FINAL EXECUTIVE SUMMARY

The Hongkong Electric Co., Ltd.
香港電燈有限公司

Renewable Energy by a Wind Turbine System on Lamma Island:

Final Executive Summary

September 2004

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For and on behalf of	
Environmental Resources Management	
Approved by:	Freeman Cheung
Signed:	
Position:	Executive Director
Date:	1st September 2004

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1 INTRODUCTION

1.1 BACKGROUND TO THE STUDY

The Hongkong Electric Co Ltd (HEC) is committed to providing a high quality power supply to its customers with due care for the environment. Recognizing the importance of sustainable development, HEC is proposing to install a wind turbine of capacity ranging from 600 to 850kW as a demonstration project of the utilization of wind energy for renewable power generation on Lamma Island, Hong Kong.

Following the completion of a 12-month wind power monitoring exercise on Lamma Island in November 2002, a wind atlas was developed to assess the wind potential of the Island. A number of areas were identified as having wind power density over 150W/m^2, equivalent to the average wind speed of about 5.5m/s, and generally considered suitable for wind energy utilization. The existing power supply to Lamma Island is by means of 11kV power lines, transformer pillars and low voltage distribution cables from the Lamma Power Station.

Following the completion of a site selection exercise Tai Ling Tsuen was chosen as the optimum location for the wind turbine (*Figure 1.1*). The output will be connected to the existing power grid for supplying renewable energy to HEC customers.

1.2 PURPOSE AND SCOPE OF THE EIA

The Project is classified as a Designated Project by virtue of Item D.1 of Part I of Schedule 2 under the *Environmental Impact Assessment Ordinance (Cap. 499) (EIAO).*

The main objective of this Environmental Impact Assessment (EIA) study is to provide information on the nature and extent of potential environmental impacts arising from the construction and operation of the proposed Project and related activities taking place concurrently. The study will also contribute to decisions on the overall environmental acceptability of the Project, after the implementation of environmental mitigation measures.

The EIA provides a detailed assessment of the potential environmental impacts associated with the Project, in relation to the issues specified in the *EIA Study Brief* (No. ESB-112/2004), including noise, ecology, landscape and visual, air quality and water quality.

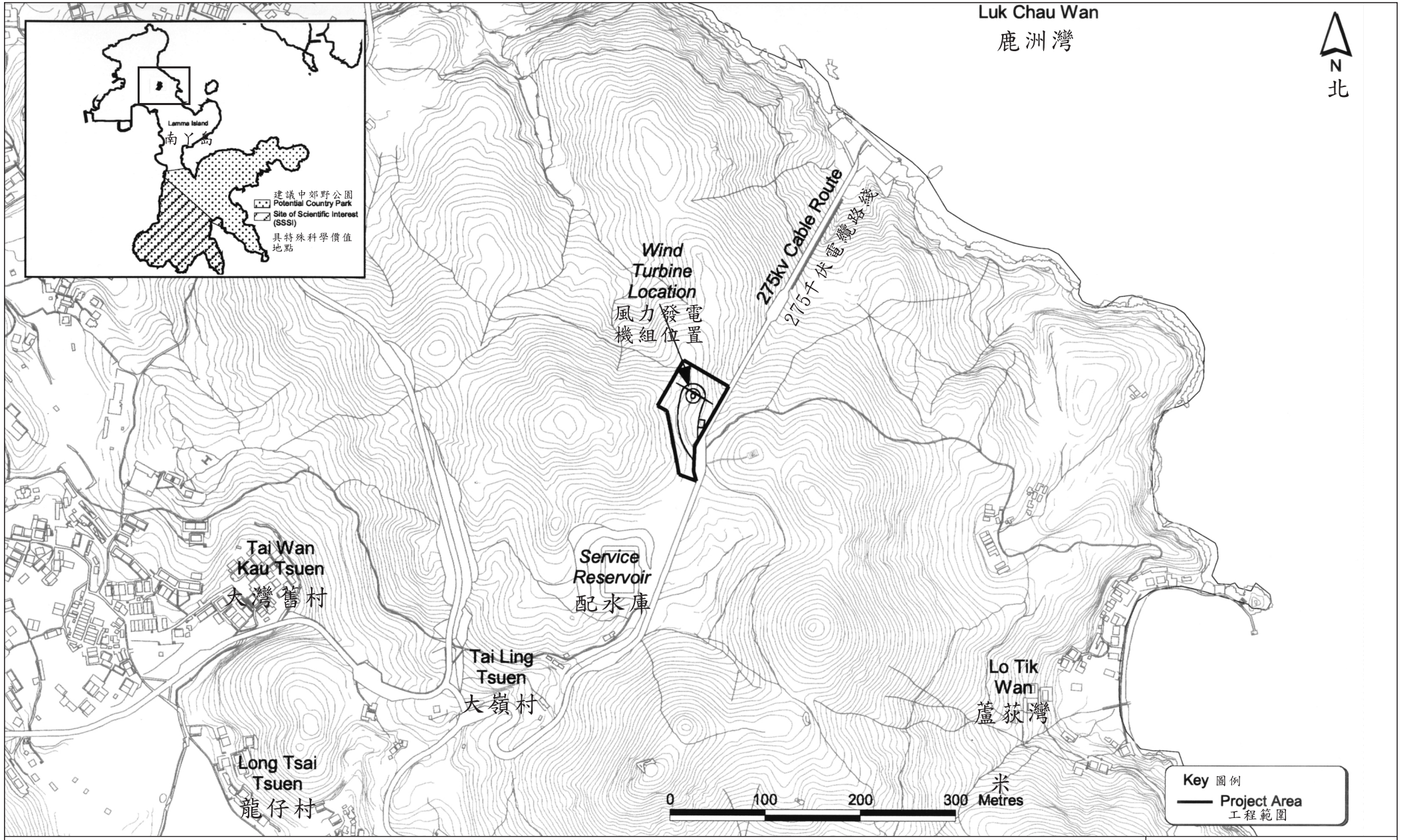

Figure 1.1
圖1.1

Location of the Proposed Wind Turbine
建議中風力發電機組位置圖

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2 PROJECT DESCRIPTION

2.1 OBJECTIVES OF THE PROJECT

HEC is proposing to install a 600-850kW wind turbine as a demonstration of the potential for wind utilization in generating power. The wind turbine will be built in a grid connection scheme for supplying "green" electricity to HEC customers. The objectives of the project are as follows:

- *Demonstration of utilizing wind energy for power generation*: The proposed wind turbine will be the first utility scale and grid-connected wind project in Hong Kong. Based on the wind potential on Lamma, the proposed wind turbine will harvest about 700MWh of electricity per annum, helping to avoid the use of up to 240 tonnes of coal and reduce the associated emissions every year.

- *Education purpose*: Visitors' facilities such as display boards and guided tour will be provided at the wind turbine site to explain the principle of power generation by wind and the benefits of renewable energy. The wind turbine project will serve as educational use for promotion of green awareness among the public, in particular with students.

- *Wider application of renewable energy*: The project will provide invaluable local experience on the design, construction, operation and maintenance of wind turbines. Future utilization of wind energy in Hong Kong can be explored based on the information collected and experience gained, keeping pace with Government's policy, and the publics expectation of the promotion of renewable energy and improvement in air quality.

2.2 LOCATION AND SCALE OF THE PROJECT

The Project is the construction and operation of a 600-850 kW wind turbine and associated equipment at Tai Ling Tsuen on Lamma Island. The output will be connected to the existing power grid for supplying renewable energy to HEC customers. The operation of the wind turbine will be monitored and controlled through a central monitoring system located in a control room of the Lamma Power Station. The wind turbine site will be unmanned and will only require attendance of operational personnel during emergency or routine maintenance.

The proposed wind turbine is a "horizontal axis" machine which consists of three rotor blades turning around a horizontal hub. The hub is connected to a gearbox and a generator which are located inside a nacelle. The nacelle houses the mechanical and electrical components and is mounted on the top of a tubular tower. A transformer will be installed at the bottom of the wind turbine tower. Switchgear and power conditioning devices will be housed inside a high voltage distribution pillar (HVDP) made of stainless steel (4.6m

L x 2.5m W x 2.8 m H) installed within the site boundary of wind turbine. Power cables will be buried underground for connecting the wind turbine, HVDP and the nearby 11kV power grid on the 275kV cable route. The output from the wind turbine is thereby transmitted to the existing power grid. The synchronous generators of the grid system supply magnetizing current for the induction generator of the wind turbine. An Auto-synchronous Controller will be required to control the operation of a Synchronizing Breaker with respect to the wind turbine output voltage and frequency.

2.3 CONSTRUCTION AND OPERATIONAL ACTIVITIES

The facilities required at the wind turbine site are as described in *Section 2.2*. Most of the equipment will be delivered to the site via the existing 275kV Cable Route. The wind turbine site (Project Area) covers an area of about 4,400 m^2 and is situated adjacent to the existing 275kV cable road. All the construction activities will be restricted within the Project Area. A flat area for siting the wind turbine, the associated electrical equipment and access platform will be formed by cutting back the hill slope. The site platform will be formed by excavation with minor retaining wall constructed around the perimeter of the site. A circular concrete footing will be constructed for supporting the wind turbine. The construction work on site is minimal and will not result in adverse impacts to the environment.

The main activities and construction sequence are:

- Excavate the site by cutting and filling to form a site platform (affected area is approximately 3,100 m^2 and excavated materials is approximately 1,300 m^3);
- Construct retaining wall around site perimeter;
- Backfill and level site (nearly 95% of the excavated materials could be used for backfilling, the remaining materials will be transported by trucks to the HEC Power Station for offsite disposal);
- Construct circular concrete footing for wind turbine foundation;
- Reinstate ground;
- Erect wind turbine using one heavy duty mobile crane and one light duty mobile crane, and high voltage distribution pillar;
- Lay cables;
- Landscaping works including planting of trees and shrubs.

The wind turbine will be designed for fully automatic start up, synchronization to the 11kV power grid, power regulation, disconnection from the grid and shut down. It will produce electricity when the wind

speeds are in the range of 2.5 to 25 m/s. The rotor blade will rotate from 14 to 31 rpm approximately under normal circumstances. The wind turbine will cut-off from the grid when wind speeds are below 2.5 m/s or above 25 m/s.

The operation of the wind turbine will be monitored and controlled through a central monitoring system located in a control room of the Lamma Power Station. The wind turbine site will be unmanned and require attendance of operational personnel only during emergency or routine maintenance.

2.4 PROJECT PROGRAMME

The construction of the Project is scheduled to commence in the first quarter of 2005 and will be completed within about 12 months, 8 months for civil works including site preparation and foundation, and 4 months for electrical and mechanical works (such as installation & erection of the wind turbine).

2.5 PREFERRED ALTERNATIVE

Desktop screening and site surveys were conducted to identify potential sites for a wind turbine of suitable size on Lamma and Po Toi Island and were based on the criteria recommended in the guidelines for wind energy development issued by reputable international organizations of wind energy. The site search was confined to Lamma and Po Toi where reliable wind data are available and locations away from the densely populated area.

Po Toi Island is an ecologically sensitive area which has been identified as a potential Country Park. In view of the accessibility considerations and absence of a power grid, Po Toi is considered neither technically feasible nor environmentally and economically attractive for a demonstration project with commercial scale wind turbine.

Once the above considerations had been accounted for, site selection was focussed on Lamma Island. The wind turbine site was then examined against engineering requirements and environmental concerns and further refined using the following site screening criteria:

- Wind potential;
- Site access;
- Height restriction;
- Electrical connection; and
- Area and land-use

Taking into account the above criteria, six potential sites were identified with the application of constraint mapping techniques (*Figure 2.1*). The six long-listed sites are:

Site 1 - Lamma Power Station Extension

Site 2 - Tai Ling

Site 3 - Yung Shue Long

Site 4 - Tai Peng

Site 5 - Pak Kok Tsui

Site 6 - Lamma Quarry

All of the sites avoided ecologically sensitive areas, SSSI and the potential Country Park at South Lamma. The six identified sites are situated along the existing 275 kV Cable Routes which are the only vehicular roads on Lamma island.

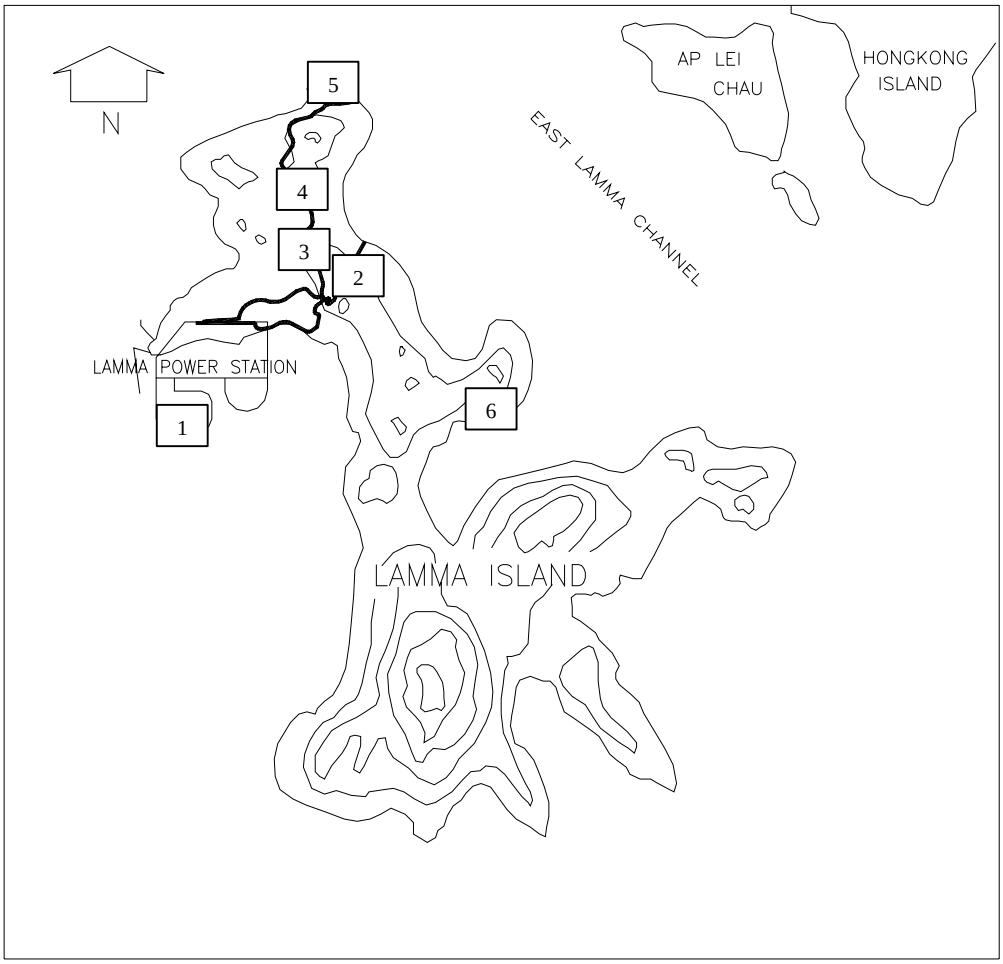

Figure 2.1 Long-listed Sites for Wind Turbine Installation

Having identified sites that meet the broad environmental and engineering criteria, a site-specific appraisal has been conducted to establish a short-list of feasible sites for further detailed investigation.

Qualitative approaches have been adopted to identify potential conflicts with the development of the wind turbine. Each potential site was scrutinized more closely with engineering criteria on wind potential, geological considerations and electrical connection; and environmental criteria concerning visual, noise and ecological impacts. Of the 6 long-listed sites within the areas of least constraints, four sites have been excluded due to principal conflicts identified, leaving the following two sites for the final comparative assessment:

Site 2 - Tai Ling

Site 4 - Tai Peng

The two sites have been evaluated and compared according to the potential impacts likely to arise as a sequence of construction and operation of the wind turbine system. Site 2 – Tai Ling is identified as the overall preferred site due to its distinct merits in site access, ground conditions, noise and visual impact compared with Site 4 – Tai Peng. The site at Tai Ling is also the more remote of the two in terms of proximity to village houses.

The preferred site at Tai Ling is a relatively level platform to the west of the joint bay of HEC's existing cable route. Taking advantage of the joint bay area as part of the works area for erection of the wind turbine, the landtake requirement can be optimized. Moving the wind turbine site further north away from the noise sensitive receivers are not preferred due to the need for extensive excavation of the hill slope to form access road for the wind turbine.

2.6 POTENTIAL CAPACITY FOR THE WIND TURBINE

The planned capacity of the wind turbine at Tai Ling is 600 to 850 kW depending on the model sizes available from respective suppliers. The wind turbine capacity is selected based on the following considerations:

- 600 kW class wind turbine is of proven design with a large number of installations worldwide.
- 600 kW class wind turbine is now becoming the smallest size available from the majority of the suppliers due to the worldwide trend for large capacity machines.
- 600 kW class wind turbine is the maximum size of machine complying with the height restriction at Tai Ling Site.

On the other hand, the wind turbine is beneficial to the environment over the traditional coal-fired or gas-fired plant as it helps to reduce the air pollutant and greenhouse gas emissions. Assuming a 600 kW wind turbine producing electricity of 700 MWh/yr, the emission reduction of major air pollutants compared with that of the same capacity at the existing coal-fired plant is presented in *Table 2.1*.

Table 2.1 Air Pollutant Emission Reduction by Wind Turbine [(a) (b)]

Air Pollutants	Annual Emission Reduced (kg)
Sulphur dioxide (SO_2)	1941
Nitrogen oxides (NO_x)	1008
Particulates	100
Carbon dioxide (CO_2)	605.5 tonnes/yr (i.e., 605,500 kg/yr)

Note:

(a) Assuming 600 kW wind turbine produce electricity of 700 MWh/yr.

(b) Based on average emission generated from the existing coal-fired units including of 2.773 kg/MWhr of SO_2, 1.44 kg/MWhr of NO_x, 0.143 kg/MWhr of TSP and 865 kg/MWhr CO_2

It can be seen from above table that the operation of the wind turbine can bring about benefits through the reduction in emissions of air pollutants such as SO_2, NO_x, CO_2 and particulates.

3 ENVIRONMENTAL IMPACTS

The nature and extent of the environmental impacts associated with the construction and operation phases of the Project are summarised below. Specific mitigation measures for the Project, as well as environmental monitoring and auditing procedures, have been developed during this EIA. The Implementation Schedule of the recommended measures is presented in *Annex D* of the EIA Report.

3.1 NOISE

Unmitigated construction activities associated with the Project will not cause adverse noise impact to the nearby NSRs with the predicted construction noise levels in the range of 46 – 61 dB(A), which comply with the stipulated noise criterion. The mitigation measure of adopting good site practices is proposed to further minimise the construction noise impact to the environment. Regular site audits will be conducted during construction to ensure the plant inventory used on site is consistent with the assumptions in the EIA report.

With the adoption of a maximum sound power level of 100 dB(A) and a pure tone free wind turbine , the predicted facade noise levels will comply with the night-time noise criterion at all NSRs. It is proposed that the allowable maximum sound power level of 100 dB(A) with no pure tones shall be included in the tender specification of wind turbine. The supplier shall guarantee this noise level by providing certificate of measurement and verify the overall noise level during commissioning and testing in accordance to international standard procedures such as IEC 61400-11. Whenever necessary, the supplier shall apply attenuation measures to achieve the guaranteed noise level. There has been information from the suppliers that the 100 dB(A) and pure tone free wind turbine of 600-850 kW range is available and practicable. Noise monitoring during the operational phase is recommended to be carried out during the night-time period at the agreed monitoring location once every fourteen days for a period of six consecutive months so as to ensure the compliance with the stipulated noise criterion at the nearby NSRs.

3.2 ECOLOGY

The ecological resources recorded within the Study Area included secondary woodland, shrubland, shrubby grassland, stream and village/ developed areas, as well as associated wildlife. Of these habitats, secondary woodland (at least 200 m from the wind turbine) and the middle course of a stream near to Lo Tik Wan (Stream S4, approximately 500 m from the wind turbine) have moderate to high and high ecological value respectively. The remaining habitats are of low or low to moderate ecological value. A total of 14 species

of conservation interest were recorded within the Study Area, including five bird species (Black Kite, Greater Coucal, Lesser Coucal, Emerald Dove and White-bellied Sea Eagle), eight uncommon butterfly species (Red Lacewing, Bush Hopper, Common Duffer, White-edged Blue Baron, Tree Flitter, Yellow Orange Tip, Swallowtail and Small Cabbage White) and one amphibian (Romer's Tree Frog). Three calling male Romer's Tree Frog were recorded within and adjacent to the Project Area during the surveys. A total of 17 bird species were observed during the vantage point surveys, with a total of 1,290 flight attempts in the Study Area. The flight attempts of most of the recorded species were generally flying < 10 m above the ground level near the Project Area. Only Black Kite (144 attempts, the maximum number of individuals recorded was 23 during the surveys), Barn Swallow (3 attempts) and Little Swift (2 attempts) were recorded flying over and crossing the location of the proposed wind turbine at a height > 10 m and <100 m above the ground level during the surveys.

In conclusion, the direct ecological impact due to the construction of the wind turbine is expected to be low, and will not contribute to any potential cumulative impact. In view of the generally poor vegetation cover and the dryness of the upland areas, it is believed that the Project Area and areas in the vicinity do not provide optimal habitats for the Romer's Tree Frog. The impacts on the Romer's Tree Frog are expected to be low given that pre-construction translocation of Romer's Tree Frogs (adult and tadpoles, if any) present at the site will be conducted.

Bird collisions are the main concern of the operational impacts of any wind turbine development. Barn Swallow, Little Swift and Black Kite, recorded as utilising the Project Area in this study, are the confirmed potential species that may be affected by the wind turbine during operation. Site selection is crucial to minimizing wind turbine bird collision. Since the wind turbine site is not considered to be either within important bird habitat or on the flight path of migratory birds, the impacts due to bird collision are of low magnitude and therefore not considered to be unacceptable.

No adverse residual impact is expected after the implementation of the recommended mitigation measures. One year bird monitoring will be undertaken to demonstrate that the wind turbine is having low magnitude of and not having an unacceptable impact on bird species.

3.3 LANDSCAPE AND VISUAL

The whole Study Area is considered to be covered under one single Landscape Character Area, LCA 1 - North Lamma Coastal Uplands. Landscape Resources found within the Study Area include LR1 - secondary woodland, LR2 - shrubland, LR3 - shrubby grassland, LR4 - streams and LR5 - village/developed area.

The Project would result in the disturbance of only LCA1 and LR3 involving approximately 3,100 m2 out of which approximately 1,400 m2 will be reinstated. Resulting in a net loss of 1,700 sq.m. .

Specific mitigation measures have been proposed to minimize identified impacts, including reinstatement of disturbed areas, compensatory planting, colour scheme, soil conservation and selection of low rotating speed machine.

With the implementation of the mitigation measures proposed, the magnitude of change to LCA1 and LR3 are small. The residual impact significance threshold of LCA1 is moderate/ adverse for both years 1 & 10. Appropriate landscape planting including trees, shrubs and grasses will result in a net increase in the quantity of vegetation at the Project Site resulting in a significance threshold of the residual impact for LR3 to "slight/adverse" during Year 1 of operation and "slight/beneficial" during Year 10 of operation.

Visually, the proposed wind turbine would result in slight to moderate/ adverse residual visual impact on views from Lamma Island and Hong Kong Island during operation except for the case of viewers from Tai Ling Pavilion and the cable route adjacent to the site where the significance threshold would be significant. With the gain in knowledge of the benefits of renewable energy such as the improvement of air quality, the likelihood of acceptance of the visual impact would be increased.

The overall residual impacts on landscape and visual aspects are considered to be acceptable with mitigation measures.

3.4 AIR QUALITY

Dust nuisance is the only potential air quality impact during the construction of the Project. Site formation, foundation construction, cable laying, wind turbine erection and landscaping works are the main construction activities. Wind erosion, materials handling, on-site stockpiling and vehicle movements are the main dusty activities. Since the site area is small, construction period is short with minimal construction activities and the distance from the ASRs is more than 185 m away, therefore, with the implementation of dust suppression measures, the potential for causing dust impact is very low. However, to protect the ASRs, regular site auditing is recommended to ensure the recommended mitigation measures are properly implemented.

No air quality impact would be envisaged during the operation of the wind turbine. The wind turbine will displace emissions of greenhouse gases and other emissions from conventional power generating plant. Estimates of the potential emission reductions have been presented in the Table 2.1.

3.5 *WATER QUALITY*

The EIA has dealt with the assessment of impacts on water quality from the construction and operation of the wind turbine on Lamma Island.

During the construction phase it was determined that minor impacts to water quality could arise directly from land-based construction works. These works relate to excavation and construction of the foundation for the wind turbine, and underground cable laying. No direct construction runoff is expected. However, stormwater runoff from the construction site could occur during rainstorms. Mitigation measures were described, which would provide a series of good site management practices to minimise the impact of stormwater runoff.

No operational impacts to water quality are expected to occur. No mitigation measures are therefore necessary. Based on the impact assessment, no EM&A measures are required. The mitigation measures specified as well as good site management skills are considered sufficient to prevent impacts occurring.

3.6 *ENVIRONMENTAL MONITORING AND AUDIT (EM&A)*

During construction of the Project, environmental monitoring will be necessary to assess the effectiveness of measures implemented to mitigate potential environmental impacts. Regular site auditing is also recommended to ensure that potential impacts from other sources are adequately addressed through the implementation of the mitigation measures defined in this EIA Report.

During operation of the Project, the monitoring work is focussed on ecology, specifically operation phase impacts to birds and to a noise sensitive receiver. Details are presented in the EM&A Manual.

4 OVERALL CONCLUSIONS

The EIA has critically assessed the overall acceptability of any environmental impacts likely to arise as a result of the construction and operation of the wind turbine on Lamma Island. Where necessary and practicable, the EIA has specified the conditions and requirements for the detailed design, construction and operation of the Project in order to mitigate environmental impacts to acceptable levels.

This EIA Study has predicted that the Project will comply with all environmental standards and legislation after the mitigation measures are implemented. The EIA has thus demonstrated the acceptability of any residual impacts from the Project and the protection of the population and environmentally sensitive resources. Where appropriate, EM&A mechanisms have been recommended during construction and operation to verify the accuracy of the EIA predictions and the effectiveness of recommended mitigation measures.

The study concluded that there would be no adverse long term or cumulative effects/impacts on the environment.

In conclusion, it is considered that the EIA provides a suitable basis for the Director of Environmental Protection to consider granting the Environmental Permit to allow the construction and operation of the Project.