation and protection devices.

At the substation, a medium voltage switchboard contains protection devices and circuit breakers for the incoming radial cables, and feeds all the power to the main transformer and onto the high voltage switch room before connecting into the transmission line to Sta Ana.

This layout is shown below in Figure 11.

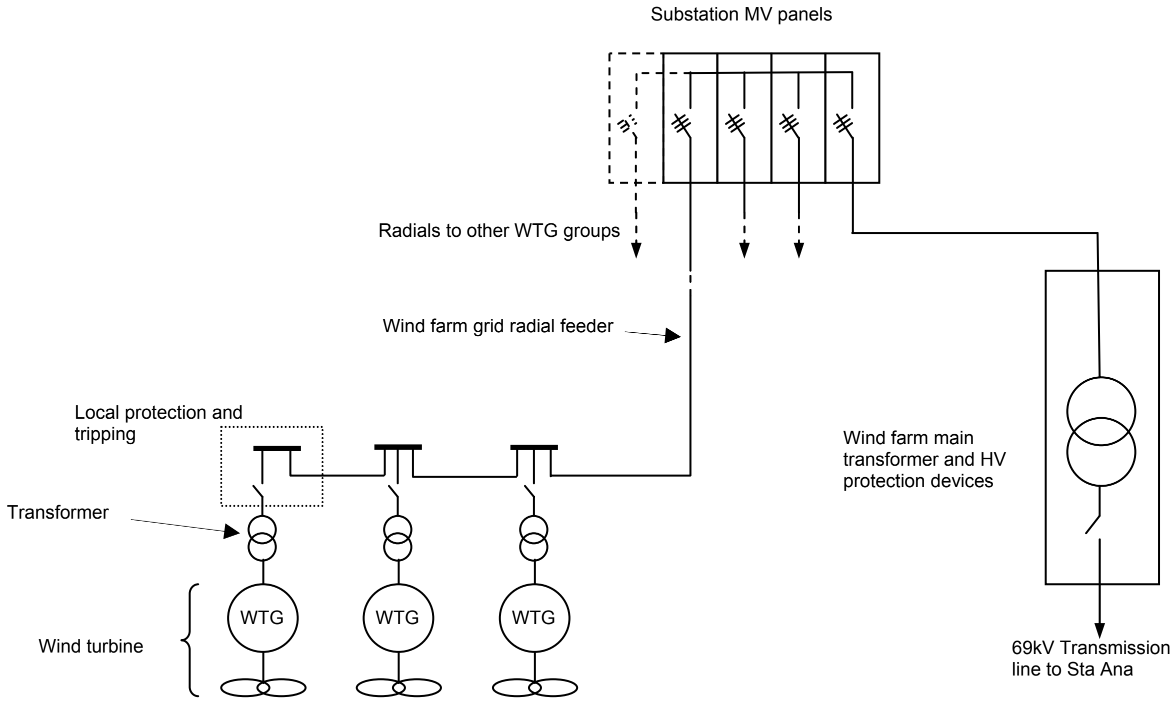


Figure 11 Electrical layout of the Sta. Ana wind farm

3.2.5.4 Estimated electricity production

Two wind turbines in the two different layouts as shown above in Figure 10 were considered for the 30 MW wind farm. The results are shown in Table 3 below.

Wind turbine	Wind farm #1	Wind farm #2
V66	61 GWh	43 GWh
V80	79 GWh	57 GWh

Table 3: Estimation of annual energy production at Sta. Ana

For the study wind farm layout #1 is used and based on the wind measurement from September 2005 to August 2006 from the 15 units of wind turbines the annual energy production is 79 GWh. If we assume 7% electrical losses the net production is 73.5 GWh. This net production will correspond to a 28 % capacity factor.

For the “hot spot” wind turbine site located in the mountains NE of the site 260 m above the sea level (see Figure 9) WAsP predict significantly higher wind speeds and annual capacity factors in excess of 40% for the wind turbines. This should be confirmed by measurements.

3.2.6 EIA – Environmental impact assessment

The PNOC EDC conduct of EIA for its proposed development projects is in compliance to environmental regulation policies, which is under the Department of Environment and Natural Resources, and at the same time, an internal planning tool to identify, assess, and mitigate project impact to the people and environment.

As a regulatory compliance activity, the PNOC EDC follows the standard steps in the conduct of EIA:

- **Scoping.** The initial determination of the project impact coverage, depth, and scope where all the EIA stakeholders (proponent, regulatory agency, LGU, NGO, and the community) can participate and partake in the discussion related to the nature of the project and its impact to the environment.

- **Preparation of the Technical and Social Assessment Studies.** The PNOC EDC having an in-house multi-disciplinary staff catering to the environmental concerns and initiatives of the company conducts technical and social assessment in areas where there are proposed project. This particular step involves (i) profiling and site characterization, (ii) prediction and evaluation of impact, (iii) formulation of alternatives and options, and (iv) identification and assessment of mitigating measures. For highly specialized assessment activities, the company hires the services of consultants and laboratories.

- **Review of the EIA Statement.** After the preparation of the assessment studies and submission to the regulatory agency, the review process begins. The agency forms a Review Committee (also multi-disciplinary) to check the EIA Statement for its acceptability and comprehensiveness. Validation of the EIA Statement is done by the Review Committee with other EIA stakeholders, when necessary.

- **Public Hearing.** When the proposed project is anticipated to affect a number of people, including their livelihood and settlement, public hearing is required by the regulatory agency. The main objective of this particular step is to thresh out issues and concerns, and how mitigation can be enhanced and applied.

As an internal environmental planning tool, the company ensures that proper environmental management strategies and mitigating measures are in place. As a planning tool, there are two main avenues where environmental (including social) impacts are dealt with. The first is the Environmental Management Plan or EMP wherein impacts are identified according to scope and depth, and their corresponding mitigating measures. Second, is the Environmental Monitoring Plan or EMP where in impact monitoring protocols are defined per distinct parameter such as water, air, land, flora and fauna, people, among others.

3.2.7 Findings and recommendations

3.2.7.1 Findings

On average, the Philippines faces about 20 typhoons annually, with five of them expected to cause major damages to life and property. The Sta. Ana site is located in an area with regular typhoon activity especially in the period July to December. During the first year of the project the activity from tropical cyclones was limited, while in 2006 the activity was more severe. The Philippines was hit by three typhoons in a span of only 10 weeks from 25 September to 1 December 2006, then another lower order typhoon on 9 December. These events triggered landslides, flash floods, mudslides, widespread flooding and together with the associated high winds, caused destruction and damage to homes, community buildings, communications, infrastructure, roads, bridges, agricultural crops and fishing farms. The paths of these typhoons across the country are shown in Figure 12 below.

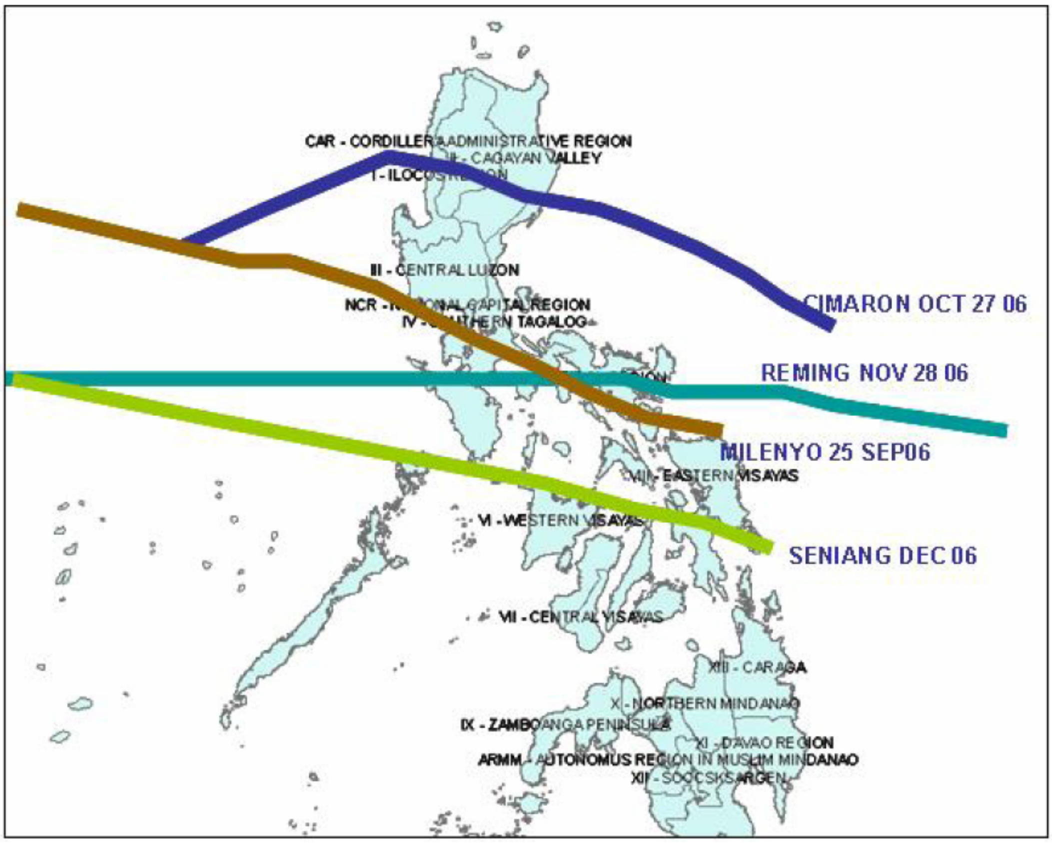


Figure 12: Tropical cyclone activity during 2006 in the Philippines. Source National Disaster coordinating Council (NDCC) of the Philippines annual report 2006

None of these typhoons were near the Sta. Ana site.

At the same time the measured wind climate available for normal operation of wind turbines appears to be moderate to low at the site with annual average wind speeds of 5 m/s in 27 m height. This appears to be somewhat inferior to that found elsewhere at the northern coast of Luzon, but further to the east. At the NorthWind site at Bangui Bay (NE Luzon) the expected annual capacity factor is 34%. This is consistent with earlier measurements conducted by PNOC-EDC in the same Ilocos Norte also pointing to a good wind climate. As NE Luzon is considered zone II the expected impact on wind farm investment due to the risk of typhoons is considered less than at that at Sta. Ana.

In conclusion it appears that based on the preliminary information collected in the project that Sta. Ana has a less attractive wind resource and at the same time a potentially higher wind farm investment due to a more severe extreme wind climate. The modelling of the wind climate using WASP suggests a significantly better wind climate in the mountains east of the site. Here a wind farm would be better exposed to the prevailing NE monsoon in the winter and also less protected from typhoons. This area is protected land and at the same time inaccessible due to no roads, which makes it less attractive as a candidate wind farm area.

3.2.7.2 Recommendations

Before developing further the wind farm project at Sta. Ana it is recommended to consider carefully to

- Investigate further the possibility of acquiring land and conducting measurements east of Sta. Ana site in the mountains.
- Conduct meso-scale modelling of northern part of Luzon to assist revealing the good wind farm sites more efficiently compared to large measurement campaigns using a large number of masts.
- Develop wind farms at the north-eastern coast of Luzon in typhoon zone II

3.3 Dinagat Case – 180 kW island system

During the course of site selection, PNOC-EDC has not undertaken a wind resource campaign on small islands like the Dinagat Island. Though this island is not in the category of small island if one considers the other much smaller populated islands in the Philippines, Dinagat Island is small in terms of its being isolated from the Philippine national grid. The Philippine Wind Atlas prepared by the US National Renewable Energy Laboratory categorizes Dinagat Island as having a good to excellent wind potential. In addition, the island is exposed to the north east monsoon coming from the Pacific Ocean, which is the prevailing wind direction normally experienced in the Philippines. Also known by the local people to have strong winds as evidenced by frequent big and strong waves in the area, Dinagat Island was selected.

Dinagat island is located in the South eastern part of the Philippines (see

Figure 2)
The island is relatively large holding seven towns and located between Southern Leyte and Surigao del Norte, of which it is a part, within the newly formed Caraga region. Access to the island is by means of boat only and the boat trip to the main town Wilson of the San José municipality is about one hour's boat ride from Surigao City's port.

The island has a total population of 106,951 (year 2000), with an annual growth rate of 1.55 percent in the 2000 census and a total land area of 80,205 hectares. Around 54,223 hectares of the total 80,205 hectares of Dinagat Island are considered to be mineral lands. Among minerals found abundantly are Nickel Silicate ores, Saprolite, and Limonite and Metallurgical Chromite, gold, and silver.

3.3.1 Wind conditions

3.3.1.1 Wind resources

The wind resource was measured by PNOC-EDC from a 30 m mast one year from 13 August 2005 to 11 August 2006. Although the overall average wind speed from all directions is relatively low the annual average wind speeds from the dominating two directions East and Southwest is 5.2 and 7.6 m/s respectively.

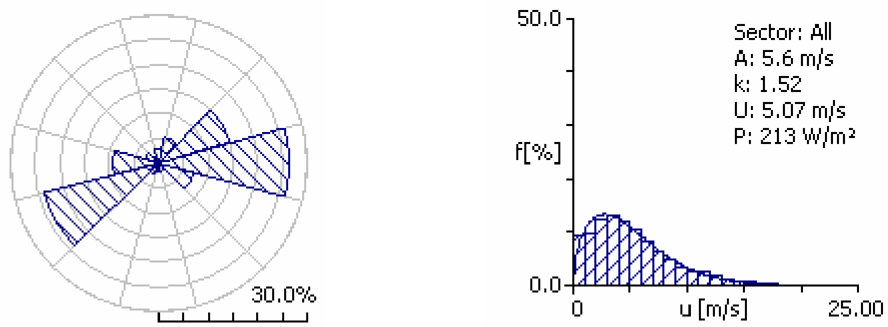


Figure 13: Wind rose and frequency distribution of measured data at Dinagat at 30 m height

3.3.1.2 Design wind conditions

Typhoon class II according to National structural code of the Philippines.

3.3.2 The power system

The Dinagat power system is based around a power plant with diesel generators feeding into a distribution system operated at 13.2kV. The system operates for 19 hours each day providing electrical power for domestic use and light commercial activity. The Dinagat system is now connected with the Loreto system on the north of the island.

The Dinagat power plant (see Figure 14) houses nine diesel generators, although two of these are not operational. They vary in age and capacity as shown in Table 4. Loreto power station has a further two diesel generators of 0.220MW capacity.

Table 4 Diesel generators in Dinagat power plant

Unit No.	Make	Rating (MW)	Dependable (MW)	Date commissioned
2	Dale-Perkins	0.260	0.180	18-Dec-01
3	Dale-Perkins	0.260	0.180	12-Jun-02
4	Cumper Perkins	0.275	0.250	27-Feb-05
5	Dale-Perkins	0.160	0.140	28-Apr-99
6	Cumper	0.275	0.250	17-Jul-05
7	Cumper	0.275	0.250	25-Nov-04
8	Cumper	0.275	0.250	24-Nov-04

Figure 14 Power plant building on Dinagat island

A photograph of one of the Dale-Perkins engines is shown in Figure 15.

Figure 15 Dale-Perkins diesel generator in Dinagat power plant

The diesel generators are dispatched manually according to the load and required reserve. The load curves for Dinagat and Loreto are shown in Figure 16 which clearly shows the time when the system operates and the peak which occurs at around 1900hrs.

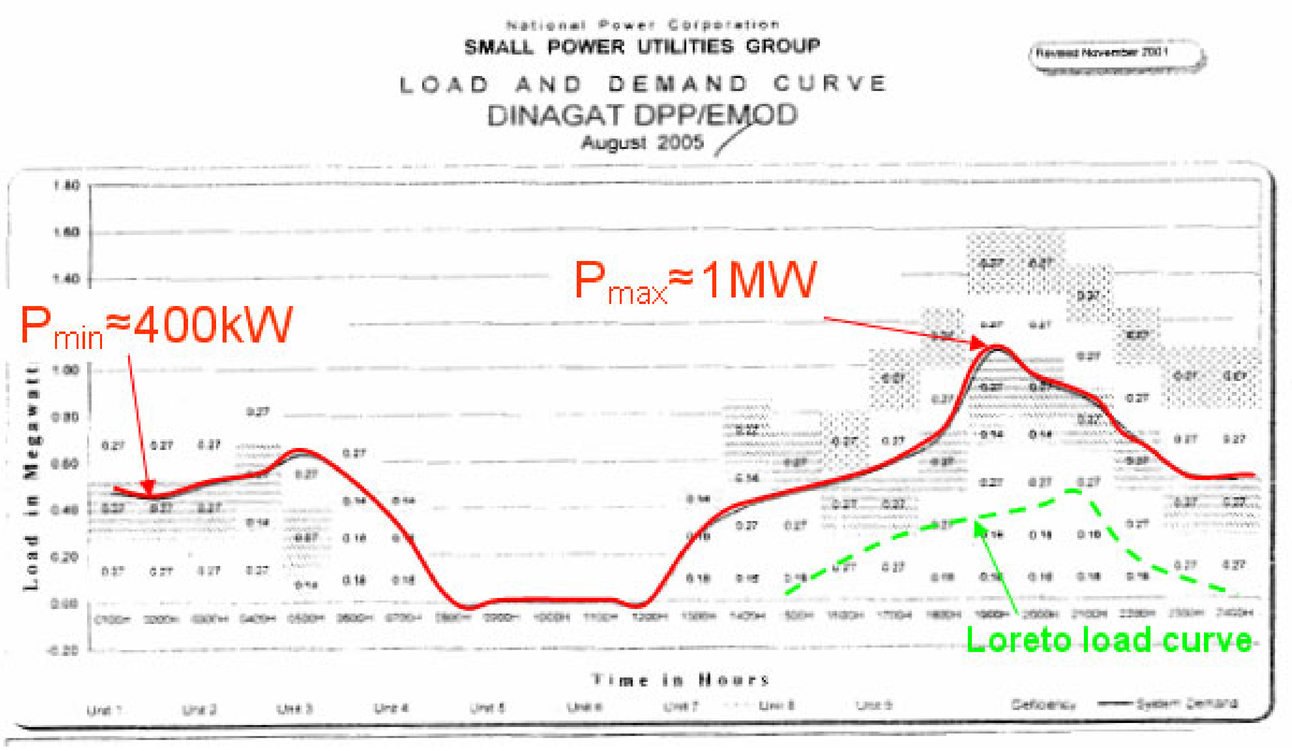


Figure 16 Load profiles for Dinagat and Loreto systems

The distribution system consists of overhead lines on wooden poles on which are also mounted the step down transformers for the direct supplies to customers. A typical arrangement is shown in Figure 17.

Information from NPG-SPUG shows that the numbers of customers have been increasing year on year: 6973 in 2002, 7657 in 2003, 8372 in 2004, and a forecast of 9075 at the end of 2006. As would be expected, the energy consumption has likewise increased as detailed in Table 5.

Table 5 Electrical energy consumption for Dinagat island

Year	2000	2001	2002	2003	2004	2006 est
Energy consumption (MWh)	2233	2308	2449	2750	3253	4284

Figure 17 Typical pole mounted arrangement for 13.2kV distribution system

3.3.2.1 Grid access

The proposed location of the wind farm on Dinagat is approximately 1km from the 13.2kV backbone of the island.

3.3.2.2 Grid connection

The connection into the island grid system is a straightforward overhead line connection from the wind farm mini sub-station to the 13.2kV line about 1km away. Back at the power plant there is the need to install a small dump load to help the assimilation of the wind energy. This can be connected to the diesel generators' main bus bar.

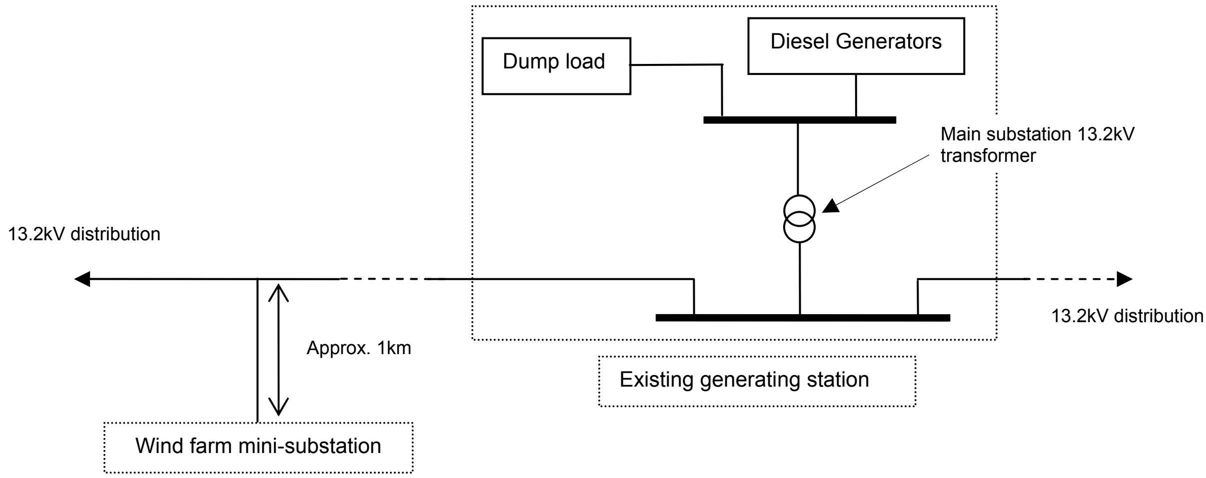


Figure 18 Connection into the island grid system

3.3.2.3 The value of wind power

3.3.3 Land issues

It was confirmed that ownership of the land in Dinagat Island would not be an issue as the land is classified as Public (government-owned) owned.

A Special Land Use Permit (SLUP) will be secured from the Department of Environment and Natural Resources (DENR), in coordination with the Local Government Units (LGU's) holding jurisdiction on the land. The coordination should already identify land administrators who were entrusted to use for productive endeavors said lands. The LGU shall arrange the negotiations with these administrators to come up with mutually agreed arrangement. Application fees and annual rental fee for the SLUP still applies.

3.3.3.1 Land access

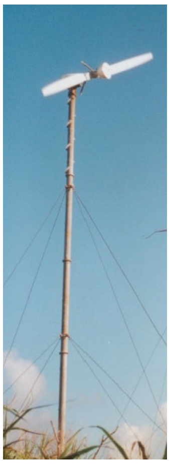
The roads on Dinagat island are few and of rather poor quality. Access to the site for wind turbines and other equipment will be from the San Jose Port in Dinagat, which has a tonnage capacity of 35t.

3.3.4 Wind farm

A wind farm consisting of three 60 kW wind turbines is considered for the study.

3.3.4.1 Wind turbine

The wind turbine applied for the study is a 60 kW Vergnet wind turbine (see Figure 19 below). This wind turbine was applied previously in the Philippines at the Batan island (Batanes group of islands) in a hybrid wind-diesel system.



The Vergnet GEV 15/60 wind turbine is a two-bladed down-wind turbine with 15 m rotor diameter and a hub height of 24, 30 or 40 m. It is equipped with a tubular tower supported with 4 guy wires. The tower is erected by an electric winch by means of a gin pole and can be tilted down in case of a typhoon.

For the case study at Dinagat we have considered a 30 m hub height.

Figure 19: The Vergnet GEV 15/60 wind turbine

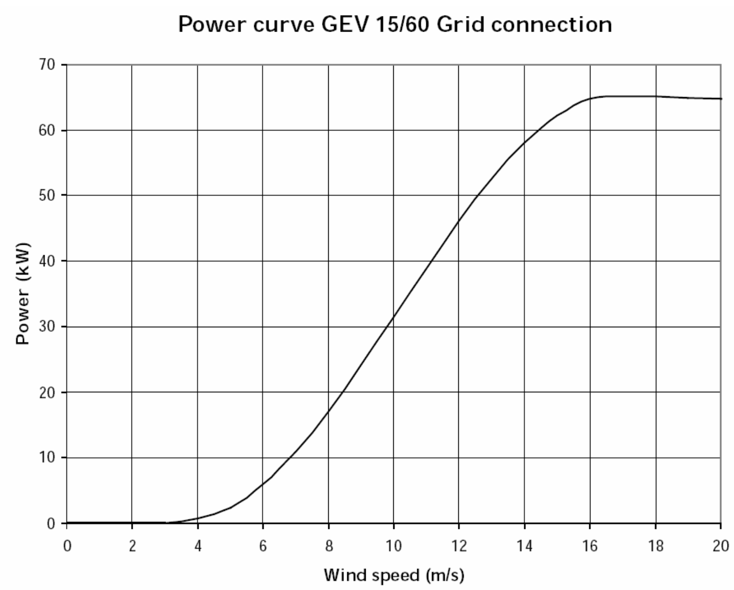


Figure 20: Power curve of the Vergnet GEV 15/60 wind turbine with a rated output of 60 kW

3.3.4.2 Wind farm physical layout

The three wind turbines are placed on a hill near Wilson Barangay (village) with a spacing of 700-800 m.

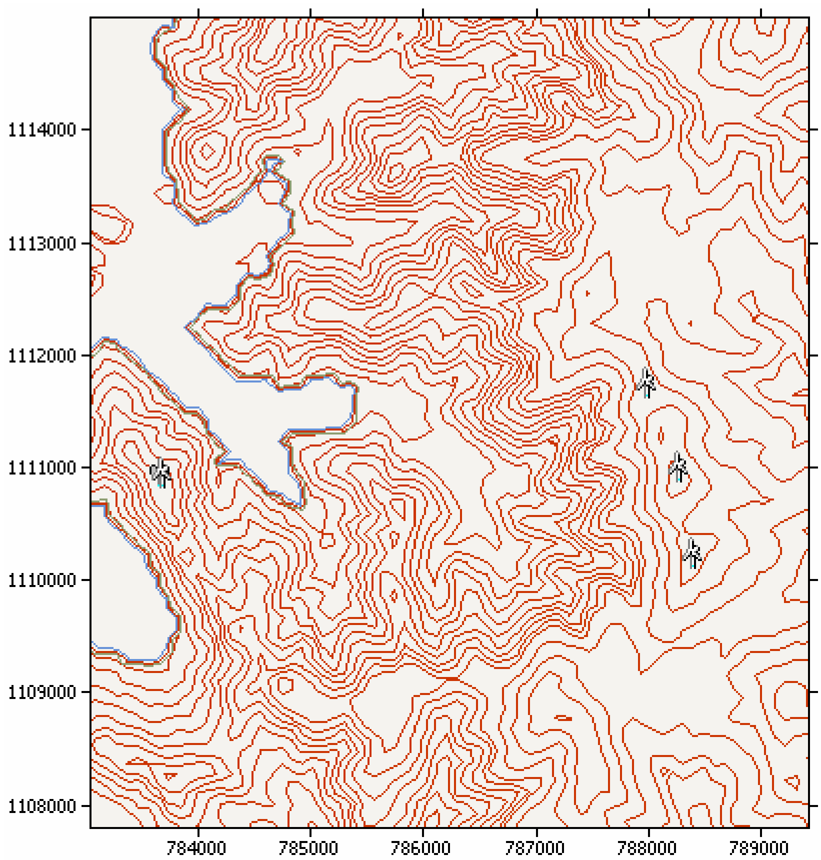


Figure 21: Layout of wind farm near Wilson Barangay on Dinagat island. The wind turbine to the left marks the position of the meteorological mast.

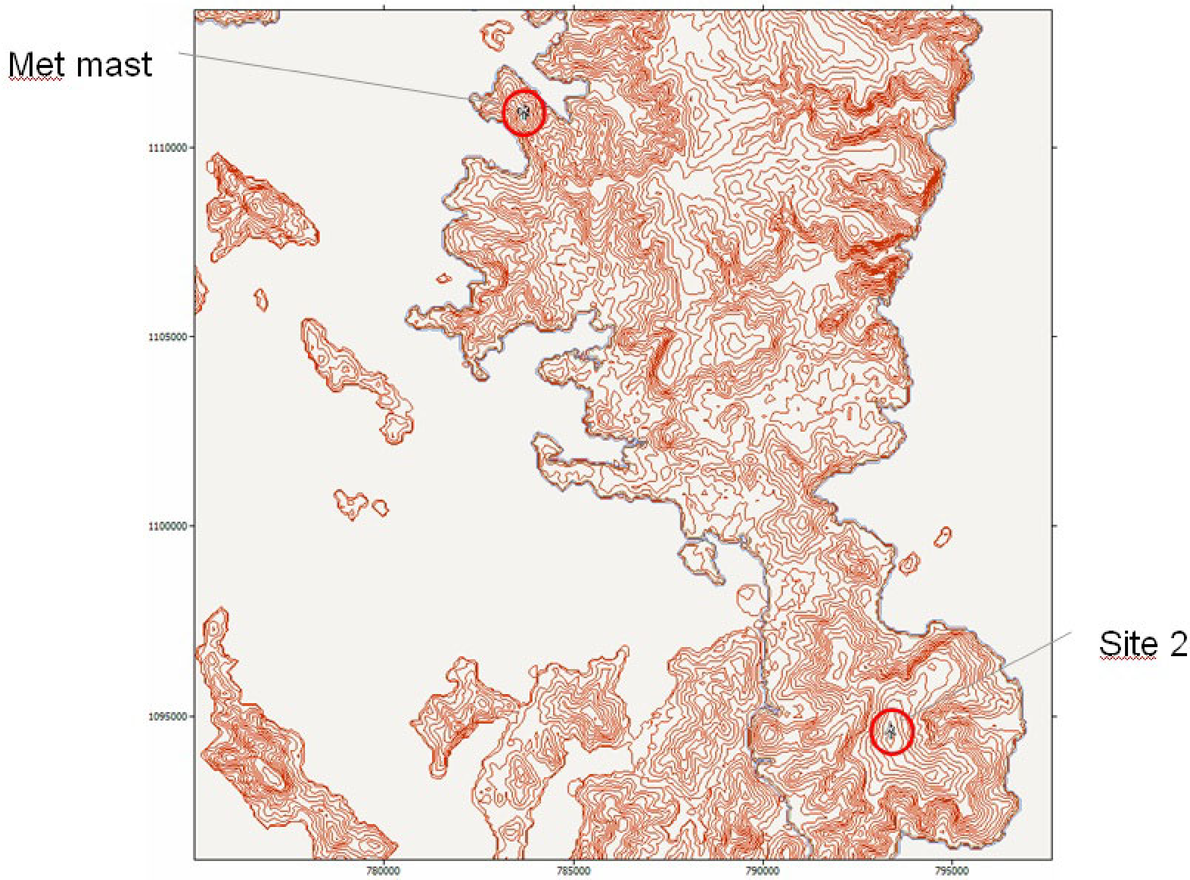


Figure 22: Dinagat island. Location of the measurement site just outside Wilson village (Barangay) and the alternative wind farm location (site 2) on the hill top on the Southern part of the island.

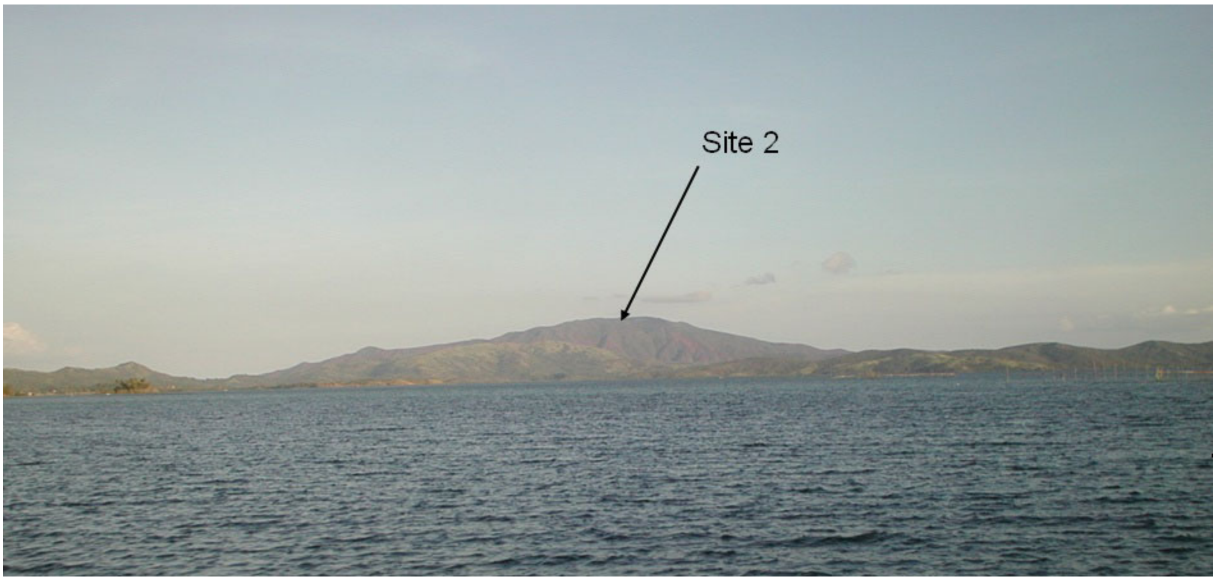


Figure 23: The prospective site for a wind farm at the southern part of Dinagat Island. This site is well exposed for the winter monsoon from north-east as well as the prevailing wind during summer from south-west.

3.3.4.3 Wind farm electrical layout

The proposed electrical layout is shown in Figure 24 below. Each wind turbine has a transformer to convert the output voltage up to the distribution voltage used on the island. A mini sub-station houses the power factor correction equipment and switchgear/protection devices for the wind farm.

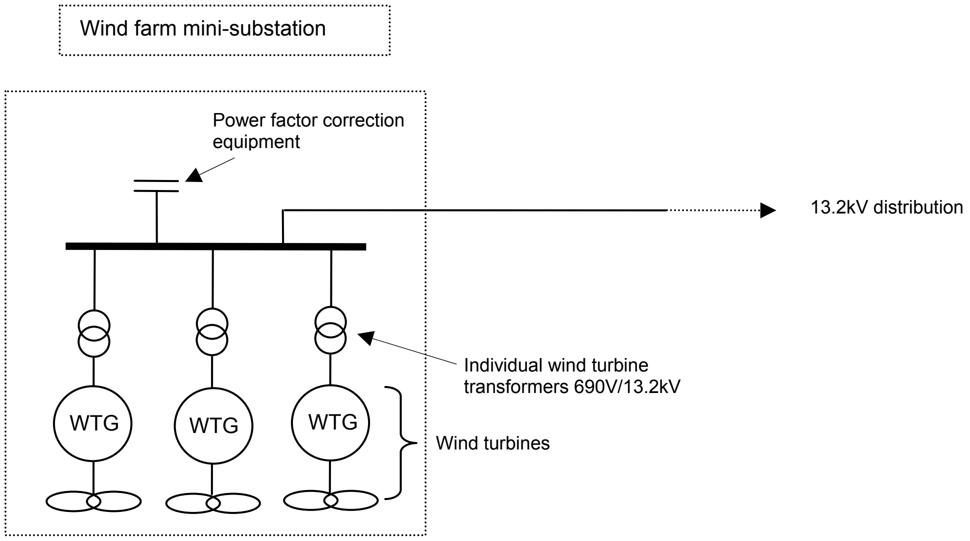


Figure 24 Electrical layout of Dinagat wind farm

3.3.4.4 Estimated production

The estimated annual production based on the wind measurement from August 2005 to August 2006 from the three wind turbines is 291 MWh. If we assume 8% electrical losses the net production is 268 MWh. This is considered a relatively low production corresponding to only 17% capacity factor. The annual electricity consumption in the Dinagat grid was 3253 MWh in 2004 (Table 5), so the estimated production from the wind turbines is contributing only approximately 8%.

The estimated annual output from the wind turbines if we place the wind farm on the hilltop on the southern part of the island (Figure 23) is estimated to be nearly doubled based on modelling of the landscape and the wind measurements at Wilson village.

3.3.5 EIA – Environmental impact assessment

The PNOC EDC conduct of EIA for its proposed development projects is in compliance to environmental regulation policies, which is under the Department of Environment and Natural Resources, and at the same time, an internal planning tool to identify, assess, and mitigate project impact to the people and environment.

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- **Review of the EIA Statement.** After the preparation of the assessment studies and submission to the regulatory agency, the review process begins. The agency forms a Review Committee (also multi-disciplinary) to check the EIA Statement for its acceptability and comprehensiveness. Validation of the EIA Statement is done by the Review Committee with other EIA stakeholders, when necessary.

- **Public Hearing.** When the proposed project is anticipated to affect a number of people, including their livelihood and settlement, public hearing is required by the regulatory agency. The main objective of this particular step is to thresh out issues and concerns, and how mitigation can be enhanced and applied.

As an internal environmental planning tool, the company ensures that proper environmental management strategies and mitigating measures are in place. As a planning tool, there are two main avenues where environmental (including social) impacts are dealt with. The first is the Environmental Management Plan or EMP wherein impacts are identified according to scope and depth, and their corresponding mitigating measures. Second, is the Environmental Monitoring Plan or EMP where in impact monitoring protocols are defined per distinct parameter such as water, air, land, flora and fauna, people, among others.

3.3.6 Findings and recommendations

3.3.6.1 Findings

Two options for integration of wind power at Dinagat island were investigated.

OPTION A: Island power system with limited wind energy for domestic supply

Today the diesel power plant at Dinagat is operated approximately 19 hrs a day. For calculation of the fuel savings we assume that all wind energy is utilised and that we have 24 hrs operation of the power station. This is considered an absolute pre-requisite for a feasible project that the power station is operated 24 hrs a day. The reasons are technical as well as economical.

The addition of the three wind turbines of totally 180 kW installed capacity is equivalent to approximately 45% of the minimum load at the Dinagat power station (see Figure 16). With the two independent grids at Loreto and Dinagat (both Dinagat Island) combined the minimum load will increase and the 180 kW wind energy capacity will constitute an even smaller fraction than 45% of the minimum load.

The average fuel consumption of the diesels was informed at our visit to the island in October 2005 to be 0.32 l diesel oil /kWh leading to an estimated annual fuel saving of 85,760 l diesel oil.

OPTION B: Mining Power System with a significant contribution from wind

This option was investigated briefly. At a meeting in Manila with the managing director of Philnico in October 2005 we were informed about Philnico's plans for re-starting the mines at the southern part of Dinagat Island. As the minimum power demand of the mine is around 15 MW this would secure a constant load (24 hrs / 7 days a week) and a 5 MW wind farm could be erected somewhere between the existing local grid and the mine feeding into both grids. The new power diesel plant to be constructed in connection with a revival of the mine was estimated at capacity of 20 to 30 MW. The wind regime in the southern part of the island is likely to give a higher number of full load energy production hours. Especially if the wind farm could be placed e.g. on the hilltop (site 2 in Figure 22).

The larger wind farm in this case will open up for a potential use of larger and more cost-effective wind turbines providing wind power at a lower cost per kWh. The trade-off here is how large wind turbines can be transported to and installed on the island. Due to lack of information this option was not developed economically.

3.3.6.2 Recommendations

The domestic load at the island today is considered too low for any significant wind power integration and there are no clear indications for a future increase of the load. The two power stations are owned and operated by NPC Spug. The electricity production is significantly subsidised by the Philippine Government through NPC Spug as the production costs (19- 22 PHP/kWh) are significantly higher than the price (4.8 PHP/kWh) from NPC Spug to the local electricity cooperative. This means that each kWh produced is subsidised by around 15 PHP corresponding to around 28 USc/kWh.

It is recommended to:

- Take contact to the mine company and seek permission to conduct wind measurements at the hilltop at the southern part of Dinagat.
- Establish a suitable long-term wind reference data series for Dinagat Island /Surigao del Norte

- Involve NPC Spug in the development of the wind farm as they are responsible for the operation of the two power stations at Dinagat Island and is providing financial support to the power stations.

4 Summary

The feasibility of wind power has been analysed for two selected cases in the Philippines; the grid connected site at Sta. Ana basically at the end of the Luzon grid and the Dinagat Island with a potential for combined wind-diesel operation. As apart of project data for the feasibility analyses have been collected by visit to both sites by project staff.

4.1 Main findings

Key figures from the technical feasibility analyses for all four cases

	Vietnam		**Philippines**	
	Phouc Minh	Ly Son	Sta. Ana	Dinagat
	Grid	Island	Grid	Island
Location	11.5°N	15.38°N	18.45°N	10.05°N
	109.0°E	109.12°E	122.13°E	125.58°E
From date	Jan 2006	060123	050912	050813
To date	Dec 2006	070110	060918	060926
Height	60 m	60 m	27 m	30 m
Mean speed	7 m/s	6.0 m/s	5.0 m/s	5.1 m/s
Mean power	400 W/m^2	290 W/m^2	132 W/m^2	210 W/m^2
Max speed		29 m/s	18 m/s	21 m/s
Capacity	50 MW	1050 kW	30 MW	180 kW
Units	2MW V80/67m	S33-60 350kW	2 MW V66 / 67 m	286 MWh/y
Production	130 GWh/y	1.8 GWh/y	60 GWh/y	
Units			2 MW V80 / 67 m	
Production			80 GWh/y	
Investment	50-75 M$	2 M$	30 M$	0.5 M$
Step-up trafo			69 kV / 30 MVA	13.2 kV
Power line			12 km / 69 kV	
Investment				
Updated	2007-01-22	2007-01-22	2007-01-30	2007-01-22

4.2 Conclusions

Based on the one year wind data collected as a part of the project it appears that Sta. Ana has a less attractive wind resource (annual average wind speed and at the same time might be facing a potentially higher wind farm investment due to a severe extreme wind climate with frequent typhoon activity in the region. The modelling of the wind climate using WASP suggests a significantly better wind climate in the mountains to the east of the site. Here a wind farm would be better exposed to the prevailing NE monsoon in the winter and a higher annual average wind speed is expected. At the same time the wind farm would also be less protected from typhoons. This area is protected land and at the same time inaccessible due to no roads, which makes it less attractive as a candidate wind farm area.

For Dinagat the existing domestic load at the island is considered too low for any significant wind power integration and there are no clear indications for a future increase of the load. The two power stations are owned and operated by NPC Spug and electricity production is significantly subsidised by the Philippine Government through NPC Spug as the production costs (19- 22 PHP/kWh) are significantly higher than the price (4.8 PHP/kWh) NPC Spug receives from the local electricity cooperative. This means that each kWh produced is subsidised by around 15 PHP corresponding to around 28 USc/kWh.

A different approach is to develop a wind farm in cooperation with the mine company Philnico, who have plans for re-starting the mines at the southern part of Dinagat Island. As the minimum power demand of the new mine is around 15 MW this would secure a constant load (24 hrs / 7 days a week) and a 5 MW wind farm could be erected somewhere between the existing local grid and the mine feeding into both grids. The wind regime in the southern part of the island is likely to give a significantly higher contribution from wind power in this case. A large part of the land at the southern part of Dinagat Island is covered by the mining concession meaning it should be easy to find suitable land for a wind farm here.

4.3 Recommendations

Before developing further the wind farm project at Sta. Ana it is recommended to consider carefully to

- Investigate further the possibility of acquiring land and conducting measurements east of Sta. Ana site in the mountains.
- Conduct meso-scale modelling of northern part of Luzon to assist revealing the good wind farm sites more efficiently compared to large measurement campaigns using a large number of masts.
- Develop wind farms at the north-eastern coast of Luzon in typhoon zone II

And for Dinagat Island

- Take contact to the mine company and seek permission to conduct wind measurements at the hilltop at the southern part of Dinagat.
- Establish a suitable long-term wind reference data series for Dinagat Island /Surigao del Norte
- Involve NPC Spug in the development of the wind farm as they are responsible for the operation of the two power stations at Dinagat Island and is providing financial support to the power stations.

Annex

List of Project Deliverable Reports

#	Task	Title	Country
1	1.6	Extreme wind analysis	The Region
2	4.2	Design of WTG in Typhoon area	The Region
3	3.4	GIS analysis	Philippines
4	1	Wind resource assessment report	Philippines
5	1	Wind resource assessment report	Vietnam
6	2.2	Overview of grid infrastructure	Philippines
7	2.2	Overview of grid infrastructure	Vietnam
8	2.2	Overview of grid infrastructure	Cambodia
9+10	2.3	Analysis of power quality and voltage stability	Philippines & Vietnam
11	3	Policy and market study	Philippines
12	3	Policy and market study	Vietnam
13	3	Policy and market study	Cambodia
14	4	Technical feasibility report	Philippines
15	4	Technical feasibility report	Vietnam
16	5	Economical feasibility report	Philippines
17	5	Economical feasibility report	Vietnam
18+19	6	CDM analysis	Philippines & Vietnam
20+21	7	Financial Framework	Philippines & Vietnam
22	8	Guideline report	Philippines & Vietnam
23	All	Mid-term status report	All 3
24-31	All WS	Workshop reports	All 3