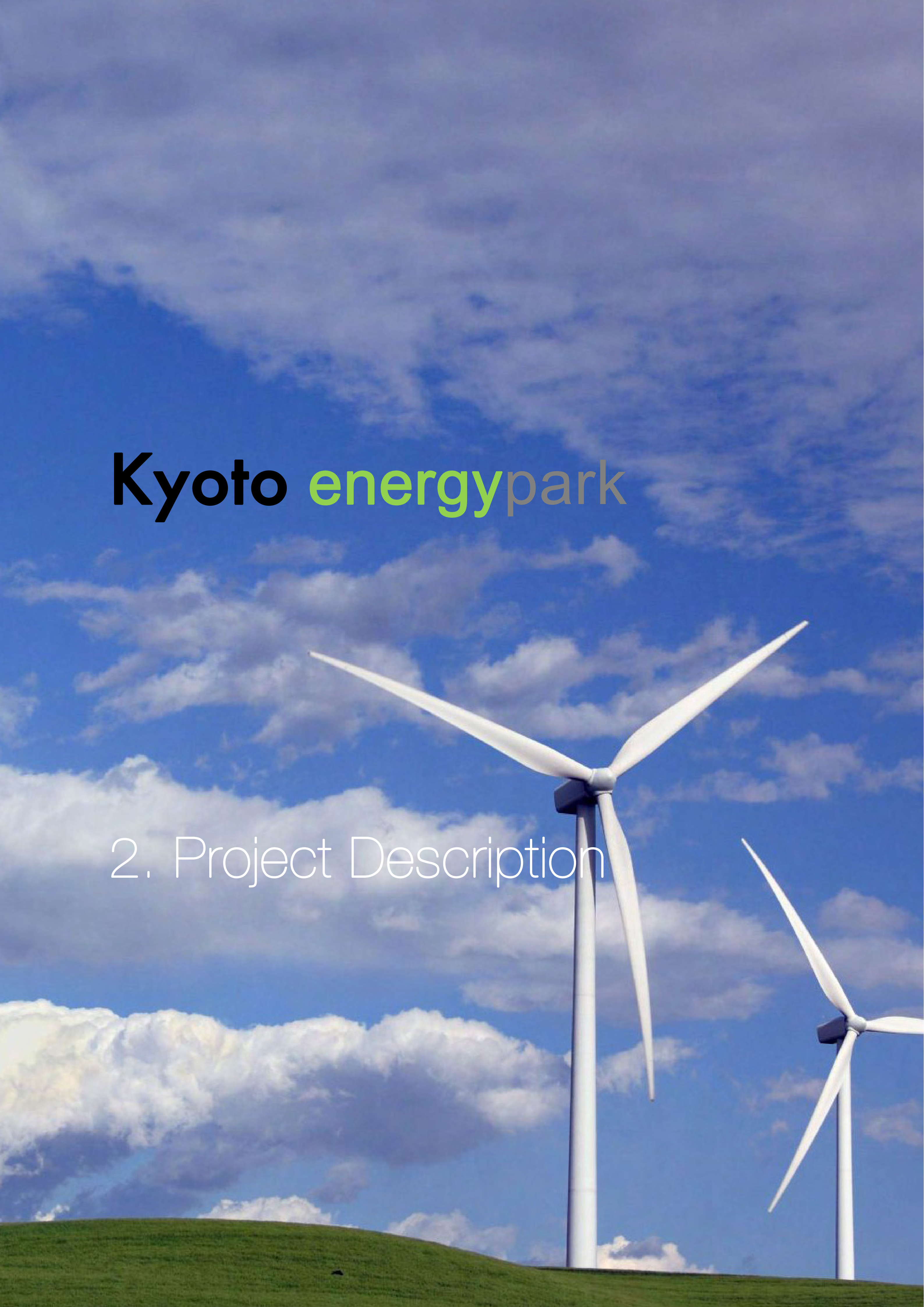


Kyoto energypark

2. Project Description

2.0 PROJECT DESCRIPTION

2.1 Introduction

The proposed development will include renewable energy generator components including Wind Turbine Generators (WTGs), a Solar Photovoltaic Plant (PV Plant), a mini hydro plant (Closed loop) and associated ancillary works. The application also covers work that will be required to connect the Energy Park to the local electricity grid network.

Most of the generator components and ancillary facilities are proposed on Mountain Station.
The application also covers work that will be required to upgrade existing power lines in the Scone area along transmission line routes. The transmission line connection to the grid has been assessed in Section 19.0 of this report.

2.1.1 What is the Project Application seeking approval for?

The project application seeks approval for the construction and installation of the following eco-generating devices and associated facilities. These include the following components:

Mountain Station

- 31 x 2.1-3.0MW Wind Turbine Generators;
- 31 x Kiosk step-up transformers at base of turbines;
- Installation of a 3-10MW Solar Photovoltaic Plant on Mount Moobi (Mt Moobi Solar PV Farm);
- Installation of a 1MW Closed loop Mini Hydro-electric Plant;
- 1 x Site substation, Switchyard and Control room;
- Construction of internal access tracks and hardstand areas;
- A Maintenance shed;
- A Manager's residence;
- A Visitor's and Education Centre;
- 33kV underground internal reticulation cabling.

Proposed facilities on Mountain Station are illustrated in Figure 2.0.

Middlebrook Station

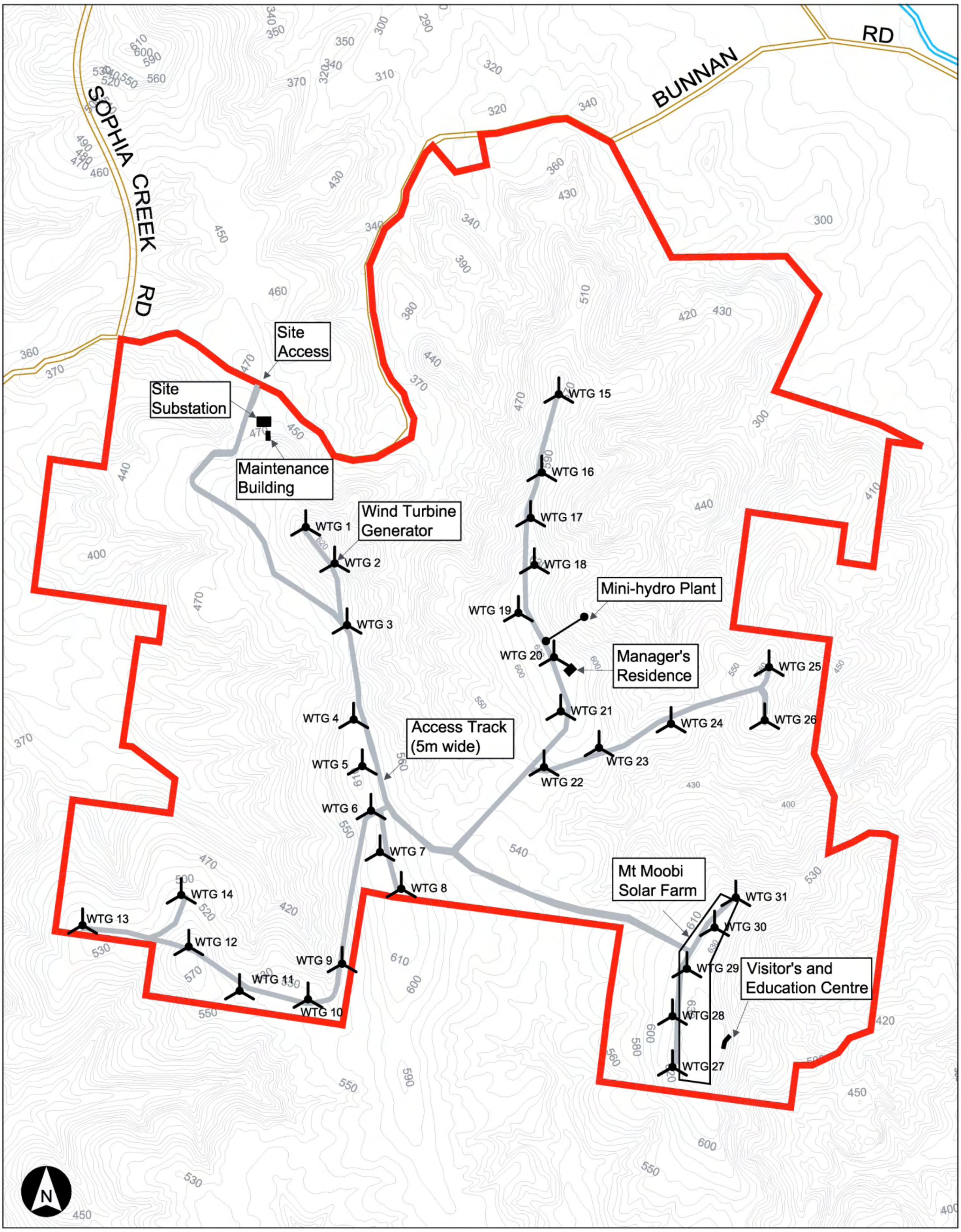
- 11 x 2.1-3.0MW Wind Turbine Generators;
- 11 x Kiosk step-up transformers at base of turbines
- 33kV underground cable network

Proposed facilities on Middlebrook Station are illustrated in Figure 2.1.

Transmission line Connection to the Grid

- Either a 66kV(Option 2) or 132 kV(Option 4) overhead transmission line to connection point to grid network;
- Construction of overhead 33kV transmission line for connection of Middlebrook Station turbines to Mountain station site substation;
- Construction of overhead communications lines for connection of Middlebrook Station turbines to Mountain station site substation.

Some temporary facilities will be required during the construction stage of the Kyoto Energy Park including a concrete batching plant, site offices and laydown area.



Legend:

Property Boundary

National Park/Nature Reserve

Minor road

Natural Contour (10m Interval)

Natural Drainage

0 0.5 1.5 Kilometres

Kyoto energypark | *Figure 2.0 - Proposed facilities (Mountain Station)* | pamada | A4

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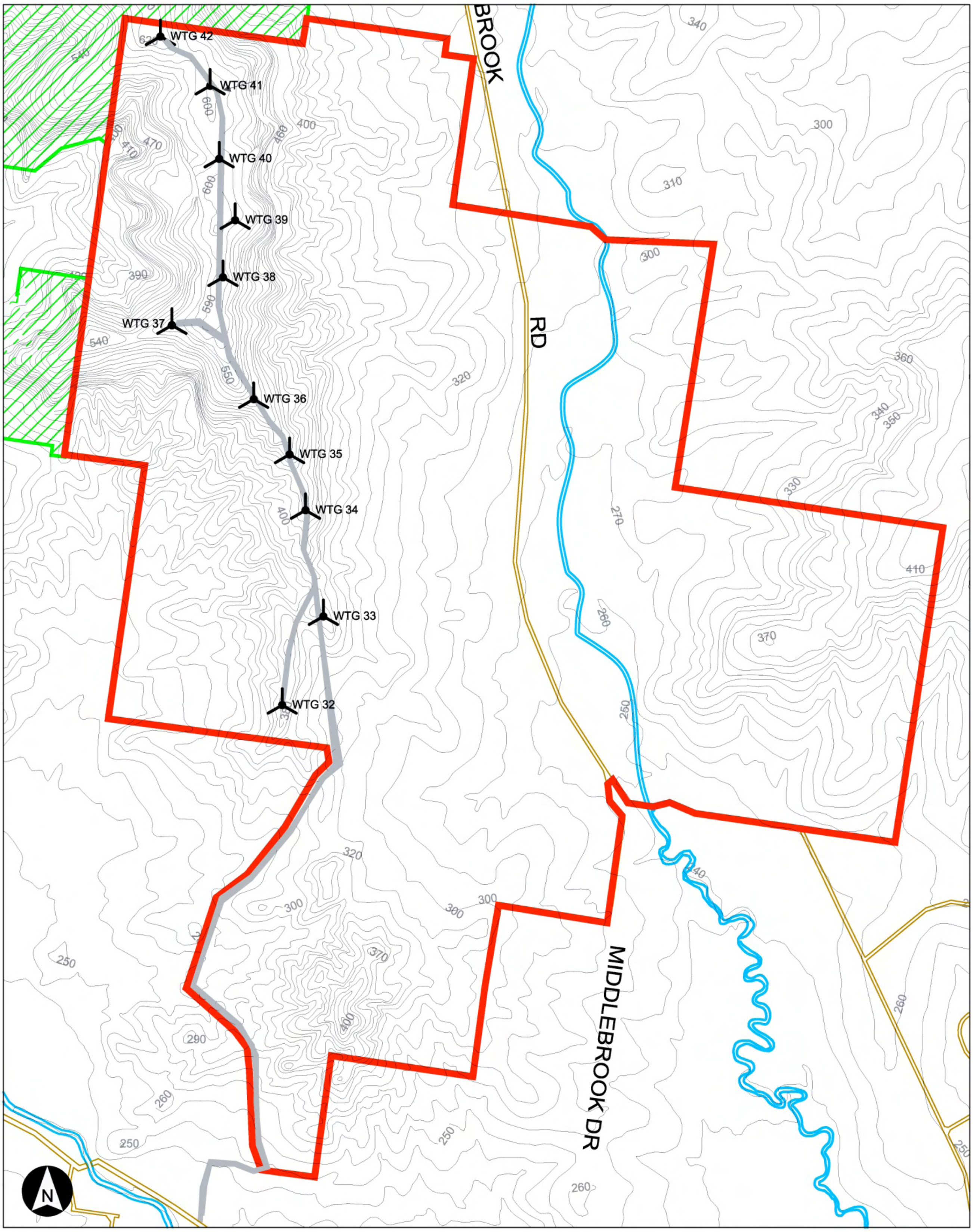

Legend:

- Property Boundary
- National Park/Nature Reserve
- Minor road
- Natural Contour (10m Interval)
- Natural Drainage

0 0.5 1.5
Kilometres

Kyoto energypark | *Figure 2.1 - Proposed facilities (Middlebrook Station)* | pamada | A4

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2.1.2 Capacity of the Kyoto Energy Park

The anticipated final capacity of the Kyoto Energy Park is shown in Table 2.0.

Table 2.0 Kyoto Energy Park Rated Capacity

Component	Minimum Capacity (MW)	Maximum Capacity (MW)	Max Generation Capacity (MW/hr) p.a.
Wind Turbine Generators	89 (96%)	126 (92%)	320,000
Solar Photovoltaic Plant	3 (3%)	10 (7%)	26,300
Closed-loop hydro plant	1 (1%)	1 (0.7%)	8,300
Estimated Total	**93 (100%)**	**137 (100%)**	**354,600**

Upon completion of all stages of the project the Kyoto Energy Park will generate approximately 137MW of electricity combined from wind generation, (92-96%), solar (3-7%) and a Closed loop mini-hydro system (0.7-1%), which will be fed by transmission lines into the local electricity grid. The background into each technology, evaluation and feasibility is discussed below. The design of each component of the Kyoto Energy Park has taken into consideration all of the proposed eco-generation technologies currently available and suitable for the location. It should be noted that for the purposes of evaluation of the potential for adverse environmental impacts, the worst case scenarios have been modelled in this report.

Final design of the plant technology, configuration and capacity will be evaluated at the time of procurement of system components. A description of the various technologies suitable for the site is provided in Section 2.2 below.

2.2. Generator Components

2.2.1 Wind Turbine Generators

Introduction

The first large wind turbines were designed and manufactured by the Danish, basically to improve energy utilisation for agricultural activities and farmers. In the 1970s the Danish government introduced government policies to promote research and development of wind turbines following two oil shortage crises that occurred. In the early 1980s California introduced tax incentives for wind energy development which resulted in thousands of smaller sized turbines being installed, mainly imported from Denmark. The original Danish turbines were 55kW, with a hub-height of about 18 metres and rotor diameter of 15 metres. The turbines were designed with a 20 year life and many are still in operation today.

In the 1990's the first megawatt machines (i.e. gross capacity of more than 1 MW) were introduced. In the last 10 years, with much research, development and implementation around the world, energy created from wind turbines has become an extremely effective and efficient form of generation in the right places. Large modern turbines are typically installed with a capacity of 1.5MW to 3MW each, with some off-shore installations using generators of up to 5MW in rated capacity. Typical modern inland turbines vary in height between 50m and 105m (this is the hub height or height above ground level to the top of the nacelle). The Nacelle is the generator housing which is seated on top of the tower. A typical wind turbine generator is shown in Figure 2.2

All typical modern turbines have three blades, with the blades varying between 40m and 50m in length. Current designs are allowing for taller towers and greater blade lengths. Often a small transformer or switchboard is located adjacent to the base of the tower. It is possible for agricultural uses to co-exist right up to the tower base and is common in most circumstances. The bigger machines offer greater rotor area which equates to greater energy production per machine, more efficient generators, reduced construction costs for foundations cabling and erection, and associated maintenance requirements. Larger machines with slower uniformly spinning rotors at greater turbine spacings are also considered more pleasing to the eye and reduce potential bird and bat strike impacts in areas with large numbers of avifauna. (Ecogeneration May/June 2008).

With rapid annual global growth in the wind industry and technology improvements, manufacturers are continually developing new equipment. In general this has meant a trend to larger wind turbines but it has also yielded improved designs from an engineering and environmental perspective. The preparation of this environmental assessment has included consideration of the potential for variations in environmental impact related to differing designs and has sought to provide an assessment that will be representative of the development that would be installed if consent is obtained.

The electricity generated by the wind farm is supplied to the electricity grid network for use by the network customers. The Kyoto Energy Park will include a fully operational ‘wind farm’ as a component of the project. The wind farm component of the park will be able to produce about 89-126 million watts (MW) of electrical energy capacity from the combined output of about 42 wind turbines. Each turbine could have a generation capacity of about 2 to 3 megawatts. Turbines will be mounted on towers up to 103m in height (hub-height up to 105m) and have the general form as shown in Figure 2.2. The turbines are large structures and the top of the blade sweep for each turbine will have an overall height of up to 150 metres above ground level (150m agl). The turbines have automatic controls that enable them to face into the wind and to vary their speed of operation with wind speed.

A full description of wind turbine components is discussed below.

Wind Turbine description

A Wind Turbine Generator is made up of five main components, that being the footing, tower, nacelle and rotor assembly. A step-up transformer is also located at the base of the tower for configuration of the voltage prior to transmission to the site substation.

Foundation

The design of the turbine foundation or footing is dependant on the geological strength of the bedrock foundation around each turbine. Footings under consideration in the Kyoto Energy Park wind turbines include a gravity footing and a reinforced concrete anchored design dependant on the geological strength around each turbine base.

The gravity footing is used in areas where there is insufficient strength in the bedrock to anchor the turbine. The reinforced footing generally consists of a reinforced concrete structure with post tensioned rock anchors into stable rock material.

Sizes for turbine foundations will therefore be determined based on final design considerations of footing type (gravity, reinforced anchored, combination), and bedrock strength. Turbine footings would be in the order of 5-6 metres in diameter and 3-5 metres deep, dependent on the above variables in final design. Turbine footings are completely buried beneath the existing ground surface level and are therefore not visible to the eye. Upon decommissioning footings would remain buried beneath the ground level surface. A full description of turbine footing construction is provided in Section 3.1.6

Tower

The purpose of the tower is to support the nacelle and rotor assembly which are the moving components of the wind turbine. The tower tubes are prefabricated and delivered to site in tubular steel sections where they are erected on site. Each section is bolted together and to the concrete foundation to form a total height of either 78 metres (80 hub-height) or 103 metres (105m hub-height).

Nacelle

The nacelle is the housing at the top of the tower which contains the internal components including the drive-train, gearbox, generator, brakes, pumps and control equipment. The nacelle is mounted on a large bearing allowing it to rotate around the top of the tower. The control equipment ensures safe and optimum operating efficiency is maintained by the turbine. Control equipment also directs the rotor blades into dominant wind speeds and control blade pitch which minimizes blade noises. The nacelle housing is acoustically insulated to reduce noise emissions from mechanical components.

Rotor Assembly
The rotor refers to the configuration of the three blades, hub and nose cone mounted on the turbine nacelle. Air is caught by the blades causing the rotor to spin, and thus driving the generator. Each blade consists of two blade shells, bonded to a supporting beam. The rotor would rotate in a clockwise direction at a speed of between 7-19 revolutions per minute depending on the machine used (refer Table 2.1)

Step-up Voltage Transformer
The generator located in the nacelle converts the rotational energy of the rotor to electricity which is passed through a step-up transformer located at the base of the tower. The generator operates at 50/60Hz and 690V. The electricity is fed into the transformer which 'steps up' the voltage to either 22,000V or 33,000V for reticulation to the site substation. By increasing the voltage the transmission losses from the cables are reduced.

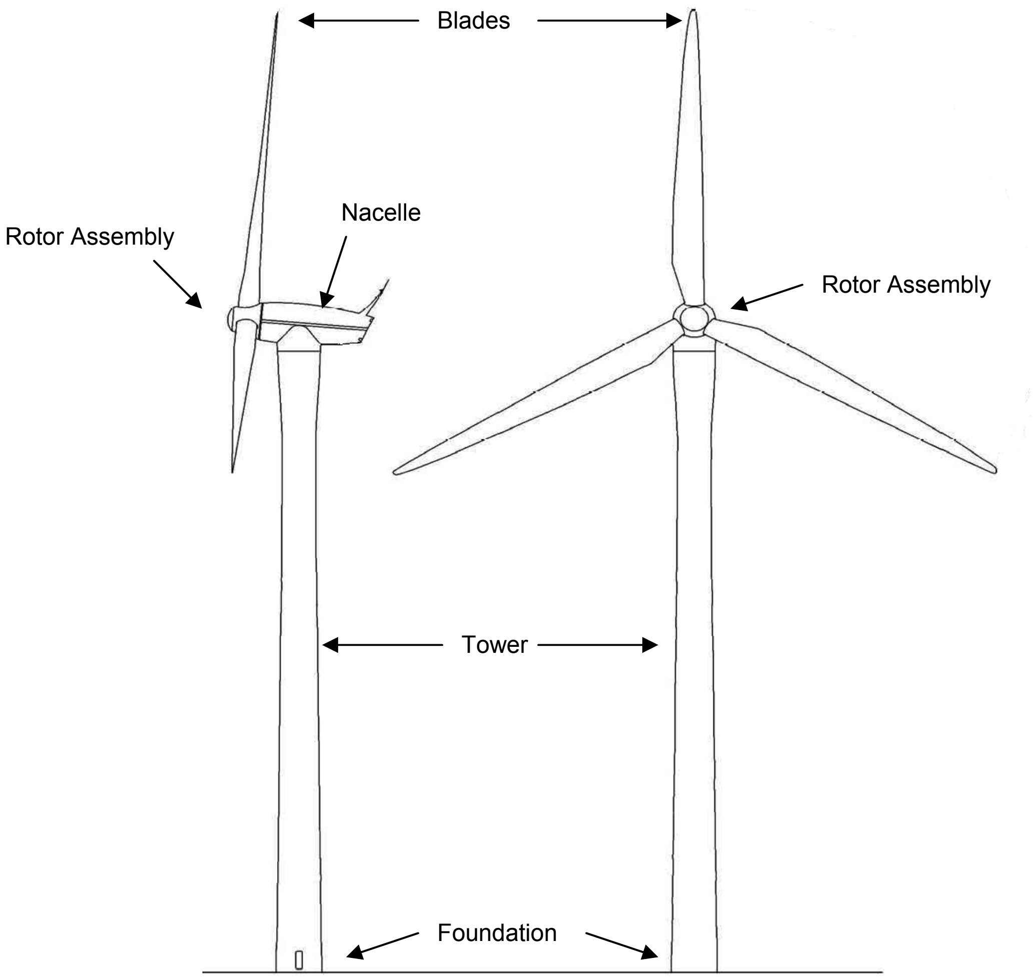


Figure 2.2 –Wind Turbine components

Wind Turbine independent control
The computer housed in each turbine nacelle controls the tip angle or pitch of the blades. The tip angle of the blade would be constantly regulated so that the blades are always pitched at the angle which optimises power production and noise reduction for current wind conditions. The internal computer also controls the stopping and starting of the rotor. Breaking is achieved by full feathering of the blades (i.e. angling the blades perpendicular to the wind direction). A parking brake located in the nacelle would then be automatically activated. The rotor begins to spin at the 'cut-in' wind speed, until it reaches the optimum wind speed for energy generation. Braking (or pitching of the blades) of the rotor to reduce rotor speed occurs at 'cut-out' speed, when wind speeds would be too high for the safe operation of the turbine.

2.2.2 Selection of Wind Turbine

Each wind turbine would be a three bladed type of the “up-wind” design. That is blades are facing up into the wind and in front of the tower. The wind turbine would have a diameter of 88 to 92.5 metres and a hub height (centre of the nacelle) of up to 105 metres, with the blade tip at its apex up to 150 metres above ground level. Blades would be of various material configuration but mostly are constructed of fibreglass attached to a steel hub, and would include lightning rods for the entire length of the blade in each model. Each wind turbine would have a rated power capacity of between 2.1MW to 3.0 MW, depending on turbine selection.

Wind turbines can be fixed speed or variable speed machines, that is, the turbine blades would either rotate at a constant speed (when operating) or a variable speed depending on wind speeds. Variable speed machines have better performance over a wider range of wind speeds, provide higher quality power to the electricity grid, and help reduce wind turbine noise levels at low speeds. However, they are more expensive to install. It is likely that variable speed machines would be used in the Kyoto Energy Park, with a rotational speed in the range of 7 to 19 revolutions per minute (rpm) depending on wind conditions.

Wind farms are a highly capital-intensive business, with a high proportion of the long term costs of a wind farm being related to its construction and financing. Likewise, revenues are directly linked to energy production, which is basically fixed by the turbine selection and capacity factor for the site. For this reason, to keep generation costs down and to ensure the projects financial viability, it is essential that the appropriate wind turbine is selected for a site, and that a competitive approach is used between manufacturers to minimise the capital costs of the project. At this stage, the specific wind turbine model and manufacturer have not been selected for this project. Various international wind turbine manufacturers have products available that are ideally suited for the low to medium wind speed conditions present at the site. These wind turbine suppliers include Vestas (Denmark),RE Power (Germany), Suzlon Energy (India) and GE Wind (US).

Even small changes in wind speeds or minor modifications to turbine locations can impact a turbine’s suitability for a site, and energy production at a site. Also of consideration in the final turbine selection is the availability of turbines on the market and current supply of generators to the Australasian market.

Another factor influencing turbine selection is contractual considerations of project delivery. Some turbine manufacturers currently also project manage wind farm projects within Australia (Suzlon, Vestas) for design, construct and delivery arrangements which are referred to as ‘turnkey delivery’ of projects. Benefits are obtained in contracting an overall delivery of the project by turbine suppliers experienced in design, construction and installation of turbines.

The final selection of the wind turbine generator model and capacity shall be determined during final design stages of the project. The type of turbine used will depend upon the availability of the turbine model at the time of procurement. Accordingly, the final turbine selection can only be carried out under a competitive tendering process once this development application has been determined and the final approval conditions are known.

Four wind turbine models have been considered in this report as outlined in Table 2.1.

2.2.3 Wind turbine operation

Each wind turbine would have its own individual control system, and would be fully automated. Start-up and shutdown (including safety shutdowns) are fully automated, with manual interruption available via onsite control systems and remote computer. Generally, wind turbines would commence operation at around 3 – 5 metres per second (11 – 18 km per hour) and gradually increase in production to their maximum capacity, usually at around 12 – 15 metres per second (44 – 54 km per hour). Once at this maximum capacity, the wind turbine would control its output by altering the pitch of the wind turbine blades. Under high wind conditions in excess of 25 metres per second (90 kilometres per hour) the wind turbine would automatically shut down to prevent damage. It would continue measuring the wind speeds during this state via an anemometer mounted on the nacelle, and would restart once wind speeds drop again to a suitable level. Various operating constraints can be programmed into the control system to prevent operation under certain conditions.

2.2.4 Environmental considerations of turbine selection

As discussed in the previous section the final turbine selection will consider turbine supply, contractual arrangements, commercial considerations and environmental criteria. Wind turbine design is constantly being researched and developed increasing turbine power efficiencies, power quality, reducing overall weights and improvements in structure design, blade development and aerodynamics.

Table 2.1 Wind Turbine Models under Consideration

Turbine component	Turbine Manufacturer			
	Suzlon*	RePower	Vestas**	GE Wind
Turbine Model/Capacity	S88 (2.1MW)	MM92 (2.0MW)	V90 (3.0MW)	2.5xl (2.5MW)
Hub Height	100m	100m	105m	100m
Blade Diameter	88m	92.5m	90m	100m
Blade Tip Height	144m	146.25m	150m	150m
Rotor Swept Area	$6082m^2$	$6720m^2$	$6082m^2$	$7854\ m^2$
Blade material type	Fiberglass/Epoxy	GFC shell construction	Fiberglass/Epoxy carbon	Fiberglass/Epoxy carbon
No of Blades	3	3	3	3
Rotational Speed (rpm)	Variable 15.0-17.6 rpm	variable 7.8-15 rpm	variable 8.6-18.4 rpm	variable
Cut-in wind speed (m/s)	4m/s	3.0m/s	4m/s	3.5m/s
Cut-out wind speed (m/s)	25m/s	24.0m/s	25m/s	25m/s
Rated wind speed (m/s)	14m/s	11.2m/s	15m/s	12.5m/s
Rated voltage	690/600V	690/575V	1000V	-
Rated frequency	50/60 Hz	50/60 Hz	50Hz	50/60 Hz
Noise (dBA at 8m/s)	106.3	105	102.0-109.2**	-
Lightning protection	Full	Full	Full	Full

Table 3.2 shows a list of wind turbines currently under consideration for the Kyoto Energy Park , together with key parameters of these turbines. All these turbines have been selected based on the suitability to low to medium wind conditions present on site. Final wind turbine selection would be carried out based on commercial considerations, turbine availability and environmental considerations which have been modelled on a worst case basis within this report.

This Environmental Assessment, and the related specialist studies, is based on the selection of a turbine which is representative of the ‘worst case’ scenario for consideration of environmental impacts (Noise and Visual Impact) associated with each turbine type. The turbines selected are:

Visual Impact Selection
The Vestas V90 3.0MW is one of the largest available wind turbines in the 2-3 MW range. This machine has been modelled in the Visual assessment for photomontages.

Suzlon S88 2.1MW.

This turbine has been cost competitive in Australia producing a high capacity factor due to the increased ratio of rotor diameter (88m to 90m) to generator capacity (2.1MW). The Suzlon s88 is expected to represent the highest impact case from a noise perspective. The current model utilises V3 blades with improvements in aerodynamics and noise reduction.

2.2.5 Wind Monitoring

There are currently two wind-monitoring masts located on Mountain Station that have been used in the evaluation of wind speeds and directions for the two sites. The first wind mast operating on the Mount Moobi escarpment was installed on the site in late 1999 by the Sustainable Energy Development Authority (SEDA), now the Department of Energy Utilities and Sustainability (DEUS). It is a guyed triangular lattice mast of nominal height 45m. The wind data has been recorded using an anemometer

Figure 2.3 - Mounting of the anemometer and wind

and wind vane installed at a height of 45m agl. A Data logger is installed closer to the base of the tower for logging ten minute mean wind speed and direction, standard deviation and maximum wind speeds.

Development consent for the construction of a second wind mast was granted by the Upper Hunter Shire Council on 13 May 2005. Wind Mast 2 includes anemometers installed at heights of 30m, 45m and 65m to record wind speed and direction, standard deviation and maximum speeds at 10 min intervals. The second wind mast was installed on Mountain Station in October 2006 and has been recording data since November 2006.

Remote monitoring of wind data is undertaken by Australia's Commonwealth Scientific and Industrial Research Organisation (CSIRO). The CSIRO record data on a monthly basis for preparation of a monthly report for the two masts. The CSIRO also maintain the service and calibrate the monitoring equipment under contractual arrangement with Pamada. It is proposed to continue operation of both masts to allow ongoing performance monitoring and independent verification of the site data during operational periods.

There is currently no wind monitoring on the Middlebrook Station site. It is proposed to install a wind monitoring mast on the Middlebrook site following development approval. An approval for the wind mast is not part of this application.

Note: As of February 2006 Wind Monitoring towers are considered 'exempt' development (SEPP No 4) and therefore do not require development consent if they have minimal environmental impact, less than 110 meters in height and are used for a period of less than 30 months.

2.2.6 Wind Turbine Layouts

The initial wind turbine layout for the two sites was undertaken by wind consultants Garrad Hassan Pacific Pty Ltd. The purpose of the initial assessment was to optimise layout based on wind speed characteristics of the site, and determine the projected energy capture for both sites. To prepare these layouts, Pamada provided Garrad Hassan Pacific Pty Ltd with key site parameters, including:

- general spacing requirements for turbine models;
- site boundaries;
- aerial photographs to determine extent of vegetation on site;
- site photos showing typical vegetation characteristics and distribution;
- topographical information (topography @ 10m contours);
- wind speed data collected on site by CSIRO (since 2000);
- operating parameters of selected representative wind turbines

Garrad Hassan Pacific Pty Ltd (GH) then optimised wind turbine layouts for both sites using a variety of specialised software packages including WaSP and Windfarmer. The wind speed and direction frequency distribution at the site mast at 45m height was derived for the period from January 2000 to September 2006, representing the wind speed and direction data recorded at Wind Mast 1.

Wind flow modelling was carried out to determine the hub height wind speed at the site mast location, as well as variations over the two sites relative to the anemometry mast. The long term energy production of each site was then calculated using the WaSP computational flow model taking account of array losses, topographic effects, availability, electrical transmission efficiency, air density effects, sector management and other potential losses. Energy production was determined for the Suzlon s88 2.1MW and the Vestas V90 3.0MW turbines.

The initial wind speed assessment and layout optimisation study prepared by Garrad Hassan (Nov 2006) indicated significant variability of wind speed across the site, which will help to explain the layouts proposed for each turbine type.

The original wind farm configuration included up to 47 wind turbines (35 at Mountain Station and 12 at Middlebrook Station) for both sites. Following environmental studies which took place in 2007 and early 2008 a final layout turbine configuration was determined. This included:

- Removal of 4 turbines from that initially proposed for the Mount Moobi plateau (Mountain Station) due to noise and optimisation of visual layout; and
- Removal of 1 turbine in close proximity to the Castle Rock plateau (Middlebrook Station) mainly due to visual considerations.

Further wind shear calculations (Garrad Hassan 2007) were performed using the latest collected data from the second wind mast which was installed in Oct 2006 on the Mountain Station site. This data was used to estimate wind speedup factors at the wind mast to be used in determination of wind speed at turbine hub heights of 80 and 105m on both sites.

Wind shear calculations were used to estimate long term mean wind speed averaged over each site at a hub height of 105m above ground level. The following conclusions were made using wind shear information up to and including Jan 2008.

- The long-term speed across all turbine locations at a hub height of 105m for the Mountain Station site is estimated to be 6.5-7.5 m/s.
- The long-term wind speed across all turbine locations at a hub height of 105m for the Middlebrook Station site is estimated to be 6.5-7.5 m/s.

When lengthy periods of wind regime data are not available it is usual to include long-term measurements from a local meteorological station. In this case, due to the long period of wind speed and direction monitoring, the onsite data was considered representative of the long term wind climate for the area. More detailed wind profiling and a turbine micro siting analysis will be performed on both sites following approval of the proposed development.

2.2.7 Wind turbine Micro-siting

Prior to construction the project will undergo a final engineering design phase as discussed in Section 3.4-Development Phases. During this phase a detailed Wind Energy Assessment will be undertaken by a specialist consultant using the preferred turbine model.

Following approval, final turbine locations would need to be micro sited to allow for the following:

- Slight variations in layout for each preferred turbine model (see Section 2.2.4) in accordance with the turbine manufacturers warranty;
- Optimisation of the layout for the selected turbine capacity i.e. 2MW or 3MW (spacing of turbines is mainly a factor of rotor diameter). Sufficient spacing between turbines prevents shielding of wind and reduced power output. Proposed models utilise a rotor diameter in the range of 88 to 100m based mainly on capacity)
- Detailed analysis of localised wind patterns over the land including a site inspection and detailed computer modelling for layout optimisation;
- Variances in geo-technical strength of sub grade material for turbine footings. Turbine footings would be designed during final design stages of the project.

There are many potential reasons for small changes to the preliminary wind turbine layout. These reasons may relate to construction issues, or energy considerations as described above. An allowance for micro-siting of each turbine structure by up to 150 m radius, from existing coordinates, would be required to accommodate final design variables, best practice engineering design and construction considerations as described above.

An allowance for these variations to turbine positions has been considered during all environmental investigations, site inspections and environmental considerations for the two sites. Any variances to turbine locations as a result of modifications to turbine layout would not increase likely impacts to environmental factors in each case. Turbine spacings would not be reduced as a result of micro-siting and therefore visual consistency of turbine clusters would be maintained as originally designed.

2.3 Mt Moobi Solar PV Farm

2.3.1 Preliminary solar plant investigation

During the initial project application stages a number of technologies were investigated for the solar energy component of the project. These included Solar-thermal variations and solar photovoltaic (PV) plants.

Essentially solar thermal electric power plants generate heat by using lenses and reflectors to concentrate the sun's energy. Because the heat can be stored, these plants are unique because they can generate power when it is needed, day or night, rain or shine. The solar thermal variations include parabolic troughs, parabolic dish and heliostat configurations for heating of a fluid or material for later conversion to steam. This steam would then be used to power a conventional steam turbine plant for generation of electricity. Other variations of solar thermal technology were also considered including the Compact Linear Fresnel Reflector (CLFR) system used to preheat water at the Liddell Power Plant.

There are rapid changes in solar technology developing in the field particularly in the area of storage of renewable energy. Hybrid variations can include even more variations for storage of solar energy used for manufacturing of SolarGas and geothermal storage of energy. SolarGas technology is currently being researched at the CSIRO National Solar Energy Centre (NSEC) in Newcastle.

Photovoltaic literally means ‘electricity-from-light’. Currently large-scale solar PV plants have not been as commercially competitive as wind and hydro options in Australia but their emergence is underway with some large scale pilot plants in some of the sun belt regions. One of the current disadvantages with solar photovoltaic plants are the large areas of land required to achieve comparably small outputs of energy. In addition the relatively high cost of solar cells has made PV Plants more expensive to build per MW than conventional solar thermal plants by comparison. This has generally limited the PV market to smaller scale applications such as rooftop PVs and for remote access power supply (RAPS).

A description of the technologies initially investigated at the project application stage is summarised in Table 2.2.

Table 2.2 - Solar Plant technologies investigated in Preliminary Assessment Report

Technology	Solar-receiver	Manufacturer (Example)	Description	Comments	Photograph
Solar-thermal	Solar Parabolic Troughs	Ausra Inc (US)	Consisting of curved mirrors which form troughs that focus the sun's energy on a pipe. A fluid, typically oil, is circulated through the pipe which is used to drive a conventional steam generator to create electricity.	• Environmental considerations • Water consumption for cooling towers • Viable for large scale plants >30MW capacity • More suited to sunbelt regions	
	Solar Parabolic Dish	Solar Systems (Australia)	Systems which consist of a parabolic-shaped concentrator (similar in shape to a satellite dish) that reflects solar radiation onto a receiver mounted at the focal point at the centre. The collected heat is utilised directly by a heat engine (or concentrated high quality photovoltaic cells) mounted on the receiver which generates electricity.	• Concentration of sunlight up to 500 times natural light intensity. • High efficiency photovoltaic cells used for higher gains • Higher cost of frame structure • Cost effective in higher sunbelt regions	
	Solar Central Receivers or	EnviroMission	Consists of a tower surrounded by a large	• Elaborate design with various receiver	

Technology	Solar-receiver	Manufacturer (Example)	Description	Comments	Photograph
Solar-thermal (cont)	"Power Towers"		array of heliostats or mirrors.	technologies mediums • Suitable for larger scale applications >30MW • Requires steam generation technology such as a steam turbine for electricity production	
	Compact Linear Fresnel Reflector (CLFR)	Ausra Inc	The first 35MW commercial plant under construction was at the Liddell Power Station in the Hunter Valley NSW as a pre-heater operating at 270°C using the existing coal plant turbines infrastructure.	• Cost effective technology used in the preheating of water for at Liddell Power Station • Requires conventional downstream steam generation turbine and recovery system	
Solar Hybrid	SolarGas™	CSIRO	SolarGas™ uses solar energy to increase the energy content of coal-seam methane or natural gas by about 26%. Hydrogen gas is generated which can be used in Hydrogen cells.	• Current pilot plant used at the Newcastle CSIRO facility • Requires methane or gas for conversion process.	

Technology	Solar-receiver	Manufacturer (Example)	Description	Comments	Photograph
Solar Hybrid (cont)					
Solar-photovoltaic	Fixed/single axis /dual axes or Concentrated structures	Sunpower Corporation (US) Meca-Solar (Spain)	Solar modules are mounted on either fixed, or tracking frames in an orientation to optimise sunlight over the daylight period.	• Modular system • No downstream infrastructure such as steam turbine generators/cooling towers • Reduced environmental considerations • Low maintenance • Remote monitoring • Generally low production output on commercial scale • High cost of cells	

The overall efficiency of solar thermal plants increases with size. That is, solar thermal plants are generally more adaptable to larger scale plants typically of at least 30MW, in high sun regions similar to that which exists west of the Great Dividing Range. However, given the current limitations to the technology for the size of the plant initially proposed (30-40MW) and other environmental considerations at the time, it was considered that a solar thermal plant in the order of 30-40MW capacity was unsuitable for the site.

A commercial scale solar photovoltaic plant was chosen as an ideal application based on the ability to supply power during peak demand periods. A further consideration was the ability to supplement fluctuations in wind power and efficiencies of grid integration and stability.

A full description of the Solar photovoltaic technology under consideration is provided below.

2.3.2 Solar Photovoltaic Technology and Application

PV systems use silicon cells to convert energy from sunlight into electricity. The DC electricity from PV modules is converted to AC by an electronic inverter(s). Systems can either be stand-alone or grid-connected. In grid-connected systems, the system produces power which is converted and fed into the grid. Silicon shortages on the global market have lead to growing need for thin film modules and concentrator PV systems. The Sliver Cell ™ was developed by the Australian National University (ANU) and uses 20 times less silicon than conventional cells, which significantly reduces the cost of production.

One of the major advantages of photovoltaic when compared to other solar technologies is that they produce electricity directly from sunlight and do not require a thermal conversion process such as a steam turbine. This reduces infrastructure considerations, operational costs and also environmental concerns associated with solar thermal systems. Solar photovoltaic technology was seen as an environmentally acceptable and potentially cost effective technology for the Kyoto Energy Park based on the following considerations:

- low overall environmental impacts associated with infrastructure i.e. no requirements for fluids, steam turbines and cooling towers used for solar thermal conversion systems;
- reduced on-site maintenance costs and on site operational requirements as compared to solar thermal systems;
- ability to remote monitor system performance and ease of maintenance;
- utilisation of the existing 33kV internal HV electrical network for reduced transmission and connection costs;
- utilisation of site substation to reduce electrical infrastructure costs;
- balancing of power output intermittency with combined generator technologies;
- ease of installation of components mainly due to off site prefabrication of solar trackers and modulation of cell panels;
- reduced transportation requirements in comparison to solar thermal systems;
- utilisation of on-site staff and local technical skills for operation and maintenance

Photo-Voltaic plants are very effective energy generators for small quantities of power which is why they have been effective in remote locations all over the world. The transition from small scale and remote application to medium sized applications is emerging in some overseas countries such as Spain, Germany and the US. Solar PV micro-generation is disadvantaged in Australia as the market fails to take into account of the true value and many benefits to the electricity network which arise from the adoption of renewable energy technologies embedded within the electricity grid. Solar PV, like other renewable energy sources, provide environmental benefits through reduced greenhouse gases and atmospheric pollution, and social benefits through industry development and job creation, each with related economic benefit.

The emergence of these systems in Australia will depend largely on Government policies and incentive schemes, feed in tariffs, cost reductions from global developments and improvements in cell efficiency. Very significant global investment is going into solar-voltaic design efficiency, engineering and cost of manufacture. Currently the most efficient photo-voltaic solar cells manufactured in the world have a foreseeable life span of approximately 25 years.

The Solar farm component of the Kyoto Energy Park is designed to be modular in nature. Additional capacity can be added by adding additional solar modules. Solar modules can be supported on frame structures varying from fixed to concentrated. Total overall capacity of the farm will be based upon final system design.

2.3.3 Viability of Commercial Solar PV Plants

Solar photovoltaic plants are generally expensive for large scale electricity generation. This is due to the relatively high cost of solar modules and the required large surface area of solar modules for electricity production. The proposed Mt Moobi Solar PV farm has been designed based on most suitable and viable technology for the site conditions. Large-scale applications (2-30MW) have been developed overseas but have been supported by government programs for implementation and overall higher electricity prices.

As an example in 1991 the German government introduced the Electricity Feed Act, legally regulating the feed-in to the grid of electricity generated from renewable resources. This act required utilities to purchase electricity generated from renewable resources at set rates (feed-in tariffs). The scheme, originally introduced in 1991, was expanded and enhanced in 2000, and has been responsible for the dramatic growth in Germany's renewable energy market and the solar photovoltaic industry in particular. The quantity of electricity fed into the grid from eligible sources has more than doubled, with a seven-fold increase in installed solar photovoltaic (PV) capacity to over 1,500 MW by the end of 2005. By comparison, at the same time Australia had in the order of 7MW of grid-connected solar PV, or less than 0.5% of Germany's capacity.

Australia currently supports renewable energy schemes through overall capital funding allocations for selective projects. Recently some states have introduced solar feed in-tariffs for electricity generated by solar panels however this has been limited to rooftop PVs (non-commercial scale) at this stage.

The Mt Moobi solar PV farm has been designed based on site conditions, peak operating sunlight hours, commercial considerations and a cost effective and viable combination of solar panels and tracking designs. Options for solar design have been included in this report (see Section 2.38). The final solar option is to be decided based on commercial considerations, procurement of cells and frames, cell efficiency, and government funding.

2.3.4 Solar PV Site suitability and location

The Mt Moobi plateau was chosen as an ideal location for the solar photovoltaic plant due to the
- availability of cleared flat land;
- good exposure to annual peak sunlight hours (PSA);
- and potential to absorb upstream infrastructure costs associate with transmission reticulation.

By co-locating this new PV power plant with other renewable generators (wind turbines and mini hydro components) the Kyoto Energy Park infrastructure and the associated interconnection and transmission facilities, will be optimised. As a result, the impact to the immediate environment is minimal and the project completion timeline will be shorter. The PV power plant is expected to serve customers in Scone and surrounding areas.

The area is relatively flat and located on what is part of a disused grassed private airstrip which is used infrequently for accessing the Mountain Station property by private light aircraft. The location of the Mt Moobi Solar PV Farm is illustrated in Figure 2.4 below. There is approximately 15 hectares of flat and an additional 6 hectares of relatively flat land for utilization i.e. Total area of utilization of 15-21 hectares. Minor earthworks may be required on the additional 6 hectares of land to dependent on the final option used for the solar plant.

During the investigation stages other areas within the Middlebrook and Mountain Station sites were identified as suitable for large-scale solar modules, which may be investigated in future stages.

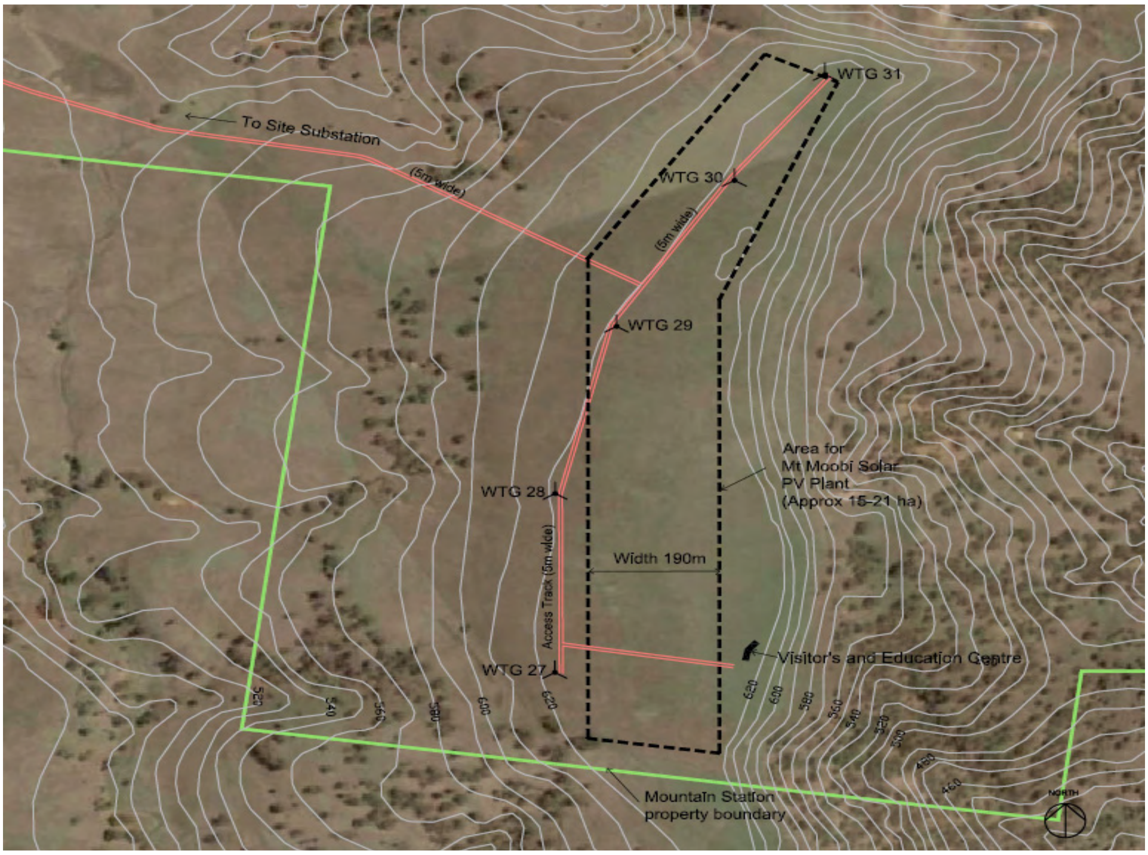


Figure 2.4 Location of Mt Moobi Solar PV Farm

2.3.5 Solar PV Options

Maximum plant capacity and estimates of gross power output have been designed on a maximum solar photovoltaic area of 21 hectares. The size of the Mt Moobi Solar PV Farm and configuration will depend on the type of supporting structure selected. Fixed structures allow for longer cells or rows, whereas power tracker structures are designed to carry between 10-35kW solar modules each.

Four solar options are being considered in the final layout for the solar farm component as shown in Table 2.3.

Table 2.3 Estimated Solar PV Plant Size for Different Structures Types

Description	Solar Photovoltaic Plant Options			
	1. Fixed Structure	2. Single Axis Tracker	3. Concentrator Photovoltaic (CPV)	4. Double Axis Tracker
Expected land use (ha/MW installed)	2	2-3	4-5	2-6
Estimated Plant capacity (MW)*	10	7-10	4-5	3-5
MW per structure	0.1	0.01	0.035	0.01
Number of structures	Up to 100	Up to 1000	Up to 150	Up to 1000
Area covered by solar modules (ha)	8.1	6.5	4	4

**Assuming a total site area for photovoltaic array of 21 hectares (Mt Moobi Plateau)*

2.3.6 Solar PV Design and Electrical Infrastructure

The Mt Moobi Solar PV Farm will be composed of the following electrical infrastructure:

- Up to 1000 Solar modules
- Up to 1000 supporting structures (fixed, single, dual axes or CPV trackers)
- 0.690kV low-voltage reticulation system
- Up to 6 step up 0.690/33kV substations
- 33kV HV reticulation system
- Metering cubicles
- Lightning protection

An indicative single line diagram of the proposed electrical infrastructure is provided in Figure 2.5.

2.3.7 Solar Modules

The solar farm will be composed of photo-voltaic solar cells which will be regrouped in solar modules with an output of a few kW (generally sold in panels of sizes 10W to 140W capacity). Solar modules will be mounted on supporting structures to allow for greater areas of cells for commercial installation. The frames may be fixed or mobile to allow PV racks to follow the Sun's path, increasing efficiency. Solar modules generate a DC current which is generated at low voltage of few hundred volts. Normally, the DC output of the solar module is converted to 50Hz AC current via a power inverter in each individual module, which would be mounted on the supporting structures.

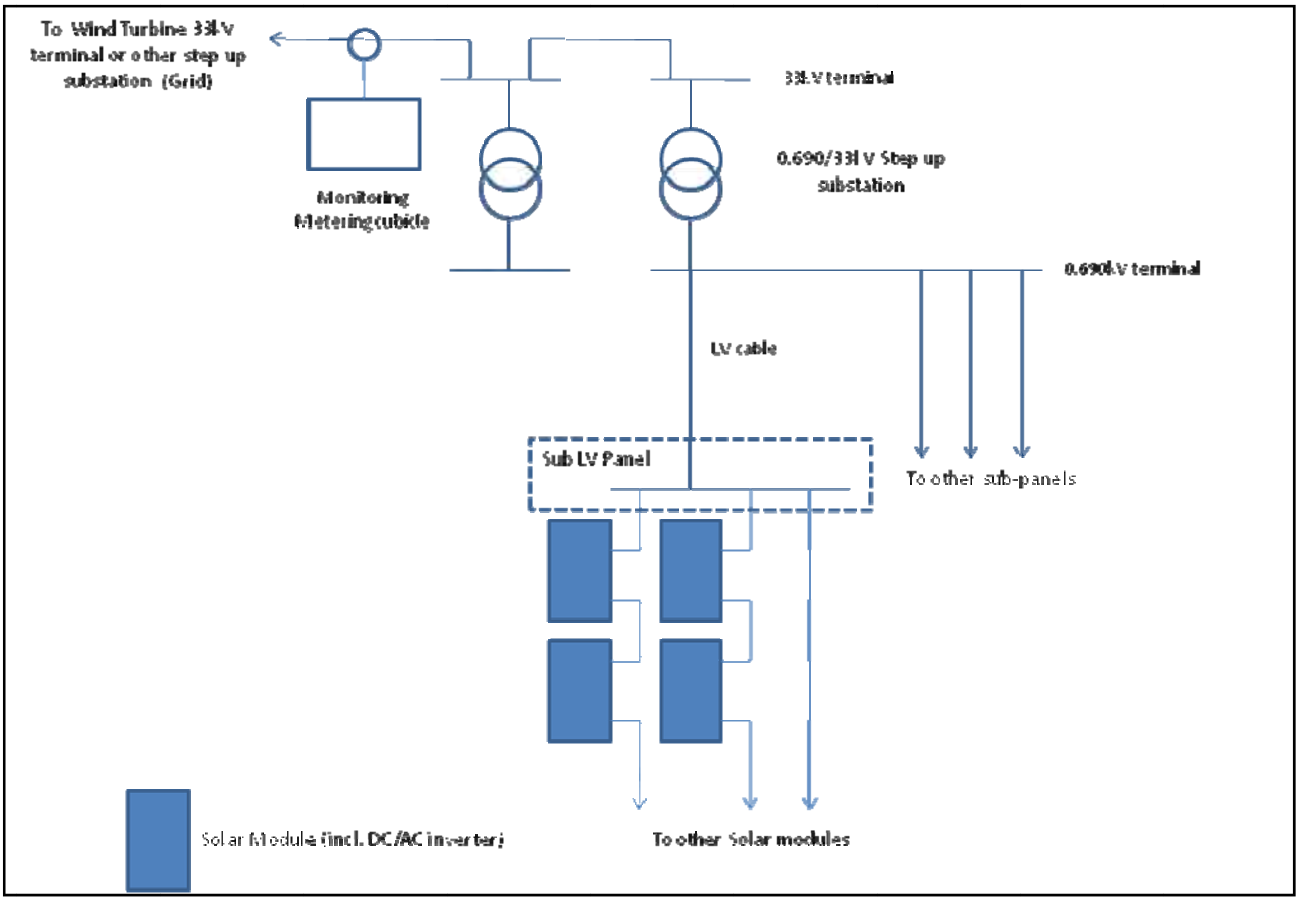


Figure 2.5 Mt Moobi Solar PV Farm Electrical Installation (Econnect 2008)

Solar panels would be sourced from Australian suppliers (eg BP Solar, Origin Energy) or internationally from Europe, China or the US. With the cost of cells a major cost of the project the supply would be based on a commercial decision.

2.3.8 Supporting Structure Options

A number of structure designs remain under consideration including fixed tilt, single or double axis power tracker, or concentrating dish structures as described below.

Option 1- Fixed Tilt / Fixed Orientation Structures

Fixed tilt structures are a simple frame structure made of steel or aluminium. They are designed to position the solar modules in the optimal fixed incident angle for sunlight. Fixed structures are generally configured in rows. The dimensions of the structure would depend on the final design; however, it is expected to be no more than 4 metres high and less than 10 metres wide. Row length will depend on final configuration; however, it is not expected to be greater than 200 metres. Figure 2.6 shows an example of a fixed structure installation. The structure's foundations are made of wire mesh reinforced concrete. The foundations are fixed with earth bolts that have a minimal sealing impact on the ground.

Figure 2.6- Solar PV Fixed Supporting Structure (Example)

Power Tracker Frames (Single or Dual Axis Tracker Structures)

Single or dual axis tracking systems are mobile structures also known as power trackers. They are designed to enhance solar panel energy production when compared to fixed structure design. This is achieved by continuous adjustment of the solar panel inclination to an optimal incident angle for sunlight, dependent on the movement of the sun and meteorological conditions. Power trackers are powered by three phase AC induction motors and controlled by a PLC controller usually connected to a GPS or a meteorology station. Power trackers are fitted with individual DC/AC inverters and their own protective electrical cabinet. The power tracker foundations are made of wire mesh reinforced concrete. Structures are designed to carry solar modules of up to approximately 10-15kW and are able to withstand strong winds of up to 140-170 km per hour depending on the manufacturer and tracker used. In the event of high winds, some structures are programmed to set panels in a horizontal position to minimize wind loading on the structure.

Option 2 - Single-Axis or Horizontal Trackers

Single axis horizontal axis trackers consist of a series of long horizontal tubes supported on bearings mounted upon pylons or frames. The axis of the tube is on a North-South line. Panels are mounted upon the tube, and the tube will rotate on its axis to track the apparent motion of the sun through the day. Since these do not tilt toward the equator they are not especially effective during winter mid day (unless located near the equator), but add a substantial amount of productivity during the spring and summer seasons when the solar path is high in the sky. These devices are therefore less effective at higher latitudes such as Australia. The principal advantage of these systems is the robustness of the supporting structure (for high wind areas), the simplicity of the mechanism and the lower cost of installation.

Since the panels are horizontal, they can be compactly placed on the axle tube without danger of self-shading and are also readily accessible for cleaning. Also a single control and motor could be used to rotate multiple rows of panels. Horizontal axis systems are therefore simple in design and installation, more compact and require minimal foundation construction. They are therefore less costly to install. Overall cell efficiency of these systems is limited in lower latitudes such as Australia with the single axis tracking system, reducing power output efficiency of the overall system.

Tracked arrays substantially improve the amount of power produced by a fixed system by enhancing morning and late afternoon performance. Strong afternoon performance is particularly desirable for grid-tied photovoltaic systems, as production at this time will match the peak demand time for summer season air-conditioning. For residential loads this peak period is normally in the mid to late afternoon. In very hot summer days this peak period can extend to 6 or 7pm in the evening.

Figure 2.7 – Solar PV Single Axis Power Tracker Supporting Structure (Example)

Option 3 - Dual Axis Solar tracker

The dual axes tracker follows the sun's path, using a controller, motor, and drive to rotate the PV array. That gives between 18% and 35% more energy output than rigid systems in which the panels are installed at a fixed angle of inclination. The systems use a galvanised, corrosion-resistant steel frame, and withstand high winds up to 130km/hr (MecaSolar). The construction scales from small to large multi-MW installations.
A typical dual-axis solar tracker system under consideration is shown in Figure 2.8.

Dual axis trackers are ideally mounted on high support structures to avoid contact of the rotating PV array with the ground. Improvements are also made in the cell efficiency by increasing air-flow around the back of the array for cooling of the cells which increases cell performance. The performance of crystalline silicon cell arrays can decline with very high temperatures, where ventilation is limited and the cell temperatures can be 30 to 40 degrees higher than existing air temperature.

Figure 2.8 Solar PV Typical 11kV Dual-axis Tracker (Courtesy of Meca Solar Pty Ltd)

A 7.5 m3 concrete foundation would be required for each tracker foundation based on a 11kW module. Up to 1000 units have been allowed for in the design. Solar trackers are delivered to site on flat bed truck and bolted on to the foundation. Cell panels are delivered to site and fitted to the tracker frames prior to erection onto the tracker base.

Other indirect benefits to using solar trackers include the ease of installation and minimal earthworks requirements for large areas of sloping gradients. Solar trackers also reduce the amount of ground coverage required making it easier for grazing of livestock with minimal disturbance, which maintains the grass cover to a suitable height.

Option 4 Photovoltaic Concentrator (PVC)

Solar photovoltaic concentrator technology (PVC) is different from conventional PV installation. Curved mirrors, grouped to form a dish, are used to concentrate the sun 500 times on an array of closed packed, high efficiency PV cells. The mirror and the PV array are mounted on a power tracker as described. PVC structures are taller than the conventional PV system. Structure height is expected to be in the order of 14 metres. Structures are designed to withstand wind loading of up to 190 km. In the event of wind above 50km per hour the system is designed to horizontally orient the dish to minimize wind loading on the structure.

2.3.9 Other components of the Solar PV plant

Low-Voltage (LV) Reticulation system

A number of solar modules will be connected in series to form solar arrays. Solar arrays will be connected in parallel to sub-distribution LV switchboards (Sub-Panels). These sub-panels will collect the plant output, provide electrical protection of solar arrays, and will be used as a transition point to increase LV cable sizes before connecting to the step-up substations which may be located at a distance of a few hundred meters. LV cables may be installed above or underground, unenclosed or enclosed depending on final design. Sub-panels are relatively modest in size (e.g. 1000 x 1000 x 200mm) and will be mounted either on the solar system structure or on a small stand alone post.

Figure 2.9 – Example of a Photovoltaic Concentrator Structure (PVC)
(Courtesy of Solar Systems Australia)

Lightning Protection
Lightning protection of the Solar PV System would be in accordance with standard practice for solar structures and electrical systems. Solar tracker units would be earthed with a lightning rod to protect inverters, and component electrical systems. Underground cables would also be earthed as per normal design.

Step-up substations
Groups of sub-panels will be connected to a single step-up substation. The step-up substation will be composed of an LV switchboard, 0.690 / 33kV transformer and 33kV switchgear. All the equipment will be enclosed in an outdoor kiosk. Pad mounted transformer sizes have not yet been selected, but are expected to have a rating between 1.5 and 2.5MVA. Based on a 2.5MVA step-up substation, the footprint will be 3 x 8 x 3 metres (dimensions are inclusive of the concrete slab). At this stage up to 6 step-up substations are expected to be distributed around the proposed site. Final locations will depend on detailed design.

Medium voltage (MV) reticulation system
The step-up substations will be electrically connected together via 33kV underground cables. The solar farm output will be connected to the grid via one or several wind turbine 33kV terminals depending on final design.

Monitoring and metering
Independent monitoring and metering of the solar farm output may be required and will be installed in an outdoor cubicle. The dimensions of this may be expected to be 3 x 10 x 3 metres. Figure 2.10 shows an example of such a cubicle.

Figure 2.10 – PV Farm - Monitoring & Metering Cubicle (Econnect)

2.4 Mini Hydro Plant (Closed-loop)

2.4.1 Introduction

Hydropower is one of the most cost-effective and reliable energy technologies available for clean-electricity generation. Sometimes referred to as 'pumped storage' or 'load balancing' the hydro-plant is used to store surplus electrical energy in water as potential or stored energy. This energy is later released for generation of electricity into the grid during peak demand periods or high electricity pricing. Stored hydropower is different to conventional stream or lake feed micro hydro turbine systems which supply a constant rate of electricity from constant flows.

Conventional 'pumped storage' plants pump water from a lower elevation reservoir to a higher elevation reservoir at times when electricity demand is low, usually at night times. The water is later discharged during high peak demand periods (usually the day) when electricity pricing is highest. Pumped storage plants have also been used in large-scale applications for balancing of power output from conventional generators and reducing the need for installation of expensive peaking plants.

A major advantage of larger pumped storage systems is the ability to flatten out load variations on the grid, permitting thermal power stations such as coal-fired plants that provide base-load electricity to continue operating at peak efficiency while reducing the need for "peaking" power plants that use costly fuels such as gas and diesel. Thermal plants are much less able to respond to sudden changes in electrical demand, potentially causing frequency and voltage instability. Pumped storage plants can respond to load changes within seconds. Pumped storage is currently one of the most cost-effective and efficient means of storing large amounts of electrical energy on an operating basis.

Although overall losses from the recharging procedure makes the pump storage plant a net consumer of energy overall, the system increases revenue by selling more electricity during periods of peak demand, when electricity prices are highest. Small scale decentralised peaking plants can be cost effective and efficient because they reduce the need for installation of centralised and large-scaled generation plants (traditionally coal fired plants).

Pumped storage and hydro generation is well suited to meeting these peak demand spikes, however scarcity of water resources means there is little opportunity for further large or medium scale hydro generation developments within Australia. Hydro power alone represents approximately 82% of NSW's current renewable energy generation capacity. The Snowy Mountains Hydro Scheme is the major contributor representing 3.5% of Australia's total generation capacity to the grid.

We have recently seen the effects of drought on large scale hydro power. In 2007 the escalation of the drought had a sever effect on the project with plans to increase flows through cloud seeding and even plans to shut down the Snowy operation until water levels in the dams were replenished (Reuters Foundation 2007).

2.4.2 Proposed 1MW Mini-hydro Plant (Closed Loop)

The proposed Closed loop mini-hydro plant (referred to as mini-hydro plant) would be a mini generation plant of 1MW total capacity. The system has been designed to supply electricity for short periods (discharges or bursts) during peak periods of electricity demand on the grid or during unstable variations in power output. The system is closed (sealed) and therefore has minimal water requirements. The final capacity of the holding tanks have not been finalised but are expected to have a detention time in the order of between 30 mins to 4 hours duration.

The main benefits of the mini-hydro plant are:
- to satisfy peak electricity demand;
- to generate revenue during peak demand and high electricity pricing;
- for load balancing of intermittent power generation mainly from wind turbine generators;
- storage of renewable energy from wind and solar generator components during low electricity demand periods or low electricity pricing

Peak demand period

The peak demand peak is driven primarily by lifestyle changes such as more appliances in the home for example larger electrical appliances (particularly air conditioners), more computers, larger televisions etc.

Building electrical infrastructure is the traditional solution to meeting peak demands periods on the grid. Electricity infrastructure is a costly and inefficient use of capital because it is required for less than 1% of the year (during peak periods). Such infrastructure can be in the form of building a peaking generator/s or new interconnectors (or increasing the capacity of an existing interconnector) to take advantage of excess capacity in another state/s whenever possible.

Other generator types are even more expensive, and some, such as wind generators, photo-voltaic cells, brown and black coal generators are not well suited to peak generation. Hydro plants respond to rapid fluctuation in demand with discharge and electricity generation relatively instantaneously.

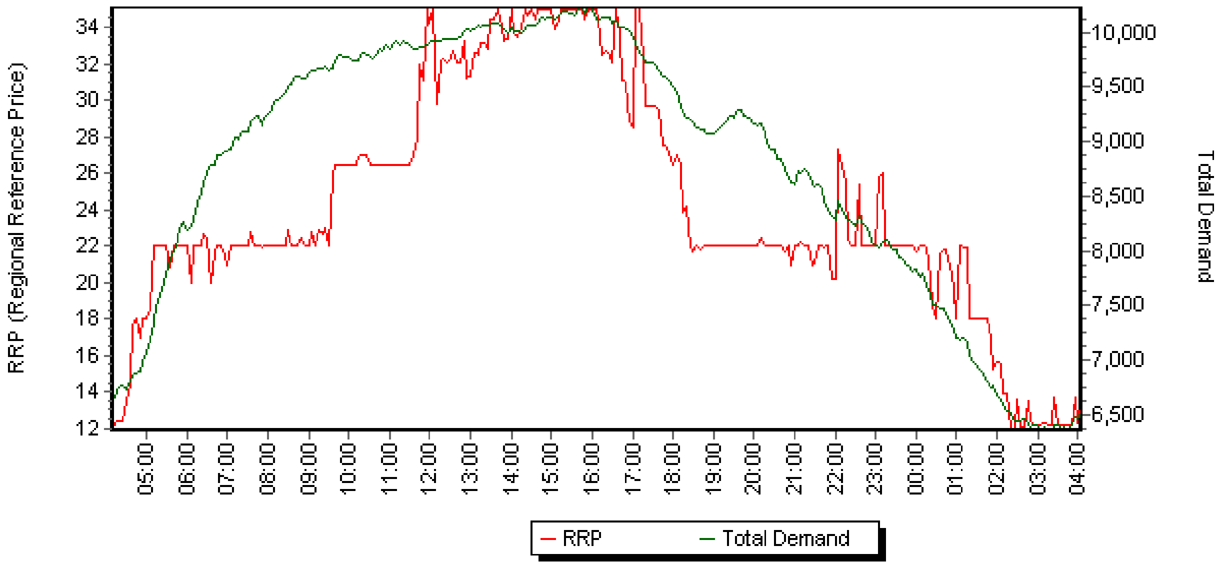


Figure 2.11 – Example showing Wholesale electricity price versus demand (NEMMCO 2008)

Peak electricity pricing

The wholesale electricity price (RRP) can rise from an average of around $34/MWh to a maximum of $10,000/MWh in any five minute period. Wholesale price peaks are not necessarily linked to a demand peak (it may be a failure of plant or other supply side constraint that causes the wholesale price to peak), but generally higher demand causes an increase in the wholesale price. Price rises may occur for short periods of time as shown in Figure 2.11 below.

The mini hydro plant would be used as a peak generator during periods when electricity pricing is high. Fluctuations in demand would need appropriate monitoring of market prices to determine optimal conditions for discharge. Hydro plants are considered one of the most efficient (around 90-95%) for conversion of electricity.

Load Balancing of power output

Electricity industry operators keep deviations in frequency and voltage within acceptable limits to prevent network faults and maintain security. Renewable energy generators such as wind and solar are considered intermittent power sources and therefore power output fluctuates with variables such as weather and seasonal patterns, topographical features (eg turbulence), wind turbine layout, and long term phenomena such as climate change.

This variability in power output will affect the ‘smoothing factor’ of the combination of generators in supplying optimum power quality to the grid connection. The ‘smoother’ the combined power output or the more predictable the supply to the grid (forecasting) the easier the integration of the Kyoto Energy Park onto the grid. Wind turbine layout (as and example) has a significant influence on power variability (as each turbine is operating under variable localised wind conditions) and hence power output fluctuations can be reduced. This smoothing effect can also reduce turbine infrastructure costs (such as reactive power compensators) needed to improve power quality for connection to the grid. In weak grid networks power quality and ‘phasing’ are extremely important and affect overall network integrity, security and final pricing.

The operation of various renewable technologies (including solar, wind and hydro) will greatly improve the power quality and phasing of the Kyoto Energy Park into the grid. The mini hydro plant will be used to balance variability in overall power supply to the grid for power smoothing effects.

Pumped storage of renewable energy

Currently large scaled electrical energy generated by the Kyoto Energy Park cannot be stored cost effectively and must be delivered to the grid during operation of the various generator components. The operation of the main renewable components (wind and solar) will be determined by the weather conditions favourable to each technology.

Power generated on site by the solar and wind farm components of the Kyoto Energy Park would be used to recharge the system. Recharging of the closed system would occur during low electricity demand periods, while discharging would take place during high peak demand periods and for load balancing of power output during instable network conditions. As described above this system has conventionally been used on large scale dam hydro applications for balancing supply and as a peaking plant. The Kyoto Energy Park mini hydro plant can either be monitored on site or remotely to allow optimum discharge of the system.

By using renewable energy sources to store electricity during low electricity demand net energy consumption is positive, however electricity is sourced from renewable sources. Conventional pumped storage reservoirs are not replenished by streams and evaporation losses can be significant over large storage areas. This is a significant consideration in a large scale plant and of particular importance in hot climates such as Australia, where water resources are valuable. A closed loop system has been designed to improve efficiency of the system and reduce overall water usage in charging the system. Losses within the system are expected to be negligible with any net water usage sourced from within the site from rainfall runoff.

2.4.3 Site suitability

The location of the mini hydro plant has been determined based on a site inspection of the Mountain Station site by Pamada. The exact site was chosen based design parameters of slope gradient (approx 50%), uniformity of grade (for ease of construction) and initial environmental considerations such as noise, flora and fauna, Indigenous heritage and visual.

The site is predominantly cleared of vegetation on upper reaches, with exotic grass species existing over the area for grazing purposes. Some scattered trees are present on the lower reaches which would be selectively removed during construction of the plant facility and lower tanks (see Figure 2.12). During the environmental assessment stage inspections were made and considerations given by individual consultants in key areas as summarised below.

2.4.4 Noise Issues

A noise assessment of the mini–hydro plant under construction and operational conditions was undertaken by Wilkinson Murray. Noise during operations has been modelled based on worst case conditions (i.e. cumulative noise impacts for the full operation of Kyoto Energy Park facilities

including wind turbines, solar plant and mini-hydro plant, under adverse wind conditions). The nearest residence is 2.5 km away from the proposed mini hydro plant. The cumulative noise impact associated with the operation of the mini hydro plant under worst conditions would be below background noise levels at closest residence.

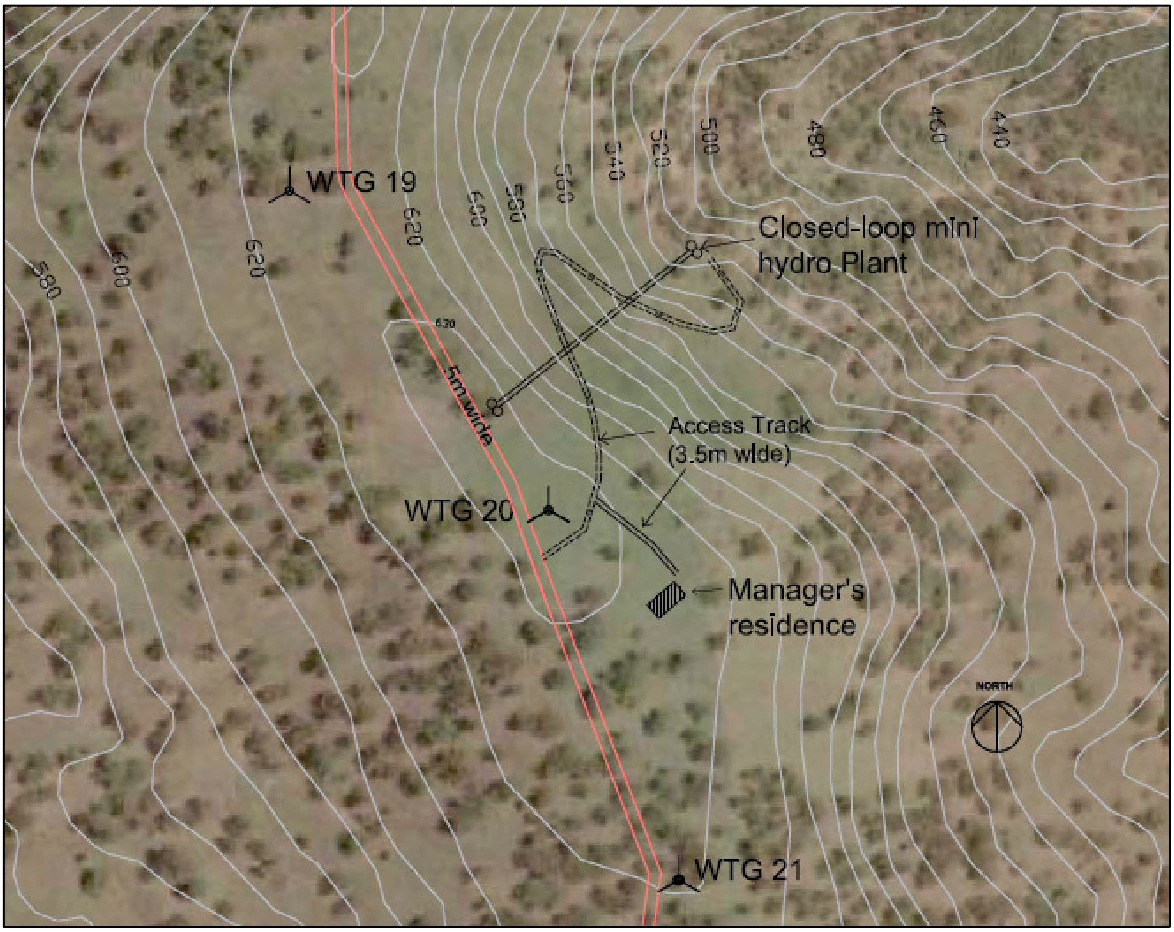


Figure 2.12 - Location of the Mini Hydro Plant- Closed-loop

To achieve noise criteria the plant units would be fully enclosed in a shed structure to limit the SWL noise emission at source to below 120dBA.

2.4.5 Heritage Issues

As site inspection for Indigenous artefacts and cultural significant of the location was undertaken by Myall Coast Archaeological Pty Ltd. A site inspection and survey was conducted on two separate occasions (13th and 30th August 2007), with Indigenous stakeholders and Aboriginal groups, Myall Coast representatives and Pamada representatives all in attendance. No artefacts or Aboriginal objects were uncovered during the site surveys on both occasions. The area has been extensively cleared in the past and under inspection was unlikely to contain Aboriginal Artefacts or objects. No objections to the site were made by Indigenous stakeholders present. No recommendations for further work prior to construction were made.

2.4.6 Flora and Fauna Issues

An inspection of the location and surrounding areas was undertaken by Conacher Travers Pty Ltd for significant flora and fauna species. The area is predominantly cleared of vegetation and has been replaced with exotic pasture for grazing purposes. Tracts of disturbed Box Woodland Grassy Forest community are present on the lower reaches (see Figure 8.0 in Section 8.0). This community is a variant of the White Box Yellow Box Blakely's Red Gum Woodland however the location has been extensively cleared and disturbed and correspondingly has significant exotic grass species and effects from nearby grazing.

Removal of this vegetation for construction of the mini hydro plant in the lower reaches will be minimal. Replanting and revegetation will be undertaken as part of the site restoration process following construction activities.

2.4.7 Visual considerations

Consideration of visibility of mini hydro plant (particularly the header tanks) from extremities of the site has been taken into consideration. Based on the visual impact assessment it was recommended that the header tanks be painted with an olive green colour and vegetation screening be adopted for the header tanks.

Design of the screening vegetation shall be detailed in the Vegetation Management Plan prepared during the final design stages of the project prior to commencement of construction.

2.4.8 Mini-hydro Plant (Closed loop) Design layout

The proposed mini-hydro plant (1MW) is simple in nature. Water will be sourced from on-site or trucked in and used to fill the header tanks. Additional top up water will be collected from rooftops during rainfall, diverted and stored in the tanks located at a high point. This stored water has a potential energy storage called ‘gross head’ which is the vertical distance measured between the header tank and the outlet. This potential energy is then converted to kinetic energy (moving energy) when water in the header tank is discharged under gravity.

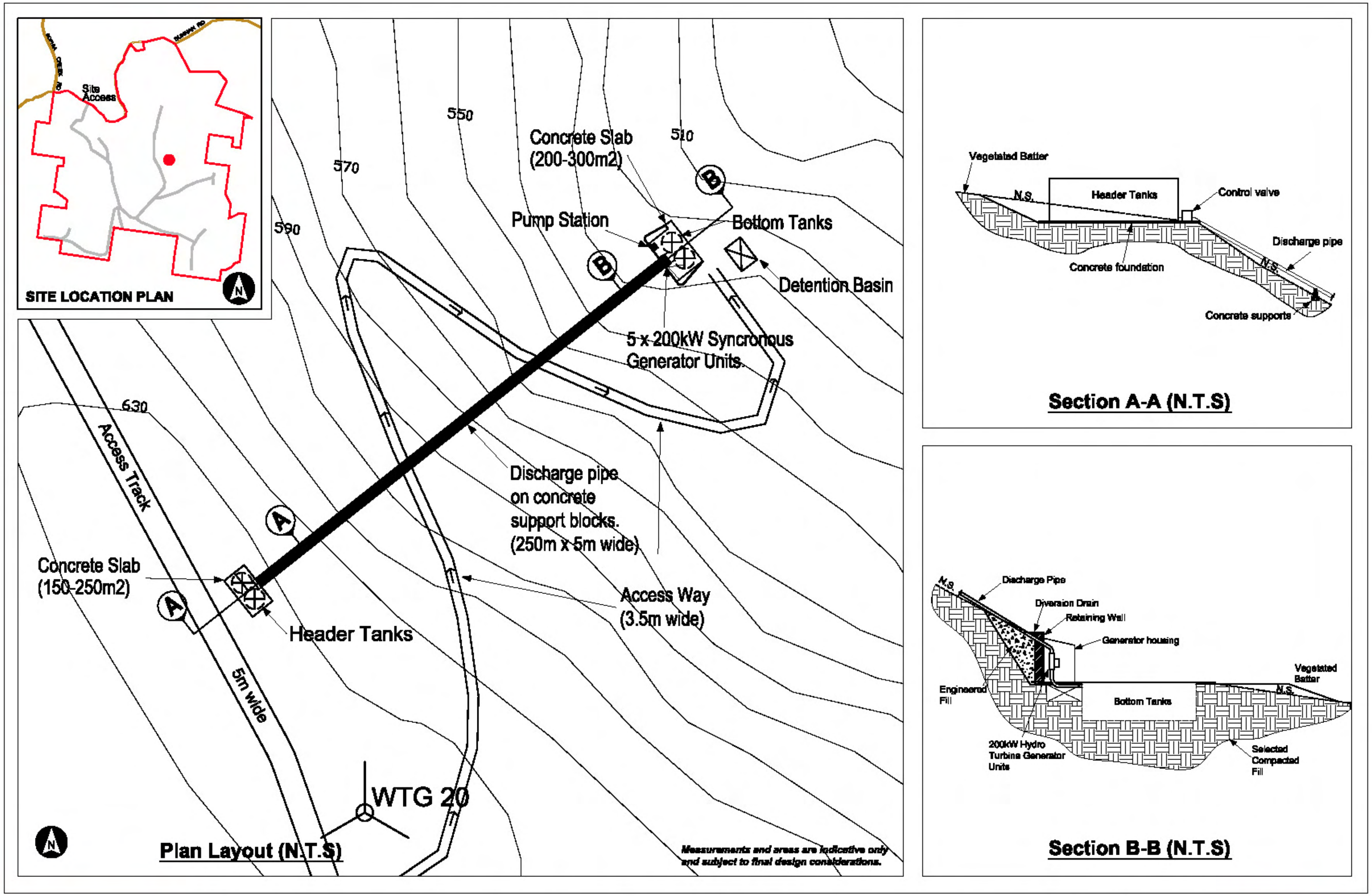
Discharging water drives a series of smaller hydro turbine units located at the lowest point of the loop. The impact of the water on turbine propellers generates electricity which is reticulated into a small connecting step-up transformer and reticulated into the site substation. At times of low electrical demand, electricity from renewable devices from solar photovoltaic and wind turbines are used to pump water into the higher reservoir. When there is higher demand, or as the power regime requires, water is released back into the lower tanks through the mini-hydro turbines, generating electricity. Reversible turbine/generator assemblies may be used as a pump and turbine combination.

Electricity for reverse pumping of water to header storage shall be sourced from excess energy generators from the wind and/or solar plants. A dedicated low voltage cable will be feed from the site substation to supply power to the plant. A separate control cable will also link the plant with the control room at the site substation for on site monitoring of the system.

The preliminary design of the mini hydro plant is shown in Figure 2.13. Final design of the plant will be undertaken during final design stages of the project. Design parameters will consider:
- Size of header/lower tanks and detention time
- Geotechnical and Reinforced concrete design;
- Installation of 5 x 200kW (rated capacity) synchronous generator hydro units
- Size and grade of pipe(s)
- Control facilities
- Top up water storage from Managers Residence

Figure 2.13 illustrates the overall preliminary design of the Mini Hydro Plant (Closed Loop).

pamada HDB Town Planning & Design



Kyoto energypark | *Figure 2.13 - Mini hydro Plant (Closed Loop) - Preliminary Design*

pamada A4

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2.5 Internal Electrical Transmission Infrastructure

2.5.1 Site Substation

A substation would be constructed on the Mountain Station site for connection of all proposed electrical generators. The proposed substation has been situated in a flat area that is clear of vegetation and with minimum visibility to traffic along Bunnan Road. The substation site has been inspected for aboriginal and archaeological significance, flora and flora species or habitats, visual considerations and bushfire risk, by individual consultants. These issues are addressed in further sections to this report.

The site is suitable for construction access, fire protection and access for inspections and maintenance for utility network staff. The substation is also located on the Mountain Station site to reduce electrical losses associated with transmission of power to connection point options. The substation would contain a control room, compound area and 66 kV/132kV switchyard, all enclosed within a chain wire mesh security fence. The area of the substation compound would be typically 60m x 40m. The final design of the substation would depend upon the connection agreement and final electrical design of components.

Each of these components of the substation is described in further detail below. The location of the site substation is shown in Figure 2.14.

Switchyard

The switchyard would contain up to two transformers. The transformers would be installed on concrete raft foundations, with oil bunding around the perimeter. Two 33 kV/415 V local service transformers would be located within the bunded area. A below-ground oil separation tank would be installed to separate oil and water. The separation tank will be sized to allow for total loss of oil from a transformer.

Control Room

The control building would contain instrumentation, control and communications equipment, a small workshop, meeting room, kitchen, and a 33 kV switch room housing the switchgear, protection and communications equipment with associated power and low voltage cabling.

The control room would contain a centralised computer SCADA (Supervisory Control and Data Acquisition) system. The computer within each turbine is linked to the control room by fibre-optic communication cables laid in the same trench as the electrical cables. The SCADA system enables monitoring and controls of all wind turbines within the wind farm component, either from the control room or remotely. The SCADA system continuously scans the information received from the wind sensors in each turbine and optimises the performance of each turbine for the current wind conditions.

The control building would be of concrete slab on ground construction with steel frame, metal or brick walls, a non-reflective sheet steel roof, and would include rainwater collection and storage for domestic use. A composting or septic toilet system would be installed for staff use. It is likely that the control building will be air-conditioned.

A telephone connection to the control building would be required to allow remote monitoring and control of some of the Kyoto Energy Park components. This connection could consist of overhead telephone lines or a satellite connection.

Standard 240 V/ 415 V power would also be installed at the control building. The control building will be located within the site substation as shown in Figure 2.15 or adjacent to the substation, and is expected to be a joint facility for control of the substation as well as the mini hydro and solar generators. The control building will occupy around 60 m2 (10 metres by 6 metres). A perimeter area within 25 metres of the substation and control room will be managed as an Asset Protection Zone to maintain low fuel levels.

Bund Wall

The noise assessment recommended as a precaution the construction of a 4m high bund wall around the north westerly edge of the proposed site substation. This is proposed to eliminate any possible noise exceedances at the nearby Clifton Hills Estate as a result of the operation of the substation. The bund wall will be constructed with clean overburden sourced from within the site, topsoiled and grassed with native grasses species suitable for the application.

A preliminary design layout of the site substation is illustrated in Figure 2.15 below.

Figure 2.14 - Location of Site Substation and Maintenance Building (Mountain Station)

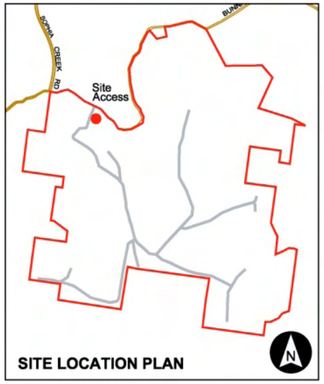
2.5.2 Internal power cables

Internal power cables shall be reticulated from the each generator component (wind turbines, solar PV plant, mini hydro plant) to the site substation.

Within each wind turbine, or in the adjacent pad-mount transformer, the power voltage is stepped up from generation voltage to 33,000V (33kV) for reticulation around the site. Each wind turbine must be connected together at reticulation voltage, and then connected to the site substation. 33,000kV step up transformers would also be used for the solar photovoltaic plant (up to 6) and mini-hydro plant (1) prior to reticulation into the underground 33kV cables.

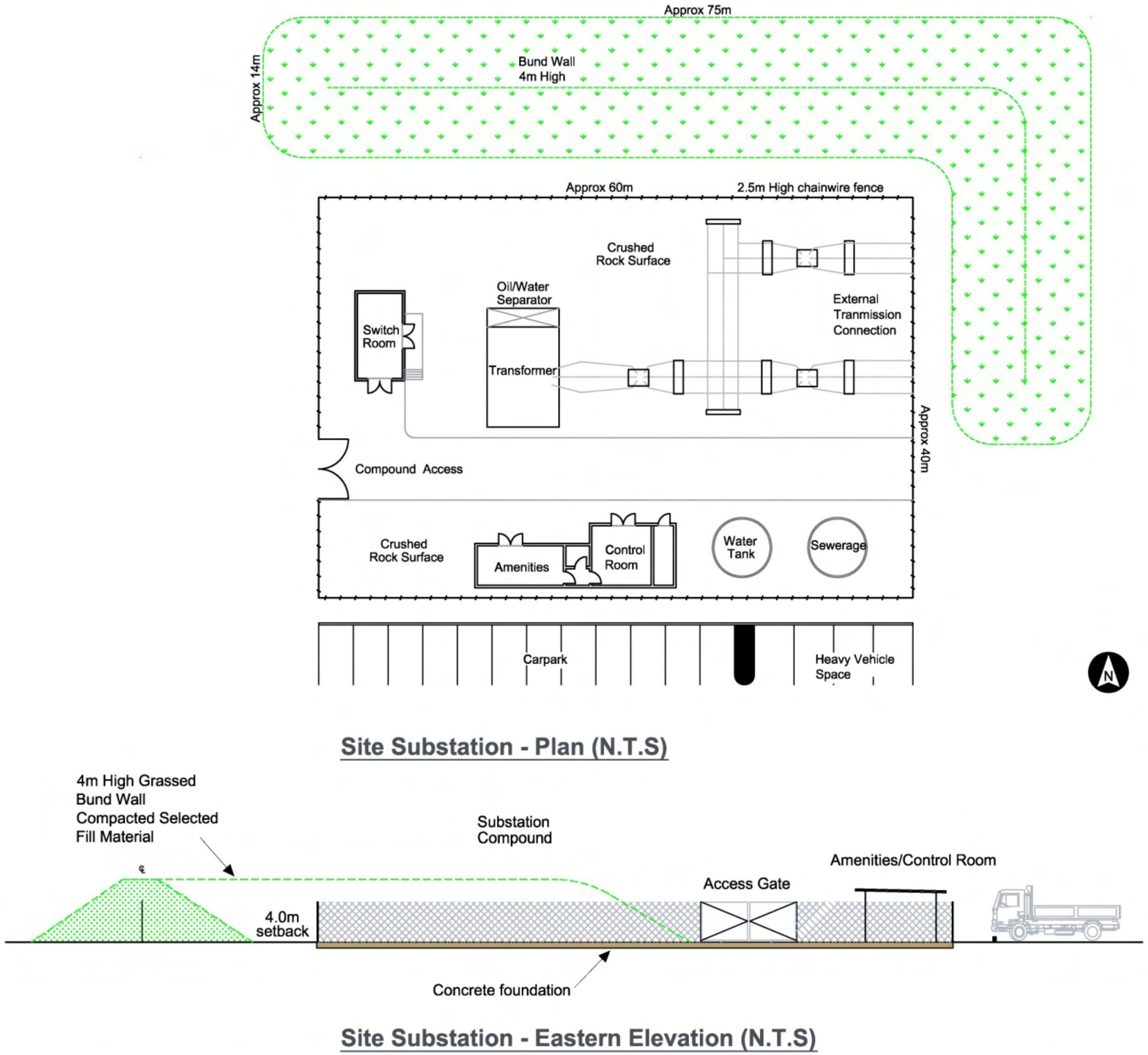
Permanent internal cabling would be installed, connecting the power output of each generator back to the site substation. Cabling would be located in buried service trenches. Underground cabling will be used along visible ridgelines to reduce the overall visual effect of the proposal. Underground cabling would generally run adjacent to the site access tracks, and include both electrical cables, control and fibre optic cables. Trenches will be approximately 1.5 metres deep and 0.75 metres wide. Independent control cables would likely be used for wind turbines, solar and mini-hydro systems.

There is approximately 14,900 metres of internal power cable for the Mountain Station site and 6,200 metres on Middlebrook Station.



NOTES :

1. Final design os site substation to be completed prior to construction.
2. Approximate dimensions are shown based on preliminary design of substation compound (Econnect 2008)
3. Grassed bund wall shall be designed in accordance with recommendations from Wilkinson Murray Acoustics and as shown in this diagram.



Kyoto energypark | *Figure 2.15 - Site Substation (Preliminary Design Layout)*

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Control Cables

Control cables that enable monitoring and control of turbine operation will be co-located in trenches with the power cables. Cable trenches would, where possible, be dug within or adjacent to access tracks to minimise any related ground disturbance. Short spur connections would come off a main cable run which would approximately follow the access track route on site.

In addition to the power reticulation cabling, control and communications cabling is required from the control building to each wind turbine. A dedicated control cable will be installed from the solar PV plant and the mini hydro plant to the site substation. Control cables would consist of twisted pair cables, multi-core cables or optical fibres, and would be used for central and remote control of individual wind turbines; substation controls; monitoring of weather data and equipment; and communications to offsite control centres where required.

2.5.3 Internal Access tracks

Internal access tracks are required, both during construction, and operation, to enable construction and ongoing maintenance of the wind farm infrastructure, in particular the turbines. i.e. the construction access roads will become the permanent access roads upon completion of construction activities.

Access tracks would be upgraded to 5m wide with a top layer of gravel supplied from an existing road base/gravel quarry in the area. New access tracks would be constructed in certain areas to provide access to the ridgeline and turbine and substation positions where required. The grade of tracks would not exceed 14%. The tracks would include drainage trenches to collect rainwater runoff from the compacted surface of the track. All access tracks would be permanently retained to provide ongoing access during operation of the Energy Park.

Table 2.4 below summarises the total length of existing and newly constructed internal access road required under the proposal.

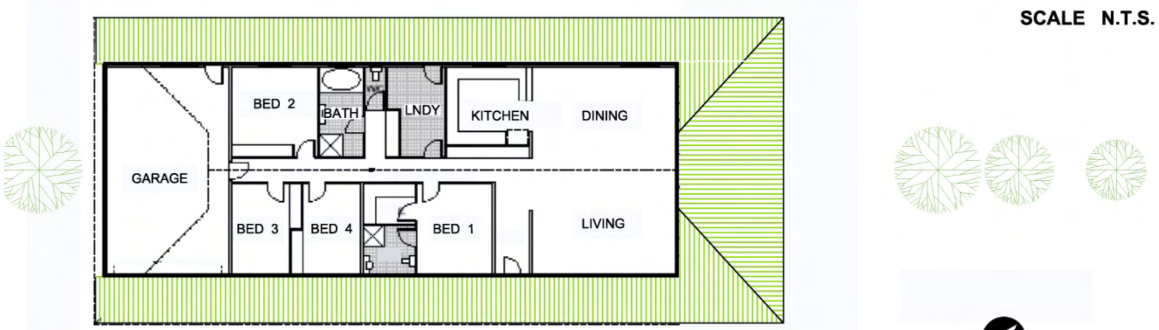
Table 2.4 - Length of Internal Access Tracks and Material selection

Site	Length of Existing Access road (m)	Length of new access road (m)	Total length of access road (m)	Construction Material
Mountain Station	11658(85%)	2112(15%)	13770 (100%)	DGB road base
Middlebrook Station	9047(97%)	310(3%)	9357(100%)	DGB road base
Total	**20.71km**	**2.42km**	**23.13km**	-

2.5.4 Manager’s Residence

The Manager’s residence would be used as accommodation for the Energy Park Site Manager. The proposed location of the residence is in close proximity to Wind turbine 20 on Mountain Station. The house will be screened with vegetation with minimal visibility from the extremities of the site. The location of the proposed Manager’s Residence is shown in Figure 2.12 and a typical design of the proposed Manager’s Residence is shown in Figure 2.16.

Final design of the Managers Residence shall be undertaken during final design phases subject to approval. The residence shall be of similar size to a typical of 4 or 5 bedroom house.



FLOOR PLAN

Kyoto energypark | *Figure 2.16 - Manager's Residence (Conceptual Layout)*

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2.5.5 Visitor’s and Education Centre

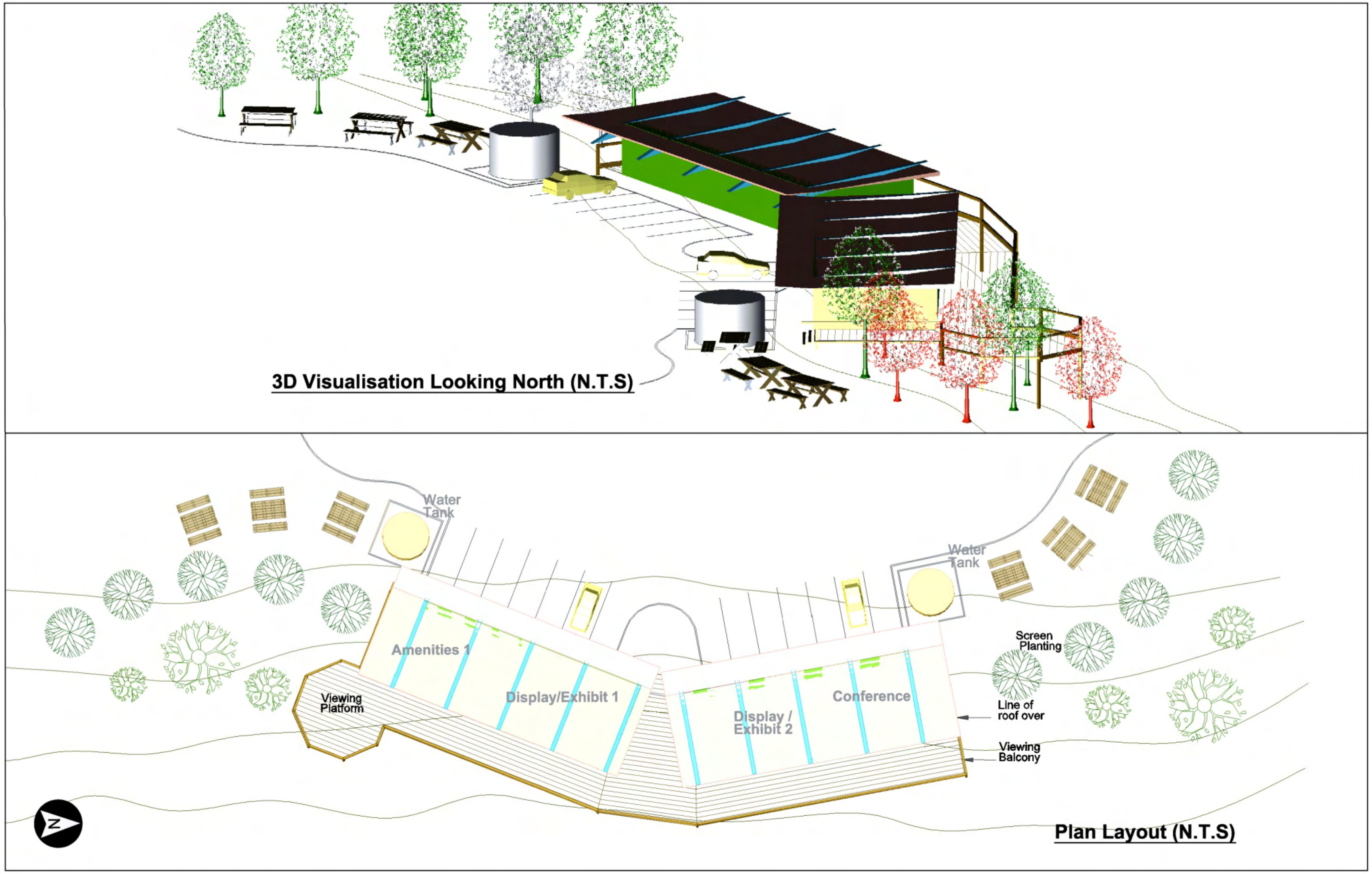
It is proposed to construct a Visitor’s and Education Centre on the Mount Moobi escarpment at Mountain Station adjacent to the proposed Mt Moobi Solar PV Farm. The final layout of the centre may include an Indigenous heritage display, information about the Kyoto Energy Park, conference facilities, educational displays and amenities and a viewing balcony. The objective of the centre is to provide information for visitors, educational facilities, displays and research development for the Energy Park.

During operation of the park facilities, it will be used by organised groups, educational institutions and research institutions. The facility would be initially open on a part time basis for organised tours, educational and scientific uses and conferences. This would limit the amount of traffic using the site.

Existing tourist operations based at Middlebrook Station would continue to operate and merge with proposed activities. Following further development of the facility it may be opened on a more regular basis dependent on demand for use.

The proposed location of the Visitors and Education Facility is shown in Figure 2.4. A preliminary design of the centre is presented in Figure 2.17 below. A 3D visualisation of the centre is illustrated in Figure 2.17(i).

Final detailed design of the Visitors and Education Centre shall be undertaken during the design phase of the project. The centre shall be of sized based on agreements reached between third parties for possible use of facilities such as educational institutions or Indigenous groups. The overall internal floor space of the centre would typically be in the order of 400-600 sqm. Approximately 10-15 carspaces would also be provided behind the centre.



Kyoto energypark | *Figure 2.17 - Visitor's & Education Centre "Boomerang Place"*

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NOTES :

1. Building to comply with requirements of Kyoto Visual Assessment Study 2008.
2. Final design to be completed prior to construction.

3D Visulization - View looking North West (N.T.S)

Kyoto energypark	*Figure 2.17(i) - Visitor's & Education Centre (3D Visualization)*	This drawing is protected by copyright. Reproduction or publication of the whole or part of the drawing without a license of the owner of the copyright is an infringement of copyright.	pamada	A4

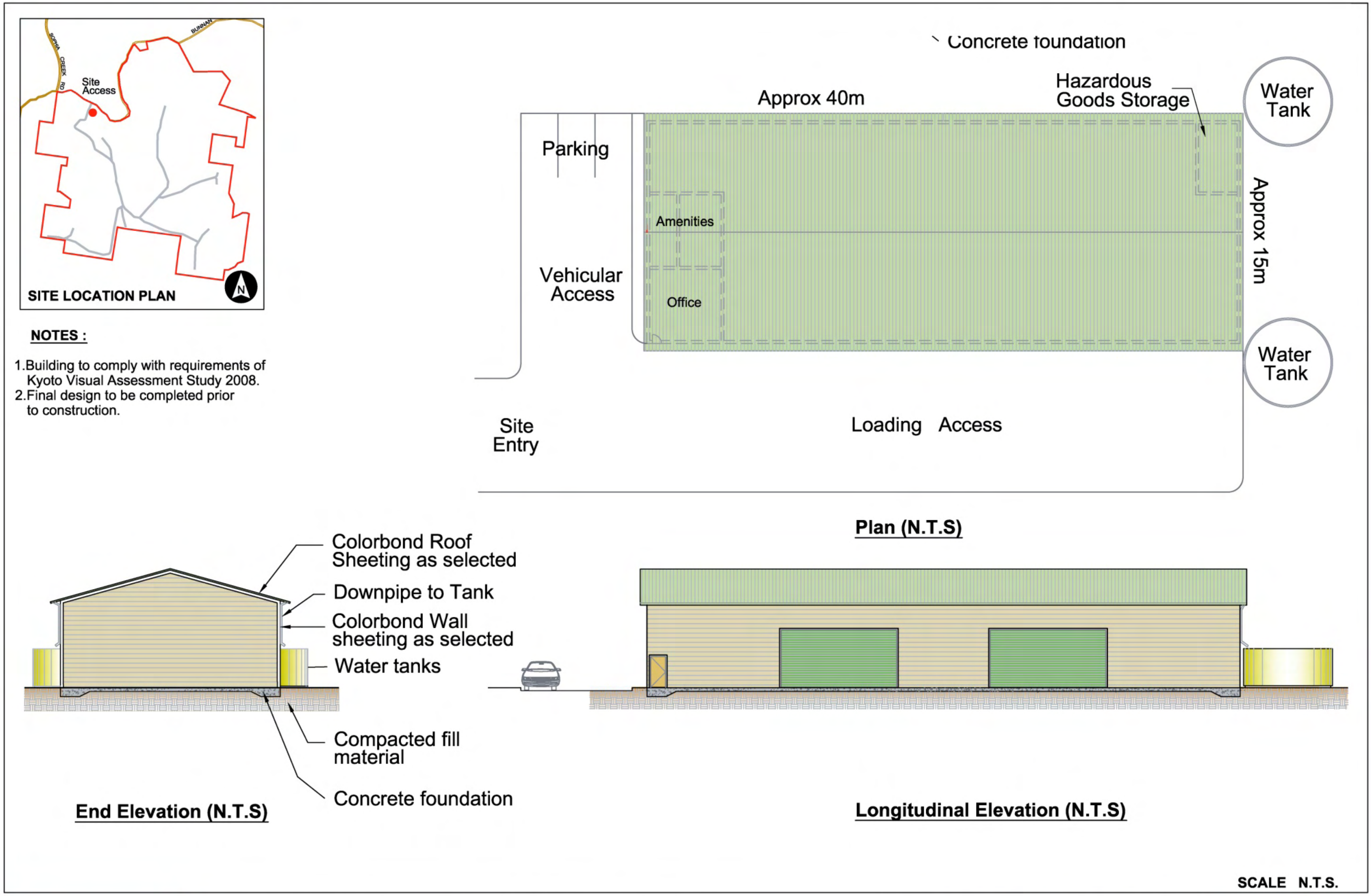
2.5.6 Maintenance Shed

It is proposed to construct a maintenance shed of approximately 40 metres long by 15 metres wide in close proximity to the site substation as shown in Figure 2.14. The building is located close to the site substation while remaining at a low visibility when viewed from the site extremities. Its location is close to the main access road at Mountain Station to facilitate ongoing operations and maintenance. The building will house instrumentation, electrical and communications equipment, routine maintenance stores, a small work area and staff amenities. A water storage tank would be used to store rainwater for use on site in the building and on site.

An option for a dual septic tank/ aerated tank system would also be considered in combination with the amenities facilities from the control room. A small shed-sized structure for storage of flammable liquids, hazardous chemicals and chemicals for servicing the turbines would be provided internally. Hazardous goods that would be stored include solvent cleaners, turbine lubrication oil and grease and hydraulic fluid. The store would be constructed of concrete and built within a fully bunded area of the building. Smoke/fire detectors and fire fighting equipment as appropriate and as required by regulation, would be provided.

The structure is proposed to be a slab on ground construction with steel portal frame, metal or brick walls and a sheet steel roof. It will be of sturdy construction, suitable for the weather conditions it will be exposed to and will be visually compatible with the rural environment surrounds.

The preliminary design layout of the Maintenance Shed is illustrated in Figure 2.18 below.



Kyoto energypark | *Figure 2.18 - Maintenance Shed (Preliminary Design Layout)* | pamada A4

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2.5.7 Site Utility Services

Domestic Water Supply

Town water supply would not be connected to either of the two sites or to any proposed facilities under this application. Water supply to the site will be mainly from rainfall runoff from rooftops. Storage tanks will be used to store rainwater generated from all rooftops. The tanks will be used for amenities in all building facilities. Water would be required in the site substation for domestic use. Rainwater would also be collected from the maintenance building and control room facility building roof and stored in a rainwater tank to provide water for use at the site, with a reserve water storage tank available for 'top up' from potable water delivery. Additional potable water would be transported to the site by truck and stored in water tanks within the compound when rainfall generated supply is low.

Water for Dust Suppression

During the construction stage of the project water will be required on an intermittent basis for dust suppression on access roads and also for landscaping works. Additional water for dust suppression and landscaping may be sourced from existing dams located at either Middlebrook or Mountain Station. During dry conditions water would be trucked to site. A maximum of 3 water trucks per day have been assumed for use however this will vary based mainly on weather conditions (temperature, wind) but also during intensive traffic usage.

Water for Firefighting

The proposed Kyoto Energy Park project is located on land that is bushfire prone. Conacher Travers have undertaken a full assessment of Bushfire risk potential for facilities located on site. A separate water tank shall be installed at each of the building sites (Managers Residence, Maintenance Shed and Visitors and Education Centre) solely for the purposes of backup water for fire fighting purposes. Water for these tanks shall be sourced from rooftops of the individual buildings, with additional top up water trucked in. For full details refer to *Section 18.4.2.3 Water Supply for Firefighting.*

Sewage Disposal

All sewage from the site substation, maintenance building, Managers residence and Visitor's and Education Centre would be treated in either a composting septic tank system or self composting system. Self composting toilets may be used for treatment of septic waste and grey water for infrequent use at the Visitors and Education Centre. Suitable subsoil conditions for hygienic disposal will need to be investigated in proximity to these facilities to allow for possible wastewater aerated, clarification and irrigation systems. Final type, size and capacity of systems will be specified during the final design of the system.

Waste Disposal

Only small amounts of domestic waste would be generated on a day to day basis and would be stored on site and removed by an appropriate licensed contractor. Disposal of oil and other hazardous chemicals shall be undertaken by licensed maintenance contractors during the operation of the site.

Farm Electrical Supply

The electrical system internal to the site will be designed to allow electricity to be drawn from the existing grid network during times when no power is being generated by the wind turbines, mini-hydro or solar array. An auxiliary transformer would be installed in the substation to allow for domestic power supply to the substation and maintenance building during operation. This electricity would be required for normal operation of the substation and other domestic buildings and facilities. A separate dedicated meter shall be installed for use by the landowner for continuation of farming activities at Mountain Station.

Kyoto Energy Park Scone is wholly an Australian Enterprise. The Management is 100% Australian.
The funding of this proposal and report is 100% Australian.
An Australian Project

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