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National Renewable Energy Laboratory

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# Analysis of the Use of Wind Energy to Supplement Power Needs at McMurdo Station and Amundsen-Scott South Pole Station, Antarctica

E.I. Baring-Gould, *NREL/NWTC* R. Robichaud, *NREL/FEMP* K. McLain, *Accurate Engineering*

Presented at

Photo credit: Josh Landia – National Science Foundation

## McMurdo Station

McMurdo is located on a volcanic island about 20 miles from the mainland of Antarctica and 2400 miles south of New Zealand. The town site, with a population over 1000, is located on a southwest-facing beach at the foot of several large hills, including Arrival Heights/Twin Craters and Crater Hill. The station consists of many buildings and provides the primary hub of research facilities, housing, and services to all U.S. activities in Antarctica. The site has a seasonal harbor where supply and fuel vessels can dock and unload cargo after an icebreaker creates a channel. Power requirements for the town site's infrastructure, laboratories, and science experiments are quite large and reliable, high-quality power is essential.

## Amundsen-Scott South Pole Station

At a 9,400-ft elevation and with temperatures ranging from -115°F to +6°F (-82°C to -14°C), South Pole Station sits on a slowly moving Polar Plateau ice field at the earth's geophysical south pole. The station supports year-round scientific activity, hosting a summer scientific staff of more than 150 while fewer than 100 spend the long, cold winter. The original dome facility (left) is currently being replaced by a new above-snow facility (right) that will greatly expand the services and living conditions at the Pole. The station staffing is expected to increase with the completion of the new facility. One limiting factor at the South Pole is that all supplies, equipment, and personnel must be flown into the site during a short, 4-month summer season. The station is 840 miles (1350 km) from McMurdo Station.

Photo credit: Forest Banks – National Science Foundation

# The Problem

Diesel power plants at each station supply power and heat and melt or desalinate water. Potential fuel supply disruptions and increasing storage demands are a major logistical issue.

Photo credit: Brian Barnett – National Science Foundation

**Fuel is delivered once a year by ship – if the icebreaker can get through**

Photo credit: Brian Barnett – National Science Foundation

**Diesel power station at McMurdo**

Photo credit: Josh Landia – National Science Foundation

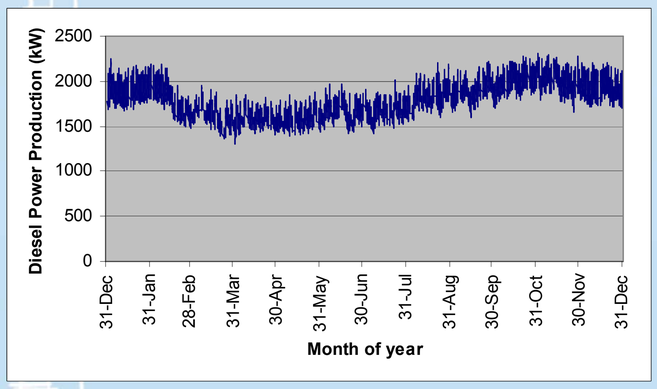
**Fuel for power and heat is transported to remote site in 55G barrels**

Photo credit: Emily Stone– National Science Foundation

**Limited number of ski-mounted C-130 cargo planes are currently the only way to transport supplies to the Pole, creating a huge supply bottleneck**

**McMurdo Station**

- Diesel plant production is consistent at just below 2.0 MW (see figure)
- Electrical consumption for 2002 was 15,823 MWh
- The soon-to-be-renovated power plant consumes approximately 1,300,000 gallons/year (4,921,000 liters/year) for power, heat, and water desalination
- The 2002 cost of delivered fuel was $1.71/gallon ($0.451/liter).




**2001 power plant production from the diesel station at McMurdo**

**Amundsen-Scott South Pole Station**

- Reliable energy is truly a life-and-death issue at the Pole
- Power requirements at new facility are estimated to be between 467 kW and 510 kW for the summer and winter, respectively
- Yearly fuel usage for power generation at the new facility is projected to be 341,000 gallons (1,290,821 liters)
- 1,160 short tons (1,052 metric tons) of fuel must be transported to the station each summer
- The delivered cost of fuel is approaching $15/gallon.

The large amount of diesel fuel needed to power and heat the station continues to constrain the cargo capacity and places extreme logistics and performance pressure on support personnel, scientific research, and station services. As the electrical needs at the site grow, this problem continues to worsen.

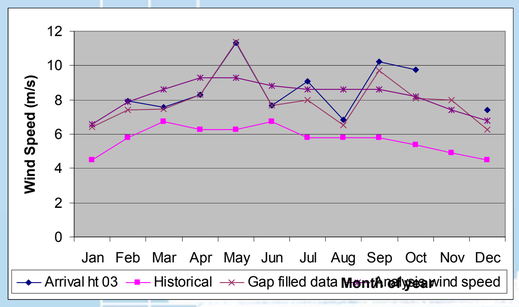
# An Approach

Staff at the U.S. Department of Energy's National Renewable Energy Laboratory, with the help of Raytheon Polar Services, conducted the analysis to assess the use of wind energy to lower costs and reduce the need for diesel fuel.



Photo credit: Kotzebue Electric Association

**NW 100/19 installed in Kotzebue Alaska: Arctic design with a temperature rating of -50C**




**Wind speed data collected at locations around McMurdo Station, Antarctica**

**McMurdo Station**

- Due to land availability constraints and current lift capabilities, installations of 100-kW and 250-kW wind turbines were considered
- Installed capacity up to 1250 kW were analyzed
- Analysis using a small peaking diesel was also considered.

**Amundsen-Scott South Pole Station**

- No utility wind turbines can currently operate in the extreme temperatures at the South Pole, so modifications to an existing type would have to be undertaken
- The North Wind 100/19 was designed for the arctic and fits all of the design requirements for shipment to the South Pole; only cold hardening should be required
- The number of wind turbines considered was limited due to the current inexperience of operating turbines in these conditions
- Further analysis could be conducted to assess using wind energy to further reduce the need for diesel-based power generation.

# Conclusions

Analysis using NREL's Hybrid2 software indicates clear potential to use wind energy to reduce the power generation costs, fuel consumption, harmful air emissions, and fuel needs at both stations.

**McMurdo Station**

After examining several different system options, there is the potential to:

- Result in a medium-penetration power system, similar to others installed around the world
- Reduce the total cost of generating power by between 0.5 and 2 cents per kWh produced
- Save between $1 million and $4 million over 20 years
- Reduce fuel consumption between 158,000 and 317,000 gallons (600,000 to 1,200,000 liters) per year
- Cost between $2 million and $3 million.

**Amundsen-Scott South Pole Station**

The installation of nine 100-kW wind turbines would result in:

- Net savings of almost $18 million over 20 years
- Reduced annual fuel consumption by ~23%, or 116,500 gallons (440,783 liters) per year
- Cost approximately $4.3 million.

An increased use of wind power could be considered in further analysis.

| Input | | | Economic Results | | | |
|---|---|---|---|---|---|---|
| *Type of turbine* | *Turbine #* | *Engine Size (kW)* | *COE $/kWh* | *Difference $/kWh prod* | *20-Year NPC $* | *Capital Cost, $* |
| All diesel system | | | $ 0.1589 | $ - | $ 30,809,210 | $ - |
| NW 100 | 7 | 6x1135 kW | $ 0.1542 | $ 0.0047 | $ 29,889,266 | $2,302,886 |
| FL 250 | 4 | 6x1135 kW | $ 0.1423 | $ 0.0166 | $ 27,589,012 | $2,140,400 |
| FL 250 | 4 | Small Dsl | $ 0.1377 | $ 0.0212 | $ 26,693,168 | $2,140,400 |
| FL 250 | 5 | 6x1135 kW | $ 0.1383 | $ 0.0206 | $ 26,824,676 | $2,675,500 |

**Economic impact of the installation of 100- and 250-kW wind turbines at McMurdo Station**

# Next Steps

To improve this analysis, several actions should be taken:

- Obtain up-to-date and more detailed load and power system data from each of the sites, including the undertaking of a detailed energy audit for all facilities
- Conduct more advanced wind measurement at McMurdo, including hub-height wind assessment
- Initiate a site-specific wind measurement program at South Pole
- Quantify the impact of reducing the available heat from the generators for space heating
- Identify appropriate hardware for the South Pole, including floating-ice wind turbine foundations
- Assess wind turbine impact on existing or planned scientific work, including meetings with senior science staff.

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