Using large commercial wind turbines in Antarctica

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Wind power for Australian Antarctic stations

Antarctica is the windiest place on earth, but using wind power there presents many problems.

After several years of research and collecting data, we have concluded that the best option for Australian stations is to install a small number of large, minimally modified, commercially available wind-turbines. These would be variable-speed, 280kW machines without gearboxes, mounted on 33m or 50m steel towers.

Vital to the efficient operation of such a wind-farm is a computerised power-house management system which optimises the instantaneous wind resource and diesel generator outputs to the station load. When the wind resource exceeds around 40% of the station load, short-term energy storage systems such as fly-wheels, batteries or hydrogen powered fuel cells are required to hold the station load while different combinations of wind and diesel are switched onto the grid.

The availability of large (greater than say 100kW) wind turbines which are capable of with-standing the high wind-regimes and cold temperatures in Antarctica now allow "off-the-shelf" cost effective replacement of diesel-burning power stations. Matching an appropriate design to the local climatic conditions must be coupled with innovative solutions to the logistics and installation phases. However, total power-house replacement will also rely on the provision of efficient energy storage systems.

Timeline

Government Policy
Cost Savings
Easily Achievable
Savings directed to Other Research
Environmental Protection
Spills - Transport, Handling, Storage
Greenhouse Emissions

1993

JOINT FRENCH-AUSTRALIAN PROGRAM

1994

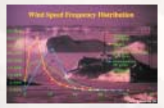
1995

Casey Turbine

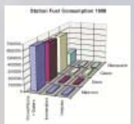
1996

Data collection all Stations
Contacts maintained with Renewable Energy Groups and Manufacturers
ASAC Supported
Papers presented at National & International Forums

1997



1998



1999

Issues for All Stations
3 Stages for Renewables
40% Penetration Easy + Quick payback
80% Penetration needs Electronics + Storage
100% Penetration needs Lots of Storage
Solar Useful in Summer but Expensive
Cost of Infrastructure (Storage, Cables, Electronics, New Engines, Buildings)
Diesels and SAB always required as Emergency Power supply
Environmental Concerns

2000

Enough Data and Information Collected
Macquarie - HEC Consultancy
Mawson Feasibility Study
Funding Options
AGO RAPs/RECP program
AGO Greenhouse Gas Abatement program
Inhouse Loan ?

2001

2002

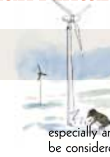
2003

2004

Issues

TRANSPORT
Large (up to 250kW) commercial turbines can have individual components weighing up to 13 tonnes and 15 meters in length. Special cranes and transport equipment may be required to move the components from the re-supply vessel to the site.

ERECTION
Usually, cranes of 100 tonnes or greater are required to erect large turbines. Alternative erection systems such as tilt-up or self-erecting climbing cranes will need to be considered for remote installations such as those in Antarctica. Also to be considered is the small window of opportunity over summer to undertake an installation.

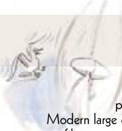


ELECTROSTATIC
Static build-up on cables, turbine blades etc due to the low humidity and blowing drift snow can be a problem at some sites. Sound earthing practices especially around control electronics need to be considered at the design stage.

ICING
Icing of blades, furling mechanisms and monitoring equipment would normally only be a problem at sites where on-shore wind-blown wet snow or rain occurs. At most Antarctic stations, cold dry snow from the continental interior prevail and icing would not be an issue. Most large turbines are now available with blade heating.

SITING
Turbine design life and annual output can be greatly decreased by turbulence generated by buildings, other turbines and prominent land formations upwind and in the near vicinity. Depending on wind speeds, "near vicinity" can be many hundreds of meters.

TRAINING
Specialised maintenance and servicing of turbines will need to be undertaken by station staff for which specialised training will be required each year. The training would include safety aspects of working at heights.



WILDLIFE
Experience has shown that the chance of bird-strikes is greatly reduced if the turbine is un-guyed, mounted as high as possible and is slow revving. Modern large commercial wind-turbines fit this profile.

WIND ABRASION
At sites where the prevailing wind direction is from areas which are substantially ice-free, "sand-blasting" of the blades could be a problem which needs to be considered. A loss of efficiency and a decreased design life could result if precautions are not taken. Wind driven snow can also be a problem, but to a lesser extent.

FOUNDATIONS
Special consideration should be given to foundation design due to the high winds and cold temperatures. Permafrost ground conditions at some coastal sites are also a critical factor in the design. In general, concrete mass and cantilever designs are required with high quality control during construction.

RADIO FREQUENCY INTERFERENCE
Large variable-speed turbines use complex switching electronics to maintain fixed voltage and frequency output to the load. Care must be taken to ensure that interference from these electronics systems does not impact on sensitive scientific instrumentation which can be located near-by.

TEMPERATURE
The constant low temperatures in Antarctica can lead to costly problems with gearbox oils, oil seals etc. Turbine designs which do not use gearboxes are therefore to be recommended.

FATIGUE
Compounded by the cold temperatures, metal fatigue due to the cyclic loadings in high winds, is the biggest issue in adapting large commercial turbines for use in Antarctica. Design modifications to the turbine and tower, including the use of specialist steels and castings, could be required.

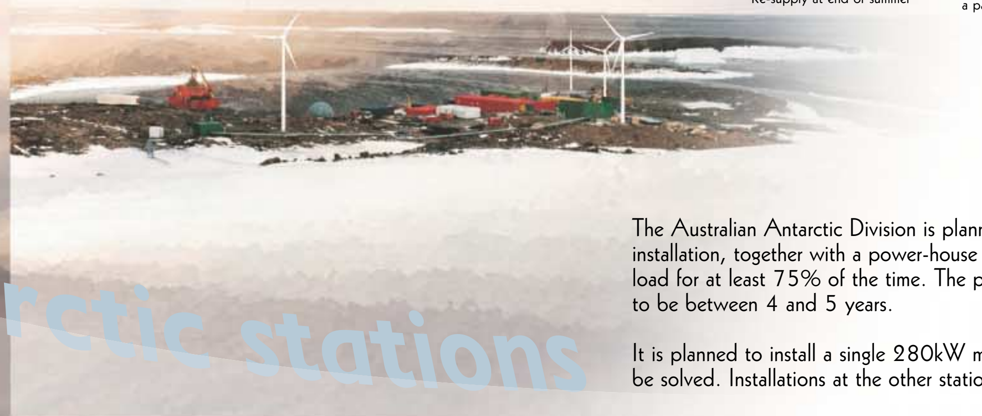
Stations

Mawson
11m/s annual average and maximum wind gusts of 70m/sec
But lack of available land
Average energy load 530kW
Small (30t) cranes
Re-supply at end of summer

Macquarie Island
Maritime climate, 9.5m/sec annual average
Resupply through surf or by helicopter
No cranes
Bird-strikes may be a problem with a particular species

Casey
Greatest max wind gusts (81m/sec)
Long periods of calm weather
More turbines and storage needed
Longer pay-back

Davis
Very average wind resource
More turbines and much more storage required
Much longer pay-back



The Australian Antarctic Division is planning to install 3 or 4 280kW turbines at Mawson by 2003. This installation, together with a power-house control and flywheel storage system will provide 100% of the station load for at least 75% of the time. The pay-back period in terms of fuel and infrastructure savings is expected to be between 4 and 5 years.

It is planned to install a single 280kW machine at Macquarie Island by 2004 if the transportation system can be solved. Installations at the other stations will follow to different degrees depending upon further studies.

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