POTENTIAL FOR SIGNIFICANT WIND POWER GENERATION AT ANTARCTIC STATIONS

by

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Abstract

The Antarctic scientific stations are generally powered by conventional diesel boilers and generator sets which consume large amounts of fossil fuels. In addition to being difficult and expensive to ship, fuel can threaten the local environment.

The potential for wind power generation is high, but few commercial wind turbines can resist the harsh local conditions. The 10 kW “UM70X/GEV7.10” turbine was identified as the most suitable unit currently available. Its production potential was assessed and used as a basis for analysing several configurations of wind-diesel systems at the stations.

At some stations where conditions have been found to be favorable, modest investments in wind turbines would make significant contributions to the overall station energy requirements, while larger, more ambitious systems could make the stations near independent of fossil fuels.

Résumé

Les stations scientifiques de l’Antarctique utilisent généralement pour leurs besoins en énergie des chaudières et groupes électrogènes conventionnels qui consomment de larges quantités de combustibles fossiles. En plus d’être difficile et coûteux à acheminer, ce combustible peux menacer l’environnement local.

Le potentiel de production d’énergie éolienne est élevé, mais peu d’aérogénérateurs disponibles commercialement peuvent résister aux rudes conditions locales. L’aérogénérateur de 10 kW “UM70X/GEV7.10” a été identifié comme l’unité actuellement disponible la mieux adaptée. Son potentiel de production a été estimé et a servi de base à l’analyse de plusieurs configurations de systèmes éolien-diesel.

A certaines stations dont les conditions se révèlent favorables, des investissements modestes en aérogénérateurs contribueraient d’une façon significative aux besoins en énergie de la station tandis que des systémes plus importants et ambitieux pourraient rendre la station presque indépendante de tout combustible fossil.

1. INTRODUCTION

The Antarctic scientific stations require highly reliable power to ensure both the continuity of scientific activities and a suitable level of comfort for the expeditioners. Engineers have turned their minds to the use of renewable energy at the stations and, because of the high winds generally experienced, wind power has always appeared to be the most promising solution.

The early expeditions encountered reliability problems with wind turbines and found that conventional generator sets and boilers were the only satisfactory, practical answer to the reliable provision of the energy required at the stations. Although continually improved, the present energy systems still rely on the same basic principles. The primary power supply is diesel fuel based, with generator sets providing AC power as well as heat through jacket-water and exhaust heat recovery systems, supplemented by conventional boilers. This has the advantage of relying on well known highly reliable technology. The compactness of such systems is also an advantage at sites where space is scarce and where station installations have to share the area with local wildlife.

In addition to the atmospheric pollution caused by the exhaust gases, the operation of diesel power systems holds an inherent risk of fuel spills, notably during ship-to-shore transfers which can often take place under difficult circumstances. Sophisticated, expensive marine science vessels with tight schedules and numerous scientists on board can often be forced to spend several unproductive days at stations, while critical station fuel is transferred ashore. The absolute reliance of the station on imported fuel can exert pressure on logistic operations, and unexpected events, such as technical breakdowns or natural phenomena (storms, heavy ice cover), can threaten the closure or downgrading of station scientific activities and ultimately jeopardise the safety of expeditioners. This can be despite the existence of safety stocks and depots of fuel.

The pressure then is on to move away from the reliance on imported and environmentally unfriendly fuels by using renewables. Preliminary studies conducted in the framework of a cooperative French-Australian Project have identified wind power as the most promising solution for immediate implementation at the two nations' stations (Guichard, 1994a,b).

2. WIND CHARACTERISTICS AT STATION SITES

2.1 General conditions

Remote Antarctic stations generally have to face difficult wind conditions. Typical average wind speeds at coastal sites range from 5 to 10 m/s with a high frequency of strong winds and extreme top speeds where katabatic winds rush down the slopes of the ice cap. The area subject to the highest katabatic winds is the portion of the East Antarctic coast directly south of Tasmania. The average wind speed recorded by Douglas Mawson's Australasian Antarctic Expedition over 2 years (1912-13) at Cape Denison (66°59'S, 142°39'E) was 19.0 m/s, while at nearby Port-Martin (66°49'S, 141°24'E) Expéditions Polaires Françaises recorded over 1950-51 an average wind speed of 16.9 m/s (Parish, 1981). A record monthly average of 29.1 m/s was observed at Port-Martin in March 1951, which is three times higher than the highest monthly average recorded at Lerwick in the Shetland Islands, a place famous for its storms (Pettre & Andre, 1990). A record 2 minute average of 90 m/s has been experienced at Dumont d'Urville (66°40'S, 140°01'E) (Payan & Periard, 1991).

The Sub-Antarctic islands typically experience severe storms, with frequent gusty winds from 5 to 15 m/s, generally from the West. Top wind speeds are also very high with for example a highest gust of 80m/s recorded at Kerguelen Island (49°21'S, 70°14'E) in August 1970 (Météo France data), but temperatures are relatively mild. On the other hand, inland Antarctic sites are in the high pressure zone sitting on the Antarctic Ice Cap and face extremely low temperatures but moderate winds. For example, at South Pole, the minimum temperature recorded is -82.8°C with an average of -49°C, but the maximum wind gust is of only 24.2m/s for an average wind speed of 5.4 m/s.

Table 1 summarises temperature and wind conditions at French and Australian Stations plus some other selected Antarctic and Sub-Antarctic sites. Two Tasmanian sites are included for comparison. The table demonstrates how the average wind speeds encountered in Antarctic coastal and sub-Antarctic sites (5 to 19 m/s) are promising for wind power generation, but the maximum wind gusts (51 to over 90 m/s) threaten to destroy the turbines.

2.2 Wind Speed Frequency Distribution

The preliminary assessments of wind power potential presented in Guichard (1994b) were based exclusively on average wind speeds by assuming the wind speed frequency distributions to be a Weibull distribution of factor 2. Extensive data sets obtained since have allowed actual wind speed (at 10m height) frequency distributions to be determined for several stations. More stations will be added as data sets come in. The frequency distributions shown here were calculated by separating wind speeds into 20 bins of 3 m/s range between zero m/s (non inclusive) and 60 m/s (inclusive), plus the zero value and the values larger than 60 m/s.

Figure 1 outlines the shape of the frequency distributions obtained, at Casey, Davis, Dumont d'Urville, Macquarie Island and Mawson for all complete years of available data. Only complete years were used to eliminate the bias introduced by seasonal variations. Casey and Davis show a sharp peak located between 0 and 10 m/s while Macquarie Island shows a sharp peak between 5 and 15 m/s. Dumont d'Urville and Mawson have a larger spread of speeds from 0 to 20 m/s, with a larger concentration in the lower half (0 to 10 m/s) for Dumont d'Urville and in the higher half (10 to 20 m/s) for Mawson.

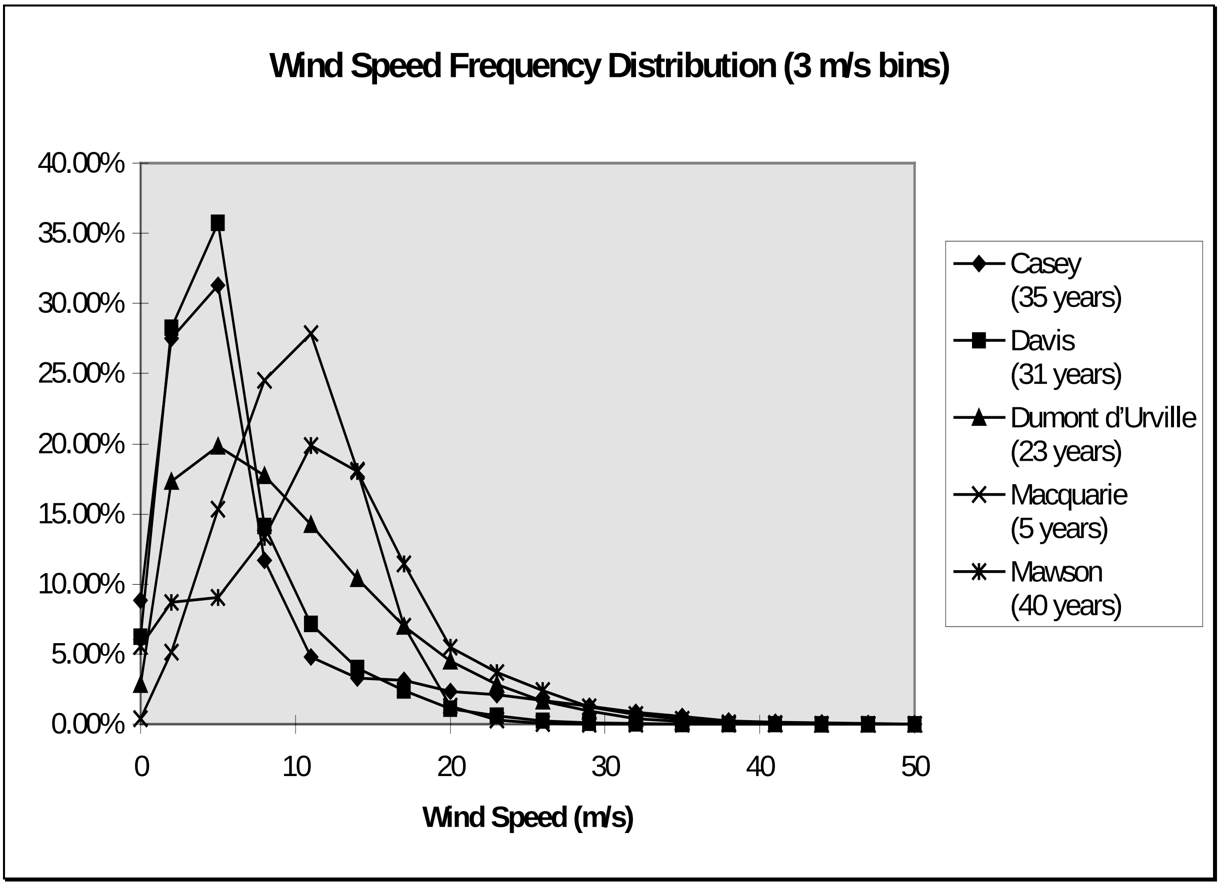

Figure 1: Wind Speed Frequency Distribution at Selected Locations

Air Temperature and Wind Speed Summary at selected locations (Antarctic, Sub-Antarctic & Oceanic, Tasmania)					*Antoine Guichard - July 1996*	**Air temperature (Deg. C)**					**Wind Speed (m/s)**						
						Average			**Minimum**	**Maximum**	**Average**		**Maximum**			**Highest**	**Lowest**
Location	**Data Availability**	**Comment**	**Lat**	**Long**	**Elev.**	from 3h measures (1)	from daily (Min+Max)/2 (5)	(Mean Min + Mean Max)/2 (6)	from spot measures (1)	from spot measures (1)	from Daily Run	from 3h 10minAv (2)	from 3h 10minAv (2)	from spot 2min av. (3)	from spot Inst. Gust (4)	Monthly Average (2)	Monthly Average (2)
Casey	from 1960	Antarctic, Coastal	66°17S	110°32E	12 m			(a) -8.85	(a) -41.0	(a) 9.2	(a) 6.77	(h) 6.5	(h) 50.9		(a) 80.76		
Davis	1957-64, then from 69	Antarctic, Coastal	68°35S	77°58E	12 m			(a) -10.25	(a) -40.0	(a) 13.0	(a) 4.88	(h) 5.1	(h) 47.3		(a) 57.1		
Mawson	from 1954	Antarctic, Coastal	67°36S	62°52E	8 m			(a) -11.25	(a) -36.0	(a) 10.6	(a) 10.66	(h) 11.2	(h) 50.9		(a) 68.9		
Dumont d'Urville	from 1956	Antarctic, Coastal	66°40S	140°01E	43 m		(e) -10.6					(p) 9.4	(p) 50.0	(k) 90		(e) 19.5	(e) 5.0
Port Martin	1950-51	Antarctic, Coastal	66°49S	141°24E	20 m							(m) 16.9				(n) 29.1	
Cape Denison	1912-13	Antarctic, Coastal	66°59S	142°39E	25 m							(m) 19.0					
South Pole	from 1957	Antarctic, Inland	90°00S	-	2 835 m	(f) -49			(f) -82.8	(f) -13.6		(f)? 5.4			(f)? 24.2		
Dome C	1980-82 & 84-92	Antarctic, Inland	74°40S	124°10E	3 200 m	(g)? -50.8			(g)? -84.6			(g)? 2.8			(g)? 17		
Macquarie	from 1948	Island, Sub-Antarctic	54°30S	158°56E	6 m			(a) 4.75	(a) -8.9	(a) 14.4	(a) 7.93	(i) 9.4	(i) 28.8		(a) 51.4		
Kerguelen	from 1951	Island, Sub-Antarctic	49°21S	70°14E	29 m	(b) 4.7		(b) 4.75	(b) -9.4	(b) 25.8		(b) 9.8			(b) 80		
Crozet	from 1956	Island, Sub-Antarctic	46°26S	51°52E	142 m			(c) 5.6	(c) -4.0	(c) 21.9		(d) 10.7			(d) 70	(d) 16.6	(d) 7.5
Amsterdam	from 1950	Island, Oceanic	37°50S	77°34E	28 m	(b) 13.8		(b) 13.9	(b) 1.8	(b) 25.2		(b) 7.4			(b) 56		
Hobart	?	Tasmania	42°53S	147°20E	55 m			(a) 12.5	(a) -2.8	(a) 40.8	(a) 3.14	(i) 4.0	(i) 16.5		(a) 41.67		
Maatsuyker	from 1891	Island off Tasmania	43°39S	146°16E	147 m							(i) 10.3	(i) 41.2				

Notes:

(1) Obtained from the set of standard 3hourly (3h) Temperature measures
(instantaneous measures taken every 3 hours, usually at 00h, 03h, 06h...UTC)
(2) Obtained from the set of standard 3hourly 10minute Average (3h 10minAv) Wind Speed measures
(averages over the previous 10 minutes, taken every 3 hours, usually at 00h, 03h, 06h...UTC)
(3) Highest 2minutes average over full time (that is, not restricted to set of standard measures)
(4) Highest instaneous gust over full time (that is, not restricted to set of standard measures)
(5) Obtained by averaging of all the daily "(Absolute Daily Temp. Maximum+Absolute Daily Temp. Minimum)/2"
(6) Equals "(Mean of all Absolute Daily Minimums + Mean of all Absolute Daily Maximums)/2"

(?) Method used to measure/process data not confirmed

(a) in Australian Bureau of Meteorology (MetBureau) Summary Data Sheets for all years of record to the end of 1991
(b) in Météo France Summary Data Sheets for all years of record to the end of 1993
(c) computed from Météo France Summary Data Sheets for individual years 1989,90,91,92,93
(d) in Météo France Summary Tables of Monthly Mean Wind Speed and Monthly Maximum Gust for 1966 to 1990
(e) computed from Météo France Summary Tables of Monthly Mean Wind Speed and Temperature for 1956 to 92
(f) Originates from U.S. Meteorology data, no details on original data set
(g) computed from AWS data 1980-82 & 84-92 found in Keller et al., 1994 and previous years
(h) computed from MetBureau standard 3hourly data for all complete years available
(Casey: 61-94, Davis: 58-63 & 70-94, Mawson: 55-94)
(i) computed from MetBureau standard 3hourly data for 5 complete years (1990-94)
(k) in Payan & Periard, 1991
(m) in Parish, 1981
(n) in Pettre & Andre, 1990
(p) computed from Météo France standard 3hourly data for all complete years available (1970-87 & 88-93)

Table 1: Air Temperature and Wind Speed Summary at Selected Sites.

3. TURBINE PERFORMANCE

The problems of finding suitable turbines for Antarctic sites have been discussed comprehensively (in Guichard & Steel, 1993; Guichard, 1994a & 1994b; Guichard, Magill, Steel & Lyons, 1995; Guichard, Magill, Godon, Lyons & Brown, 1995). The following account is an up-to-date summary of these discussions.

The potential for wind power generation was recognised during the first expeditions and wind generators were tested and used. The powerful gusty winds combined with low temperatures brought high failure rates. This, as well as energy storage problems and the continuing need for complete back-up systems, led to the withdrawal of wind turbines from Antarctic operations, with the exception of a few small remote field installations for powering limited scientific and communication equipment. The small turbines which worked in field installations were usually rugged oversized turbines. They are not a realistic option for larger systems designed to power the permanent stations. Several interesting developments and trials of prototypes have taken place, notably since the mid eighties, but with mixed results.

At Amsterdam Island (37°50S, 77°34E, Sub-Antarctic to Oceanic conditions) in December 1986 an experimental vertical axis 10m diameter Darrieus rotor "CEA30-AD10" (3 blades, 67.7 m2 swept area, rated 30 kW at 13.5 m/s) was installed. It showed early promise with daily energy production of 400 kWh recorded for wind speeds ranging from 12 to 25 m/s (Perroud et al., 1991). But serious braking problems threatened on several occasions to destroy the machine. These problems were not solved, partly because of their difficulties and also because the main engineer supporting the project retired. The rotor was locked, then scrapped, the project having lapsed in an atmosphere of general indifference and lack of support.

At Georg Von Neumayer Station (70°37S, 8°22W, Coastal Antarctic) in 1991 a vertical axis 10m diameter H rotor “HMW-56” (3 blades, 56 m2 swept area, rated 20 kW at 9 m/s) was installed. It is characterised by simplicity (permanent magnet, no mechanical transmission), has a survival wind speed of 68 m/s and a minimum operating temperature of -55°C (Heidelberg et al., 1990). In its second year of operation, it was running continuously without interruptions and breakdowns and producing roughly 5 to 15% of the energy requirement of the station (Kohnen, pers. com., 1993).

Meanwhile, a small number of manufacturers have developed mature commercial products for the limited and specialised market of stand-alone operation in very difficult wind conditions, cold and/or corrosive environments. These high quality products have already proven their reliability and cost effectiveness in conditions nearly as difficult as the East Antarctic coastal stations and Sub-Antarctic islands where they are now starting to show satisfactory results.

In McMurdo Sound, deep in the Ross Sea, Northern Power Systems “HR3” horizontal axis turbines (3-bladed, 5m diameter, 19.6m2 swept area, 3 kW at 12.5 m/s, DC output, rated survival wind speed of 74 m/s -gusts-) have operated since 1985 in gusts of up to 71 m/s (256 km/h), contributing to a wind-solar-diesel hybrid system powering communication facilities at Black Island near McMurdo Station.

At Heard Island (53°6S, 73°57E, Sub-Antarctic) in 1992/93, a 10kW horizontal axis Aérowatt “UM70X” turbine (2-bladed, variable pitch, 7m diameter, 38.5 m2 swept area, 3-phase 380/415V AC output, rated survival wind speed of 110 m/s -gusts-) was used successfully for 3 months, at times producing all of the electrical needs at the five persons Spit Bay station.

This same UM70X unit was reerected in March 1995 at Casey Station (66°17S, 110°32E, East Antarctic Coast) and upgraded in May 1996 to its new improved version, the Vergnet “GEV7.10”. The turbine operation initially encountered problems which although sometimes difficult to identify ended up being minor and relatively easy to fix. For example, insufficient sealing resulted in snow filling up one of the inertia bars, significantly unbalancing the rotor. The turbine is now running smoothly and despite the initial problems has generated around 10 MWh in the year July95-June96, with a peak of 2 MWh in April 96.

The Vergnet turbines are well designed for extreme wind conditions and, to the best of our knowledge, currently offer the highest resistance to extreme winds in the medium power range together with high efficiency and low maintenance requirements. They have proved their effectiveness in difficult conditions, have survived 90†m/s gusts in the Indian Ocean at Tromelin and have operated satisfactorily since early 1995 at Kerguelen Island (49°21S, 70°14E, Sub-Antarctic).

Although long term reliability has not yet been fully demonstrated at the stations, these last two examples tend to indicate that satisfactory operation can be achieved with selected high quality products after proper trials and minor adaptations.

Table 2 lists the characteristics of the two successful horizontal axis commercial turbines HR3 (3kW) and GEV7.10/UM70X(10 kW), the two experimental vertical axis turbines "CEA30-AD10" (Darrieus Rotor, 30 kW) and "HMW-56" (H Rotor, 20 kW), two medium size Australian machines "BW-10" (10 kW) and "S-20000" (3 kW equivalent -no official rating-) as well as the Danish 'Utility Size' Vestas "V29" (225 kW). We have to note that the last three machines are not designed for extreme conditions such as those encountered down south, and that the V29 would not even be suited to the size of the stations and to the associated logistic support. The V29 is definitely not an option for Antarctica but can act as an interesting benchmark.

The respective power curves which provide a qualitative measure of the various turbines' potential output and suitability to various wind conditions are shown in Figure 2. The following points should be noted: the relatively large curve envelopes of the V29, S20000 and GEV7.10/UM70X which could generate large amounts of power in windy areas, and the very early start of the S20000 which allows good production in areas of moderate winds.

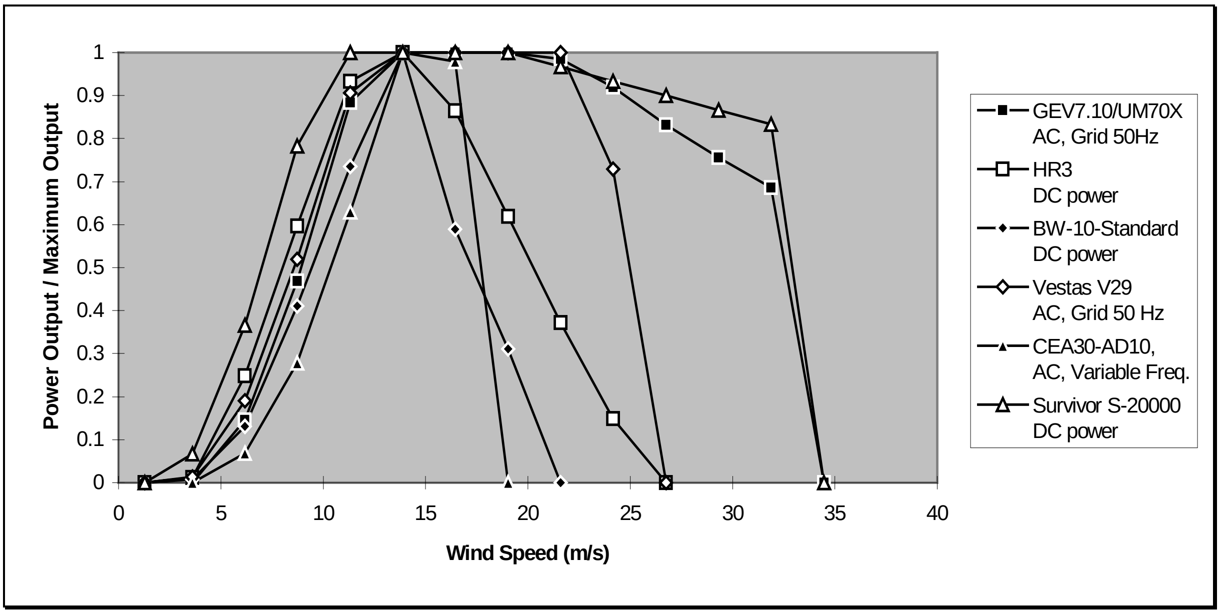

Fig. 2: Normalised Power Curves of Selected Wind Turbines

4. WIND POWER POTENTIAL

The outline power curves and purchase costs were used to assess the relative potential output and power generation cost of these turbines at Casey, Davis, Dumont d'Urville, Macquarie Island and Mawson (in Guichard, Magill, Godon, Lyons & Brown, 1995). The relative cost indicators combined with the proven or expected reliability of the turbines at such sites led to the conclusion that the Aérowatt UM70X / Vergnet GEV 7.10 was currently our best option.

TURBINE	Rotor Type:	Rotor Diameter (m)	Swept Area (m2)	Hub Height (m)	Nb of blades	Output:	Rated Power (kW)	Max Power (kW)	Min. Operating Temp. (°C)	Survival Wind Gust (m/s)	Priced Configuration	Listed Price	Purchase Price Est. ($A)
GEV 7.10 / UM70X (Vergnet S.A.)	Horizontal Axis, Upwind, Stall Regulated Rotation Speed by Blade Pitch Control	7.0	38.5	18, 24 or 30	2	AC- 3 phase grid compatible, Asynchronous Generator 220-240V, 380-415V, 50Hz	10	12.44	?	90	Turbine, 18m tower : with Grid Connection :	224 800 251 600 (FRF)	59 200 66 200
HR3 (Northern Power Systems)	Horizontal Axis, Upwind, Fixed Pitch, Variable Axis Control, Direct Drive	5.0	19.6	12 to 30	3	DC - 24, 48 or 110V, 3 phase synchronous generator	3	3.10	-60	74	turbine, tower & controller :	17 000 (USD)	22 000
BW-10-Standard (Bergey/Westwind)	Horizontal Axis, Upwind, Auto Tail Furl, Direct Drive	7.0	38.5	12 or 18	3	DC - 96 or 120V, Permanent Magnet Generator	10	9.95	-40	60	turbine, 18m tower, controller, extra stiff blade option :		36 125
Survivor S-20000 (Synergy Power Corporation)	Horizontal Axis, Downwind Variable Rotor Area, Gearbox 2.78:1	5.8	26.4		3	DC - 24 or 48 V Permanent Magnet Generator	3	3.00	?	?	turbine, 25m tower, Control Panel :		22 863
HMW 56 (Heidelberg Motor et al.)	Vertical Axis, H-Rotor Direct Drive	10.0	56.0	10.0	3	AC- Variable Frequency, Permanent Magnet Travelling Field generator	20	?	-55	68	n/a	n/a	n/a
CEA-30 AD10 Variable Speed (CEA-Grenoble)	Vertical Axis, Darrieus Rotor, Gearbox	10.0	67.0	15.0	3	AC - 3 phase Variable Frequency, Synchronous Generator	30	29.10	?	?	n/a	n/a	n/a
Vestas V29 (Vestas Wind Systems A/S)	Horizontal Axis, Pitch Regulated, Gearbox 24.6:1	29.0	661.0	31.5	3	AC - 3 phase Grid Compatible, Asynchronous Generator 420V, 50Hz	225	225	?	?			

Antoine Guichard - July 1996

Table 2 : Main Characteristics of Selected Wind Turbines

4.1 Average Output

The estimation of the average output (and average load or utilisation factor) of this turbine at the stations is the first step towards the assessment of complete production systems, and is a good way to overview the potential for wind generation, notably as a simple additional contributor to the existing systems. The utilisation factor is the proportion of the rated output that will effectively be produced by the turbine on average.

Figure 3 summarises the general wind parameters at our five stations along with the average utilisation factor currently estimated for the UM70X/GEV7.10 turbine. Casey and Davis show reasonable although limited potential while Dumont d'Urville, Macquarie and Mawson show high potential.

	Average Wind Speed [3h data] (m/s)	Maximum Wind Speed [3h data] (m/s)	Maximum Recorded Wind Gust (m/s)	UM70X /GEV7.10 Utilisation Factor
CASEY	**6.5**	**50.9**	**80.8**	**26.6%**
DAVIS	**5.1**	**47.3**	**57.1**	**22.8%**
DUMONT D'URVILLE	**9.4**	**50.0**	**90.0 ***	**59.8%**
MACQUARIE ISLAND	**9.5**	**28.8**	**51.4**	**68.6%**
MAWSON	**11.2**	**50.9**	**68.9**	**76.5%**

Note: * 2 minute average

Table 3: Wind Conditions and Estimated Utilisation Factor of the UM70X/GEV7.10 Turbine

4.2 Optimum Wind-Diesel System Options

The average output is only significant if all of the turbine's output can be used. In a Wind-Diesel system, it means being able, at any given time, to feed whatever amount of power is produced by the wind farm into the grid, without affecting the operation of the diesel generators. The practical limit is generally estimated at 40% penetration of wind power, corresponding to 60% of the grid being still supplied by the diesel generators (Brown, 1997).

Different system options were extensively investigated by Brown as part of an MSc project at IASOS (Brown, 1997; Brown et al. 1996a,b). In addition to the direct connection limited to 40% penetration, Brown has considered:

- The addition to the grid of limited power regulation equipment allowing 100% penetration of wind power and intermittent operation of the diesel generators (excess wind power is dumped).
- The inclusion of battery storage with two way inverters sized to take all excess wind power and take all station load (excess wind power is dumped once storage is full). Diesel generators only come in when the amount of energy stored is too low to supplement the wind farm to the level required by the station.

Table 3 summarises some of the optimum options identified by Brown for the four Australian Stations (in Brown, 1997; Brown et al., 1996a). The wind capacity is proportional to the physical size of the wind farm but also to the capital outlay, the proportion of station load met by wind energy is proportional to the diminution of fuel needs and atmospheric pollution while the utilisation factor is proportional to the effective usage of the wind farm then also to the return on the capital outlay. On a financial point of view, it must be remembered that each system evolution considered below involves an additional cost for existing stations.

	Installed Wind Capacity (kW)	Portion of Station Load Met	Annual Fuel Savings (ltrs/yr)	Wind Farm Utilisation Factor
- CASEY -				
Direct (up to 40% Penetration)	**75**	**8%**	**37 776**	**0.19**
with Additional Load Regulation	**200**	**20%**	**94 440**	**0.18**
- DAVIS -				
Direct (up to 40% Penetration)	**100**	**10%**	**56 708**	**0.23**
with Additional Load Regulation	**200**	**20%**	**113 417**	**0.23**
- MAWSON -				
Direct (up to 40% Penetration)	**110**	**25%**	**164 602**	**0.61**
with Additional Load Regulation	**250**	**60%**	**394 995**	**0.65**
with 6 hours Storage Capacity	**450**	**80%**	**526 661**	**0.48**
with 1 day Storage Capacity	**525**	**90%**	**592 494**	**0.46**
- MACQUARIE -				
Direct (up to 40% Penetration)	**55**	**30%**	**57 170**	**0.37**
with Additional Load Regulation	**70**	**60%**	**114 337**	**0.58**
with 6 hours Storage Capacity	**100**	**80%**	**152 450**	**0.54**
with 1 day Storage Capacity	**125**	**90%**	**171 506**	**0.49**

Table 4: Some Optimum Wind-Diesel System Options [from Brown (1997) & Brown et al. (1996a)]

The figures clearly show that significant fuel savings can be achieved at Casey and Davis with simple systems while the potential is high to make Mawson and above all Macquarie near independant of fossil fuels.

It should be noted that a large increase in installed wind capacity (250 to 450 kW) is required at Mawson to go from 60 to 80% fuel savings, and that there is relatively little performance effect brought by extending storage from 6 hours to 1 day capacity. The decrease of the utilisation factors (and hence of the financial returns) is linked to the dumping of excess power. Future studies will add to the system options ways to meet some station needs with this excess power.

It is especially important to note how modest installed capacities of 110 and 55 kW simply connected to the existing systems could immediately meet 25 and 30% of the station load at Mawson and Macquarie Island respectively.

The configurations were identified as "optimum" with respect to various parameters, notably with a view towards meeting a high proportion of the load with wind power (priority to fuel savings). Giving the priority to other factors such as the return on investment independantly of the fuel cost would lead to different optimum configurations. Future studies will include the costing of all system components and assess the different configurations with respect to a wide range of parameters.

5. CONCLUSIONS

There is considerable potential for the application of wind power at Antarctic station sites, particularly given the need for environmentally sound, locally produced power. But experience shows that very few turbines will survive the severe conditions. The high failure rates of the past have not only led to the withdrawal of turbines from the stations but have seriously discredited wind power and its ability to serve Antarctic stations.

Recent and ongoing trials of selected machines have showed promise. Further trials and progressive installation of wind generators, connected to the existing grid or powering specific buildings or applications can allow a progressive increase of wind power generation. The introduction of further load regulation or energy storage systems can then lead to significant energy sustainability at the Antarctic stations.

6. ACKNOWLEDGMENTS

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