Appendix P

Renewable Energy

Assessment of Feasibility of Renewable Energy Technologies for the Proposed Facility

1.0 Introduction

Renewable energy is an essential part of Australia's low emissions energy mix and is important to Australia's energy security. It plays a strong role in reducing Australia's greenhouse gas emissions and helping Australia stay on track to meet its Kyoto target and beyond. Australian Government support for renewable energy assists industry development, reduces barriers to the national electricity market, and provides community access to renewable energy.

The feasibility of adopting three renewable energy strategies at the Lake Macquarie recycling facility have been investigated as part of this analysis. The strategies investigated being photovoltaics, solar hot water and wind turbine technologies.

The intent of the analysis is not to rank the strategies based on energy generation or cost, but rather to inform the client of the potential output of the different systems. The client can then decide which strategies could be considered for adoption within the project's planning submission. The feasibility assessment of adopting these strategies at the recycling facility at Teralba has been assessed based on recent industry experience and currently available data. In order to quantify the actual benefit of one technology over another, however, detailed local wind data must be collected on site.

2.0 Photovoltaic Array

Photovoltaic modules transform the energy provided by the sun into electrical current for use in conventionally powered applications. The energy output of the cell is dependent on how much sunlight is available and the efficiency of the cell.

2.1 Annual Solar Radiation

Data for the average daily solar exposure representative of the area is presented in Figure 1. The data is obtained from the NASA satellite data for Newcastle, which is the location closest to the recycling facility for which data is available. The actual amount of energy transferred by the PV module is determined by the following factors:

- PV module tilt angle (0 to 90 degrees) – the inclination of the panel relative to the horizontal
- PV module azimuth angle (0 to 360 degrees) – the direction of the PV module faces measured clockwise from true north in the southern hemisphere.
- The area of the PV module
- PV module efficiency
- System performance ratio

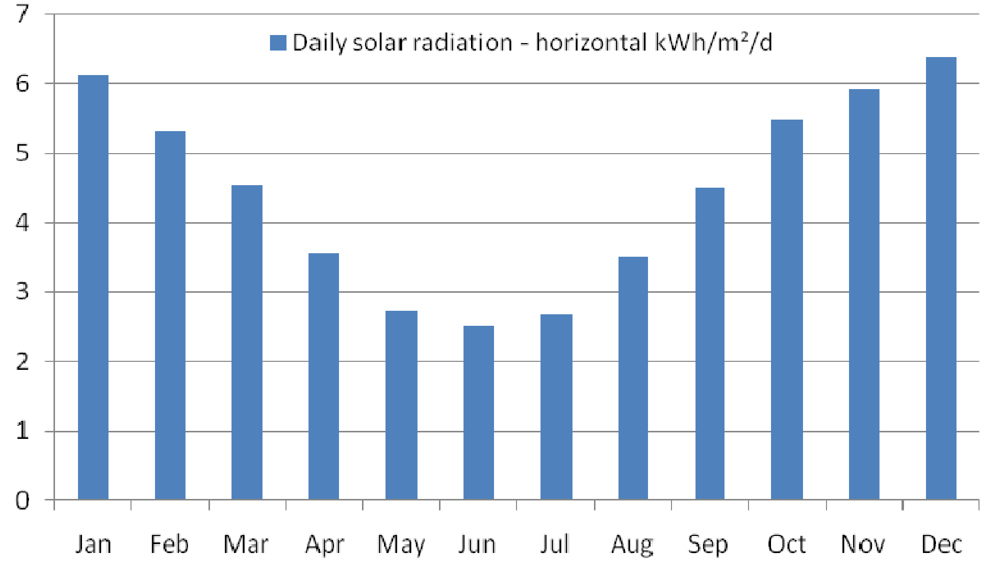


Figure 1: Average daily solar exposure for Newcastle (NASA Retscreen data)

2.2 PV Array Location and Output

The proposed region is relatively flat and open. This allows reasonably unrestricted access to solar insolation. The 500m² roof of each of the two storage sheds are facing northwest and are acceptable for a PV array installation. To achieve the maximum solar radiation, the array should be tilted between 22 and 28 degrees above the horizontal plane, for a north-westerly facing array. Figure 2 indicates the potential annual output of a PV array tilted at 25 degrees above the horizontal plane. It has been assumed that 80% of the roof area can be covered in PV arrays.

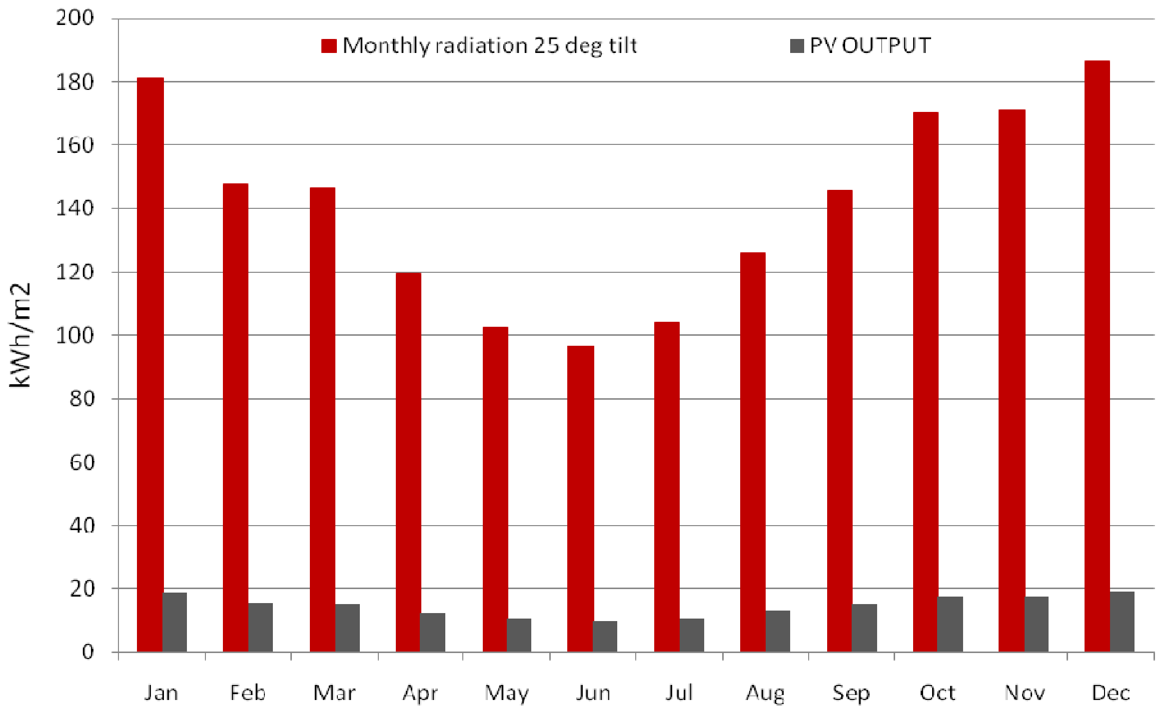


Figure 2: Energy output for a north-west array tilted at 25 degrees

A multicrystalline cell efficiency of 13% and a system performance ratio of 0.8 have been assumed in the above analysis.

2.3 Energy Production and Carbon Savings

The potential energy output of a 800m² PV system at the proposed site is approximately 141,000 kWh/year. The maximum system size that could be installed within this space would be 100kW. A higher yield is expected during summer months and a lower yield is expected during winter months. Table 1 below provides a summary of the annual energy output and carbon savings for a 100kW, 3kW and 30kW system. The maximum expected carbon savings using a 100kW system (800m²) would be 149 tonnes per annum.

Table 1: Energy production and CO2e savings

	100kW	3kW	30kW
Annual average solar radiation (kWh/m²/yr)	1,618		
Annual average insolation on tilted array (kWh/m²/yr)	1,697		
PV system orientation	North-west		
Tilt angle	25 degrees		
PV system area (m²)	800	23	230
Annual energy output (kWh/yr)	141,000	4,070	40,700
Annual carbon saving (tonne.CO2e/yr)	149	4	43

2.4 Cost

A simple cost estimate was completed for three system sizes in Table 2. The cost estimate of $1450/m^2 for multicrystalline is for a fully installed system from BP Solar, including labour, cables and expert design advice but excluding additional mounting brackets if required.

Table 2: Basic PV array cost estimate

Estimate System cost ($ /m2 of cell area)	$1,450		
Installation capital cost $ (Lake Macquarie)	$ 1,160,000	$33,462	$334,615
Retail electricity tariff (starting flat-rate price)	$0.13		
Electricity savings per year @ flat 13 cents per kWh [$]	$18,300	$529	$5,290

3.0 Solar Hot Water

Solar water heating systems use the energy from the sun to heat water. The systems use a heat collector, generally mounted on the roof or a north facing façade in which a fluid is heated by the sun. Ideally the collectors should be mounted in a north-facing location. The solar panels can be bolted onto the roof or walls or integrated into the roof.

3.1 Heating Requirements

A general and conservative rule of thumb for domestic hot water consumption is 50L/day per person. The typical expectation is that one solar panel (2m^2 of collector area) is sufficient for two people. The solar hot water system can provide up to 90% of a residential building's hot water requirement and commercial systems are typically sized to meet 45-50% of the annual DHW demand.

Number of persons served	Capacity (litres)	Collector area (m^2)
1–2	160–200	2
3–4	300–370	4
5–6	440	6

Source: www.sustainabiliy.vic.gov.au

The north facing roof of the approximately 200m^2 office block provides the optimal location for the solar hot water system installation. An estimation of the solar hot water system required for around 5 occupants and associated energy savings are presented in the table below.

Table 3: Solar hot water system energy savings and CO2 reductions

Occupant (estimated)	5
Hot water requirements (L/person/day)	50
Estimate of collector area required [m2]	5m^2
Daily energy required to heat hot water (kWh/day)	14
Annual energy required to heat hot water (kWh/year)	5, 100
Annual solar contribution percentage	90%
Annual energy saving (kWh/yr)	4,400
Annual carbon saving (kgCO2/yr)	4,700

For comparison, typical figures from the Victorian sustainability guide indicate that the hot water system of a medium sized home has the following greenhouse gas emissions: 4.2 tonnes for off-peak electric, 1.4 tonnes for a 5-star storage gas system and 0.2 tonnes for a flat-plate solar system with a gas booster [2].

3.2 Sizing and Cost

The final cost will be dependent on the hot water system selected, for example:

- Active or passive
- Flat-plate or evacuated tube
- Electric or gas boost
- System size (number of panels and tank size)

The approximate cost of a five-star gas in-line boost household system is in the order of $7000, excluding installation. Such a system would be comprised of the following:

- Stella 360L tank
- 200L per hour recovery
- 3 solar panels (5 people)

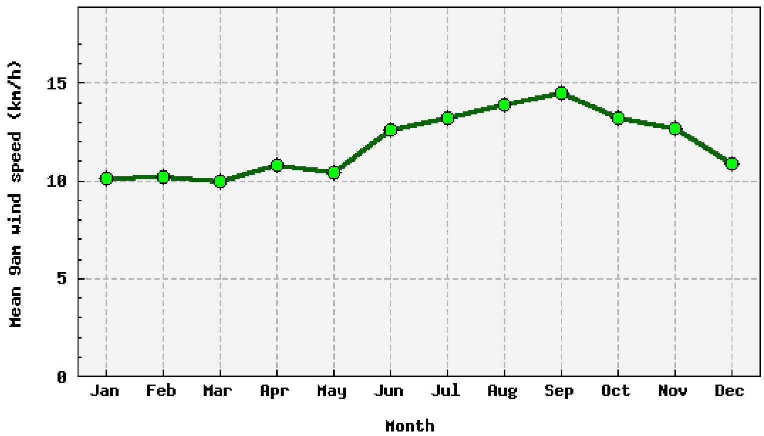
4.0 Wind Turbine

Wind turbines produce electricity by using the natural power of the wind to drive a generator. As the wind power is proportional to the wind speed cubed, a doubling of the wind speed could potentially produce an eight-fold increase in the harvested power. Locating the turbine to take advantage of high wind speeds is, therefore, critical for an installation. Turbines should be sited away from obstruction, ideally on a smooth hill top in the prevailing wind direction.

The proposed recycling facility is located in a low lying area and is surrounded by bushland. The location is thus not optimal for a wind turbine installation.

4.1 Local Wind Climate

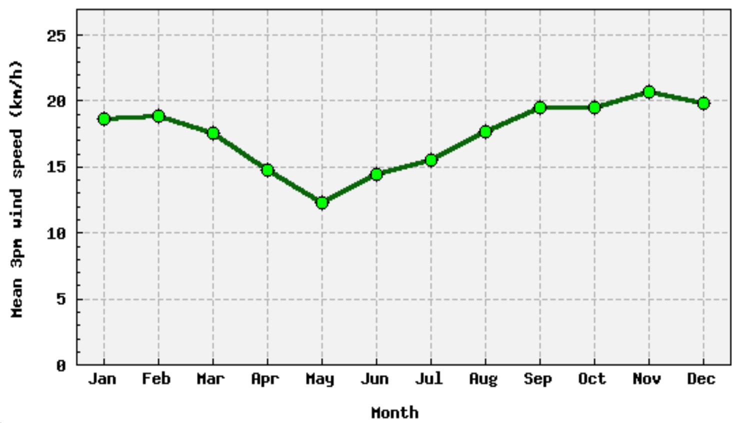
The wind speed presented in Figure 3 and Figure 4 is from the Bureau of Meteorology data for Maryville, which is 20km to the east of the proposed site. The data is the average wind speed at 9am and 3pm from 1990 to 2009, measured at 8m above ground level. The average wind speed is 3.3m/s at 9am and 4.8m/s at 3pm. The more conservative wind speed of 3.3m/s is used in calculations below.



Statistics	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Years
Mean 9am wind speed (km/h)	10.1	10.2	10.0	10.8	10.4	12.6	13.2	13.9	14.5	13.2	12.7	10.9	11.9	24

12.3 = Not quality controlled

Figure 3: Average wind speed at 9am for Maryville



Statistics	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Years
Mean 3pm wind speed (km/h)	18.6	18.9	17.6	14.8	12.3	14.5	15.5	17.7	19.5	19.5	20.7	19.8	17.4	24

Figure 4: Average wind speed at 3pm for Maryville

4.2 Wind turbine selection – example

An example of a small, stand-alone, horizontal axis turbine is the Aerogenesis 5kW turbine. This turbine has an 18m hub height.

Figure 5: Aerogenesis 5kW turbine

4.3 Wind Speed - Effect of Height

Wind speed varies with height; at ground level (zero metres) the speed is low and turbulent and at some higher altitude it is faster and smoother. This is due to friction as wind passes across the earth's surface. If selecting the Aerogenesis 5kW stand-alone turbine with an 18m hub height, the wind speed at 18m can be gained from scaling up data collected at 8m to the height of the proposed tower using empirical relations. For example, if the wind speed is 3.3 m/s at 8 metres, the wind speed is expected to increase to 3.7 m/s at 18 metres altitude.

4.4 Energy Output and Carbon Savings

Figure 6 indicates the decline in average energy output with reducing wind speed for the Aerogenesis 5kW turbine. Figure 7 indicates the power curve with wind speed, showing a maximum of 5kW when the wind speed reaches 10.5 m/s. From Figure 6,the turbine can produce 23kWh of energy per day, with an average wind speed of 5m/s. The energy output reduces to 8 kWh per day at a wind speed of 3.3 m/s. Although the Aerogenesis turbine hub is 18m high, that is 10 metres above the datum at which the wind data was collected, a wind speed of 3.3 m/s is still used in the energy calculations listed in Table 4. This is in order to conservatively account for some site depression, tree blockage effects and the fact that a consistent wind of any magnitude cannot be relied upon.

Note also that the cut-in wind speed provided by the manufacture is 3m/s, indicating that the turbine will not have any power output below this speed. The cut-in wind speed will vary between turbine models; note that the Aerogenesis is only provided as an indication of a typical small wind turbine.

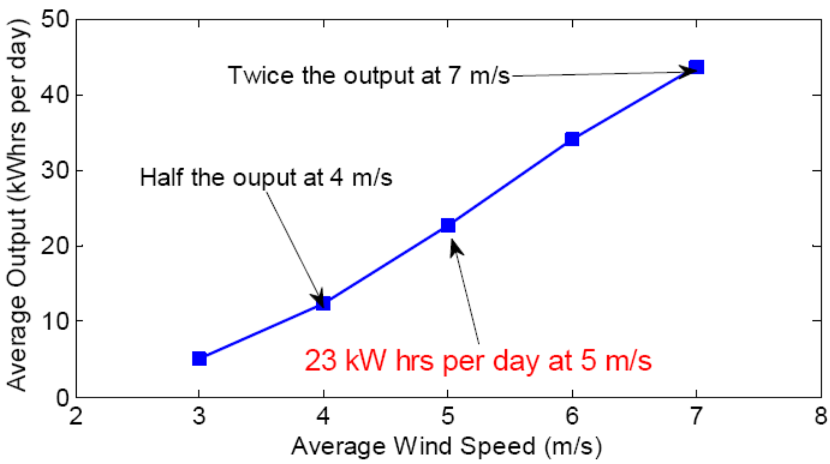


Figure 6: Aerogenesis 5kW turbine average energy output [Source: Aerogenesis Australia]

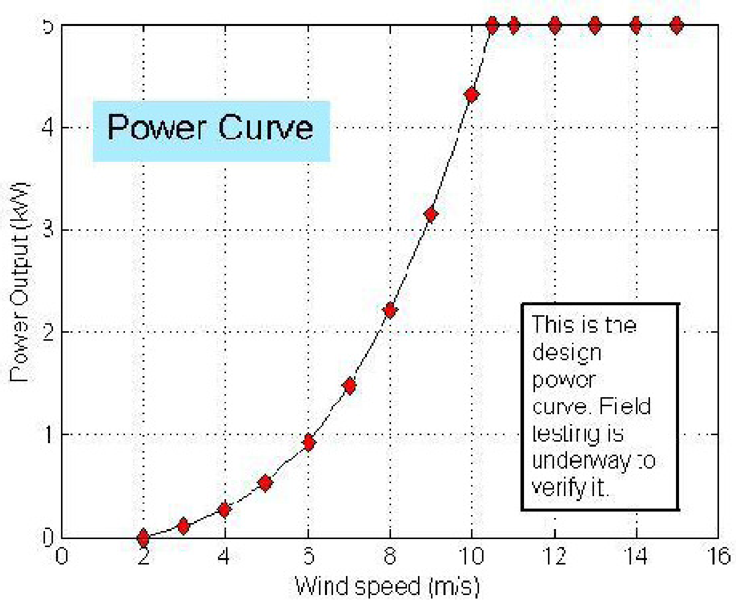


Figure 7: Power curve for the Aerogenesis 5kW turbine (source: Aerogenesis)

Table 4: Aerogenesis 5kW turbine: energy output and CO_{2e} reduction estimates

Average daily energy output @ 3.3m/s wind	8 kWh per day
Average annual energy output @ 3.3 m/s wind	2,920 kWh per annum
Annual electricity saving (@ 13cents flat rate)	$380 saving per annum
Annual carbon saving (tonneCO2/yr)	3 per annum
Cost of Aerogenesis 5kW turbine	$30,000 cost installed

Table 4 indicates that a $30,000 investment in a small wind turbine could generate approximately 3,000 kWh per annum. This assumes that a consistent wind with an average speed of 3.3m/s, and not less than 3m/s, is available on site. For comparison, a $30,000 investment in a small (3kW) photovoltaic array could generate approximately 4,000 kWh per annum.

When making a final selection between alternative renewable technologies, it is important to consider the following:

- Solar radiation is more consistent and reliable at a fixed location, compared with local winds;
- Wind turbines are highly sensitive to the wind speed at the local site. Even a small change in wind speed can have a large effect on the power output (refer to Figure 7);
- Should wind be considered by Council, it is recommended that local winds be determined at the proposed installation site in order to assess the actual potential energy output of a particular wind turbine. Local winds are best determined via an anemometer or small weather station; data logging for at least one year is desirable.
- Local topography, including low lying area and wind blockage effects, can significantly alter local wind speed. Consequently, if any future buildings or changes to the site are anticipated, these should also be considered in assessing the feasibility of a wind installation.

5 kW WIND GENERATOR SPECIFICATION	
GENERAL FEATURES	
Rated Output and Rated Wind Speed	5 kW at 10.5 m/s
Cut-in Wind Speed	3.0 m/s
Survival Wind Speed	50 m/s without lowering
Total Weight of Turbine & Tower	< 1.3 tonne
IEC Turbine Class	3
ROTOR	
Number of blades & Diameter	2, 5.0 m
Swept Area	19.64 m^2
Blade Material	Vacuum infused fibre glass reinforced epoxy
Rotor Position	Upwind
Airfoil	SD7062
Tip Speed Ratio	8.0
Rotor Speed at Rated Output	320 rpm
Over Speed Control	Microprocessor control of generator & electro-mechanical brake
Yaw System	Passive regulation by tail fin
DRIVETRAIN	
Generator	Fan cooled 4 pole, 3 phase induction generator
Generator Output Voltage	80 - 500 V AC
Generator Frequency	20 to 70 Hz
Gearbox	8.15:1 helical inline gearbox
Brake	Electro-mechanical disk brake behind generator
Brake Torque	40 Nm at generator
Brake Power Consumption	40 W maximum, 10 W average
CONTROLLER / INVERTER	
Control System	Microprocessor controlled power point tracking for maximum efficiency for wind speed below 10 m/s. Stall governing for power reduction at higher wind speeds
DC Output Voltage	DC: 24V, 48V or other as specified by customer
AC Inverter Output	110V, 60 Hz; 220V, 240V (both 50 Hz) as specified by customer
TOWER	
First Option: 18 m hinged tower	Needs crane for installation. Turbine can be raised & lowered manually
Second Option: 18 m Tower Hinged at Base (can be assembled with hand winch)	Turbine can be raised and lowered with a hand winch