Westenwind nv

Environmental registration
Charlottetown

Environmental registration pursuant to Section 7 of the Environmental Assessment Act

Labrador Coast Wind Project

Charlottetown

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1 NAME OF THE UNDERTAKING AND PROJECT PROPONENT

1.1. Name of the undertaking

Labrador Coast Wind project – Charlottetown

1.2. Project proponent

(i) Name of corporate Body:

Westenwind NV

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Westenwind was founded as a cooperative partnership with limited liability on the 25th of February 1997. The Company had as a primary goal to invest in renewable energy systems, especially in wind energy installations, and to do the exploitation of the Wind turbine generators that were built.

To maintain its position in an ever-changing juridical context the goal of the company was changed to be able to develop projects and act as consultant in the sector of wind energy for third companies and investors. This change of policy was sealed with the transfer from a co-operative company with limited liability to a limited liability company. Electrabel NV (www.electrabel.com) also took a participation of 31% in the company and a manager of Electrabel took place in the board of directors of Westenwind N.V..

In August 2001 there was a new and important change in the structure of Westenwind N.V.. Electrabel expanded it's participation from 31% up to 80%. At the same time the board of Directors was extended from 3 to 5 persons. 3 of the 5 persons are, since than, appointed by the largest shareholder Electrabel N.V..

From the beginning, the clientele of the companies in Westenwind NV consisted mainly of electricity companies. The largest part of the turn over originated in the first year almost entirely from the projects of the WVEM (The electricity company of the West - Flanders). The rest was created due to the projects of Wind - en Waterkracht Vlaanderen CVBA, a partnership formed by mixed intercommunales of Flanders (shareholders are 85% of all the communities of Flanders), who distribute electricity in Flanders (IMEWO, GASELWEST, IMEA, IVERLEK, INTERGEM ,IVEKA). Westenwind N.V. is also associated with Wind- en Waterkracht Vlaanderen CVBA. Other important partners for the development of specific projects were Electrabel N.V., CPTE, SPE, Tractebel Energy Engineering (www.tractebel.com) and Interelectra (www.interelectra.be). Westenwind N.V. studied several small projects for the VEM and IVEG. Notwithstanding the close cooperation with the electricity companies, several projects were started up with private investors, like Alex Heestermans (project E19 Hoogstraten), Gerard Timmermans (project verkeerswisselaar Oostkamp), Gerry Claeys (project Middelkerke – Slijpe), Janssen Pharmaceutica (project Geel), Matthijs (project Gistel- E40), ….

Westenwind NV has four shareholders:

Electrabel NV	Revalk Beheer BV	Wilfried De Smet	Boreas & Zephyr BVBA
80%	7.5%	7.5%	5%

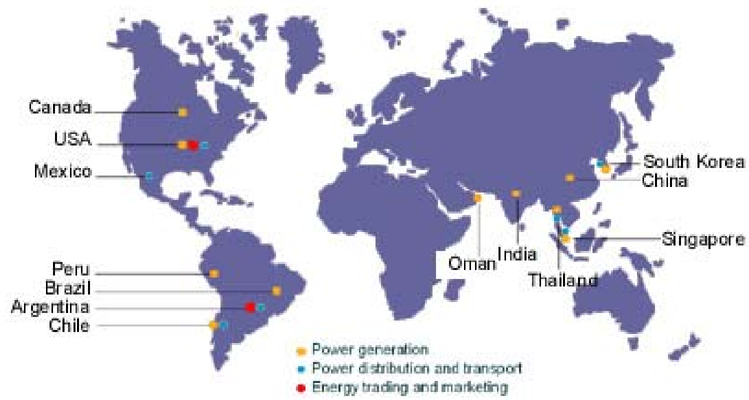
ELECTRABEL

Electrabel NV (www.electrabel.com), main shareholder of Westenwind NV is the biggest electricity producer in Belgium and controls about 95 % of the Belgian market. Electrabel NV is a subsidiary of Tractebel .

Tractebel

Tractebel (www.tractebel.com) is the energy arm of Suez (www.suez.fr) and can be considered as a global energy and services business. Its core business is electricity and gas, including the generation of electricity, trading, transport, distribution of electricity and gas, and sale of electricity. Its skills are correlated enabling Tractebel to offer fully coordinated services, covering energy and industrial services, engineering and technical installations.

New projects undertaken by Tractebel Electricity and Gas International since the beginning of 1999 represent a total investment of around USD +/- 1 billion. Worldwide, Tractebel Electricity and Gas International operates, manages, or shares in power-related projects totaling 17 000 MW in terms of generating capacity. In addition, the division operates gas transportation networks on three continents.



Since the potential for developing wind energy projects in Belgium is rather limited in the future the managers and minority shareholders started up projects in other countries two years ago. A regional company was founded in France to continue further development in that region.

Following the recent developments in the market of renewable energy the group also directed her aim further abroad. Especially Brazil, Canada and Northern Africa can count on serious attention of Westenwind NV, seeing the recent opportunities, created by those governments.

Westenwind NV will be working in close cooperation with local companies that will intervene in all stages of the development of the projects (such as local consultancy companies specialized in environmental assessment analyses, local contractors for access roads, transmission lines, transportation …).

Boreas & Zephyr sprl and Coolconsult BVBA, are in charge of the management of the group. Frederik De Smet is president of the company of the group as where Wilfried De Smet is the president of the board of directors.

For the development of the projects, Westenwind NV will be working in close contact with different partners. The field of operation of the partners extends from the construction of the electrical infrastructures to the investment in the WTGs itself. Due to this integrated structure, Westenwind NV can develop a project, starting from the first prospecting tour up until the final operation of the Wind turbine generator farm. The flexible structure however permits Westenwind NV also to create a solution of development – construction – operation – ownership that is designed in function of every local need and sensitivity, specific for every region or project.

For the design and the conception of these projects there will be a cooperation with a number of specialists, who are familiar with the subject for years. This could offer an important surplus value, because of the experience acquired in Westenwind NV. The partners of Westenwind NV have a strong link with each other because of their common shareholders and the control of management in the hands of the same people. These companies characterize themselves with a shared vision on the development of renewable energy systems and wind energy systems in particular. Because of the synergy of the experiences a package of consultancy services can be offered that present an obvious surplus value.

Westenwind N.V mainly executes the design of the project.. Westenwind N.V also makes the environmental assessment analyses in co-operation with local companies.. Westenwind has already more than 5 years experience with making different environmental impact analyses concerning the realization of Wind turbine generator projects. The calculation of the profits and the conceptualization of the implantation of the WTGs are also the work of Westenwind N.V..

For the execution of these projects we will use as much local firms as possible. At this moment there still is an investigation on going the execution of the projects. Several companies will execute works on the site.

The transport and the building of the Wind turbine generators will be completely coordinated by the supplier of the Wind turbine generators. They will coordinate with the local government and the local police to accompany the turbines safely to the work site.

The exploitation of the Wind turbine generators will be carried out by an S.P.C. (Special purpose company) that will be created by the shareholders of Westenwind NV and a local coorperator for these projects.

The maintenance and the service of the wind farm will be the responsibility of the supplier of the Wind turbine generators. A maintenance contract can be foreseen for a period of 5 year. Both parties can renegotiate this contract after 5 years. The contract foresees a guaranty of availability and a guaranty of the Power curve for the first period of 2 years. The service foresees a 24/7 assistance of the supplier for solving problems.

The activities of Westenwind NV can be summarized as follows:

PROSPECTION:

- Identification of the potential site
- Investigation and detailed study of the maps
- Collecting data on wind potential
- Evaluation of the sensitivity of the site
- Pre-design of the potential wind farm
- Collecting of data on political key persons and administration
- Collecting data on urban planning
- Identification of the parcels to be contracted
- Collecting data on the owners

CONTRACTING:

- Contacting of the owner
- Negotiation with the owner for concluding a contract
- Contracting of the selected owner

DEVELOPMENT:

- Obtaining land use agreement
- Design of the wind turbine project
- Estimation of the investment costs
- Calculation of the viability and the internal rate of return
- Selection of the manufacturer
- Measuring of wind speed on site
- Calculation of the production of the wind turbines

- Preparing presentation files for decision makers
- Acquiring deforestation permit
- Making of Environmental assessment analyses
- Acquiring building permit
- Acquiring exploitation permit
- Defining access to the grid
- Obtaining Grid Connection
- Obtaining Power purchase agreement (PPA)

CONSTRUCTION:

- Control of the execution of the construction

The construction of the wind farm is actually done by the manufacturer of the WTGs who will work with local sub – contractors. The role of WESTENWIND NV is limited to the control of the execution of the works in relation to the design of the projects. WESTENWIND NV does the selection of the manufacturer and the contracting of the manufacturer on behalf of the final owner of the project in close co-operation with the final owner and the EPC - manager.

EXPLOITATION:

- Administration of the WTGs (including accounting).
    - Monthly rapport of the production
    - Monthly rapport of the malfunctions
    - Monthly rapport on the maintenance
    - Monthly rapport on the most relevant occurrences
- Follow up of the maintenance of the Wind turbine generators
- Follow up of the insurance matter of the Wind turbine generators
- Communication with the owner of the land
- Communication with third parties considering the project

2 NATURE AND RATIONALE OF THE UNDERTAKING

2.1. Rationale for the undertaking

2.1.1 National and provincial policy

Recently, the Canadian federal Government announced an incentive scheme to promote the development of wind turbine projects in Canada. Also Quebec, the local provinces and some local electricity companies have set goals for acquiring a higher amount of production by means of Wind turbine generators.

Today about 205 MW of installed power for Wind turbine generators (WTGs) are in operation in Canada. However it is clear that the potential for developing wind energy projects in Canada is very high. The Canadian Wind Energy association (CanWEA) set a goal of 10,000 MW of installed power to be obtained by means of WTGs. This power should be installed before the year 2010. Seen the experience in Europe (25,000 MW by the end of 2003) this goal cannot be considered as being too high. The land for installing WTGs is abundant and the areas with a high mean wind speed are clearly defined.

In addition to that, certain regions remain isolated from the national grid, having only a diesel generator for their energy production. The cost of electricity, produced by those diesel systems, is rather high in comparison with the cost of the energy from hydro-electrical plants or WTGs. Also the local governments often financially support the operation of diesel systems, in that way, households can obtain a lower price for their electricity. For example, for the region of Labrador this support implies a yearly cost of about 15 million Canadian dollar.

Providing energy to remote areas is the basis for further local development of the whole region. New industries need energy as Tourism does too. Wind energy is the primary non – fossil fuel solution for providing this power. Hydro – electricity can in most cases not be considered to be a solution for providing this energy. The impact on the eco – system, of Hydro – electricity plants, is too high. Native people want to preserve their land for future generations as previous generations did for them. With the introduction of wind energy systems, the land can be preserved and power can be provided.

2.1.2 Benefits of wind energy

2.1.2.1 Significant reduction of emission of NOX, CO2 and SO2

Global climate change resulting from the widespread burning of fossil fuels is the most important environmental problem of our time, and the most serious that have ever confronted humanity.

By the year 2100, according to the prestigious Intergovernmental Panel on Climate Change (IPCC), the Earth's average temperature can be expected to warm by 1 to 4 degrees Celsius. This is a modest increase, but likely consequences include: the spread of tropical diseases; disruption of agriculture due to drought and changes in rainfall patterns; elimination of many now endangered species; increasing numbers of deaths during summer heat waves; and increasingly severe tropical storms.

Recent disclosures that acid rain is causing greater damage to the environment than previously thought and that human-induced greenhouse gas emissions are increasing ocean temperatures highlight the need for aggressive investments in wind power, the American Wind Energy Association (AWEA) said:

"We are allowing some of our nation's ecosystems to be battered by acid rain, and contributing to global warming, while part of the solution lies close at hand," said American Wind Energy Association (AWEA) Executive Director Randall Swisher. Clean air standards can be improved and new power brought on line without delay, by tapping an abundant, affordable, clean energy source -- the wind.

The acid rain report, undertaken by the Hubbard Brook Research Foundation and published in the journal Bioscience (vol. 51, no.3, 2001), found that, while sulfur dioxide (SO_2) emissions have been reduced since 1970, ecosystems are not recovering as expected from acid rain damage in sensitive areas of the Northeast. Emissions of SO_2 from electricity generation need to be cut by an additional 80%, with cuts in emissions of nitrogen oxides (NO_x) as well in order for affected streams and other ecosystems to come back within the next 20-25 years, according to the study. Ecosystem recovery was one of the goals of the 1990 Clean Air Act Amendments that set a cap on emissions of sulfur dioxide.

Two studies on climate change, published in the April issue of Science magazine and carried out by the National Oceanographic Data Center and by the Scripps Institution of Oceanography, found a direct link between rising ocean temperatures and emissions of greenhouse gases (carbon dioxide and other gases that can trap heat within the atmosphere). Sydney Levitus, the lead author of the National Oceanographic Data Center study, said he believes its results are the strongest evidence to date that the Earth's climate system is being altered by human activity. Carbon dioxide (CO_2) from fossil fuel combustion is a leading greenhouse gas.

"The impact of electricity generation on these environmental problems can be reduced," said Swisher. "With wind power, we can substantially lower air pollution and carbon dioxide emissions without constraining power supplies. This year's record-breaking investments in wind farms demonstrate that the technology is ready to play an increasing role in the nation's energy portfolio."

About 1,500 megawatts (MW) of new wind energy generating capacity--a 60% increase for the industry--are expected to come on line in the U.S. in 2002, according to initial AWEA estimates. By year's end, wind farms will be generating 10 billion kilowatt-hours (kWh), enough to power one million average American households, without any emissions of pollutants or carbon dioxide. If that amount of electricity were produced by the average utility fuel mix, it would generate 40,000 tons of SO_2 and 24,500 tons of NO_x, the lead agents of acid rain and smog, and 7.5 million tons of CO_2, a leading greenhouse gas. An area of 4,000 square miles of forest, larger than the states of Rhode Island and Delaware combined, would be needed to absorb that much CO_2.

Aggressive steps to sustain the wind industry's high growth rate are in the nation's immediate economic as well as environmental benefit, Swisher said. A steep and steady increase in the use of wind power in the U.S. would help ease the pressure of soaring demand on the price of natural gas, the current fuel of preference for new electricity generation.

Quotation: "Wind power can help fight pollution and global warming, while providing a low-cost solution to the current energy crisis." --Randall Swisher, AWEA Executive Director

Wind energy and other renewable energy sources can play a crucial role in reducing emissions of carbon dioxide (CO_2), the leading "greenhouse gas" associated with global warming. This single utility-scale wind turbine, by displacing power generated by fossil fuels, can prevent the emission of 1,500 tons of CO2 into the atmosphere each year.

Wind turbines are extremely effective at reducing emissions of carbon dioxide (CO2), the leading greenhouse gas.

2.1.2.2 Alternative for diesel systems

Diesel generators are a major source of pollution. In 1996, they released 293,000 tons of nitrogen oxides (NOx) in the U.S., a major cause of urban smog and a contributor to respiratory ailments and acid rain. The total makes diesel generators almost on par with all NOx emissions from electric power plants in New York, New Jersey and Pennsylvania. Diesel generators also released 40% more carbon dioxide (CO2) than all power plants in New Jersey combined.

The above statistics are especially troubling since diesel generators are poised to grow in capacity. In 1996, there were 102,000 MW of diesel generators in the U.S.. With a 1.7% annual growth rate, they may reach 127,500 MW in 2010, releasing 371,000 tons of NOx emissions and 16.7 million tons of CO2 emissions. Recent experience shows that they may grow at an even higher rate (2.65% per year) with important consequences to air quality. Right now, “distributed generation” equals “diesel generators.”

Further in this document has been calculated how much emissions will be avoided in this project by using wind energy as an alternative for diesel power .

2.1.2.3 Employment

“If the average turbine costs approximately C$ 1.5 million dollars for 1 megawatt, then the direct investment to achieve the 10,000 megawatt goal would be $15 billion dollars. Based on the breakdowns studied by Subcommittee 3 (of the CanWEA), for materials and labor contribution, there are 9,980 man –hours for the engineering, production and construction per megawatt installed. This represents almost 50,000 person – years to meet the Canadian objective.”

“In addition to manufacturing and construction employment, industry sources indicate that for every 100 megawatts of installed wind power, ten full-time operation and maintenance (O&M) positions are created (direct and subcontracted). This is a good employment factor in the power sector and represents a total of 1,000 full-time O&M positions to achieve CanWEA’s objective”.

For the realization of this project stable local employment will be a necessity. This for the operation and maintenance of the wind turbine but also for erecting the turbine, placing the foundations, installing and operating the wind measurement mast, …

2.1.2.4 Industrial development

Wind turbine generators can have a positive effect on new industries. The power provided by the WTGs, erected in the Labrador communities, should be considered as an additional power source, next to the traditional diesel generators.

Most of the isolated coastal communities of Labrador suffer from a lack of power. No companies want to invest in the economy of these communities as these communities have a restricted amount of power. The now present diesel generators are dimensioned on the number of inhabitants and the now present (fish)industries. There is no room for new energy consuming activities. On the long term this might bring the future of these communities in peril of life.

Installing a wind turbine would expand their power and thus be the main engine of new industries and further development of the region.

2.1.2.5 Other advantages

- Payments to landowners (Crownland): for the use of land an annual payment will be done by the local company founded for the acquisition of the lands needed for the installing of the wind turbine.

- Stable electricity prices: A recent study (January, 2000) found Iowa's electric utility customers could save over $300 million over a 25-year period if a proposal to meet 10% of the state's electric demand through wind energy is adopted. The savings result because the cost of fossil fuels is expected to rise over time, while wind costs decline. Savings in California, where prices have skyrocketed because of supply constraints, would be enormous. In the isolated communities of coastal Labrador we can expect the same story.

- Reduction of annual subsidies: due to the provision of electricity by WTGs less subsidies would have to be paid to Hydro for obtaining a lower consumption price of the electricity.

- Cheaper energy for remote areas: In comparison with the diesel systems that provide energy to the communities now, Wind Energy can provide cheaper energy. It is to be expected that the difference will even become bigger, as prices for diesel fuel are rising. The normal tariff for a kWh wind energy will be 10 ctCan$. Though, electricity prices are being set by the provincial energy utility, i.e. Newfoundland & Labrador Hydro (NF&L Hydro). NF&L Hydro is the appropriate authority in this matter.

- Independence – no import of fossil fuels: The necessity to store spare fuel can significantly be reduced due to the provision of power by WTGs. Wind energy is a clean, domestic electricity source that is not subject to the sorts of supply constraints and price spikes we have seen with natural gas or fuel.

- Low impact on Eco – system: In comparison with Hydro – electrical plants building WTGs has a very low impact on the eco system.

- Wind is present everywhere and abundant: since wind is present everywhere and it is easy to harvest wind in all areas. This is specifically relevant for remote areas, where energy can be produced by means of WTGs independently.

2.2. Nature of the undertaking

This project foresees in first instance the installation of one wind turbine in the surroundings of the community of Charlottetown. This project forms part of the Labrador Coast wind project which foresees the implantation of each time one wind turbine in the surroundings of the diesel powered communities in the coastal area of Labrador. In a later stage more wind turbines can be installed if the local power consumption augments.
The power will be sold to the local electricity company, Newfoundland & Labrador Hydro, who will distribute and resell it to the consumers.

Only a limited number of coastal communities, such as Charlottetown, were selected for the development of a wind turbine project.
Hydro provided Westenwind NV with information about every coastal community in Labrador. This information consists of the number of customers, the actual installed power, the daily energy consumption, the maximum capacity, the peak capacity,…for every community.
Wind turbines have a minimum size, i.e. 225 kW, for which a local peak capacity of 450 kW is the minimum. The communities with a peak capacity lower than 450 kW were not withheld, because the energy produced by a wind turbine would not be consumed at a sufficient level.
The energy produced by a wind turbine needs to be consumed locally because of the absence of an intercommunal grid. Therefore the size of a wind turbine must be adapted to the local energy consumption. It has no use of installing a wind turbine from which the produced energy cannot be consumed!
Consequently, for every community a specific type of wind turbine will be chosen based on the local energy consumption.

On the basis of the capacity of their diesel generator eleven communities were selected. In every community a wind turbine could be installed. Every wind turbine will be connected to the local grid via the present diesel generator. Hence, the diesel generator becomes a back-up system. However with low wind speeds, it is possible that the amount of energy produced by the wind turbine is not sufficient. Then the diesel generator has to back-up the needed amount of energy.
For this reasons, it is necessary that the diesel generator operates continuously at a minimum level of 30% of it's maximum capacity, even when the wind turbine generates sufficiently.
Consequently, in the smallest of the eleven selected communities it won't be possible to develop a feasible project. A certain level of electricity will be produced continuously by the diesel generator by which only a small additional amount of wind energy is needed.

After studying all possibilities, only four communities are eligible for the connection of a wind turbine to the current diesel system.

The following communities are selected:

- Mary's Harbour
- Charlottetown
- Cartwright
- Nain

Westenwind nv is currently studying a series of wind turbine suppliers to provide the equipment most adapted to Labrador's climate and with a proven track record for reliability and availability.

The final decision will be based on a well-proven design and demonstrated operating records. Also, wind measuring equipment will be installed on the project sites in order to collect data and to establish the particular characteristics of the wind turbine most suited to the prevailing wind and climatic conditions.

3 DESCRIPTION OF THE UNDERTAKING

3.1. Geographical location

3.1.1 Project site selection

Canada's wind energy resources are considered to be among the world's most energetic and represent a significant new energy opportunity. Coastal Labrador is known as one of the windiest regions of Canada. With an expected average wind speed of ca. 8 to 9 m/s at an altitude of 60 m, this area is a very appropriate location for the installation of wind turbine generators.

Because of climatic conditions and the size of the diesel generators in the several communities along the coast, only a limited number of communities have been selected, as seen above already.

Several aspects have been taken into account before planning the exact position of a wind turbine in a community. The following criteria, among others, were relevant:

- Spatial Insertion: the location must be situated in an open landscape, close to the ocean, on a windy spot.
- Wind regime: wind directions, wind speeds (based on data provided by Environment Canada)
- Distance to the grid: the site must be as close as possible to the diesel generator . A suitable location is a site within 3 km of the present generator.
- Accessibility:
    - The access roads are present or easy to install
    - Suitabilility of topography: the construction and exploitation site is accessible
    - Shipping access
- Distance to houses: to avoid possible annoyance to the houses near to the Wind turbine generator, a buffer as large as possible has to be respected. In these projects a distance of at least 300 m will be maintained.
- Land use:
    - suitable land use is defined as not including land with high archaeological potential, national or provincial parks, reserves, bird sanctuaries or any other protected or regulated areas.
    - Compatibility with the existing land use/municipal plan: habitation area, forests, water supply area, dump site, rural area,…
- Distance from airport strips
- Presence of mining claims: no development in mining areas
- Distance from telecommunication units or radio antennas: a wind turbine should be positioned in such a manner that radar and radio connections should not be annoyed in any way.

Based on these criteria, a specific project site has been selected for every involved community.

3.1.2 Charlottetown – Site selection

The site chosen for the wind project is located to the north of the habitation area of Charlottetown, on an open hill spot close to the sea. The elevation of the site is 50 m above sea level.

Topographical map of the area where the wind turbine will be installed.

scale of map: 1:50.000

Site of the wind turbine

The project site is situated within the municipal boundaries of Charlottetown.

The distance to the nearest residential building is about 350m; the distance to the habitation area of the community about 1 km.

To access the site, a 350 m long road will have to be constructed. This road will be connected to the already existing road opening on the nearest residential building.

The distance between the wind turbine site and the diesel generator is about 2 km.

The site has been chosen in such a way so the project area is not situated in the Water Supply Area (WSA) and the buffer area all round the dump site (see Land use map). Additionally, the distance to the airport strip has been maximized (about 2 km).

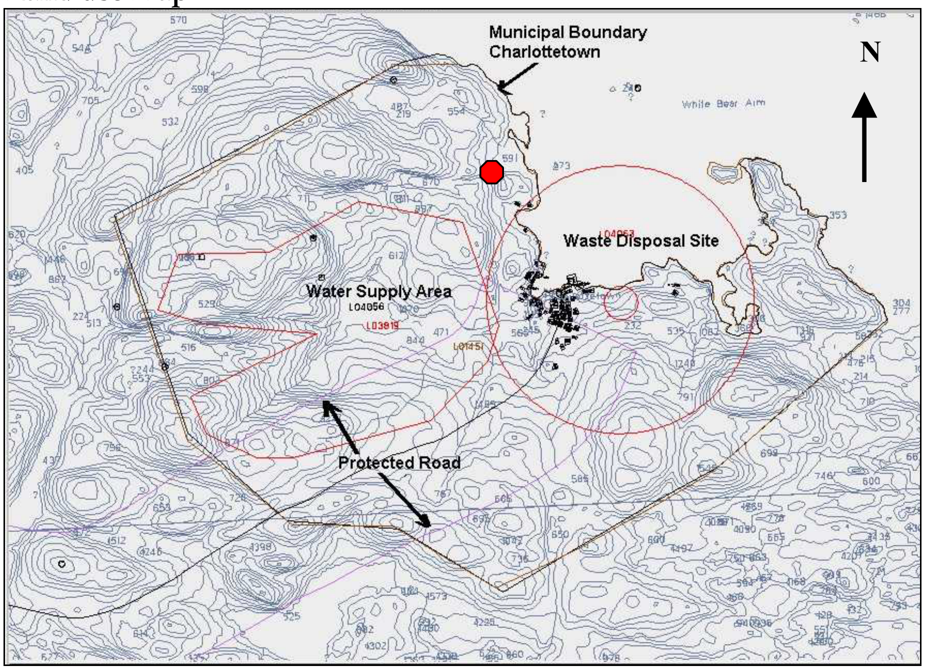
The presence of the wind turbine and an access road should present no conflict with existing land uses. The site is currently classified as 'rural area'.

The presence of a wind turbine and an access road should present no conflict with existing land uses. The site is currently classified as 'rural area' on the municipal plan. The site of this facility shows very little signs of human activity and is noticed to be only infrequently used for hiking, skidooing, berry picking and similar activities.

The site is an open barren location, with a sparse shrub/moss vegetation. The site used to be forestland, though trees have been cut in former times. The regeneration process only evolves slowly. Thus to install a wind turbine and additional appliances only few trees will have to be cut.

A large-scale base map attached to this document clearly indicates the site location, also showing the proposed route of access.

Land use map



not to scale

Site of the wind turbine

3.1.3 Physical environment

3.1.3.1 Climate

The climate of Labrador is more Arctic than Atlantic. Because it is on the eastern side of the continent, it experiences strong seasonal contrasts in the characteristics and movement of air masses. The predominant flow is off the land. The rugged Torngat Mountains in the north, with peaks above 1500 m, and the Mealy Mountains in the south, with peaks about 1200 m, confine the moderating influence of the Atlantic Ocean to the rocky islands and near shore.

The limitation of the ocean's influence,however, is not a serious disadvantage, because in this region its effect on the climate is generally unpleasant. The Labrador sea is infested with floating pack ice and icebergs for eight months of the year. The masses of ice keep sea temperatures below 4C. An east wind off the Labrador Current is a cool wind in summer, often with light rain or drizzle. In winter, when the Atlantic air is relatively mild, the accompanying weather includes cloud and frequent snowflurries. Whenever easterly winds bring very moist air from the Atlantic, widespread fog occurs.

Winters in Labrador are very cold, with typical daytime temperatures in January between -10 and –15 °C, colder than Newfoundland. Temperatures can drop to –25 and even to –35 °C. The summer season is brief and cool along the coast because of the cold Labrador Current. July average temperatures are from 10 to 15 °C along the coast but are 3 to 5 °C warmer in the interior. Nevertheless, summer temperatures can rise to 25 °C and even to 30 °C.

The pleasantness of the summer day along the coast is often determined by the wind direction--westerly winds bring clear, mild continental air, whereas easterlies, blowing off the Labrador Current, bring cold,cloudy, and moist weather. (Internet site Environment Canada)

Since the project area is situated far North special attention should be given to LT-turbines (Low Temperature turbines). It is clear that technical adjustments should be made to the turbines to survive those temperatures. However in Europe, Canada and China there is sufficient experience with LT-turbines. The temperature should not longer be considered as being a problem.

3.1.3.2 Topography

The province's coastline stretches over more than 17 000 km. It is varied with prominent headlands, coves, fiords and offshore islands. The interiors of both Labrador and Newfoundland were deeply impressed by glacial activity, continental collision, mountain-building, and volcanoes and were formed by oceans, rivers and ice sheets.

Today Labrador has a rolling, rugged topography with much of southern and central Labrador covered by a thick boreal forest, broken by numerous lakes and swift-flowing rivers.
Labrador is the easternmost part of the Canadian Shield, a vast area made up mostly of plutonic and metamorphic rock. The Canadian Shield forms the central core of the North American continent. (Internet site World of Education)

The topography of the surroundings of Charlottetown is quite hilly. The project area, situated to the north of the habitation area of the community, is an open hill side close to the coast.

3.1.3.3 Soils

The soils of Newfoundland and Labrador are strongly influenced by location, climate and geology. The surface geology of the province is characterized by large areas of coarse textured material (glacial till deposits), washed sediments, peat deposits and rock outcrops.

The coastal area mostly comprises bare rock outcrops and headlands. Exposed bedrock includes more than 80% of the area. Small area with till and other superficial materials are less then 1 m thick and discontinuous. The lack of soil is due to post-glacial marine submergence, which removed most of the unconsolidated deposits. (Internet site government of NF&L)
The absence of a soil and the severe climate conditions mean agricultural development remains minimal. (Warkentie ed., 1968)

As the project area is situated on an open hill side with only sparse vegetation, almost no soil is present. A specific foundation will have to be constructed to ancher the wind turbine in these conditions.

3.1.4 Biological environment

3.1.4.1 Vegetation

The vegetation resources of the south coast of Labrador are classified as the 'forest-tundra transition'-class. This is a transitional class between tundra and coastal barrens on the one hand, and open forest woodland on the other.

Balsam fir and black spruce with an understory of feathermoss are the dominant forest type on moist upland slopes. Black spruce, kalmia heath, and lichens grow on dry sites. Black spruce, paper birch, and aspen are found on disturbed sites. Granite rocks are the dominant rock type in this ecoregion. (Internet site Newfoundland and Labrador Heritage)

A site visit has shown the project area is an open site with only sparse low-growing vegetation. On this land barrens dominate.

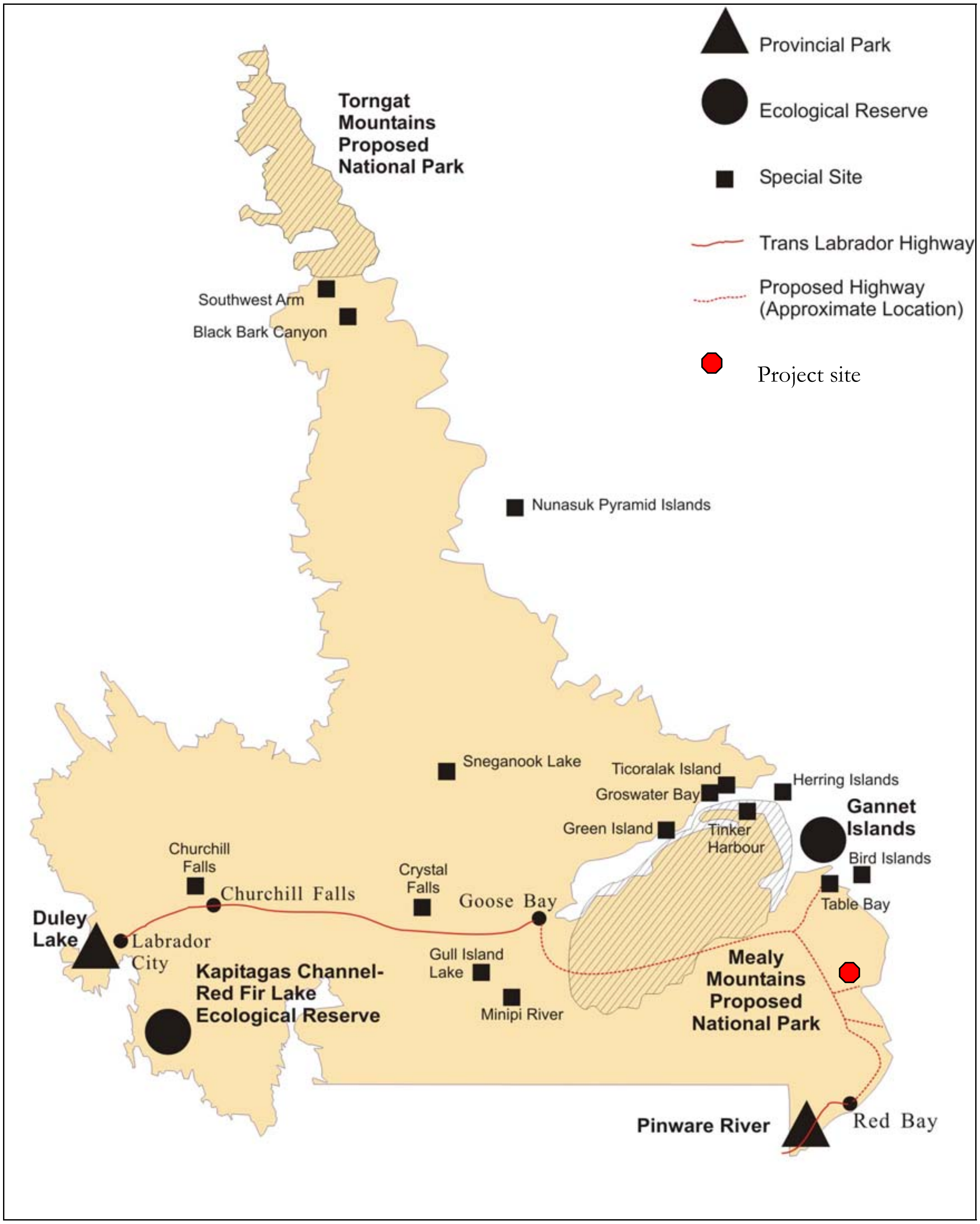
3.1.4.2 Wildlife

Relatively little is known about the fauna of Labrador. Because of it's remoteness research and inventarisations are very costly and limited usually to species of commercial interest or those threatened.

Wildlife characteristic of the boreal forest thrives here: moose, caribou, black bear, red fox, lynx, snowshoe hare, wolf, spruce grouse, raven. Along the coast congregate seabirds and waterfowl: Atlantic puffins, murres, petrels, gannets, Canada geese, eider ducks, and black ducks, among others. Seals, whales and the occasional polar bear frequent the coast.

Labrador is home to many birds. From bald eagles, golden eagles, falcons and owls to harlequin ducks, teals, geese and warblers (and all sizes in between). The coastal areas are important staging and flyway areas for scoters, loons and wading birds.

The project area is not designated as a protected natural area. The closest important zones are the Bird Islands and Table Bay, which do not have a protected status, and the ecological reserves of Gannet Islands in the north (80 km) and the ecological reserve of Pinware River in the south (140 km).



3.1.5 Resource and land use

On the municipal plan, the project site is designated as a rural area. In a rural area no development will be allowed except for agriculture, forestry, small scale mining and any legitimate activity connected with electric power generation and transmission or the provision of public utilities. Generally, any major activity under the above categories will have to be given special study and may require an amendment to the plan.

In Charlottetown, a quite vast area has been designated as a Water Supply Area. As the wind project site is located outside the boundaries of the WSA, we do not expect the wind turbine to have any impact on the water supply of Charlottetown.

The area is not in use for agricultural purposes because of the lack of soil. Though, there is some berry picking, hiking and wood lumbering activity. Hunting is not common.
During winter, when a thick snow deck covers the surface, people use their skidoo to be mobile.

3.2. Wind resources

Westenwind NV has conducted a preliminary assessment of the wind potential in Charlottetown based on a review of the topographic features of the project area and on available Environment Canada weather station data. The data extracted from Environment Canada's archives, consist of hourly wind speed and direction for all the climate stations in Labrador and Shefferville (Quebec) for the period 1997 to present. These data have been measured with measuring gauges attached to a pole at a height of 10 m. Based on these data a mean value for wind speed and direction could be calculated.

In Charlottetown no climate station is installed, so for this community no wind data are available.

We assume the wind characteristics on this site to be similar to those on the site in Mary's Harbour. The sites are geographically close to each other and have the same properties.

In Mary's Harbour the mean wind speed (at a height of 10 m) is about 5-6 m/s.

We can expect the mean wind speed at the project site to be significantly higher as the site is at a higher topographic height then the Mary's Harbour climate station. Additionally a wind turbine is minimum 30 m high, thus at least 20 m higher than the wind measuring gauges, so a wind turbine will experience higher wind speeds.

In the near future, Westenwind NV will install a tower with wind monitoring instruments. The measurement obtained will provide site-specific wind data and will allow a more precise assessment of the site's wind characteristics. As mentioned already, the measured wind speeds are expected to demonstrate better quality winds than the weather station data have shown.

3.3. Physical features

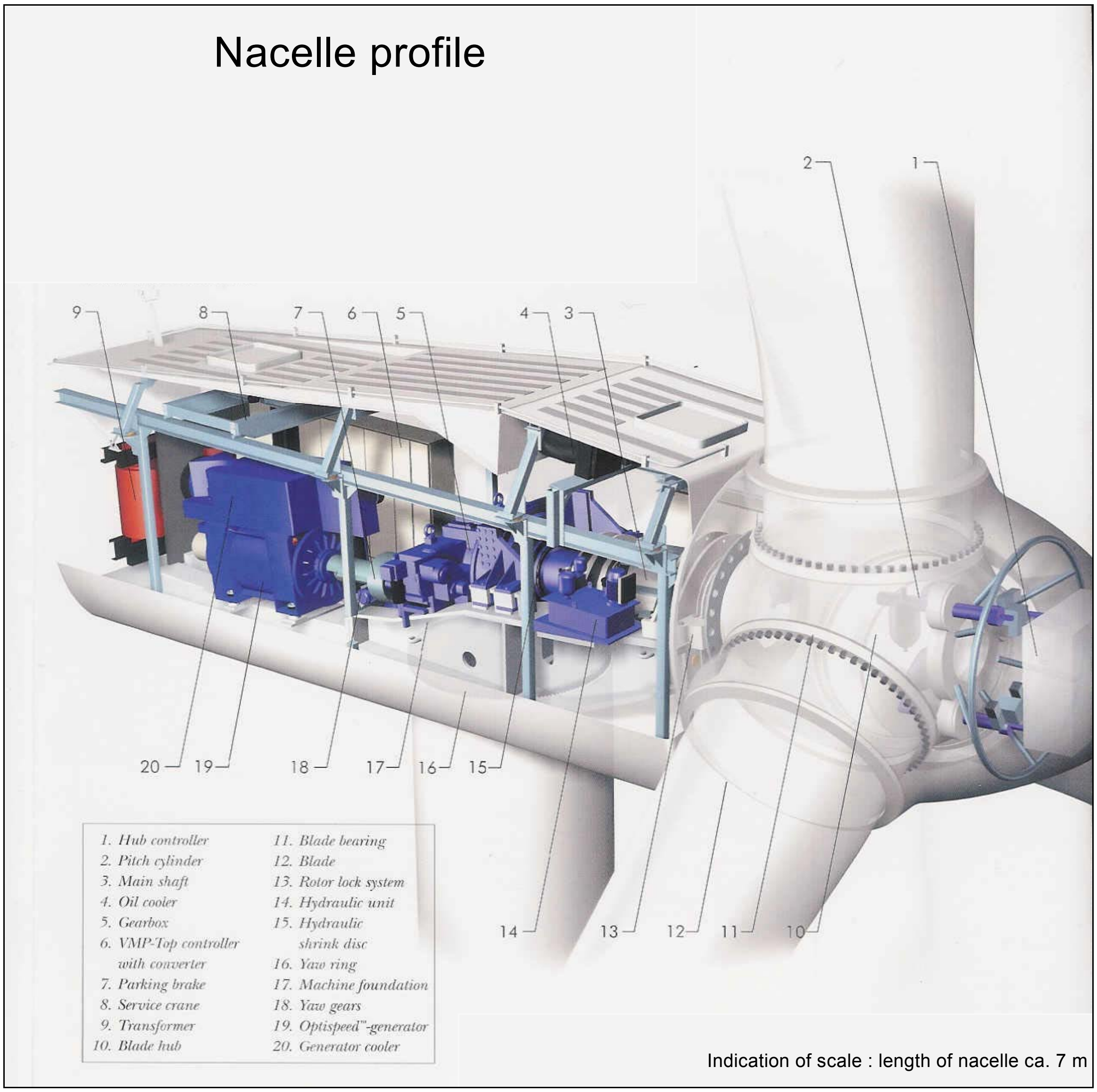
3.3.1 Type of Wind Turbine Generator

The power of the WTG will vary between 225 kW and 660 kW. For every project site a specific type of WTG will be chosen. To maximize the efficiency of every Labrador Coast wind project, the power of a WTG will be adapted to the level of electricity consumption of every community and to the power purchase agreement with Newfoundland & Labrador Hydro, the local utility company.

The selected turbine manufacturer will make the necessary adaptations and engineering changes to adapt the WTG to the specific climatic conditions experienced in the coastal area of Labrador.

3.3.2 Technical description of the Wind Turbine Generator

3.3.2.1 General



The nacelle contains the key components of the wind turbine, including the gearbox, and the electrical generator. Service personnel may enter the nacelle from the tower of the turbine.

The rotor blades capture the wind and transfer its power to the rotor hub. The length of a rotor blade varies depending on the rated power of the wind turbine, such as the height of the tower. For these projects the rotor diameter will vary between 30 and 50 m. The rotor rotates relatively slowly, about 20 to 26 revolutions per minute (rpm).
The height of the tower will vary between 30 and 60 m.

The hub of the rotor is attached to the low speed shaft of the wind turbine.

The low speed shaft of the wind turbine connects the rotor hub to the gearbox. The rotor rotates relatively slowly. The shaft contains pipes for the hydraulics system to enable the aerodynamic brakes to operate.

The gearbox has the low speed shaft to the left. It makes the high-speed shaft to the right turn approximately 50 times faster than the low speed shaft.

The high-speed shaft drives the electrical generator at a high speed level. It is equipped with an emergency mechanical disc brake. The mechanical brake is used in case of failure of the aerodynamic brake, or when the turbine is being serviced.

The electrical generator is usually a so-called induction generator or asynchronous generator. On a modern wind turbine the maximum electric power is usually between 500 and 2,500 kilowatts (kW).

The electronic controller contains a computer, which continuously monitors the condition of the wind turbine and controls the yaw mechanism. In case of any malfunction, (e.g. overheating of the gearbox or the generator), it automatically stops the wind turbine and calls the turbine operator's computer via a telephone modem link.

The hydraulics system is used to reset the aerodynamic brakes of the wind turbine.

The cooling unit contains an electric fan, which is used to cool the electrical generator. In addition, it contains an oil-cooling unit, which is used to cool the oil in the gearbox.

The tower of the wind turbine carries the nacelle and the rotor. Generally, it is an advantage to have a high tower, since wind speeds increase farther away from the ground

In every project the tower shall be a tubular tower and not a lattice tower. Tubular towers are safer for the personnel that have to maintain the turbines, as they may use an inside ladder to get to the top of the turbine.

The yaw mechanism uses electrical motors to turn the nacelle with the rotor against the wind.

The yaw mechanism is operated by the electronic controller, which senses the wind direction using the wind vane. Normally, the turbine will yaw only a few degrees at a time, when the wind changes its direction.

The anemometer and the wind vane are used to measure the speed and the direction of the wind.

The electronic signals from the anemometer are used by the wind turbine's electronic controller to start the wind turbine when the wind speed reaches approximately 4 meters per second (8 knots). The computers stops the wind turbine automatically if the wind speed exceeds 25 meters per second (50 knots) in order to protect the turbine and its surroundings.

The wind turbine’s electronic controller to turn the wind turbine against the wind, using the yaw mechanism, uses the wind vane signals.

3.3.2.2 Towers

Large, modern wind turbines normally use conical tubular steel towers. The primary advantage of this tower over a lattice tower is that it makes it safer and far more comfortable for service personnel to access the wind turbine for repair and maintenance. The disadvantage is cost.

The primary danger in working with wind turbines is the height above ground during installation and maintenance work.

New Danish wind turbines are required to have fall protection devices, i.e. the person climbing the turbine has to wear a parachutist-like set of straps.

The straps are connected with a steel wire to an anchoring system that follows the person while climbing or descending the turbine.

The wire system includes a shock absorber, so that persons are reasonably safe in case of a fall.

A Danish tradition (which has later been taken up by other manufacturers), is to place the access ladders at a certain distance from the wall. This enables service personnel to climb the tower while being able to rest the shoulders against the inside wall of the tower.

Protection from the machinery, fire protection and electrical insulation protection is governed by a number of national and international standards.

During servicing it is essential that the machinery can be stopped completely. In addition to a mechanical brake, the rotor can be locked in place with a pin, to prevent any movement of the mechanical parts whatsoever.

The price of a tower for a wind turbine is generally around 20 per cent of the total price of the turbine. For a tower around 50 meters' height, the additional cost of another 10 meters of tower is about 15,000 USD. It is therefore quite important for the final cost of energy to build towers as optimally as possible.

Lattice towers are the cheapest to manufacture, since they typically require about half the amount of steel used for a tubular steel tower.

Generally, it is an advantage to have a tall tower in areas with high terrain roughness, since the wind speeds increases farther away from the ground. Lattice towers have the advantage of giving less wind shade than a massive tower.

Obviously, you get more energy from a larger wind turbine than a small one. Clearly, we cannot sensibly fit a 47-meter rotor to a tower of less than 20 meters. But if we consider the cost of a large rotor and a large generator and gearbox, it would surely be a waste to put it on a small tower, because we get much higher wind speeds and thus more energy with a tall tower. Each meter of tower height costs money, of course, so the optimum height of the tower is a function of tower costs per meter (10 meter extra tower will presently cost you about 15,000 USD) how much the wind locally varies with the height above ground level, i.e. the average local terrain roughness (large roughness makes it more useful with a taller tower), the price the turbine owner gets for an additional kilowatt hour of electricity.

Manufacturers often deliver machines where the tower height is equal to the rotor diameter. aesthetically, many people find that turbines are more pleasant to look at, if the tower height is roughly equal to the rotor diameter.

3.3.2.3 Rotor Blades

The rotor blades of the wind turbine are made of glass fiber reinforced plastics, (GRP), i.e. glass fiber reinforced polyester or epoxy.

The rotor blades on turbines with relatively short towers will be subject to very different wind speeds (and thus different bending) when a rotor blade is in its top and in its bottom position, which will increase the fatigue loads on the turbine.

3.3.2.4 Esthetics of the Wind turbine generators

We foresee Wind turbine generators with a large capacity and a low rotor speed. Blades that turn slow give a quiet image. The dull and light color results to the fact that the turbines, viewed from a certain distance, disappear visually in the landscape (it varies according to the different weather circumstances). Also because of the dull color the sunlight doesn't reflect on the blades.

The Wind Turbine Generator is provided with an electricity cabin.

3.3.2.5 Foundations

The suppliers of the Wind Turbine Generator will also construct the foundations. Local sub - contractors will actually do the local works. The supplier does the conceptualization and he is in control of the execution, but the practical execution is done by a sub - contractor. An investigation of the quality of the soil must be done in advance. Based on the results of this soil research the design of the foundation will be constructed. Also the length of the haying poles will be based on this examination.
The exact total cost of the foundations will only be known after the soil examination.

Before starting the foundation works, the soil quality must be examined together with geological probes. Based on these results, the foundation plans will be elaborated. Generally, the foundations are installed on piles of about 12 meters long.

A soil probe is the insertion of a probe in the environment in order to determine the characteristics. It's essential to probe the soil during the construction of the wind turbine foundations.

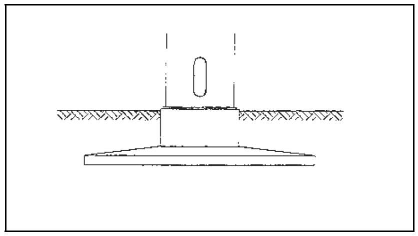
A geotechnical report will be drawn up based on the analyzed data from a specialized probe agency. This report includes a calculation of the friction force of the probe, in conformity with international standards and local norms. The probe force must be superior to the loads the wind turbines are supporting.

Based on the calculations, the type and quality of the concrete will be deducted along with other specifications needed for the construction of the foundation.

3.3.2.5.1 Foundation concept

Wind turbine foundations differ depending on local soil conditions.

The most prevailing foundation is the foundation of gravity.



A typical foundation of gravity consists of a concrete socle with a central concrete attachment.
Stability against the dash of inversion is ensured by the weight of the wind turbine, the structure of the concrete and the anchoring.
A foundation of gravity is appropriate for almost all the types of grounds, from sand to clay or rock. It is not appropriate on very movable ground like mud, and for types of soft clay in which change of the water concentration can cause a depression.

In this project a gravity foundation will be constructed because of the rocky underground. However, when the provision of concrete is limited, rock anchors can be used.
The anchors are usually fixed to the rock by injection of adhesive epoxy. Injected cement or extensions of bolts can also be used. A concrete socle provides the interface of the mast.

3.3.2.6 The Construction of Access Roads

Every Wind turbine generator must be accessible for maintenance. We plan the construction of an access road that can carry the loads of a small truck. The roads can be asphalted or can consist of small rocks and must be at least 4,5 m large. An access road in stone is sufficient, but not stable on the long run. Better is to foresee an extra layer of asphalt.

The road construction works can be carried out by local sub - contractors. The price depends on the length and the largeness of the roads.

3.3.2.7 Connection to the Electricity Grid

The transformer of the Wind turbine generator is delivered together with the turbine and is – depending on the size and type of WTG - installed in the nacelle of the WTG or on the ground next to the WTG. This transformer is used to transform the low tension that is generated by the Wind turbine generator into a high tension of 12 kV or 15 kV.

From this point high-tension cables must be installed from the turbine to the central connection point. This will necessitate transmission lines to the nearest access point.

Westenwind NV, in collaboration with local contractors, will make the design and calculations.

3.3.2.8 Telephone Connection

A telephone connection to the turbine is necessary. The control of the Wind turbine generator is assured by a modem connection. In this way, all data concerning the turbine can be seen on –line. With the help of a monitoring system it is possible for the supplier of the Wind turbine generator to survey them and to take immediate action when a problem occurs, to foresee necessary reparations and to avoid that the turbine stops running. Also, the customer/owner can receive daily information about the Wind turbine generators. The software for the control of the Wind turbine generator is offered for free by the supplier.

The Wind turbine generator must have a telephone connection. Cables must be installed in place. The actual installation of these cables can be done at the same time, together with the installation of the high-tension cables. This reduces the costs.

3.3.3 Visualisation

Technically it is possible to simulate a picture of the project site together with the wind turbine. But as we didn't have sufficient data to do so in a good manner, we decided not to make a visualization yet.

Instead, we've inserted a picture of an existing wind turbine site resemblant to this project site. This to give an idea of what it might look like after erecting the wind turbine.

This picture has been taken in France, Gavray at a distance of about 150 m from the wind turbine. The wind turbine has a mast height of approximately 40 m, and blades with a length of 14 m.

not to scale

3.3.4 Area to be affected by the undertaking

3.3.4.1 Noise Impact

Noise is a minor problem today.

It is interesting to note that the sound emission levels for all new Danish turbine designs tend to cluster around the same values. This seems to indicate that the gains due to new designs of e.g. more quiet rotor blade tips are spent in slightly increasing the tip speed (the wind speed measured at the tip of the rotor blade), and thus increasing the energy output from the machines.

The concepts of sound perception and measurement are not widely known to the public, but they are fairly easy to understand, once you get the grip of it. You can actually do the calculations by yourself in a moment.

3.3.4.1.1 Human Perception of Sound and Noise

Most people find it pleasant listen to the sound of waves at the seashore, and quite a few of us are annoyed with the noise from the neighbor's radio, even though the actual sound level may be far lower.

Apart from the question of your neighbor's taste in music, there is obviously a difference in terms of information content. Sea waves emit random "white" noise, while your neighbour's radio has some systematic content which your brain cannot avoid discerning and analyzing. If you generally dislike your neighbor you will no doubt be even more annoyed with the noise. Sound experts for lack of a better definition define "noise" as "unwanted sound".

Since the distinction between noise and sound is a highly psychological phenomenon, it is not easy to make a simple and universally satisfactory modeling of sound phenomenon. In fact, a recent study done by the Danish research institute DK Teknik seems to indicate that people's perception of noise from wind turbines is more governed by their attitude to the source of the noise, rather than the actual noise itself.

3.3.4.1.2 Measuring and Calculating Sound Levels

The dB(A) Scale:

Public authorities around the world use the so-called dB(A), or decibel (A) , scale to quantify sound measurement. To give you an idea of the scale, look at the table below.

Sound

	Level threshold of hearing	Whisper	talking	city traffic	rock concert	jet engine
10 m away						
dB(A)	0	30	60	90	120	150

The dB(A) scale measures the sound intensity over the whole range of different audible frequencies (different pitches), and then it uses a weighing scheme which accounts for the fact that the human ear has a different sensitivity to each different sound frequency. Generally, we hear better at medium (speech range) frequencies than at low or high frequencies. The dB(A) system says, that the sound pressure at the most audible frequencies are to be multiplied by high numbers while the less audible frequencies are multiplied by low numbers, and everything is then added up to get an index number.

(The (A) weighing scheme is used for weak sounds, such as wind turbines. There exist other weighing schemes for loud sounds called (B) and (C), although they are rarely used).

The dB-scale is a logarithmic, or relative scale. This means, that as you double the sound pressure (or the energy in the sound) the index increases by approximately 3. A sound level of 100 dB(A) thus contains twice the energy of a sound level of 97 dB(A). The reason for measuring sound this way is that our ears (and minds) perceive sound in terms of the logarithm of the sound pressure, rather than the sound pressure itself.

Most people will say, that if you increase the dB(A) by 10, you double the subjective loudness of the sound.

3.3.4.1.3 Sound Propagation and Distance: Inverse Square Law

The energy in sound waves (and thus the sound intensity) will drop with the square of the distance to the sound source. In other words, if you move 200 m away from a wind turbine, the sound level will generally be one quarter of what it is 100 m away. A doubling of your distance will thus make the dB(A) level drop by 6.

At one rotor diameter distance (80 m) from the base of a wind turbine emitting 100 dB(A) you will generally have a sound level of 55-60 dB(A) corresponding to a (European) clothes dryer.
A typical 600 kW wind turbine will emit noise levels of 55 dB(A) at a 50-m distance, which is reduced to 45 dB(A) at a distance of 250 m.

In practice, sound absorption and reflection (from soft or hard surfaces) may play a role on a particular site, and may modify the results indicated here.

3.3.4.1.4 Adding Sounds from Several Sources

If we have two wind turbines rather than one, located at the same distance from our ears, naturally the sound energy reaching us will double. As we have just learned, this means that two turbines will increase the sound level by 3 dB(A). Four turbines instead of one (at the same distance) will increase the sound level by 6 dB(A). You will actually need ten turbines placed at the same distance from you, in order to perceive that the subjective loudness has doubled (i.e. the dB level has increased by 10).

3.3.4.1.5 Wind Turbine Noise Information in Practice

In accordance with international standards manufacturers generally specify a theoretical dB(A) level for sound emissions which assumes that all sound originates from a central point, although in practice, of course, it will originate from the whole surface of the machine and its rotor.

The source level of the sound of the type of Wind turbine generator which will be selected for this project will be between 98 and 105 dB(A), during a wind speed of 8 m/s, measured at a height of 10 m. The figure itself is rather uninteresting, since there will not be a single point, where you can experience that sound level! Rather, it is useful for predicting the sound level at different distances from the wind turbine.

Pure tones have generally been completely eradicated for modern wind turbines, at least in the case of the modern turbines.

The distance between the Wind turbine generator and houses of third persons should be larger than 300 m. This is according to the most used distance rules in other countries. In this project the distance is at least 350 meters.

As the wind turbine generator is located more than 350 meters from the nearest residence, there should be no negative noise impact. The noise levels will not be audible at such a distance or only at a negligible level, if any.

3.3.4.1.6 Background Noise: Masking Noise Drowns out Turbine Noise

No landscape is ever completely quiet. Birds and human activities emit sound, and at winds speeds around 4-7 m/s and up the noise from the wind in leaves, shrubs, trees, masts etc. will gradually mask (drown out) any potential sound from e.g. wind turbines.

This makes it extremely difficult to measure sound from wind turbines accurately. At wind speeds around 8 m/s and above, it generally becomes a quite abstruse issue to discuss sound emissions from modern wind turbines, since background noise will generally mask any turbine noise completely.

3.3.4.1.7 The Influence of the Surroundings on Sound Propagation

Sound reflection or absorption from terrain and building surfaces may make the sound picture different in different locations. Generally, very little sound is heard upwind of wind turbines. The wind rose is therefore important to chart the potential dispersion of sound in different directions.

3.3.4.2 Shadow impact

A shadow appears when the sun is shining through the rotor of the wind turbine. In the area that lies in the projection zone of the rotor, it will be possible to see the shadow of the blades as an intermittent shadow.

In general, the shadow effect is the most intensive to the north, the west and the east of the wind turbine. On this degree of latitude the sun stands never firm in the north so the zone to the south of the wind turbine will experience only a very limited shadow effect.
The effect of the shadow is partly undone by trees, bushes and buildings close by. The more obstacles, the less shadow will be experienced.

These effects may be disturbing for local residents. However, by placing the individual wind turbine at a minimal distance of 300 m from residences, this effect should result in a negligible impact.
If it should appear that shadow is considered as a problem, a sensor will be installed. This technology allows the wind turbine to shut itself down, the moment that the shadow occurs. This technique can eliminate the shadow completely.

3.3.4.3 Landscape

Wind turbines are always highly visible elements in the landscape. Otherwise they are not located properly from a meteorological point of view.

Large wind turbines enable the same amount of energy to be produced with fewer wind turbines. There may be economic advantages to this, such as lower maintenance costs.

From an aesthetic point of view, large wind turbines may be an advantage in the landscape, because they generally have lower rotational speed than smaller turbines. Large turbines therefore do not attract the eye the way fast-moving objects generally do.

The tower and the blades have been designed with smooth lines of greater aesthetic value.
The dull white colour makes the wind turbine generator disappear in the landscape from a certain distance. Also, the dull colour prevents reflection of sunlight on the tower and the blades.

As the blades rotate relatively slowly, the wind turbine gives a restful impression.

To a large extent it is a matter of taste how people perceive that wind turbines fit into the landscape.

Numerous studies in Denmark, the UK, Germany, and the Netherlands have revealed that people, who live near wind turbines are generally more favorable towards them than city dwellers.

3.3.4.4 Birds

Birds often collide with high voltage overhead lines, masts, poles, and windows of buildings. They are also killed by cars in the traffic.

Birds are seldom bothered by wind turbines, however. Radar studies from Tjaereborg in the western part of Denmark, where a 2 megawatt wind turbine with 60 meter rotor diameter is installed, show that birds - by day or night - tend to change their flight route some 100-200 meters before the turbine and pass above the turbine at a safe distance.

In Denmark there are several examples of birds (falcons) nesting in cages mounted on wind turbine towers.

The only known site with bird collision problems is located in the Altamont Pass in California. Even there, collisions are not common, but they are of extra concern because the species involved are protected by law.

A study from the Danish Ministry of the Environment says that power lines, including power lines leading to wind farms, are a much greater danger to birds than the wind turbines themselves.

Some birds get accustomed to wind turbines very quickly, others take a somewhat longer time. The possibilities of erecting wind farms next to bird sanctuaries therefore depend on the species in question. Migratory routes of birds will usually be taken into account when siting wind farms, although bird studies from Yukon, Canada, show that migratory birds do not collide with wind turbines (Canadian Wind Energy Association Conference, 1997).

The project area is situated far from any area designated as a natural area. In the north, at about 60 km, the Bird Islands are situated, a home for hundreds of seabirds. This project will have no impact whatsoever on this protected area.

More information about avian collisions with wind turbines can be found in attachment.

3.3.4.5 Radar and other Radiation Paths

In the area where we foresee the wind turbine generator there are some radar and radio installations present. The WTG is positioned in such a manner so the radar and radio connections should not be annoyed in any way.

3.3.4.6 Airport

Because of the presence of the airport strip special considerations have been taken into account for the location of the WTG. The project site has been chosen in such a way in relation with the approach of the airport strip so safety can be guaranteed.
Further adjustmensts - such as providing the WTGs with warning lights – will be done on the advise of air traffic responsibles.

More information about lighting of WTGs can be found in attachment.

3.4. Construction

3.4.1 Construction period

From the time of obtaining the building and environmental permit, and the signing of a PPA, a period of nine months is needed to order the wind turbine itself. To construct the wind turbine and additional appliances, to connect the wind turbine to the diesel generator and to construct the road, an extra two to three months are needed.

3.4.2 Proposed date of first physical activities

The date of the first physical activity will be dependent on the time of obtaining the building and environmental permit, and the signing of a PPA.
We expect to obtain the permits in the first half year of 2003. Though, this depends whether an EIA will be requested. If not, construction should start in the spring of 2004 and setting in-service in the summer of 2004. If an EIA has to be made up, all projected dates will postpone with half a year.

3.4.3 Temporary building area

The supplier of the wind turbine generator prepares the temporary building area. One of the responsibilities is to ameliorate the accessibility of the building area during the construction phase. For building the WTGS an area of about 800 m² is needed.

3.4.4 Potential sources of pollution

During the period of construction, no harmful waste or pollutants are expected to be discharged. All necessary precautions and measures will be taken by the constructor to minimise disturbance to the site, to avoid and collect waste, to avoid oil or fuel spills, to control noise, vibrations and airborne emissions,…

The noise produced during the construction will have the most impact on the surroundings.

All sources of pollutants will be kept to a minimum by using only the newest materials and the best available techniques. Therefore civil works need to be coordinated. For this reason a local supervisor will be appointed. Also civil liability insurance must be provided.

To assure security on the work site a site security coordinator will be appointed. All necessary precautions will be taken to assure the security.

3.4.5 Potential causes of resource conflicts

As the closest surroundings of the project site are only used in an extensive way (berry picking, skidooing, hiking, wood lumbering), resource conflicts will be negligible. During the time of construction the project site and the access facilities will be temporarily inaccessible for inhabitants.

The habitation area of Charlottetown will be temporarily disturbed by the transportation of the building materials. The constructor will keep the level of disturbance to a minimum level.

3.5. Operation

3.5.1 Energy production

The amount of electricity produced by a wind turbine depends mainly on it's rated power and the prevailing wind speeds. The higher the rated power and the wind speeds, the more electricity produced.
The wind turbine will start generating from a wind speed of 3-4 m/s, the speed at which the turbine blades experience sufficient lift to begin rotating.

Wind turbines are designed to produce electrical energy as cheaply as possible. Wind turbines are therefore generally designed so that they yield maximum output at wind speeds around 15 m/s (30 knots or 33 mph). It does not pay to design turbines that maximize their output at stronger winds, because such strong winds are rare.

In case of stronger winds it is necessary to waste part of the excess energy of the wind in order to avoid damaging the wind turbine. All wind turbines are therefore designed with some sort of power control.

In case of wind speeds of 25 m/s or more, a control system will stop the wind turbine as wind conditions are too strong and can cause mechanical damages due to overspeed.

3.5.2 The Electronic Wind Turbine Controller

The wind turbine controller consists of a number of computers, which continuously monitor the condition of the wind turbine and collect statistics on its operation. As the name implies, the controller also controls a large number of switches, hydraulic pumps, valves, and motors within the wind turbine.

The controller communicates with the owner or operator of the wind turbine via a communications link, e.g. sending alarms or requests for service over the telephone or a radio link. It is also possible to call the wind turbine to collect statistics, and check its present status. In wind parks one of the turbines will usually be equipped with a PC from which it is possible to control and collect data from the rest of the wind turbines in the park. This PC can be called over a telephone line or a radio link.

There is a controller both at the bottom of the tower and in the nacelle. The communication between the controllers is done using fiber optics.

Computers and sensors are duplicated (redundant) in all safety or operation sensitive areas. The controller continuously compares the readings from measurements throughout the wind turbine to ensure that both the sensors and the computers themselves are OK.

It is possible to monitor or set somewhere between 100 and 500 parameter values in a modern wind turbine. The controller checks the rotational speed of the rotor, the generator, its voltage and current. In addition, lightning strikes and their charge may be registered. Furthermore measurements may be made of outside air temperature, temperature in the electronic cabinets, oil temperature in the gearbox, the temperature of the generator windings, the temperature in the gearbox bearings, hydraulic pressure, the pitch angle of each rotor blade (for pitch controlled or active stall controlled machines), the yaw angle (by counting the number of teeth on yaw wheel), the number of power cable twists, wind direction, wind speed from the anemometer, the size and frequency of vibrations in the nacelle and the rotor blades, the thickness of the brake linings, whether the tower door is open or closed (alarm system).

3.5.2.1 Controlling Power Quality from Wind Turbines

Most people think of the controller as the unit, which runs the wind turbine, e.g. yaws it against the wind, checks that the safety systems are OK, and starts the turbine. The controller does indeed do all these things, but it also looks after the power quality of the current generated by the wind turbine.

3.5.2.1.1 Grid Connection and Power Quality

Electricity companies require that wind turbines connect "softly" to the grid, and how they have certain requirements that the alternating current and voltage move in step with one another.

3.5.2.1.2 Reactive Power Control

Voltage and current are typically measured 128 times per alternating current cycle, (i.e. 50 x 128 times per second or 60 x 128 times per second, depending on the electrical grid frequency). On this basis, a so-called DSP processor calculates the stability of the grid frequency and the active and reactive power of the turbine. (The reactive power component is basically a question of whether the voltage and the current are in phase or not).

In order to ensure the proper power quality, the controller may switch on or switch off a large number of electrical capacitors, which adjust the reactive power, (i.e. the phase angle between the voltage and the current).

3.5.2.1.3 Electromagnetic Compatibility (EMC)

There are very powerful electromagnetic fields around power cables and generators in a wind turbine. This means that the electronics in the controller system has to be insensitive to electromagnetic fields. Conversely, the electronics should not emit electromagnetic radiation, which can inhibit the functioning of other electronic equipment.

3.5.3 Administration of the WTGs

There has to be set up an administration and the project has to be followed up. It is best that the administration of the project is done locally. However Westenwind will also follow up the Wind turbine generators, even if there is a 24/24 h assistance of the supplier of the Wind turbine generators.

The administration of the project consists mainly of the following tasks:

- Drafting monthly report on production
- Drafting monthly report on WTG - operation errors
- Drafting monthly report on interventions
- Follow up on maintenance
- Follow up on insurances
- Accountancy
- …

3.5.4 Guaranty and maintenance of the Wind turbine generator

The supplier offers a guarantee period of at least 2 years. This period can be extended so that the cost for the customer/owner is known almost completely from the beginning of the operation of the WTGs.

A yearly amount must be paid for the maintenance of the Wind turbine generator. It is best that the maintenance is done by the manufacturer of the turbine, in co-operation with the local company. This comprehends a routine maintenance and a daily following up of the Wind turbine generators. The cleaning of the blades is not included in the maintenance contract.

The price for the maintenance is always submitted to inflation.

3.5.5 Availability

During the period of guaranty the supplier of the Wind turbine generator guarantees the availability of the Wind turbine generators, or the time that the Wind turbine generator is running. The supplier guarantees availability for at least 95%.

When the customer suffers a loss of production, because the guaranteed availability is not reached (on yearly basis for the whole wind farm), this must be reimbursed by the supplier. A credit note is edited according to the electricity rates that are in force at that moment (PPA).

3.5.6 Insurances

The supplier can provide insurance for the breakdown of the machinery. In this case the supplier together with the maintenance contract provides the insurance. The insurance is contracted in the name of the turbine owner. This contains an extra guaranty. The cost of this insurance is comprehended in the cost of the maintenance contract.

An additional insurance for production losses can be taken. This insurance covers the losses of the company, when the Wind turbine generator stops running. The yearly cost of that kind of insurance is 0.8 on thousand of the yearly profits.

Civil liability insurance also must be taken into account. For this insurance an amount is estimated in analogy of an existing project.

3.5.7 Security aspects during the exploitation of the wind turbine

The components of a wind turbine are designed to last 20 years. This means that they will have to endure more than 120,000 operating hours, often under stormy weather conditions.

If you compare with an ordinary automobile engine, it usually only operates only some 5,000 hours during its lifetime. Large wind turbines are equipped with a number of safety devices to ensure safe operation during their lifetime.

In this part we give a summary of the relevant accident scenario's and the external risks linked to them.
We can deduct, based on the experiences of wind turbines in operation, that the external risks are mostly caused by one of the following accident scenarios :

- Excessive wind speeds can lead to a wind pressure that is too high. This can lead to a structural failing of the carrying structure of the wind turbine and thus to its collapse.

- Loss of the braking couple, provided by the generator; this causes the wind turbine to accelerate without control. If in addition to this, the braking system fails, the surplus of speed can cause the detachment and the throwing off of a blade, which will cause direct or indirect damage when it comes down.
- When there is an ice-formation on the rotor blades there is a possibility that ice is thrown around, which can cause direct or indirect damage.
- Lightning impact on a rotor blade of a (turning) wind turbine can, when the lightning security fails, cause a fragmentation of the blade end, which can result in fragments being thrown off, which can eventually cause some damage where they fall.

3.5.7.1 Structural Failing

Modern wind turbines are certified following the international standard IEC 61400, Wind turbine Generator Systems. The standard IEC614000 Part 1, Safety requirements, deals especially with safety aspects, and sets, starting from the concept of structural integrity, for which environmental conditions, for which cases of heavy loads and according to which safety factors the wind turbine must be designed. IEC61400 divides sites in to classes of wind regimes and determines for each class the maximum wind speeds that the wind turbine must be able to resist.

In Belgium the standard for all constructions is NBN B03-002-1, "Wind burdening on constructions –general- wind pressure to the side and combined wind effects on building constructions." This standard also defines, depending on the terrain conditions (class I up to IV), the extreme wind speeds, to which the constructions must be able to resist.

A comparison between the IEC and the NBN standard learns us that the IEC61400 nearly always uses a higher extreme wind speed than the NBN standard, certainly for the classes I and II of IEC and for axes on altitudes, that are common for wind turbines (50 m and higher).

This shouldn't surprise us, since IEC61400 works with the extreme wind speeds over the past 50 years and the NBN standard just uses data of the last 10 years. The NBN standard was conceived in such a way that the risks for structural failure are negligible. Otherwise every building would create an unacceptable risk.

We can conclude that, when IEC61400 is used, there is no risk for a structural failure of the wind turbines because of extreme wind speeds. The demands are stricter than for buildings. Structural failing will therefore not be treated any further.

3.5.7.2 Lightning Impact

Wind turbines are easily hit by lightning, because :

- They are up to 140 m of altitude;
- They are mostly erected in wide, open terrains;
- The blades and the nacelle are created in synthetic material, which are poor conducting materials.

In the framework of the IEC61400-series, there is at this moment, a specific part concerning the lightning security in preparation: "part 24 Lightning Protection". In any case, the modern wind turbines are equipped with a lightning safety protection that can conduct an eventual power boost caused by a lightning impact, to the earth conductor. This protects important parts of the machine. When this system fails; the blade that suffered the impact, could splinter and as a result fragments could be thrown away and cause damage.

Statistics, based on the number of lightning impacts and on the applied lightning protection, can be used to calculate the chance to extreme risks. The odds that a blade gets splintered and that fragments are thrown away from the turbine are approximately 2 out of 1000 for each turbine a year. This risk is much smaller than the risk caused by the throwing off of ice: The chance on the throwing away of ice is a factor 2000 higher without ice detection and 20 times higher with an ice detection system. The fragments that are thrown off are of the same order of magnitude. For these reasons we will deal no further with the lightning impact, and we shall look upon that risk as inferior compared to the risks caused by ice throwing.

3.5.7.3 Icing

Sites with icing events require turbines with heated wind sensors. A variety of heated wind sensors are available, tested and used at sites with frequent icing conditions. Blade heating may be necessary or profitable on sites having frequent icing or on sites with high safety requirements. The break-even cost of such a system depends on many turbine and location parameters

- Site specific parameters: the probability or the time of icing, the wind resources, safety precautions required in the planning or permission granting process
- Turbine specific: the effect of the icing on the turbine power curve and production
- Economic: value of the produced energy

A simple approach to estimate the break-even conditions has been developed by Peltola et. at.. A number of different approaches for the blade heating have been presented, developed and tested. Current practice indicates that in heavy icing conditions the outer surfaces of the blades need to be heated in order to achieve satisfactory results. There have been a number of other proposed solutions, like blade-heating systems based on microwave technology but to date they have not been successfully implemented.
At the present moment there are some commercially available solutions. The Finnish blade heating system, where carbon fiber elements are mounted to the blades near there surface, has the widest operating experience, from 18 turbines at various sites, with a total of nearly 100 operating winters.
In sites where icing is slight, infrequent and the icing periods are most likely followed by temperature rising above 0°C, blades coated with black paint may be sufficient, making use of the eventual solar radiation. Stopping the turbine and circulating heated air inside the blades may be adequate in slight icing conditions. Stopping the wind turbine when icing starts may also be a sufficient solution in such environments, although ice detectors are then required.
(internet site Wind energy in cold climates)

3.5.7.4 Blade Fraction

Blade fraction is the most likely when the rotor of the wind turbine starts to accelerate at an uncontrolled speed, causing the mechanical powers in the blades to rise until the blade breaks off and is thrown away. An augmentation of speed can only emerge when the braking couple of the engine doesn't work, which causes a disconnection from the grid, and when, in addition to that, the braking system of the wind turbine fails.

To protect the surroundings against those problems, the designers put significant attention into the construction of the braking systems. The following methods can be seen as representative for modern wind turbines.

- With stall-controlled systems the wind turbine has tip brakes, these are turnable blade ends, which have to be put in a 90° position to stop the wind turbine. The three tip brakes are controlled by the same (mostly hydraulic) device. A separate mechanical brake that intervenes on the generator axe assures redundancy.
- With a pitch controlled system the complete blade is turnable around its longitudinal axe. 2 of the 3 blades in vane position are sufficient; each blade has its own actuator (electrical or hydraulic motor). Here we also have a mechanical brake system.

The aero dynamical or the mechanical brakes can be controlled by the normal control system of the turbine and by the security system. Both differ on the level of sensors and electronics, but use the same actuator, and are thus not completely independent.

3.5.8 Period of operation

A wind turbine is supposed to last a least 20 years. Of course this depends on the extremity of local weather conditions. The stronger and the more irregular the winds, the faster a wind turbine will wear out.
After 20 years the wind turbine will be revised and possibly, with some equipment upgrading, continue to generate efficiently.

3.5.9 Potential sources of pollutants

Wind energy is a clean energy source. No airborne or other pollutants are emitted during the operation of the wind turbine.

By installing a wind turbine and using wind energy a certain amount of conventional (read: based on fossil fuels) electricity, can be saved.

By this the following rate of emissions, caused by generating conventional electricity, can be avoided. These figures are based on a wind turbine of 660 kW and the hypothesis of 3000 FLEH (Full Load Equivalent Hours):

		Annual		
		Min.	**Average**	**Max.**
Production:	in GWhours	1,68	1,98	2,28
Saving natural gas:	in Nm3	163.456	192.302	221.147
Saving CO2:	in tons	920	1.082	1.244
Saving SO2	in tons	5,0	5,9	6,8
Saving NOx:	in tons	2,2	2,6	3,0

3.5.9.1 Potential causes of resource conflicts

As the surroundings of the project site are only used in an extensive way (berry picking, skidooing, hiking, wood lumbering), resource conflicts will be negligible

It will be possible to continue those activities, even in the close surroundings of the wind turbine site.
See above: 3.3.4 Area to be affected by the undertaking

3.6. Occupations

The construction of the wind turbine will require an assortment of occupational trades.
To build the access roads, to prepare the foundations, to erect the wind turbine, to connect the wind turbine to the diesel generator,….the following trades will be required:

Labourers
Engineers
Iron workers
Electricians
Concrete workers
Millwrights
Line workers
Operators
Heavy equipment
Crane operators
Safety coordinator

The project is expected to generate a half-time job associated with the operation and the maintenance of the wind turbine.

3.7. Project related documents

National Wind Coordinating Committee (2001) *Avian collisions with Wind Turbines: A Summary of Existing Studies and Comparisons of Avian Collision Mortality in the United States*

International Civil Aviation Organization (1999) *Aerodromes, International Standards and Recommended Practices – Annex 14 to the convention on international civil aviation*

4 APPROVAL OF THE UNDERTAKING

The following is a list of the main permits required for the undertaking, together with the names of the authorities responsible for issuing them:

Permit	Authority
Building permit	Municipal council
Environmental permit	Department of Environment
Application to construct a road right-of-way on Crown Land	Department of Government Services and Land
License to occupy (wind measuring mast)	Department of Government Services and Land
Crown land lease agreement (wind turbine site)	Department of Government Services and Land

5 SCHEDULE

We expect to complete the requirements of the Environmental Assessment Act within the next six months. Within 45 days of having received the registration, the Minister of Environment will advise us of their decision of the proposal. When an Environmental Impact Statement is required,we will need a couple of months to gather information, to analyze data and to draw up the EIS. If an EIS is not required, we expect to complete the procedure within the next three months.

6 FUNDING

Up to now no grants or loans of capital funds have been requested.

Westenwind NV is responsible for setting up the required funding for the project.
In order to increase the involvement of the community in WTG project, it would be interesting to enable individuals or local institutions to participate in the operation of wind energy co-operatives.

This goal corresponds to the original goal of Westenwind NV. As a matter of fact, Westenwind NV was first established as a co-operative limited liability company which aim was to attract partners to invest in wind energy projects.

6.1. Model

Practical experience was first gained through the company Middelwind CVBA (www.surf.to/middelwind). Westenwind NV together with the Electricity Company and inhabitants of the local community set up a new co-operative company in order to own and operate a 660 kW wind turbine in Middelkerke, on the Belgian coast. Westenwind possess 20% of the capital. Frederik De Smet, president of Westenwind NV, wrote the founding contract and the business plan. Westenwind NV has planned to increase her participation into the company capital in the near future. In addition to that, as soon as the required permits are delivered, two more turbines are expected to be installed and financed by this very same company.

This model could be appropriate for the present situation: for this project, an SPC will be -founded wherein local individuals can become shareholders. This company will be in charge of the exploitation and operation of the wind farm.

6.2. Management

The possibility shall be offered to individuals to be part of the board of directors of the company. The members of this Board are elected by the General Assembly.

Among those representatives, the president of the company, the chairperson and a secretary are elected. In addition to that, a person is chosen to be in charge of the communication and information towards the local inhabitants and interested people.

7 REFERENCES

Internet sites:

- Environment Canada: http://www.ns.ec.gc.ca/index_e.html
- World of Education: http://www.educationworld.net/index.html
- Government NF&L: http://www.gov.nf.ca/agric/default.htm
- Newfoundland and Labrador Heritage: http://www.heritage.nf.ca/environment/ecoregions_lab.html
- Wind Enery in Cold Climates: http://www.vtt.fi/virtual/arcticwind/index.htm

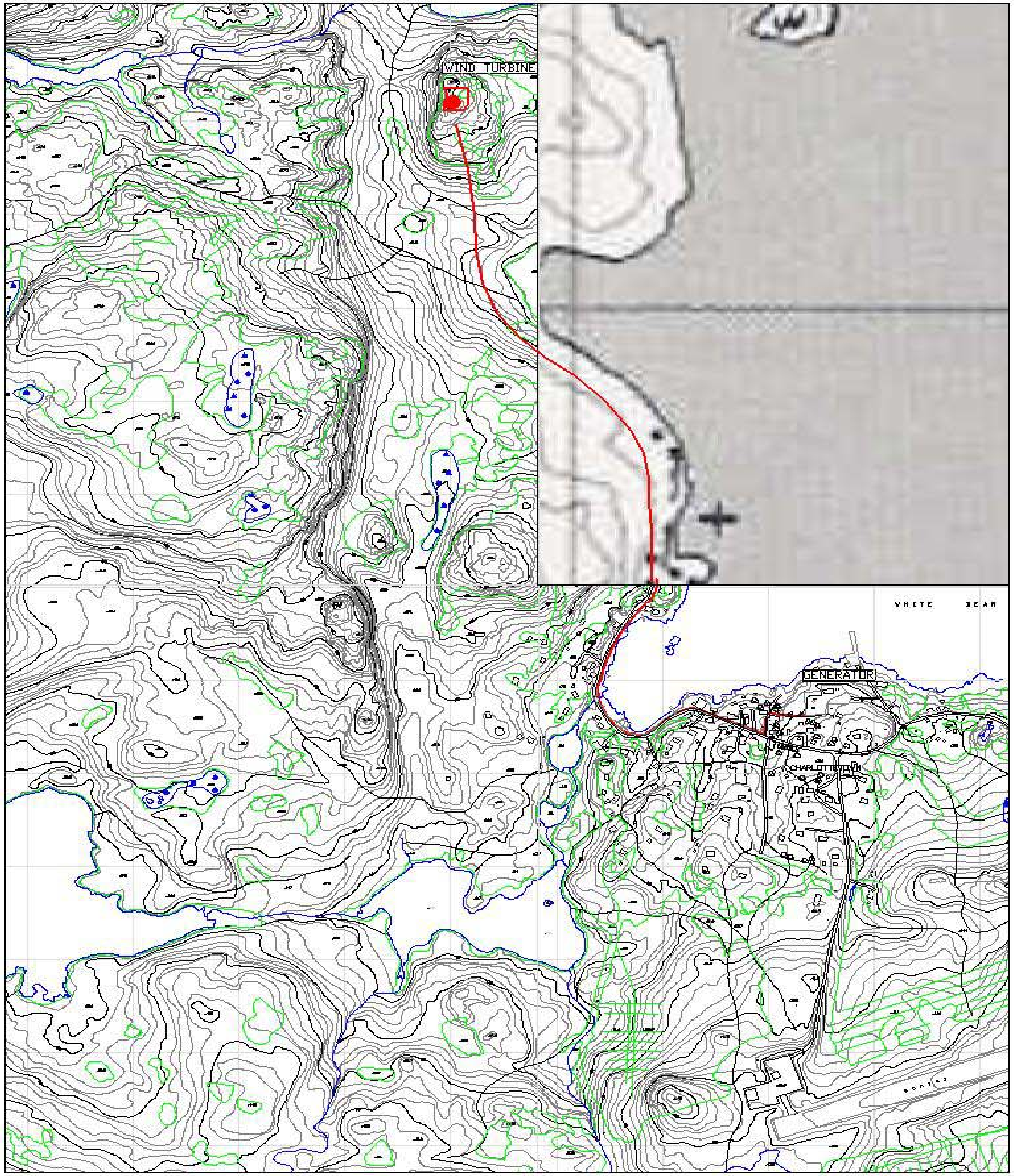
American Wind Energy Association (AWEA) – internetsite: http://www.awea.org/

F.B. Watts (1968) Canada – A geographical interpretation edited by John Warkentie (Canadian Association of Geographers)

APPENDIX

1. **Site Map**
2. **Avian collisions with wind turbines**
3. **Aerodromes: International Standards and Recommended Practices**

1. Site map



CHARLOTTETOWN
1/10.000

LEGEND
WINDTURBINE
INFRASTRUCTURE

SITUATION 1/30.000

Country:	CANADA
State:	NEW FOUNDLAND – LABRADOR
Community:	CHARLOTTETOWN
Contractor:	WESTENWIND nv Brugsesteenweg 5-7 B – 9000 GENT BELGIUM
Contact:	Stijn VAN DE WIELE
Email:	stijnvdw@westenwind.be
Signature:	Frederik DE SMET (director) tel 0032 9 329 87 00
	IMPLANTATION – MASTERPLAN (FASE 1)
Concept:	THE IMPLANTATION OF ONE WINDTURBINE
Situation:	in the surroundings of the community of CHARLOTTETOWN
	INSTALLATION OF 1 WINDTURBINE WITH AN INDIVIDUAL RATED CAPACITY OF 225 – 660 KW HEIGHT 30 – 60m ROTOR 30 – 50m
	scale : 1/10.000 – 1/30.000 date : January 2003 plan n° : Plan 02 dossier : CHARLOTTETOWN

2. Avian collisions with wind turbines

Avian Mortality due to Collisions with Wind Turbines

Many of the early avian/windpower interaction studies involved examining impacts associated with single, large experimental turbines. The first study of avian/windpower interactions took place in Sandusky, Ohio, where a single large turbine was monitored for avian mortality during four migratory seasons. Two dead birds were found during this period (Gauthreaux 1994). Two large experimental turbines and a meteorological tower in Wyoming were monitored for avian mortality in the early 1980's. Twenty-five fatalities were found over a one-year period, most of them involving passerines that had collided with guy wires on the meteorological tower (U.S. Bureau of Reclamation 1984). At a single, 60-m tower wind turbine in Solano County, California, seven fatalities were documented from September 1982 to January 1983, and the total fatality estimate with adjustments for scavenger removal and searcher efficiency was estimated at 54 birds (Byrne 1983, 1985).

The first large-scale wind energy development took place in California. In response to several reported incidents of avian collisions, the California Energy Commission (CEC) obtained data on bird strikes at the Altamont and Tehachapi windplants through interviews and review of unpublished data collected over a 4-year period from 1984 to 1988 (CEC 1989). This study documented 108 raptor fatalities of seven species. Collisions with windplant structures accounted for most of the avian fatalities (67%), including 26 golden eagles and 20 red-tailed hawks. Several subsequent studies were initiated to further examine windplant-related fatalities at California windplants. Many of these studies have been conducted at Altamont Pass, where more than 5,000 turbines exist within the WRA. In general, these studies focused on obtaining raptor fatality estimates with other bird fatalities recorded coincidentally. An early 2-year study

documented 182 bird deaths on study plots, 68% of which were raptors and 26% of which were passerines. The most common raptor fatalities were red-tailed hawk (36%), American kestrel (13%), and golden eagle (11%). Causes of raptor mortality included collisions with turbines (55%), electrocutions (8%), and wire collisions (11%) (Orloff and Flannery 1992). Based on the number of dead birds found, the authors estimated that as many as 567 raptors may have died over the 2-year period due to collision with wind turbines.

Further investigations at Altamont continued to document levels of raptor mortality sufficient to cause concern among wildlife agencies and others. During a study at Altamont, Howell (1997) found 72 fatalities over an 18-month period, of which 44 were raptors. Most of the remaining fatalities were passerines. Other avian groups with some mortality at Altamont included waterfowl, waterbirds, and doves, especially rock doves. During a one-time search of turbines included in the original 1992 Altamont study, Orloff and Flannery (1996) found 20 carcasses, including 15 raptors, two ducks, two rock doves, and one common raven. From 1998 to 2000, Thelander (2000, pers. comm.) documented 256 fresh bird carcasses at Altamont. Most (54.3%) of the fatalities were raptors, 25.0% were passerines, 18.0% were doves, and the remaining 2.8% were waterfowl and waterbirds. Many of the fatalities at Altamont have been golden eagles, and annual golden eagle mortality at this facility has been estimated to range from 25 (Howell and Didonato 1991) to 39 (Orloff and Flannery 1992). Population modeling suggests that the local golden eagle population may be declining in the Altamont region, at least in part due to windplant mortality (Hunt *et al.* 1999), with other sources (e.g., expanded housing developments and landfills, road and industrial park development and a new reservoir) also considered possible contributors. Not all studies have documented high relative proportions of raptor fatalities compared to other avian groups (e.g., passerines) at Altamont. During an experiment to assess effects of painting turbine blades in an effort to reduce collisions, Howell *et al.* (1991b) found 10 dead birds, of which only one was a raptor; however, this study was of short duration and was based on small sample sizes.

Avian mortality has also been documented at other California windplants. Researchers estimated 6,800 birds were killed annually at the San Gorgonio wind facility based on 38 dead birds found while monitoring nocturnal migrants. McCrary *et al.* (1983,1984) estimated that 69 million birds pass through the Coachella Valley annually during migration; 32 million in the spring and 37 million in the fall. The 38 avian fatalities were comprised of 25 species, including 15 passerines, seven waterfowl, two shorebirds, and one raptor. Considering the high number of passerines migrating through the area relative to the number of passerine fatalities, the authors concluded that this level of mortality was biologically insignificant (McCrary *et al.* 1986a). During a more recent 15-month study at San Gorgonio, Anderson (2000a, pers. comm.) documented 42 fatalities including nine waterfowl, five owls, six passerines, six rock doves, two waterbirds, two diurnal raptors and one shorebird, during quarterly searches of approximately 360 turbines. The waterfowl and shorebird mortality generally occurred when water was present in the vicinity of the wind resource area, attracting large numbers of waterfowl and shorebirds. At Montezuma Hills, field surveyors identified 13 confirmed collision fatalities, 9 of which were raptors during the 10-month period from November 1994 to September 1995 in a study that included 76 turbines (Howell 1997). Howell and Didonato (1991) searched 359 turbines in Alameda and Contra Costa Counties over a 1-year period and found 42 avian fatalities, of which 25 were assumed turbine strikes. Seventeen of the 25 fatalities were raptors, with the other fatalities consisting primarily of passerines and rock doves. In Solano County, Howell and Noone (1992) studied 237 turbines (178 from April 1990 to December 1990) from the spring of 1990 to the spring of 1992, and found a total of 22 fatalities, 14 of which were raptors. At Tehachapi Pass, Anderson (2000b, pers. comm.) documented 147 avian fatalities including 50 passerines, 28 diurnal raptors, and 18 owls during quarterly searches of approximately 700 of the 3,000 turbines at the windplant.

Some studies at California windplants have documented apparently very low avian mortality. No avian fatalities were found during a one-time survey of 156 turbines at Tehachapi Pass in 1991 (Orloff 1992), and nine raptor fatalities were reported over a 6-year period (1984-1989)(CEC 1989). No raptor fatalities were found during a two-year study at SeaWest's Mojave Park windplant, Tehachapi Pass (Colson and Associates 1995). The high levels of raptor mortality associated with some California windplants have not been documented at windplants constructed in other states. No avian fatalities were documented during a 9-month study of three wind turbines near Algona, Iowa (Demastes and Trainer 2000). Similarly, no avian fatalities were found during a 4-month study of 11 turbines at Searsburg, Vermont (Kerlinger 1997). No fatalities were found during a 6-month study of 8 turbines in Somerset County, Pennsylvania. During a 2-year study of 29 turbines in northern Colorado, nine avian fatalities, comprised of eight passerines and one duck, were documented (Kerlinger and Curry 1999, Kerlinger *et al.* 2000b). At the 73-turbine Phase I windplant on Buffalo Ridge, Minnesota, eight collision fatalities were documented during the initial two-year period of operation (Higgins *et al.* 1996). The fatalities consisted of one ruddy duck, one Franklin's gull, one American coot, one yellow-bellied sapsucker, and four passerines. The estimated total number of annual fatalities for the entire windplant was 36 (Osborn *et al.* 2000), equivalent to an annual mean of 0.49 collisions per turbine per year. A more extensive study of this windplant plus two additional windplants on Buffalo Ridge totaling over 350 turbines was conducted from 1996 through 1999. Total annual mortality was estimated to average 2.8 birds per turbine based on the 55 fatalities found during the study. Only one raptor, a red-tailed hawk, was found during the 4-year monitoring period. Most of the fatalities were passerines (76.4%), followed by waterfowl (9.1%), and waterbirds and upland gamebirds (5.5% each) (see Appendix G for species composition). Many of the fatalities documented were nocturnal migrants (Johnson *et al.* 2000b). Radar studies at Buffalo Ridge (Hawrot and Hanowski 1997) indicate that as many as 3.5 million birds per year may migrate over the wind development area (Johnson *et al.* 2000b). The largest single mortality event reported at a U.S. windplant was fourteen nocturnal migrating passerines at two turbines at the Buffalo Ridge, Minnesota Windplant during spring migration. We are not aware of any other mortality events greater than a few birds at single or adjacent turbines found during a single search.

At a windplant recently completed in Carbon County, Wyoming, total mortality associated with the 69 turbines and 5 meteorological towers was estimated to be approximately 159 birds per year based on the 95 turbine collision fatalities actually found during the first two years of operation (Johnson *et al.* 2001). Mean annual mortality was estimated to be 1.75 birds per turbine and 0.036 raptors per turbine per year. Of the 95 fatalities found during the first year of operation, raptors comprised only 5.2%, whereas passerines comprised 91%. Furthermore, while many of the fatalities at this location were nocturnal migrant passerines (Johnson *et al.* 2001), the largest number of carcasses detected at a turbine during one search was two. At a 38-turbine

windplant recently completed on Vansycle Ridge, Oregon, 12 avian fatalities were located during the first year of operation. The 12 avian casualties were comprised of at least six species, and most of the fatalities (58%) were passerines. Total estimated mortality was 24 birds per year, or 0.63 birds per turbine per year. No raptors were among the fatalities (Erickson *et al.* 2000a).

We summarize the species composition of avian fatalities from most windpower studies reported above (Appendix G). Composition of fatalities is most likely biased towards larger birds, since small birds are more difficult to detect and scavenging of small birds can be expected to be higher (e.g. Johnson *et al.* 2000b). Table 1 contains a description of the studies included in the species composition analysis as well as those used in the fatality projections. Of 841 avian fatalities reported in Appendix G from California studies, 41.5% were diurnal raptors, 20.1% were passerines (excluding house sparrows and European starlings), and 11.1% were owls. Non-protected birds including house sparrows, European starlings, and rock doves comprised 16.6% of the fatalities. Other avian groups generally made up <10% of the fatalities. Outside of California, diurnal raptor fatalities comprised only 2.7% of the windplant-related fatalities. Passerines (excluding house sparrows and European starlings) were the most common collision victims, comprising 78.0% of the 192 fatalities documented (Table 2). Other groups each comprised <10% of the fatalities. Low and high range percentages of nocturnal migrant fatalities are reported in Table 2. Ranges are reported due to difficulty in determining whether a fatality found during migration is a resident breeder or a nocturnal migrant passing through the area, and whether the fatality occurred during the night. The low range includes known migrants; the high range includes fatalities that could possibly be migrants (e.g., unidentified passerines, resident breeders found during early/late breeding period during migration). Unlike California, where less than 11% (range 3% to 10%) of the number of fatalities were classified as nocturnal migrant passerines, as many as 59.9% (range 34.4% to 59.9%) of the avian collision victims elsewhere are likely nocturnal migrants (Table 2). The percentage of the total number of fatalities comprised of likely nocturnal migrants has ranged from a low of 19.0% at the Wisconsin windplant to a high of 48.0% at the Foote Creek Rim, Wyoming, windplant.

These data suggest that while turbines are generally below the flight altitude of most nocturnally migrating birds, weather and other factors that reduce migrating bird flight altitudes may result in collisions with wind turbines as well as other artificial structures. This appears to be more likely outside of California, although as stated previously, we are aware of only one mortality event of more than a few fatalities found below wind turbines during a single search. There are not many reports of single mortality events (greater than a few birds) at communication structures less than 500 feet (150 m) in height (Kerlinger 2000; Manville 2000, pers. comm.). Most new wind turbines are less than 350 feet to the tip of the blades and do not have guy wires. Guy wires associated with communication towers have been considered a major source of the mortality problem. The largest single event reported at a wind generation facility was fourteen nocturnal migrating passerines at two turbines at the Buffalo Ridge, Minnesota Windplant during spring migration. Therefore, although some nocturnal migrants have been killed by wind turbines, we believe large mortality events at windplants are unlikely. Fatality data collected at many of these newer windplants with large turbines will continue to provide information regarding this issue.

Summary of Windpower Fatality Estimates

For all avian species combined, estimates of the number of bird fatalities per turbine per year from individual studies have ranged from 0 at the Searsburg, Vermont (Kerlinger 1997) and Algona, Iowa sites (Demastes and Trainer 2000) to 4.45 on the Buffalo Ridge, Minnesota Phase III site (Johnson *et al.* 2000b) (Table 3). The Phase III Buffalo Ridge site estimate was based on one field season (1999) and was greatly influenced by a fatality event involving 14 warblers, vireos and flycatchers observed during a May 17 carcass search of two turbines (Johnson *et al.* 2000b). Avian fatality rates were much lower at the Buffalo Ridge Phase I and II sites, where several years of data were collected (Osborn *et al.* 2000, Johnson *et al.* 2000b).

Table 4 contains the average fatality estimates for each wind resource area, the overall estimate of bird collisions per turbine per year for all sites, and total fatality projections based on the approximate estimate of 15,000 operational wind turbines in the U.S. by the end of 2001. The average number of avian collision fatalities per turbine is 2.19 per year. Therefore, on average, we estimate approximately 33,000 birds (range 10,000 to 40,000) die annually from collision with wind turbines in the United States (assuming 15,000 turbines). Species composition data indicate that approximately 14.0% of the projected fatalities are non-protected birds (house sparrows, European starlings and rock doves), and excluding these non-protected species yields an estimate of approximately 28,500 (protected) birds. We estimate approximately 6,400 birds will die annually outside California at the 3,500 turbines estimated to be in operation by the end of year 2001 (Table 4). Species composition data outside California indicate 3.3% of the projected fatalities are non-protected birds; excluding these non-protected species yields an estimate of approximately 6,200 avian fatalities per year.

Because much attention has been given to the issue of raptor/windpower interaction, we also developed separate fatality estimates for raptors. Estimates of raptor fatalities per turbine per year from individual studies ranged from 0 at the Vansycle, Oregon; Searsburg, Vermont; Ponnequin, Colorado; Somerset County, Pennsylvania; and Buffalo Ridge, Minnesota, Phase II and Phase III sites, to 0.10 per turbine per year at the Altamont, California site (Thelander 2000, pers. comm.) (Table 3). Based on these statistics and the estimated total number of operational turbines by the end of 2001, we estimate that approximately 488 raptors are killed annually by turbines in the United States, nearly all in California. We project raptor mortality at windplants outside California to be 20 per year based on 1 raptor found at Buffalo Ridge, Minnesota over a 6-year period and 5 raptors found at the Phase I Foote Creek Rim, Wyoming facility during a two-year study of 69 turbines (Table 4).

DISCUSSION

Using the annual avian collision mortality estimate of 200-500 million, we estimate that at the current level of development, wind turbines constitute 0.01 percent to 0.02 percent (1 out of every 10,000 to 2 out of every 10,000) of the avian collision fatalities. Communication tower fatality estimates make up 1-2 percent (1 out of every 100 or 2 out of every 100) using the conservative estimates of 4 million annual avian fatalities due to collisions with these structures. The low range estimate from buildings/windows of 98 million (Klem 1991) would comprise approximately 25 to 50 percent of the collision fatalities. The low range estimate of 60 million

vehicle collision fatalities comprises 15-30% of the total estimated collision fatalities. Our very wide range for estimates of powerline collision fatalities (>10,000 – 174 million) makes it extremely difficult to quantify the percentage of total fatalities due to this source. Nevertheless, we expect the total collisions with powerlines to be much higher than the total collisions with wind turbines given the number of miles of high-tension lines that exist across a wide range of habitats in the U.S. Given the uncertainty in the estimates, the true avian mortality, especially for communication towers, buildings and windows, powerlines and roads, could easily be different by several orders of magnitude.

Many of the collision mortality studies for other sources were conducted in response to a known or perceived risk and therefore are probably not appropriate for extrapolation in the same manner we extrapolated for wind turbines. However, it has been argued by several researchers making mortality projections that their estimates are probably conservative (underestimates), given that scavenging and searcher efficiency biases have generally not been incorporated into the estimates. For example, Banks' (1979) estimate of vehicle mortality was based on the Hodson and Snow (1965) estimate of 15.1 birds per mile (9.4 bird/km), which was based on weekly surveys that did not adjust for scavenging and searcher efficiency.

Several potential biases may also exist with windpower-related fatality estimates. We have assumed the fatality estimates provided for individual studies are representative of the true fatality estimates of other windplants that were not sampled. We currently do not have any data from Texas, where a relatively large number of turbines are present. If bird mortality is large (or small) relative to mortality at the windplants we used in our estimates (~2 birds per turbine per year which includes European starling and rock doves), we may be underestimating (or overestimating) the total number of avian fatalities due to wind turbines in the United States. Furthermore, bird fatality estimates are primarily based on studies conducted outside of California, since the focus of most studies in California has been on raptors. The estimate of approximately 2 birds per turbine per year was applied to all 15,000 turbines expected to be in operation throughout the United States at the end of 2001. A relatively high level of uncertainty exists in these estimates due to the lack of detailed fatality monitoring of small birds at Altamont and Tehachapi Pass. Distance between search transects for most studies at Altamont (e.g., Howell and Noone 1992, Howell *et al.* 1991) was greater than the 10 to 20 feet distances used in many of the more recent studies at Altamont and at other windplants outside California (Johnson *et al.* 2000b, Johnson *et al.* 2001, Erickson *et al.* 2000b, Thelander 2000, pers. comm). All studies at Altamont including Thelander (2000, pers. comm.) documented fewer small bird/passerine fatalities relative to raptor fatalities when compared to results from most studies at other windplants The lack of scavenging and searcher efficiency data and other experimental design factors (e.g., number of weeks between searches, width between transects) currently make it difficult to make all bird fatality projections for California windplants. If actual fatality rates at Altamont and Tehachapi Pass are significantly less than 2 birds per turbine per year, we may be overestimating the true total number of fatalities per year. Likewise, if actual fatality rates at Altamont and Tehachapi Pass are greater than 2 birds per turbine per year, we may be under estimating the true total number of fatalities per year. Based on species composition from past studies at Altamont and recent work by Thelander (2000, pers. comm.), we believe it is more likely our estimates are accurate or a slight overestimate of the true fatality rates.

Furthermore, turbines at the new windplants are larger than the majority of turbines at the older windplants, such as Altamont. Newer turbines are typically 600-kW – 1.5-MW machines, with tower heights ranging from 200-350 feet (60-100 m) and rotor diameters of 30 m to 70 m. Layouts of turbines at newer generation facilities are very different than the large windplants in California. Turbines at the newer windplants are typically spaced farther apart than turbines at older windplants. There is currently limited data available to understand potential differences in fatality rates for small, older generation turbines compared to the large, newer generation turbines. Based on information to date, siting of windplants appears to be the most significant factor related to bird mortality, with the effects of other factors such as turbine designs (e.g., lattice towers versus tubular towers, small versus large turbines) less understood. The range for bird mortality estimates was based on a study at the 38-turbine windplant in Vansycle (0.63 birds per turbine per year), and the bird mortality estimate at the Buffalo Ridge Windplant (highest estimate, 2.83 bird fatalities per turbine per year). Acknowledging the potential biases, we still believe using this range as a basis for the range of annual avian mortality is reasonably and likely accurate.

Scavenging and searcher efficiency estimates need to be incorporated to accurately estimate true fatality rates, especially for small birds. We feel this is especially important when fatality rates are compared between Wind Resource Areas and studies, since the habitats (and subsequent estimates of searcher efficiency), search interval, and scavenging all can influence the actual number of birds recorded by searchers. In many of the studies that report fatality estimates for all bird species and have measured scavenging and searcher efficiency rates, large adjustments are made to the observed number of carcasses for scavenging and searcher efficiency bias (Johnson *et al.* 2000b, Johnson *et al.* 2001). These adjustments, although necessary to accurately estimate true fatality rates, add uncertainty into the estimates. Nevertheless, we have reported a range of estimates for wind turbines that we believe is a reasonable range to represent true current annual avian mortality (10,000 – 40,000 fatalities).

Even with the potential biases, most of the avian collision data from windplants (especially the newer generation windplants) have been collected using standardized methods and regardless of perceived avian risk. In addition, the proportion of windplants studied is quite high relative to any other source of avian collision mortality. Therefore we believe our avian mortality estimates due to collisions with wind turbines are more accurate than the collision fatality estimates attributable to other sources. The low mortality rates of wind turbines compared with communication towers can probably be attributed to the fact that the majority of wind turbines range from 200-350 feet (60-100 m) in height, whereas television and radio communication towers are generally much taller. However, wireless cellular towers are also generally shorter and the massive current tower growth is occurring primarily within the cellular communication arena. Many of the communication towers are guyed structures, whereas nearly all of the newer-generation wind turbines are unguyed structures. There are relatively few reports of single mortality events (greater than a few birds) at communication structures less than 500 feet (150 m) in height (Kerlinger 2000; Manville 2000, pers. comm.) or at windplants.

We are unaware of any studies that directly compare communication tower mortality to wind turbine mortality; although, we do have limited information on guyed meteorological (met) tower mortality compared with wind turbine mortality at the Foote Creek Rim, Wyoming

windplant. At this site we searched both wind turbines (600-kW, approximately 200-ft (60-m) towers) and guyed met towers (200 ft (60 m) in height) once a month during the study. During this period of study, the met towers had estimates of 7.5 bird fatalities per tower per year, whereas the turbines had estimates of 1.8 bird fatalities per turbine per year (Johnson *et al.* 2001).

Most of the studies at communication towers were the result of an episodic event at a single tower, although a few long-term studies have been conducted. It appears that the collision mechanisms at wind turbines and communication towers may be different. Most bird collisions at communication towers occur during migration and during nights of inclement weather. In addition, communication tower fatalities have mainly been reported east of the Rocky Mountains. It is unclear whether lower reported mortality in the West is the result of a lack of studies, or fewer collisions. Many of the communication towers in the western United States occur in isolated locations, where dead birds are less likely to be "discovered"; such discoveries are most frequently the stimulus for communication tower studies in the East. In May 1972, 57 birds of five species were killed at the Cape Scott Lighthouse, Vancouver Island, British Columbia. Because inclement weather including low cloud ceiling and fog do occur along the Pacific Coast and other areas of the West, the potential for bird mortality due to collisions with communication towers during periods of inclement weather may exist, in spite of the lack of studies or reported occurrences in this area.

While the majority of bird fatalities reported at communication towers are comprised of nocturnal migrating passerines, bird fatalities associated with wind turbines are composed of a variety of different groups including waterfowl, seabirds, shorebirds, passerines, and raptors. Vulnerability to collisions is species- and habitat- specific; therefore, siting issues must be assessed accordingly. For example, raptor collisions with wind turbines may be more likely to occur while the raptor is concentrating on foraging, or stooping towards a prey item. A dense or abundant prey base within a wind resource area may attract a greater number of raptors within the vicinity of wind turbines, and subsequently increase the potential for collision fatalities among raptor species. Water within the vicinity of wind turbines may attract waterfowl, seabirds and shorebirds, increasing the collision potential for water bird species, although other factors such as adjacent habitats and movement patterns would also greatly influence mortality near these water sources.

3. Aerodromes, International Standards and Recommended Practices

INTERNATIONAL STANDARDS
AND RECOMMENDED PRACTICES

AERODROMES

ANNEX 14

TO THE CONVENTION ON INTERNATIONAL CIVIL AVIATION

VOLUME I
AERODROME DESIGN AND OPERATIONS

THIRD EDITION — JULY 1999

This edition incorporates all amendments to Annex 14, Volume I, adopted by the Council prior to 6 March 1999 and supersedes on 4 November 1999 all previous editions of Annex 14, Volume I.

For information regarding the applicability of the Standards and Recommended Practices, *see* Chapter 1, 1.2 and Foreword.

INTERNATIONAL CIVIL AVIATION ORGANIZATION

CHAPTER 6. VISUAL AIDS FOR DENOTING OBSTACLES

6.1 Objects to be marked and/or lighted

Note.— The marking and/or lighting of obstacles is intended to reduce hazards to aircraft by indicating the presence of the obstacles. It does not necessarily reduce operating limitations which may be imposed by an obstacle.

6.1.1 **Recommendation.—** *A fixed obstacle that extends above a take-off climb surface within 3 000 m of the inner edge the take-off climb surface should be marked and, if the runway is used at night, lighted, except that:*

a) such marking and lighting may be omitted when the obstacle is shielded by another fixed obstacle;

b) the marking may be omitted when the obstacle is lighted by medium-intensity obstacle lights, Type A, by day and its height above the level of the surrounding ground does not exceed 150 m;

c) the marking may be omitted when the obstacle is lighted by high-intensity obstacle lights by day; and

d) the lighting may be omitted where the obstacle is a lighthouse and an aeronautical study indicates the lighthouse light to be sufficient.

6.1.2 **Recommendation.—** *A fixed object, other than an obstacle, adjacent to a take-off climb surface should be marked and, if the runway is used at night, lighted if such marking and lighting is considered necessary to ensure its avoidance, except that the marking may be omitted when:*

a) the object is lighted by medium-intensity obstacle lights, Type A, by day and its height above the level of the surrounding ground does not exceed 150 m; or

b) the object is lighted by high-intensity obstacle lights by day.

6.1.3 A fixed obstacle that extends above an approach or transitional surface within 3 000 m of the inner edge of the approach surface shall be marked and, if the runway is used at night, lighted, except that:

a) such marking and lighting may be omitted when the obstacle is shielded by another fixed obstacle;

b) the marking may be omitted when the obstacle is lighted by medium-intensity obstacle lights, Type A, by day and its height above the level of the surrounding ground does not exceed 150 m;

c) the marking may be omitted when the obstacle is lighted by high-intensity obstacle lights by day; and

d) the lighting may be omitted where the obstacle is a lighthouse and an aeronautical study indicates the lighthouse light to be sufficient.

6.1.4 **Recommendation.—** *A fixed obstacle above a horizontal surface should be marked and, if the aerodrome is used at night, lighted except that:*

a) such marking and lighting may be omitted when:

1) the obstacle is shielded by another fixed obstacle; or

2) for a circuit extensively obstructed by immovable objects or terrain, procedures have been established to ensure safe vertical clearance below prescribed flight paths; or

3) an aeronautical study shows the obstacle not to be of operational significance;

b) the marking may be omitted when the obstacle is lighted by medium-intensity obstacle lights, Type A, by day and its height above the level of the surrounding ground does not exceed 150 m;

c) the marking may be omitted when the obstacle is lighted by high-intensity obstacle lights by day; and

d) the lighting may be omitted where the obstacle is a lighthouse and an aeronautical study indicates the lighthouse light to be sufficient.

6.1.5 A fixed object that extends above an obstacle protection surface shall be marked and, if the runway is used at night, lighted.

Note.— See 5.3.5 for information on the obstacle protection surface.

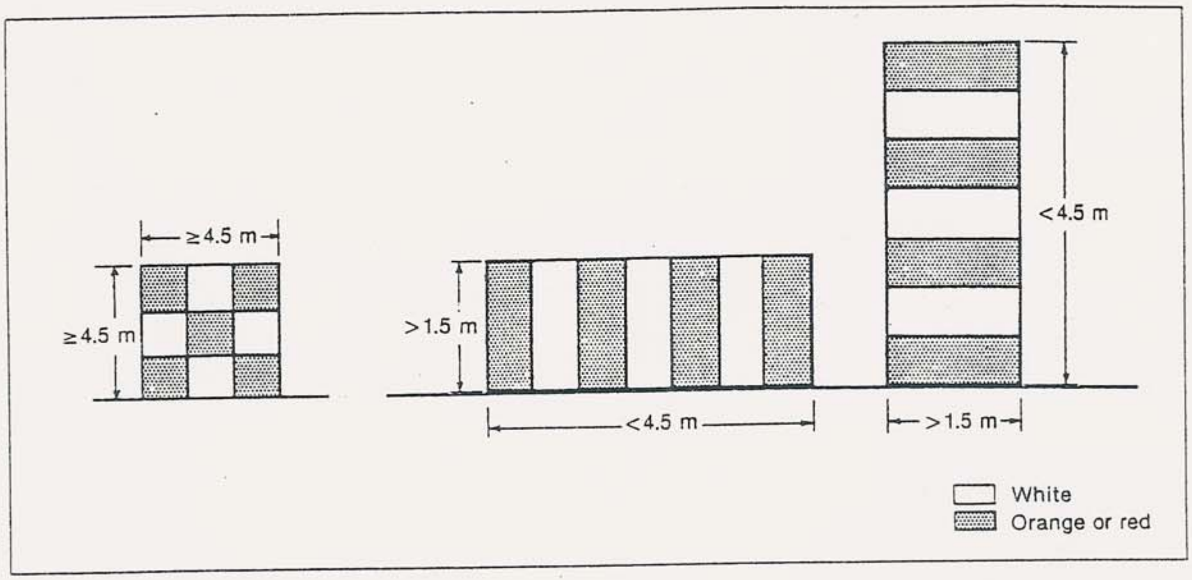


Figure 6-1. Basic marking patterns

6.1.6 Vehicles and other mobile objects, excluding aircraft, on the movement area of an aerodrome are obstacles and shall be marked and, if the vehicles and aerodrome are used at night or in conditions of low visibility, lighted, except that aircraft servicing equipment and vehicles used only on aprons may be exempt.

6.1.7 Elevated aeronautical ground lights within the movement area shall be marked so as to be conspicuous by day. Obstacle lights shall not be installed on elevated ground lights or signs in the movement area.

6.1.8 All obstacles within the distance specified in Table 3-1, column 11 or 12, from the centre line of a taxiway, an apron taxiway or aircraft stand taxilane shall be marked and, if the taxiway, apron taxiway or aircraft stand taxilane is used at night, lighted.

6.1.9 **Recommendation.**— *Obstacles in accordance with 4.3.2 should be marked and lighted, except that the marking may be omitted when the obstacle is lighted by high-intensity obstacle lights by day.*

6.1.10 **Recommendation.**— *Overhead wires, cables, etc., crossing a river, valley or highway should be marked and their supporting towers marked and lighted if an aeronautical study indicates that the wires or cables could constitute a hazard to aircraft, except that the marking of the supporting towers may be omitted when they are lighted by high-intensity obstacle lights by day.*

6.1.11 **Recommendation.**— *When it has been determined that an overhead wire, cable, etc., needs to be marked but it is not practicable to install markers on the wire, cable, etc., then high-intensity obstacle lights, Type B, should be provided on their supporting towers.*

6.2 Marking of objects

General

6.2.1 All fixed objects to be marked shall, whenever practicable, be coloured, but if this is not practicable, markers or flags shall be displayed on or above them, except that objects that are sufficiently conspicuous by their shape, size or colour need not be otherwise marked.

6.2.2 All mobile objects to be marked shall be coloured or display flags.

Use of colours

6.2.3 **Recommendation.**— *An object should be coloured to show a chequered pattern if it has essentially unbroken surfaces and its projection on any vertical plane equals or exceeds 4.5 m in both dimensions. The pattern should consist of rectangles of not less than 1.5 m and not more than 3 m on a side, the corners being of the darker colour. The colours of the pattern should contrast each with the other and with the background against which they will be seen. Orange and white or alternatively red and white should be used, except where such colours merge with the background. (See Figure 6-1.)*

6.2.4 **Recommendation.**— *An object should be coloured to show alternating contrasting bands if:*

a) it has essentially unbroken surfaces and has one dimension, horizontal or vertical, greater than 1.5 m, and the other dimension, horizontal or vertical, less than 4.5 m; or *b) it is of skeletal type with either a vertical or a horizontal dimension greater than 1.5 m.*

The bands should be perpendicular to the longest dimension and have a width approximately 1/7 of the longest dimension or 30 m, whichever is less. The colours of the bands should contrast with the background against which they will be seen. Orange and white should be used, except where such colours are not conspicuous when viewed against the background. The bands on the extremities of the object should be of the darker colour. (See Figures 6-1 and 6-2.)

Note.— Table 6-1 shows a formula for determining band widths and for having an odd number of bands, thus permitting both the top and bottom bands to be of the darker colour.

6.2.5 **Recommendation.—** *An object should be coloured in a single conspicuous colour if its projection on any vertical p· · has both dimensions less than 1.5 m. Orange or red sh..ld be used, except where such colours merge with the background.*

Note.— Against some backgrounds it may be found necessary to use a different colour from orange or red to obtain sufficient contrast.

6.2.6 **Recommendation.—** *When mobile objects are marked by colour, a single conspicuous colour, preferably red or yellowish green for emergency vehicles and yellow for service vehicles should be used.*

Table 6-1. Marking band widths

Longest dimension		
Greater than	Not exceeding	Band width
1.5 m	210 m	1/7 of longest dimension
210 m	270 m	1/9 " " "
270 m	330 m	1/11 " " "
330 m	390 m	1/13 " " "
390 m	450 m	1/15 " " "
450 m	510 m	1/17 " " "
510 m	570 m	1/19 " " "
570 m	630 m	1/21 " " "

Use of markers

6.2.7 Markers displayed on or adjacent to objects shall be located in conspicuous positions so as to retain the general definition of the object and shall be recognizable in clear weather from a distance of at least 1 000 m for an object to be viewed from the air and 300 m for an object to be viewed from the ground in all directions in which an aircraft is likely to approach the object. The shape of markers shall be distinctive to the extent necessary to ensure that they are not mistaken for markers employed to convey other information, and they shall be such that the hazard presented by the object they mark is not increased.

6.2.8 **Recommendation.—** *A marker displayed on an overhead wire, cable, etc., should be spherical and have a diameter of not less than 60 cm.*

6.2.9 **Recommendation.—** *The spacing between two consecutive markers or between a marker and a supporting tower should be appropriate to the diameter of the marker, but in no case should the spacing exceed:*

a) 30 m where the marker diameter is 60 cm progressively increasing with the diameter of the marker to

b) 35 m where the marker diameter is 80 cm and further progressively increasing to a maximum of

c) 40 m where the marker diameter is of at least 130 cm.

Where multiple wires, cables, etc. are involved, a marker should be located not lower than the level of the highest wire at the point marked.

6.2.10 **Recommendation.—** *A marker should be of one colour. When installed, white and red, or white and orange markers should be displayed alternately. The colour selected should contrast with the background against which it will be seen.*

Use of flags

6.2.11 Flags used to mark objects shall be displayed around, on top of, or around the highest edge of, the object. When flags are used to mark extensive objects or groups of closely spaced objects, they shall be displayed at least every 15 m. Flags shall not increase the hazard presented by the object they mark.

6.2.12 Flags used to mark fixed objects shall not be less than 0.6 m square and flags used to mark mobile objects, not less than 0.9 m square.

6.2.13 **Recommendation.—** *Flags used to mark fixed objects should be orange in colour or a combination of two triangular sections, one orange and the other white, or one red and the other white, except that where such colours merge with the background, other conspicuous colours should be used.*

6.2.14 Flags used to mark mobile objects shall consist of a chequered pattern, each square having sides of not less than 0.3 m. The colours of the pattern shall contrast each with the other and with the background against which they will be seen. Orange and white or alternatively red and white shall be used, except where such colours merge with the background.

b) it is of skeletal type with either a vertical or a horizontal dimension greater than 1.5 m.

The bands should be perpendicular to the longest dimension and have a width approximately 1/7 of the longest dimension or 30 m, whichever is less. The colours of the bands should contrast with the background against which they will be seen. Orange and white should be used, except where such colours are not conspicuous when viewed against the background. The bands on the extremities of the object should be of the darker colour. (See Figures 6-1 and 6-2.)

Note.— Table 6-1 shows a formula for determining band widths and for having an odd number of bands, thus permitting both the top and bottom bands to be of the darker colour.

6.2.5 **Recommendation.—** *An object should be coloured in a single conspicuous colour if its projection on any vertical p' · has both dimensions less than 1.5 m. Orange or red should be used, except where such colours merge with the background.*

Note.— Against some backgrounds it may be found necessary to use a different colour from orange or red to obtain sufficient contrast.

6.2.6 **Recommendation.—** *When mobile objects are marked by colour, a single conspicuous colour, preferably red or yellowish green for emergency vehicles and yellow for service vehicles should be used.*

Table 6-1. Marking band widths

Longest dimension: Greater than	Longest dimension: Not exceeding	Band width
1.5 m	210 m	1/7 of longest dimension
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270 m	330 m	1/11 " " "
330 m	390 m	1/13 " " "
390 m	450 m	1/15 " " "
450 m	510 m	1/17 " " "
510 m	570 m	1/19 " " "
570 m	630 m	1/21 " " "

Use of markers

6.2.7 Markers displayed on or adjacent to objects shall be located in conspicuous positions so as to retain the general definition of the object and shall be recognizable in clear weather from a distance of at least 1 000 m for an object to be viewed from the air and 300 m for an object to be viewed from the ground in all directions in which an aircraft is likely to approach the object. The shape of markers shall be distinctive to the extent necessary to ensure that they are not mistaken for markers employed to convey other information, and they shall be such that the hazard presented by the object they mark is not increased.

6.2.8 **Recommendation.—** *A marker displayed on an overhead wire, cable, etc., should be spherical and have a diameter of not less than 60 cm.*

6.2.9 **Recommendation.—** *The spacing between two consecutive markers or between a marker and a supporting tower should be appropriate to the diameter of the marker, but in no case should the spacing exceed:*

a) 30 m where the marker diameter is 60 cm progressively increasing with the diameter of the marker to

b) 35 m where the marker diameter is 80 cm and further progressively increasing to a maximum of

c) 40 m where the marker diameter is of at least 130 cm.

Where multiple wires, cables, etc. are involved, a marker should be located not lower than the level of the highest wire at the point marked.

6.2.10 **Recommendation.—** *A marker should be of one colour. When installed, white and red, or white and orange markers should be displayed alternately. The colour selected should contrast with the background against which it will be seen.*

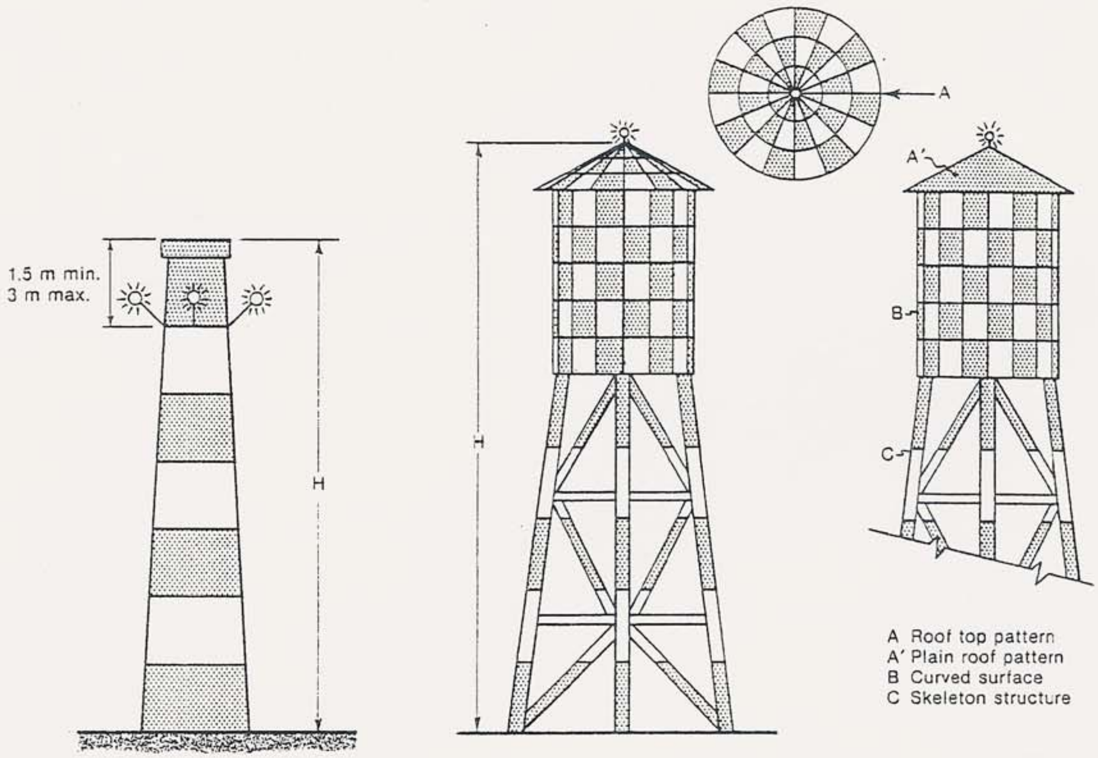
Use of flags

6.2.11 Flags used to mark objects shall be displayed around, on top of, or around the highest edge of, the object. When flags are used to mark extensive objects or groups of closely spaced objects, they shall be displayed at least every 15 m. Flags shall not increase the hazard presented by the object they mark.

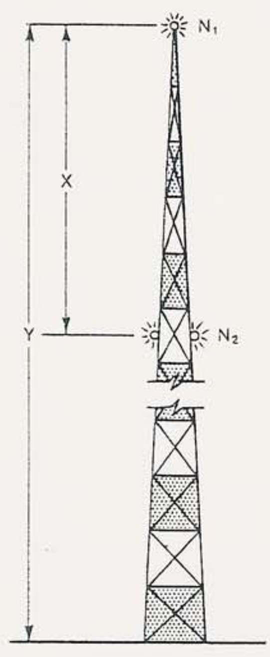
6.2.12 Flags used to mark fixed objects shall not be less than 0.6 m square and flags used to mark mobile objects, not less than 0.9 m square.

6.2.13 **Recommendation.—** *Flags used to mark fixed objects should be orange in colour or a combination of two triangular sections, one orange and the other white, or one red and the other white, except that where such colours merge with the background, other conspicuous colours should be used.*

6.2.14 Flags used to mark mobile objects shall consist of a chequered pattern, each square having sides of not less than 0.3 m. The colours of the pattern shall contrast each with the other and with the background against which they will be seen. Orange and white or alternatively red and white shall be used, except where such colours merge with the background.



Note.— H is less the 45 m for the examples shown above.
For greater heights intermediate lights must be added as shown below.



$$\text{Number of lights} = N = \frac{Y \text{ (metres)}}{45}$$

$$\text{Light spacing} = X = \frac{Y}{N} \leq 45 \text{ m}$$

Figure 6-2. Examples of marking and lighting of tall structures

6.3 Lighting of objects

Use of obstacle lights

6.3.1 The presence of objects which must be lighted, as specified in 6.1, shall be indicated by low-, medium- or high-intensity obstacle lights, or a combination of such lights.

Note.— High-intensity obstacle lights are intended for day use as well as night use. Care is needed to ensure that these lights do not create disconcerting dazzle. Guidance on the design, location and operation of high-intensity obstacle lights is given in the Aerodrome Design Manual, *Part 4.*

6.3.2 **Recommendation.—** *Low-intensity obstacle lights, Type A or B, should be used where the object is a less extensive one and its height above the surrounding ground is less than 45 m.*

6.3.3 **Recommendation.—** *Where the use of low-intensity obstacle lights, Type A or B, would be inadequate or an early special warning is required, then medium- or high-intensity obstacle lights should be used.*

6.3.4 Low-intensity obstacle lights, Type C, shall be displayed on vehicles and other mobile objects excluding aircraft.

6.3.5 Low-intensity obstacle lights, Type D, shall be displayed on follow-me vehicles.

6.3.6 **Recommendation.—** *Low-intensity obstacle lights, Type B, should be used either alone or in combination with medium-intensity obstacle lights, Type B, in accordance with 6.3.7.*

6.3.7 **Recommendation.—** *Medium-intensity obstacle lights, Type A, B or C, should be used where the object is an extensive one or its height above the level of the surrounding ground is greater than 45 m. Medium-intensity obstacle lights, Types A and C, should be used alone, whereas medium-intensity obstacle lights, Type B, should be used either alone or in combination with low-intensity obstacle lights, Type B.*

Note.— A group of trees or buildings is regarded as an extensive object.

6.3.8 **Recommendation.—** *High-intensity obstacle lights, Type A, should be used to indicate the presence of an object if its height above the level of the surrounding ground exceeds 150 m and an aeronautical study indicates such lights to be essential for the recognition of the object by day.*

6.3.9 **Recommendation.—** *High-intensity obstacle lights, Type B, should be used to indicate the presence of a tower supporting overhead wires, cables, etc., where:*

a) an aeronautical study indicates such lights to be essential for the recognition of the presence of wires, cables, etc.; or

b) it has not been found practicable to install markers on the wires, cables, etc.

6.3.10 **Recommendation.—** *Where, in the opinion of the appropriate authority, the use of high-intensity obstacle lights, Type A or B, or medium-intensity obstacle lights, Type A, at night may dazzle pilots in the vicinity of an aerodrome (within approximately 10 000 m radius) or cause significant environmental concerns, a dual obstacle lighting system should be provided. This system should be composed of high-intensity obstacle lights, Type A or B, or medium-intensity obstacle lights, Type A, as appropriate, for daytime and twilight use and medium-intensity obstacle lights, Type B or C, for night-time use.*

Location of obstacle lights

Note.— Recommendations on how a combination of low-, medium-, and/or high-intensity lights on obstacles should be displayed are given in Appendix 6.

6.3.11 One or more low-, medium- or high-intensity obstacle lights shall be located as close as practicable to the top of the object. The top lights shall be so arranged as to at least indicate the points or edges of the object highest in relation to the obstacle limitation surface.

6.3.12 **Recommendation.—** *In the case of chimney or other structure of like function, the top lights should be placed sufficiently below the top so as to minimize contamination by smoke etc. (see Figures 6-2 and 6-3).*

6.3.13 In the case of a tower or antenna structure indicated by high-intensity obstacle lights by day with an appurtenance, such as a rod or an antenna, greater than 12 m where it is not practicable to locate a high-intensity obstacle light on the top of the appurtenance, such a light shall be located at the highest practicable point and, if practicable, a medium-intensity obstacle light, Type A, mounted on the top.

6.3.14 In the case of an extensive object or of a group of closely spaced objects, top lights shall be displayed at least on the points or edges of the objects highest in relation to the obstacle limitation surface, so as to indicate the general definition and the extent of the objects. If two or more edges are of the same height, the edge nearest the landing area shall be marked. Where low-intensity lights are used, they shall be spaced at longitudinal intervals not exceeding 45 m. Where medium-intensity lights are used, they shall be spaced at longitudinal intervals not exceeding 900 m.

6.3.15 **Recommendation.—** *When the obstacle limitation surface concerned is sloping and the highest point above the* *obstacle limitation surface is not the highest point of the object, additional obstacle lights should be placed on the highest point of the object.*

6.3.16 Where an object is indicated by medium-intensity obstacle lights, Type A, and the top of the object is more than 105 m above the level of the surrounding ground or the elevation of tops of nearby buildings (when the object to be marked is surrounded by buildings), additional lights shall be provided at intermediate levels. These additional intermediate lights shall be spaced as equally as practicable, between the top lights and ground level or the level of tops of nearby buildings, as appropriate, with the spacing not exceeding 105 m (see 6.3.7).

6.3.17 Where an object is indicated by medium-intensity obstacle lights, Type B, and the top of the object is more than 45 m above the level of the surrounding ground or the elevation of tops of nearby buildings (when the object to be marked is surrounded by buildings), additional lights shall be provided at intermediate levels. These additional intermediate lights shall be alternately low-intensity obstacle lights, Type B, and medium-intensity obstacle lights, Type B, and shall be spaced as equally as practicable between the top lights and ground level or the level of tops of nearby buildings, as appropriate, with the spacing not exceeding 52 m.

6.3.18 Where an object is indicated by medium-intensity obstacle lights, Type C, and the top of the object is more than 45 m above the level of the surrounding ground or the elevation of tops of nearby buildings (when the object to be marked is surrounded by buildings), additional lights shall be provided at intermediate levels. These additional intermediate lights shall be spaced as equally as practicable, between the top lights and ground level or the level of tops of nearby buildings, as appropriate, with the spacing not exceeding 52 m.

6.3.19 Where high-intensity obstacle lights, Type A, are used, they shall be spaced at uniform intervals not exceeding 105 m between the ground level and the top light(s) specified in 6.3.11 except that where an object to be marked is surrounded by buildings, the elevation of the tops of the buildings may be used as the equivalent of the ground level when determining the number of light levels.

6.3.20 Where high-intensity obstacle lights, Type B, are used, they shall be located at three levels:

— at the top of the tower;
— at the lowest level of the catenary of the wires or cables; and
— at approximately midway between these two levels.

Note.— In some cases, this may require locating the lights off the tower.

6.3.21 **Recommendation.—** *The installation setting angles for high-intensity obstacle lights, Types A and B, should be in accordance with Table 6-2.*

6.3.22 The number and arrangement of low-, medium- or high-intensity obstacle lights at each level to be marked shall be such that the object is indicated from every angle in azimuth. Where a light is shielded in any direction by another part of the object, or by an adjacent object, additional lights shall be provided on that object in such a way as to retain the

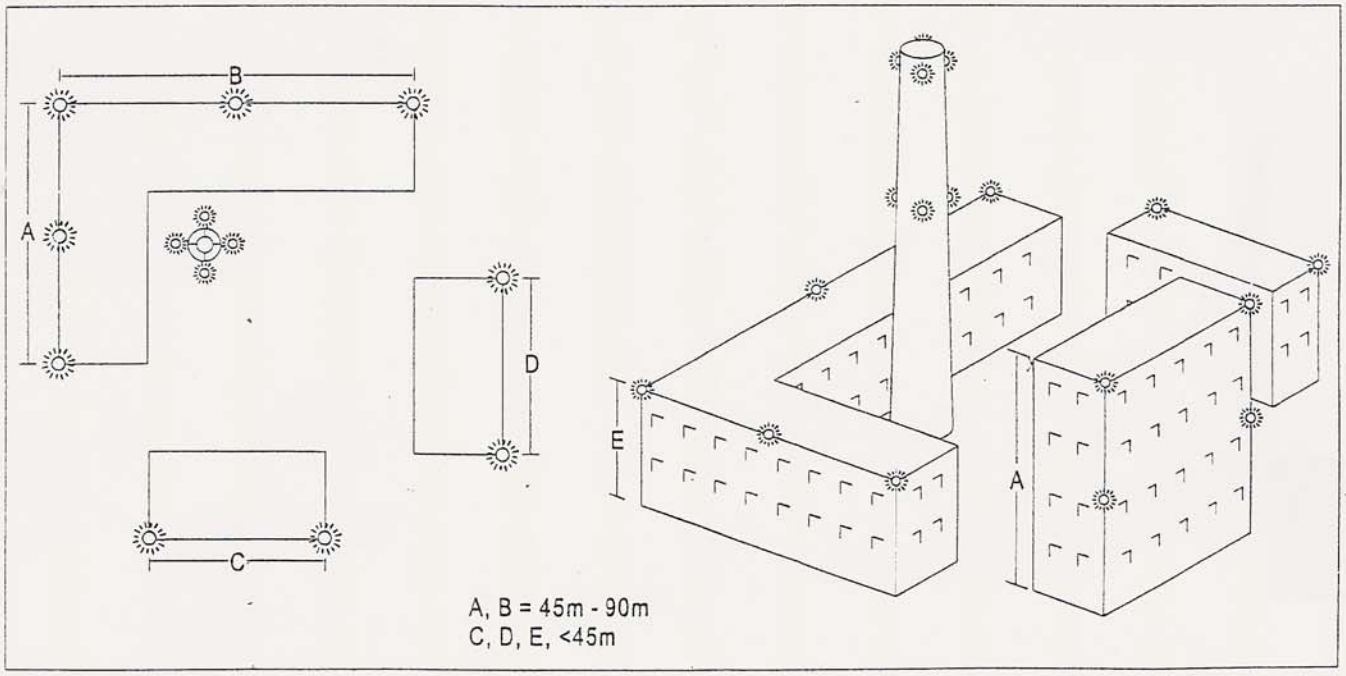


Figure 6-3. Lighting of buildings

general definition of the object to be lighted. If the shielded light does not contribute to the definition of the object to be lighted, it may be omitted.

Table 6-2. Installation setting angles for high-intensity obstacle lights

Height of light unit above terrain	*Angle of the peak of the beam above the horizontal*
greater than 151 m AGL	0°
122 m to 151 m AGL	1°
92 m to 122 m AGL	2°
less than 92 m AGL	3°

Low-intensity obstacle light — Characteristics

6.3.23 Low-intensity obstacle lights on fixed objects, Types A and B, shall be fixed-red lights.

6.3.24 Low-intensity obstacle lights, Types A and B, shall be in accordance with the specifications in Table 6-3.

6.3.25 Low-intensity obstacle lights, Type C, displayed on vehicles associated with emergency or security shall be flashing-blue and those displayed on other vehicles shall be flashing-yellow.

6.3.26 Low-intensity obstacle lights, Type D, displayed on follow-me vehicles shall be flashing-yellow.

6.3.27 Low-intensity obstacle lights, Types C and D, shall be in accordance with the specifications in Table 6-3.

6.3.28 Low-intensity obstacle lights on objects with limited mobility such as aerobridges shall be fixed-red. The intensity of the lights shall be sufficient to ensure conspicuity considering the intensity of the adjacent lights and the general levels of illumination against which they would normally be viewed.

Note.— See Annex 2 for lights to be displayed by aircraft.

6.3.29 Low-intensity obstacle lights on objects with limited mobility shall as a minimum be in accordance with the specifications for low-intensity obstacle lights, Type A, in Table 6-3.

Medium-intensity obstacle light — Characteristics

6.3.30 Medium-intensity obstacle lights, Type A, shall be flashing-white lights, Type B shall be flashing-red lights and Type C shall be fixed-red lights.

6.3.31 Medium-intensity obstacle lights, Types A, B and C, shall be in accordance with the specifications in Table 6-3.

6.3.32 Medium-intensity obstacle lights, Types A and B, located on an object shall flash simultaneously.

High-intensity obstacle light — Characteristics

6.3.33 High-intensity obstacle lights, Types A and B, shall be flashing-white lights.

6.3.34 High-intensity obstacle lights, Types A and B, shall be in accordance with the specifications in Table 6-3.

6.3.35 High-intensity obstacle lights, Type A, located on an object shall flash simultaneously.

6.3.36 **Recommendation.—** *High-intensity obstacle lights, Type B, indicating the presence of a tower supporting overhead wires, cables, etc., should flash sequentially; first the middle light, second the top light and last, the bottom light. The intervals between flashes of the lights should approximate the following ratios:*

Flash interval between	*Ratio of cycle time*
middle and top light	*1/13*
top and bottom light	*2/13*
bottom and middle light	*10/13.*

Table 6-3. Characteristics of obstacle lights

1	2	3	4	5	6	7	8	9	10	11	12
			Peak intensity (cd) at given Background Luminance			Vertical Beam Spread (c)	Intensity (cd) at given Elevation Angles when the light unit is levelled (d)				
Light Type	Colour	Signal type/ (flash rate)	Above 500 cd/m^2	50-500 cd/m^2	Below 50 cd/m^2		−10° (e)	−1° (f)	±0° (f)	+6°	+10°
Low-intensity, Type A (fixed obstacle)	Red	Fixed	N/A	10 mnm	10 mnm	10°	—	—	—	10 mnm (g)	10 mnm (g)
Low-intensity, Type B (fixed obstacle)	Red	Fixed	N/A	32 mnm	32 mnm	10°	—	—	—	32 mnm (g)	32 mnm (g)
Low-intensity, Type C (mobile obstacle)	Yellow/Blue (a)	Flashing (60-90 fpm)	N/A	40 mnm (b) 400 max	40 mnm (b) 400 max	12° (h)	—	—	—	—	—
Low-intensity, Type D Follow-me Vehicle	Yellow	Flashing (60-90 fpm)	N/A	200 mnm (b) 400 max	200 mnm (b) 400 max	12° (i)	—	—	—	—	—
Medium-intensity, Type A	White	Flashing (20-60 fpm)	20 000 (b) ± 25%	20 000 (b) ± 25%	2 000 (b) ± 25%	3° mnm	3% max	50% mnm 75% max	100% mnm	—	—
Medium-intensity, Type B	Red	Flashing (20-60 fpm)	N/A	N/A	2 000 (b) ± 25%	3° mnm	—	50% mnm 75% max	100% mnm	—	—
Medium-intensity, Type C	Red	Fixed	N/A	N/A	2 000 (b) ± 25%	3° mnm	—	50% mnm 75% max	100% mnm	—	—
High-intensity, Type A	White	Flashing (40-60 fpm)	200 000 (b) ± 25%	20 000 (b) ± 25%	2 000 (b) ± 25%	3°-7°	3% max	50% mnm 75% max	100% mnm	—	—
High-intensity, Type B	White	Flashing (40-60 fpm)	100 000 (b) ± 25%	20 000 (b) ± 25%	2 000 (b) ± 25%	3°-7°	3% max	50% mnm 75% max	100% mnm	—	—

Note.— This table does not include recommended horizontal beam spreads. 6.3.22 requires 360° coverage around an obstacle. Therefore, the number of lights needed to meet this requirement will depend on the horizontal beam spreads of each light as well as the shape of the obstacle. Thus, with narrower beam spreads, more lights will be required.

a) See 6.3.25
b) Effective intensity, as determined in accordance with the *Aerodrome Design Manual*, Part 4.
c) Beam spread is defined as the angle between two directions in a plane for which the intensity is equal to 50% of the lower tolerance value of the intensity shown in columns 4, 5 and 6. The beam pattern is not necessarily symmetrical about the elevation angle at which the peak intensity occurs.
d) Elevation (vertical) angles are referenced to the horizontal.
e) Intensity at any specified horizontal radial as a percentage of the actual peak intensity at the same radial when operated at each of the intensities shown in columns 4, 5 and 6.
f) Intensity at any specified horizontal radial as a percentage of the lower tolerance value of the intensity shown in columns 4, 5 and 6.
g) In addition to specified values, lights shall have sufficient intensity to ensure conspicuity at elevation angles between ± 0° and 50°.
h) Peak intensity should be located at approximately 2.5° vertical.
i) Peak intensity should be located at approximately 17° vertical.

fpm — flashes per minute; N/A — not applicable