WIND-ENERGY IN POLAR REGIONS: CASEY STATION ANTARCTICA

Christopher Brown, Antoine Guichard, David Lyons
IASOS (Institute of Antarctic and Southern Ocean Studies)
University of Tasmania, GPO Box 252-77, Hobart TAS 7001, Australia.
Phone: +61-3-6226 2971, Fax: +61-3-6226 2973
Electronic Mail: enquiries@iasos.utas.edu.au

ABSTRACT

The use of alternative energy for electrical and thermal power generation at the Australian Antarctic stations is currently being investigated. The conditions experienced at the stations, with recorded wind gusts of 81 m/s and minimum temperatures of -41º C, have imposed harsh restrictions on the usage of wind in all but small scale applications. With the latest design of wind turbines, however, the use of larger units is now becoming feasible. Analysis of meteorological data indicates that winds ideal for power generation exist at some of the stations.

To test for reliability, an Aérowatt UM-70X wind-turbine rated at 10 kW has been installed at Casey Station Antarctica. Casey is one of three stations operated by the Australian Antarctic Division on the Antarctic continent (with a fourth station operated in the sub-Antarctic on Macquarie Island). All stations experience high winds and cold temperatures resulting in high consumption levels of diesel fuel for power generation.

Results and problems associated with the operation of this unit over a 15 month period, in which 11.5 MWh of power has been produced, are presented after an analysis indicating the potential for exploitation of wind (in combination with solar) resources at each of the Australian Antarctic stations.

INTRODUCTION

Australia is one of a number of countries which maintain scientific research stations in Antarctica. Unlike most operators, however, Australia's stations are located in Eastern Antarctica, in some of the most isolated and remote locations on earth. Four permanent winter stations are maintained: one in the sub-Antarctic on Macquarie Island (located half way from Australia to Antarctica), and three on the continent itself. These continental stations - Casey, Davis and Mawson - are spread out along an 1,800 nautical mile stretch of coastline in eastern Antarctica, in an area dominated by vast expanses of ice cliffs, glaciers and pack ice. The location of the four Australian stations and shipping distances from Hobart are presented in Table 1.

Station	Latitude	Longitude	Distance to Hobart
Casey	66º17' S	110º32' E	3,427 km
Davis	68º35' S	77º58' E	4,816 km
Mawson	67º36' S	62º52' E	5,447 km
Macquarie Island	54º30' S	158º56' E	1,495 km

Table 1: Australian Antarctic station locations and shipping distances from Hobart

Access to the stations by sea is limited to the southern hemisphere summer due to sea ice encircling the continent over the dark cold winter. During summer, the stations are a hive of activity, forming a base for most scientific investigations conducted on land and in the surrounding waters. Station population numbers swell during this period, from the 15-20 people who remained during the winter to maintain the stations and scientific programs, to anything up to 100, depending on the stations and programs allotted for the season. All personnel and provisions to the stations must also be supplied by ship during these ice free summer periods.

As such, time and space on voyages south is at a premium. Marine science and personnel change over, in addition to resupply, all demand resources aboard Australia's resupply vessel the *Aurora Australis* (or other chartered vessels servicing the stations). Fuel, critical for the day-to-day operation of the stations, constitutes a sizeable proportion of the total cargo shipped into each station. Reductions in the amount of this fuel used in providing the electrical and thermal needs of the stations is currently being sought through the introduction of on-site power generation using renewable energy systems. Wind energy (and to a lesser degree solar energy), have been identified as offering the best opportunities to achieve these goals (Steel 1993).

To identify the possibility for the use of wind and solar energy generation systems, the following investigations have been conducted:

Energy assessment
- station energy needs
- wind and solar energy resources

Antarctic suitability
- design criteria
- reliability / survivability / maintainability testing
- impedance in performance due to cold and extreme wind events

Results from these investigations will initially be presented, indicating the potential for renewable energy generation systems at the stations, followed by results from trials of a 10 kW Aérowatt UM-70X wind turbine installed at Casey station since March 1995.

STATION DESCRIPTIONS AND ENERGY DEMANDS

During the 1980s a major upgrading of all buildings at the continental stations was undertaken. A decision was made to invest in large, modern, extremely well-equipped stations, representing an enormous investment by Australia in the region and allowing for a continuation of a research presence well into the next century.

Each continental station consists of a collection of 10 to 15 buildings, designed especially for the conditions. The largest building on each station is the Domestic building, comprising recreation/sleeping/eating and medical areas, and as such, is the focus of station life after working hours. Other buildings on station occupied regularly include the Operations building (housing all radio communication equipment and electronic workshops, meteorology and administration offices), the Science building (housing equipment for research projects into fields such as radio astronomy, upper atmosphere physics and biology) and the Workshop (providing an indoor heated area for mechanical repair and maintenance, and work areas for electricians, plumbers, and carpenters). Support buildings are also maintained for water storage, food and supply storage, waste treatment facilities, satellite communications and rescue vehicles/fire fighting equipment.

The energy systems of the stations are designed to provide a safe, efficient and above all, reliable supply of electrical and thermal energy, needed in order to maintain the array of scientific programs operated at each station and provide suitable comfort conditions for expeditioners. Reliability is of the highest priority due to isolation of the stations, necessitating their self-sufficiency over the long, cold, dark, winter months. The current energy system of the Australian Antarctic stations meets these requirements through the use of cogeneration systems comprising diesel generator sets and oil-fired boilers.

The main power houses of the continental stations consist of four 125 kVA Caterpillar 3306 diesel engines coupled with matching alternator sets. Two to three engines are typically engaged at any one time to meet station load demands. Heat recovered from the engines and supplemented by oil-fired boilers is pumped throughout the station to most buildings to meet thermal energy needs, although some buildings use their own independent heating systems. At Macquarie Island a much milder climate, combined with more traditional building methods and lower population levels, has resulted in much lower power demands. Two generator units are maintained in the main power at the station, with a single unit operated to satisfy power demands at any one time. Efficiencies of 35% (electrical) and 32% (thermal) have been reported for the generators, and 80% (thermal) for the boilers (Guichard 1993).

Even with these rather high efficiencies, electrical and thermal energy demands are high, requiring the use of large quantities of fuel. Table 2 and Table 3 indicate the quantity of fuel used in generator sets and boilers at each stations over the last four years.

Site	Yearly diesel use by generator sets (kl)			
	1992	1993	1994	1995
Casey	584.8	538.0	483.4	447.2
Davis	526.5	535.3	646.4	561.4
Mawson	630.4	607.5	629.8	652.8
Macquarie Island	202.1	173.7	168.4	174.4

Table 2: Total diesel usage in generator sets 1992 - 95 (AAD)

Site	Yearly diesel use by boilers sets (kl)			
	1992	1993	1994	1995
Casey	139.9	89.6	131.1	121.1
Davis	324.1	151.7	165.9	125.7
Mawson	122.2	133.9	144.8	141.6
Macquarie Island	37.8	51.2	45.8	29.7

Table 3: Total diesel usage in boilers 1992 - 95 (AAD)

Costs associated with the shipping and handling of fuel to Antarctica effectively triples the end price per litre. Exact costs are hard to assess, but current estimates place the unit price per litre at $1 (AUD) (Guichard 1993). This high cost has further focused attention to the possibility of on-site power generation from renewable sources.

The introduction of renewable systems also has the added advantage of reducing the overall emission levels of the stations, the most prominent local pollutant source in the near pristine air over the continent - important for scientific and environmental reasons. Reduced fuel handling also will reduce the risk of fuel spillage, another major concern in the fragile Antarctic environment. The electrical energy production levels, met by the diesel generator sets are given below in Table 4.

Site	Yearly electrical energy production (MWh)			
	1992	1993	1994	1995
Casey	1871.6	1786.1	1630.3	1595.1
Davis	1756.7	1919.9	2311.1	1996.7
Mawson	2255.1	2162.9	2283.6	2368.3
Macquarie Island	584.4	521.1	541.8	593.6

Table 4: Total electrical energy production 1992 - 95 (AAD)

To obtain an indication of the inter-daily and intra-daily variation in electrical power demands, recordings of the 10 minute average power load were initiated. A daily cycle of between 20-30 kW was identified at Davis station, superimposed onto a day-to-day varying base load, averaging approximately 220 kW over the year, with a 20-30 kW seasonal cycle. This high base load offers good potential for high penetrations of wind and solar power generation. To assess this potential, station load requirements have been compared to the availability of wind and solar energy for electrical power generation through analysis of the meteorological conditions recorded at the stations.

WIND ENERGY RESOURCES

Antarctica has the distinction of being the highest, coldest, driest and windiest continent on earth. Climatic conditions at the stations are harsh. Blizzards periodically blast the continental stations, often resulting in very high wind gusts. Continuous low temperatures also occur at the continental stations, with summer temperature rarely above 0^{o}C and never above 10^{o}C. Macquarie Island, situated north of the Antarctic convergence zone, has warmer weather with temperatures often above zero and never falling below -10^{o}C. This however results in an extra phenomenon rare at the other stations - rain! Fierce winds also lash the island, situated in the middle of the Southern Ocean in the ‘furious fifties’, creating extremely windy and wet gales that saturate the island. A summary of the climatic extremes in temperature and wind speed recorded at the stations is given in Table 5.

Site	Maximum recorded wind gust (m/s)	Minimum recorded temperature (^{o}C)
Casey	80.8	-41.0
Davis	57.1	-40.0
Mawson	68.9	-36.0
Macquarie Island	51.4	-8.9

Table 5: Extreme climatic conditions recorded at the stations (Guichard 1995)

While the maximum winds encountered at the stations are very high, the average winds are much lower. High winds, averaging above 30 m/s over a ten minute interval, were found to account for at most 5% of all observation made over the last five year at Mawson and Casey, and even less at Davis and Macquarie Island. Resolution of the wind into bins, each 2.5 m/s wide, has been presented in Figure 1, indicating the relative frequency distribution of winds at each of the stations. Weibull functions have been set to these distributions using weighted least-squares techniques with the scale parameter *c* and shape parameter *k*, calculated using the method described by Justus (1978).

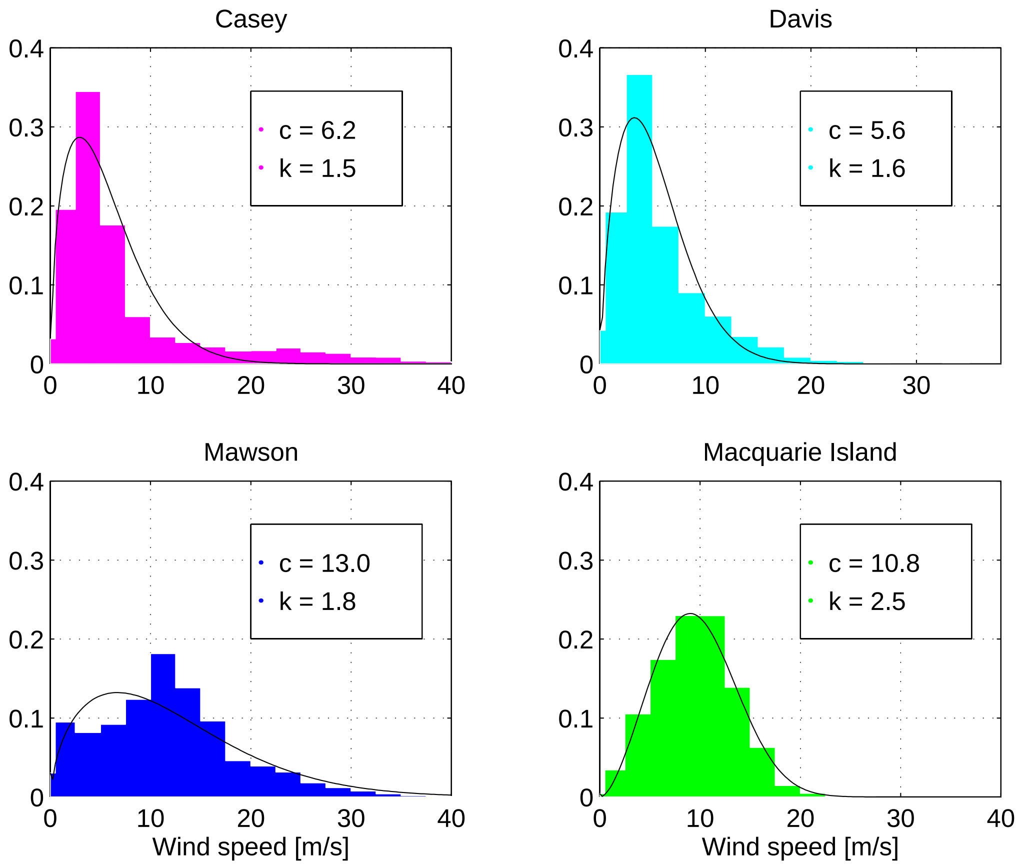

Figure 1: Frequency−of−occurence of wind speeds 1990−94

The mean wind speed giving an indication of the potential for power generation has been calculated for the stations and is presented in Table 6. To construct these figures, observations recorded by the Australian Bureau of Meteorology (BoM) over the last five years were used. These observations consist of 10 minute averages taken immediately before the hour, every three hours, starting at midnight UTC.

Station	maximum wind speed (m/s)	mean wind speed (m/s)	standard deviation (m/s)
Casey	49.4	7.15	7.88
Davis	28.8	5.07	4.15
Mawson	39.1	11.15	6.95
Macquarie Island	28.8	9.45	4.13

Table 6: Wind-speed statistics using 10 minute BoM 3-hourly observations 1990-94 (BoM)

There are however differences in the mean wind speed over the year. The best method to indicate these changes is in the diurnal mean wind speed calender of Figure 2, intended as a guide to the expected wind resources at the stations for a particular month at a particular time.

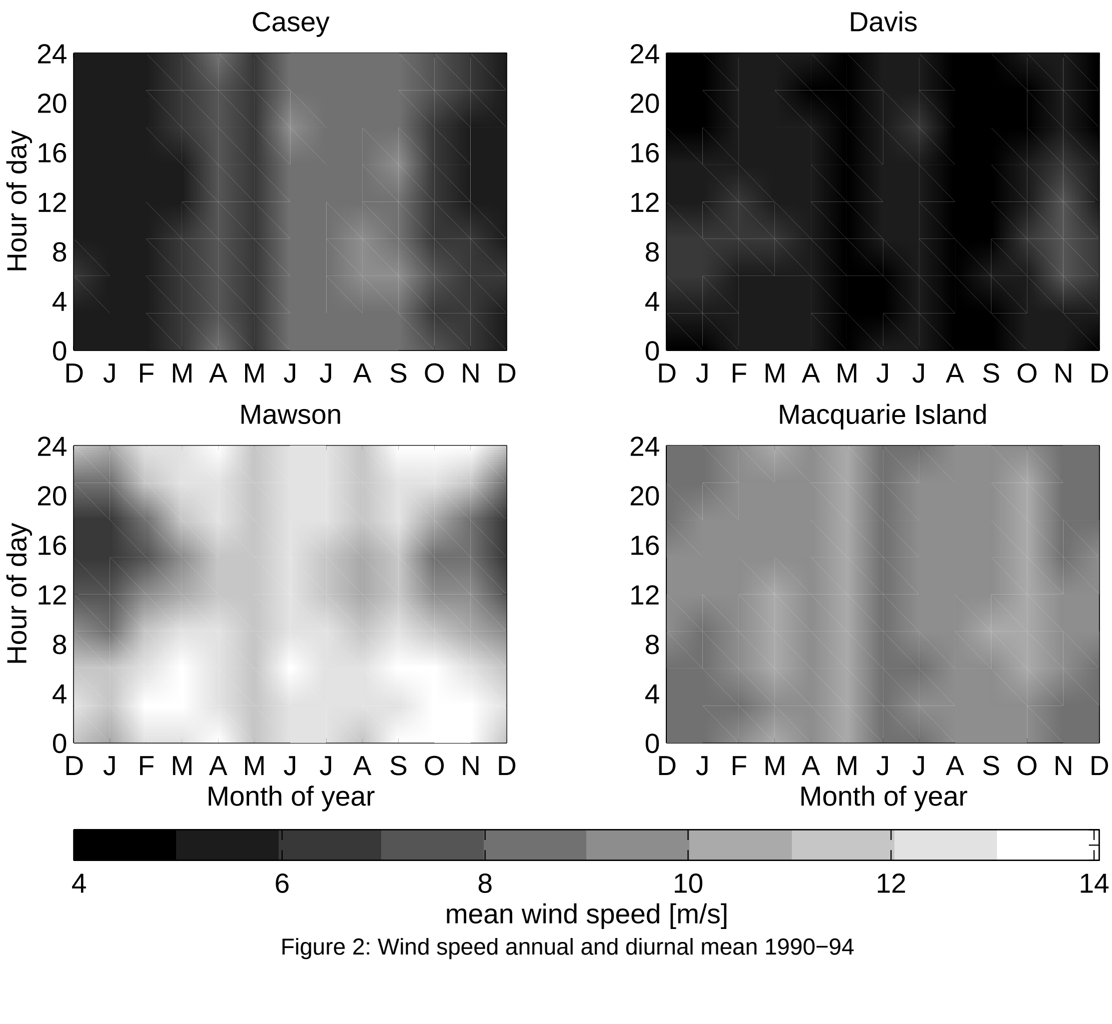

Figure 2: Wind speed annual and diurnal mean 1990−94

Mawson, which experiences strong katabatic air flow off the polar ice cap, is continuously blasted by winds averaging between 12-14 m/s except for period of relative calm during the mid day in summer, where winds drop to an average of 6 m/s. Macquarie Island experiences the second highest average winds, consistently averaging approximately 9 m/s throughout the day, increasing to just over 10 m/s during periods of the equinoctial gales. These occur in March and September whipping up winds into gales, encircling the southern hemisphere in a broad latitude band encompassing the island.

Winds at Casey and Davis are lower than that for Mawson and Macquarie Island. At Casey winds average up to 8-9 m/s during the winter months, dropping to 6 m/s over the summer. At Davis, wind speeds average around 5 m/s for most of the year, expect for early morning summer when the wind speed average increases to 7-9 m/s.

Monthly wind capacity factor estimates, based on the reported performance curve of the UM-70X using the frequency-of-occurrence wind measurements, are presented in Figure 3. The capacity factors represent the ratio of the estimated expected output of the machine against its rated output. At Mawson, high wind capacity factors of between 0.6 to 0.7 are indicated for most of the year, except for a small decrease during the summer months. Macquarie Island capacity factors are also high over most of the year, especially during the equinoctial periods. Casey and Davis indicate capacity factors at only 0.2 to 0.3, half that at Mawson and Macquarie.

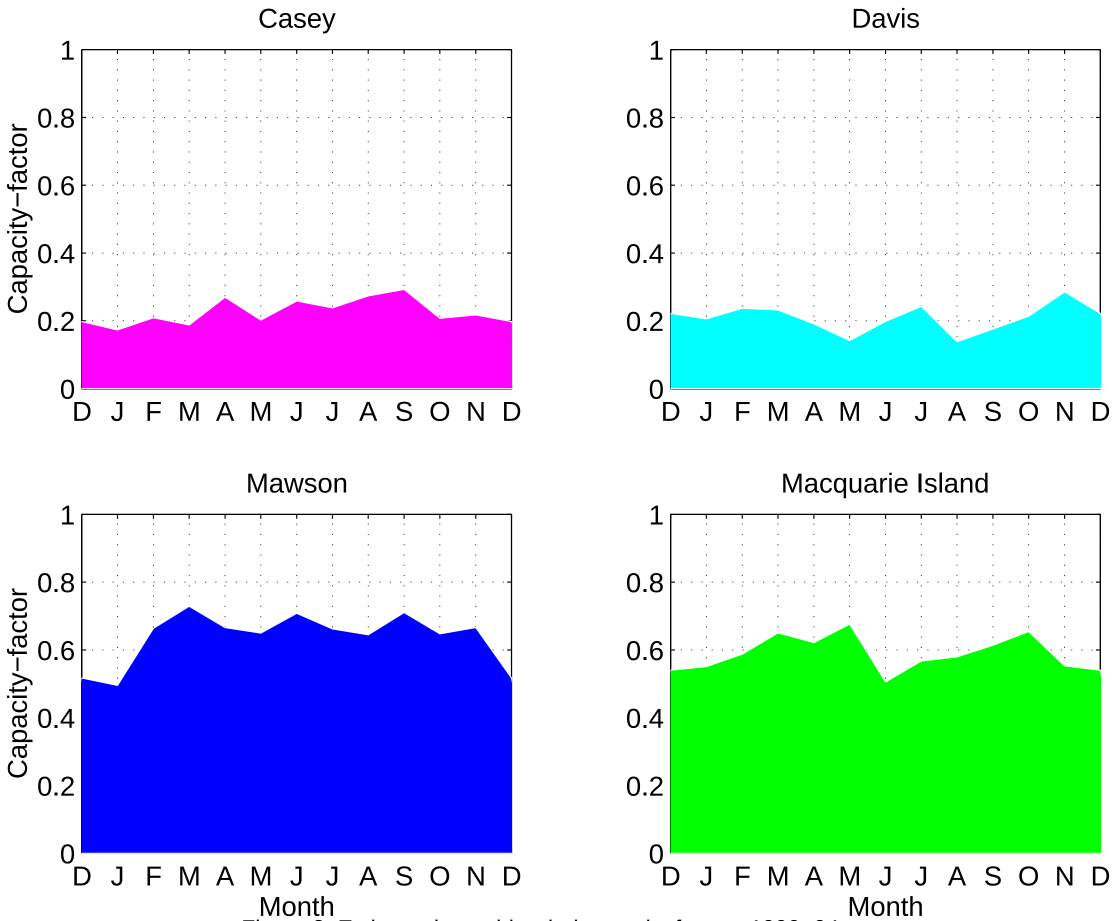

Figure 3: Estimated monthly wind capacity factors 1990−94

SOLAR ENERGY RESOURCES

Clear skies, frequent in Antarctica, offer the potential to supplement power from wind turbines with solar power using photovoltaics. Cloud cover in the latitude 60ºS band in Antarctica is characteristically U-distributed, with either complete cloud cover or no cover at all (Olseth 1984). This, combined with high albedo values due to snow cover, lack of moisture in the dry, dust free pristine air over the continent and long daylight hours during the summer months, provides for extremely high insolation rates at the continental stations. These conditions only occur during the summer months, precluding the use of photovoltaics in winter. Conditions at Macquarie Island are not as favorable, with high cloud cover (occurring for most of the year) reducing incident solar insolation levels.

Monthly averages of the daily global and diffuse radiation levels recorded at Casey, Mawson and Macquarie Island are presented in Figure 4. Data was provided by the BoM from 1973 to 1977 for Casey, from 1968 to 1993 for Macquarie Island; while for Mawson, totals are based on recordings conducted over an 18 month period from 1961 to 1963 by (Weller 1967). Unfortunately, no data was available for Davis.

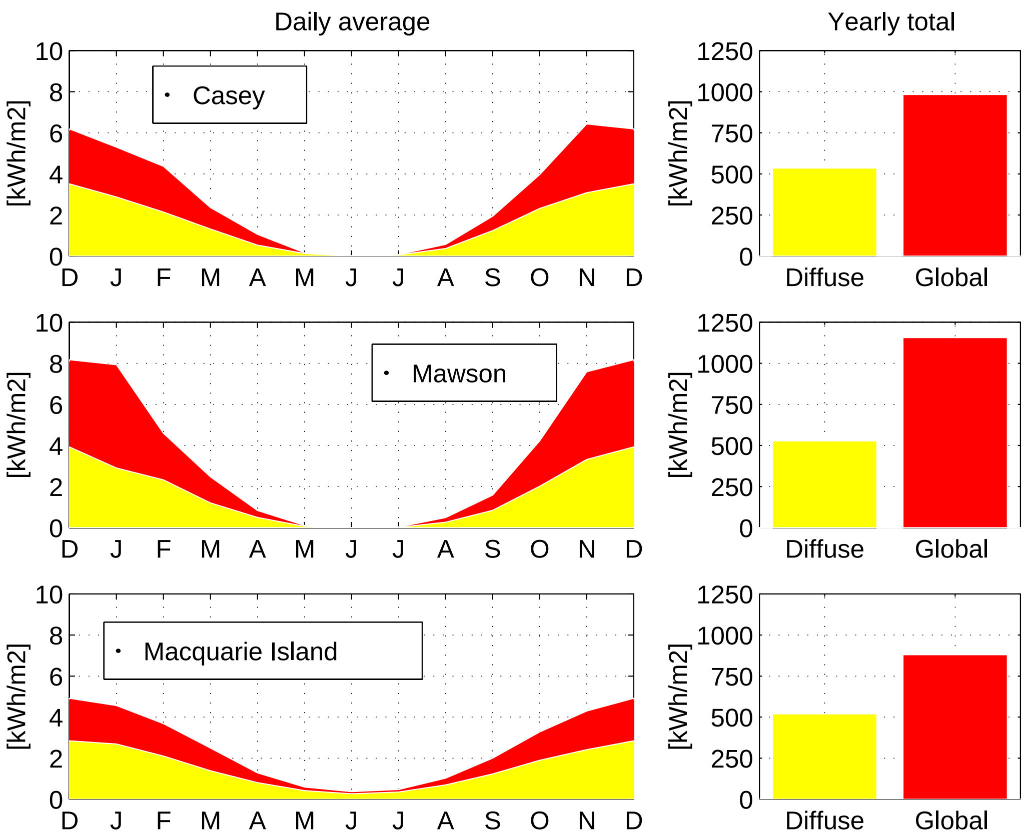

Figure 4: Monthly recorded solar rdiation levels

This data is only available on a monthly basis. To obtain daily and hourly solar radiation levels an empirical model has been used. This model incorporates an empirical relationship between solar altitude and incident radiation level, modified by an extinction factor calculated from cloud measurements (Paltridge and Platt 1976). Comparison with the recorded monthly reading indicated agreements to within 10% for global radiation estimates and 20% for diffuse radiation estimates; values deemed sufficiently accurate for our purpose. The estimated diurnal and seasonal average solar radiation incident at the stations is presented in Figure 5. (Note: the inclination angle of the photovoltaic panel was set to 60º on the continent, and 40º at Macquarie Island - calculated to maximise exposure rates from model simulation runs).

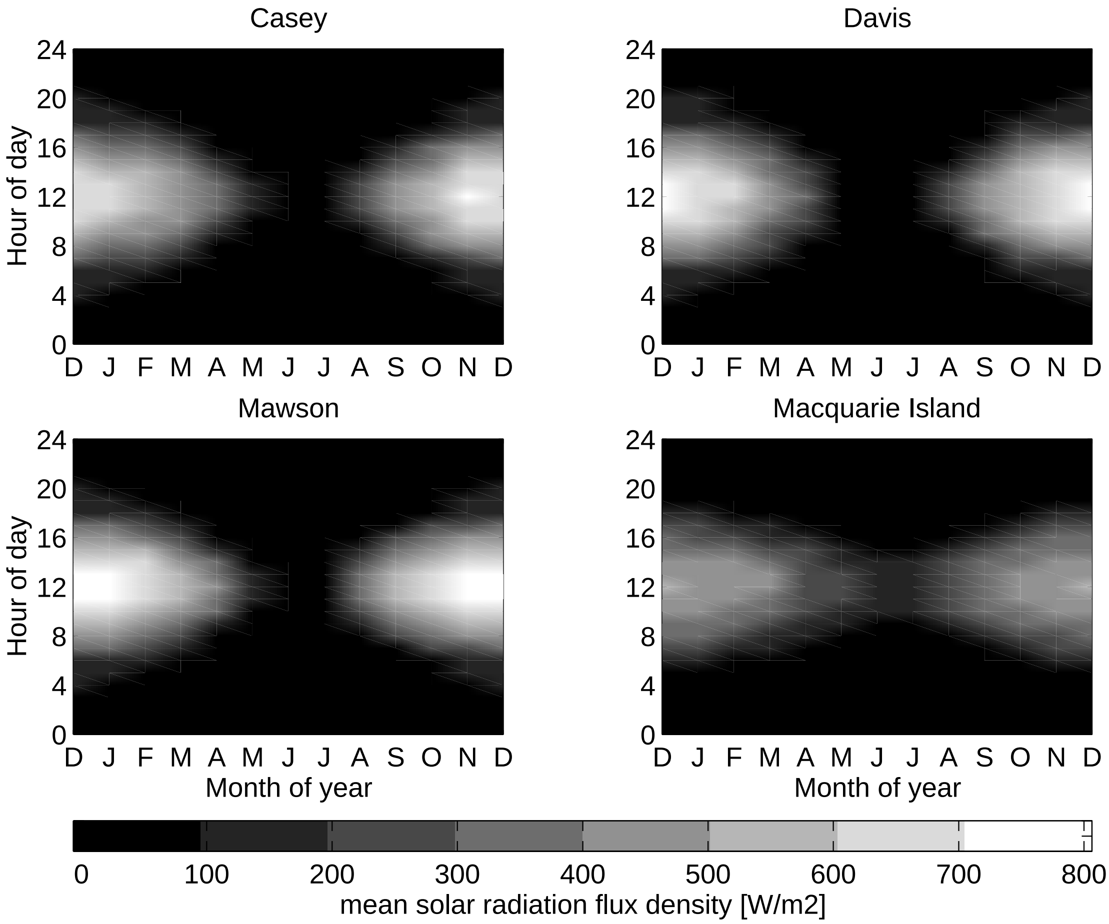

Figure 5: Solar Radiation annual and diurnal mean 1990−94

Average solar insolation levels are extremely high during the summer period centred about mid-day. The general difference between the best solar power and wind power production times, offers promising potential for mixed systems. This is clearly evident for Mawson, where times of high solar insolation almost perfectly coincide with the reduced summer mean wind speed.

Expected solar energy conversion efficiencies typically range for photovoltaic cells from 10% in production line cells and up to 23% in new-generation experimental cells. To gain an indication of the performance of these cells at the stations, a term analogous to the capacity factor of wind turbines will be used. The solar capacity factor, defined as the ratio of the expected output of the cell to the rated output of the cell under cloud free solar insolation levels of 1 kW/m^2 (for which panels are rated), has been calculated for the stations and presented in Figure 6.

High returns (useable power production for a given installed solar power capacity) are evident over the summer at each of the continental stations over a seven month period, beginning of September and ending March. Macquarie Island returns are approximately 30-40% lower than on the stations, although winter insolation levels are higher.

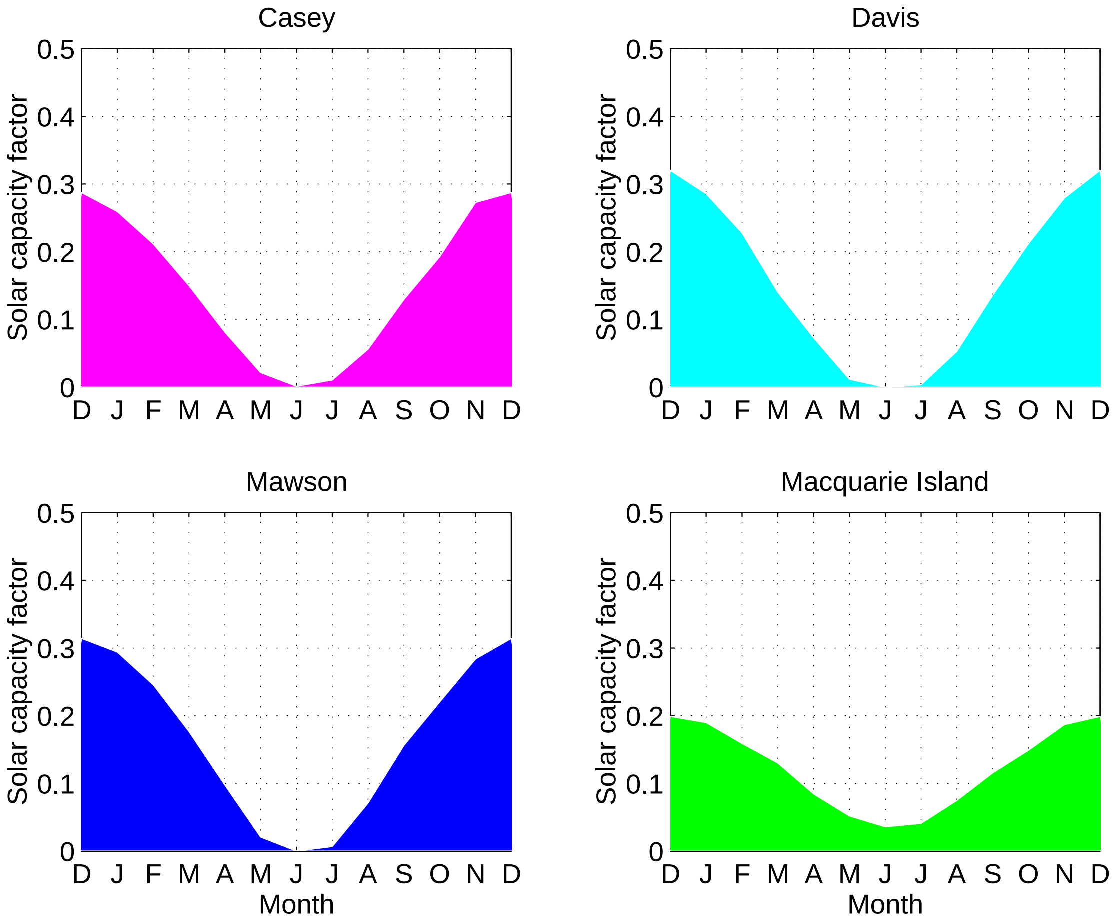

Figure 6: Estimated solar capacity factors

Analysis of the wind and solar energy resources indicate very high potential for exploitation. Comparison with station electrical energy consumption levels suggests a wind/solar mix could be advantageous, leading to high energy production levels due to the difference in production periods: but only if units can be found that are able to survive the conditions.

DESIGN SELECTION CRITERIA

Reliability, survivability and maintainability are vital for successful exploitation of the wind and solar energy resources in Antarctica. Wind turbines were first used by Australia in the Antarctic during the 1960s involving small 'Dunlite' units. These were unfortunately not of sufficiently robust design, often resulting in spectacular failure discrediting the use of wind power and it wasn't until the 1980s that further use of wind turbines was initiated. During this time a number of small scale units, combined with solar panels, were installed to charge batteries operating communications equipment and/or remote sensing devices.

Larger scale use of renewables has been hampered by the harsh meteorological conditions, which although ideal for power generation using wind turbines (supplemented with summer use of solar panels), necessitate the use of strong simple fail-safe robust designs. To be considered for use at the stations, wind turbines (and solar panel array structures) must satisfy the SOB design criteria:

- Survive wind gust up to 90 m/s
- Operate in temperatures down to -40°C
- Be impervious to snow and ice penetration

Civil works are also restricted at the stations, excluding designs requiring extensive site preparation. Cranes are available but currently only useable to a maximum height of 30 m and able to lift loads of up to 5 tonnes. All material shipped to site also has to be barged to the stations, unloaded by crane, and then driven to location along uneven ground.

Investigations during the 1980s led to the identification of a few designs reported to be capable of satisfying these conditions, and thus deemed acceptable for use by ANARE in the Antarctic and sub-Antarctic. A small 5-member ANARE expedition to Heard Island in 1992/3 was to trial the application of wind energy power generation. To meet power requirements necessary for charging batteries and generating heat, a diesel generator unit was provided, envisaged to be supplemented by a number of wind turbines. Conditions at Heard Island are harsh and although located at a similar latitude to Macquarie Island, the position of Heard Island south of the Antarctic convergence zone, results in far colder winters. High wind gusts comparable with the other stations are also compounded by sudden wind-shifts of up to ninety degrees with in the space of seconds - testing for the best of structures.

Three wind turbines were taken and installed on the island. Two Furlmatic 600 units proved to be of insufficient design strength and were unable to survive the conditions. These were found strewn over the landscape after runaway conditions caused their permanent magnets to shatter. The third unit, an Aérowatt UM-70X using an induction generator, operated very successfully over a three month period (producing an estimated 6 MWh (Vrana 1995)) before problems forced its use to be discontinued (high wind shifts resulted in failure of the blade root). After being returned to Australia the unit was repaired and plans were made for further testing on the Antarctic continent itself. Casey station, which has experienced the strongest winds recorded at the Australian stations, was selected and the unit sent for installation during the 1994/5 summer operational season.

DESCRIPTION OF THE AÉROWATT UM-70X WIND TURBINE

The UM-70X (built by the former Aérowatt company), is a 3.5 m radius, twin bladed horizontal axis up-wind wind-turbine. The turbine is coupled (via a 7:1 step-up gearbox), to a three-phase induction motor/generator rated at 10 kW/12 kVA. The operating characteristics as specified by Aérowatt for the 1983 UM-70X model, used at Heard Island and subsequently installed at Casey, are presented in Table 7 below:

Rated power	10 kW
Rated wind speed	11.5 m/s
Rated voltage	3 x 380 V @ 50 Hz
Cut-in wind speed	3 m/s
Production start	3.5 - 5.3 m/s
Cut-out wind speed	none
Survival wind speed	90 m/s

Table 7: UM-70X wind-turbine operating characteristics

The attraction of the UM-70X is its ability to survive strong winds using a clever design including the use of a variable pitch mechanism for speed control, including provisions for stall regulation for high rotational speeds (thus precluding the possibility of run-away conditions). The UM-70X has one of the highest rated survival wind speeds (at 90m/s) of any commercial designs we are aware of. The UM-70X unit purchased by the AAD, was operated in two power modes:

1. Battery Mode
2. Grid mode

In battery mode, as operated at Heard Island, capacitors were connected across the three-phase power outputs allowing for self-excitation of the induction generator. The unregulated power from the generator was then rectified and fed into a battery bank, or used directly for heating. DC power was obtained directly from the battery bank while AC power, at 50 Hz / 240 V, was provided for by an inverter.

At Casey, the unit was operated in grid mode, in which the inductive load needed to excite and maintain the magnetic field of the generator is provided for by the grid. Capacitors were also connected across phases in this mode in order to improve power factors. When insufficient winds are present, the unit is isolated from the grid with its capacitors disconnected, inhibiting the excitation of the generator. Once winds of significant strength occur, starting the turbine, a residual voltage of between 8-12 volts develops in the unexcited generator. Monitoring of this residual voltage allows for determination of the output frequency of the generator.

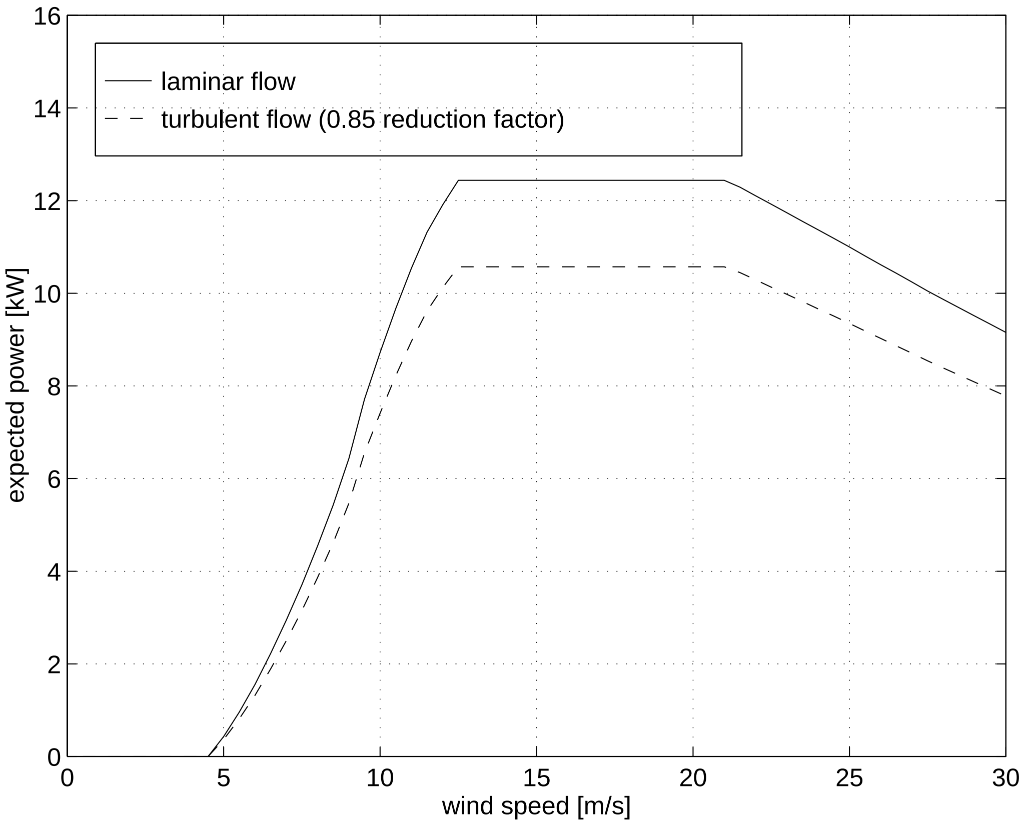

Figure 7: Power curve for UM−70X

When a frequency of 50 Hz or above is detected, the isolators are closed and the generator excites, automatically synchronising to the grid, ready for power generation. If the wind speed decreases to below generation speed, the inductive motor will attempt to drive the turbine. Consumption of power is monitored by a logic circuit which causes the unit to disconnect if a pre-set quantity of power is consumed. Under this system, grid frequency and voltage are adopted by the unit, with current and hence power, dependent on the strength of the wind. Further details and description of the operational aspects of the UM-70X can be obtained from the manufacturer. For the purpose of power production, the power response curve for a given wind speed is of interest. This curve is given in Figure 7 for the UM-70X under lamina flow conditions, and for turbulent flow as assumed for the stations (with a 0.85 reduction factor).

Aérowatt, the original manufacturer of the UM-70X, were taken over by Vergnet in the late 1980s. Design changes were made to the UM-70X to correct faults reducing the operational lifetime of the unit. A speed control mechanism with heavier, stronger blade roots and heftier blades was included in the revised design, designated the GEV 7.10. A new nacelle incorporating these features was provided by Vergnet for the Casey installation but unfortunately was not compatible with the rest of the original Aérowatt unit. A complete GEV 7.10 unit, provided for by Vergnet, was installed in May 1996 replacing the UM-70X.

FIELD TRIALS AT CASEY

To survive the anticipated 90 m/s winds, dependable foundations were needed. The site chosen for the unit was within the general stations limits on an exposed rock outcrop, close to a number of buildings and site services carrying power supply cables. The low ambient temperature at Casey required all work to be completed in a short time frame over the relative warm summer months of January and February during which sufficient thaw of the underlying ground had occurred to confirm that the foundations were located in rock. Heat blankets were required for all concrete to ensure sufficient temperature were maintained for curing. Cranes were available on site for erecting the tower, although the pivot arrangement of the unit was particularly well suited to the conditions as the cranes would have only just been able to reach the top of the nacelle.

The performance of the UM-70X at Casey over the period since erection in March 1995, to June 1996, is presented Figure 8. In total 11.5 MWh have been produced, less than the expected levels (as calculated from the average wind speed for each months from climate recorded over the five year period preceding 1995). For periods when the unit was not connected to the grid, suitable adjustments have been made to the recorded power levels, scaling them up to full month levels to allow comparison. These down-time periods were mainly due to work being conducted on the turbine requiring it to be lowered, or for when the grid connection unit was disabled.

Problems attributing to the lower than expected performance have been identified as:

- poor power factor
- icing inside one of the calibrated weight bars used in the pitch control mechanism due to a cracked sealing cap
- high currents due to high winds resulting in thermal cut-outs

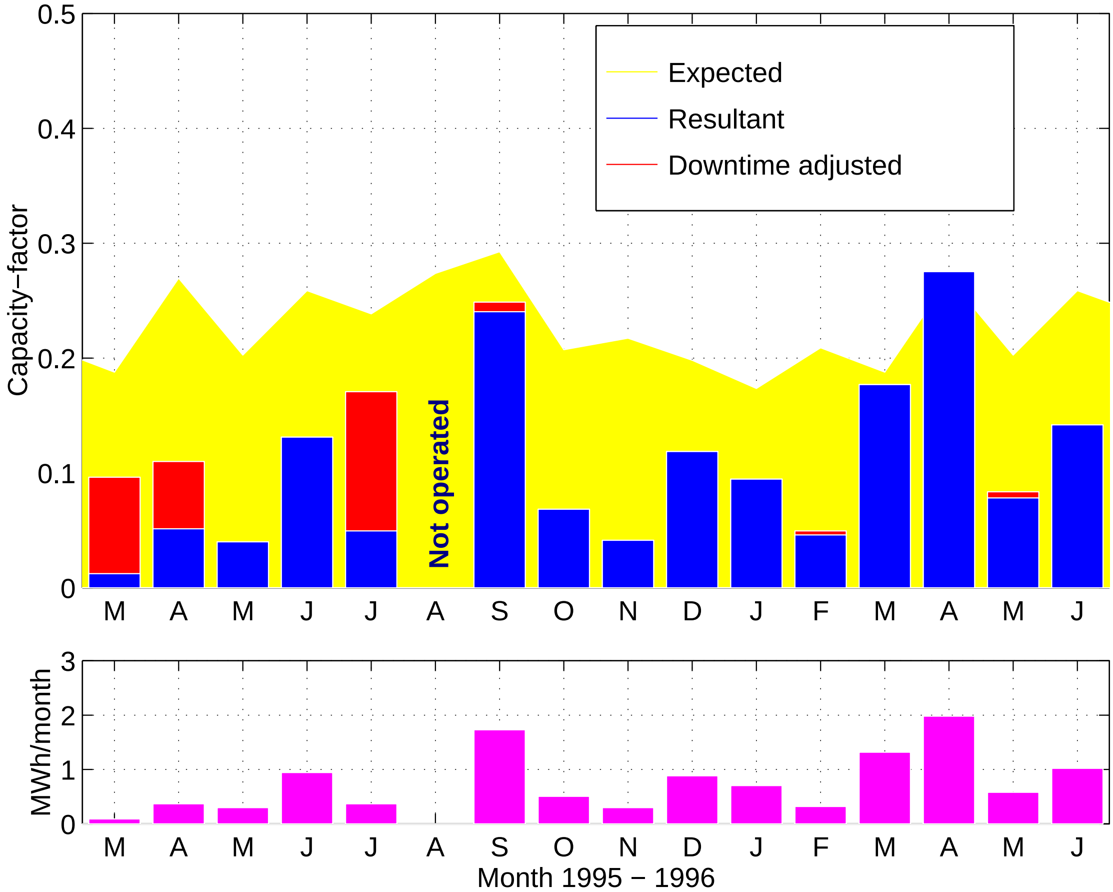

Figure 8: Performance of UM−70X / GEV 7.10 at Casey

A poor power factor was recorded for the unit (effectively limited to a maximum of 0.68), despite the use of 7 kVA capacitors connected across phases. Icing in the calibrated weight bar of the pitch control mechanism, combined with a perforated oil seal in the gearbox necessitated the lowering of the unit in July for repairs. Inclement weather (ideal for power generation) resulted in the unit remaining non-operational until re-erection in early September 1995. The periods of high currents, occurring during periods of extreme winds, resulted in thermal cut-outs removing the unit from the grid. These were usually unable to be reset until after windy conditions abated, especially in winter, resulting in much lost power. Recelebration of the pitch control mechanism occurred in February 1996 in an attempt to correct this problem, resulting in the much improved performance figures for March and April 1996.

In May 1996 the UM-70X was upgraded with a GEV 7.10. Reports from the station have indicated that this unit performs much better, although the heftier design does not perform as well in light winds, resulting in the low energy totals reported for May and June.

Break-down of the units operation over the initial generating period, from 10 April until 9 July 1995, after which the perforated oil seal forced the unit to be lowered, appear in Table 8. It can be seen that low winds resulted in the unit being stationary or of insignificant speed for 71% of the time, while in the transient stage of disconnecting (due to non-productive winds) a further 11% of the time. Power production periods accounted for 16% of the total time, with over-speeding (due to the thermal cut-outs tripping), occurred 1% of the total time under observation. These periods (resulting from thermal cutouts) were reduced during the observational period by frequent manual resetting.

Wind-turbine operational state	Percentage of total time	Equivalent time in days
Stationary	61.1%	54.4 days
Under-speed	9.8%	8.8 days
Consuming power @0.43 kW	11.4%	10.3 days
Producing power @7.31 kW	16.4%	14.8 days
Over-speeding	1.3 %	1.2 days
Total	100.0%	90 days

Table 8: UM-70X operational state at Casey

In total approximately 55% of the expected power was recovered from the unit at an average rate of 7.3 kW. Improvements of these totals is expected from changes in the configuration of the unit following identification and elimination (or at least minimisation) of problems.

Vergnet is actively encouraging and monitoring the performance of this unit, and appear receptive to suggestions for further improvements.

CONCLUSIONS AND FUTURE POSSIBILITIES FOR THE STATIONS

The wind and solar resources identified for the stations offer much promise for the use of wind-turbines and photovoltaics (especially for Mawson and Macquarie Island). It is envisaged that a number of units in the 50 kW range, possibly combined with solar panels and battery storage, could provide a significant proportion of the total energy needs of the Australian Antarctic stations in the future.

Possible configurations are currently being investigated to determine the sizing of renewables best suited to meet the following goals.

1. Maximum penetration of wind-turbines and photovoltaics for electrical power generation relying on regulation from diesel generators
2. Thermal energy generation
3. Power regulation systems to allow greater wind turbines and photovoltaics penetration
4. Energy storage systems to reduce (short term objective) or eliminate (long term objective) diesel generator run-times

ACKNOWLEDGMENTS

The author would like to thank the Australian Antarctic Foundation for their support of the project, and for providing funds necessary for research conducted during this project and for attendance at this conference. Thanks must also be given to the Antarctic Science Advisory Committee (ASAC), and the Australian Antarctic Division (AAD) for project resources and for providing the opportunity to spend time at Casey station over the 1994/5 and 1995/6 seasons; all station personnel at Casey without whose help the project would not have succeeded; and to the Australian Bureau of Meteorology and the Engineering Section of the Australian Antarctic Division for providing access to data files.

REFERENCES

AAD. "Australian Antarctic Stations Engineering Reports."

BoM. "Meteorological data." Australian Bureau of Meteorology,

Guichard, A. and J. Steel "Alternative Energy Systems for Antarctic Stations: Investing for the Future." In Growth and Environment: Challenging Extreme Frontiers, edited by the Centre for Northern Studies and Research, McGill University, Montréal, Québec, Canada, pp 347-363, 1993.

Guichard, A. "Exploiting Wind Power in Antarctica." In Solar '95 in Hobart, Tasmania, Australia, edited by P Fawcett, Australian and New Zealand Solar Energy Society (ANZSES) 1995.

Justus, C. "Methods for Estimating Wind Speed Frequency Distributions." Journal of Applied Meteorology 17 (1978): 350-353.

Olseth, J. "A Probability Density Function for Daily Insolation within the Temperate Storm Belts." Solar Energy 33 (6 1984): 533-542.

Paltridge, G and C Platt. Radiative Processes in Meteorology and Climatology. Developments in Atmospheric Science, Elsevier Scientific Publishing Company, 1976.

Steel, J. "Alternative Energy Options for Antarctic Stations." Graduate Diploma (Honours), University of Tasmania, 1993.

Vrana, A. "The use of Wind Power at Heard Island." Australian Antarctic Division, 1995.

Weller, G. Radiation Fluxes over an Antarctic Surface, Mawson, 1961-62. ANARE, 1967. ANARE Scientific Reports 96.