WIND POWER FOR A MARS MISSION

4/6/2012

INTRODUCTION

Nuclear, solar and wind energy sources are under consideration by the National Aeronautical and Space Administration (NASA) for a future Mars mission.

The humans who would land on Mars will have to dwell there for months until Mars becomes realigned back with the Earth for a shorter and less energy demanding trip home. They must establish a base at the side of cliff or underground to protect them from the cold, space and solar radiation, the high winds and the common dust storms there. The base would need an electrical generator to power it. They cannot haul chemical fuel to the surface and must rely on an on site power source. Solar collectors would be unsuitable in the cold Martian nights or during dust storms which can blacken the sky.

Thus a nuclear reactor as a power source is the most viable alternative. Another possibility is a wind power system coupled to a solar collection array. Wind turbines could generate electricity during the months long global dust storms that can make days on the red planet as dark as night.

Table 1. Comparison of the Martian and Terrestrial atmospheres, volume percent.

Characteristics	Mars	Earth
N_2	2.70	78.08
O_2	0.13	20.95
Ar	1.60	0.93
H_2O		<1-4
CO_2	95.32	0.035
O_3(Ozone, ppbv)		10-100
Surface temperature, ^oC	-53	+15
Surface pressure, mbars	6.36	1,013

NASA COLD WEATHER WIND TURBINE PROGRAM

NASA conducts planetary wind energy at Ames Research Center in Moffett Field, California. It envisions a Mars space station powered by solar energy during clear weather, with wind power as a backup up during the dark months. The small wind turbines are currently used for NASA projects in Antarctica, where the continent's six months of darkness each winter make it impossible to rely on solar power year round.

The low density of air on Mars precludes the use of wind turbines during normal times. The Mars wind blows strongly enough to move an energy turbine only during dust storms. At other times, the planet is still. Mars turbine research is carried out through

NASA's Cold Weather Wind Turbine program.

Utility scale turbines vary in size from 50 kWe to 2 MWe. The turbine under consideration for the Mars project generates about 100 kWe, depending on the location and the air density. At an Alaska test site, the turbine generated a maximum of 120 kWe in a 36mph wind. At a test site in Colorado, where air is denser, it averaged closer to its nominal rated power of 100 kWe.

On Earth, the wind needs to blow at about 10 meters/sec or 33 feet/sec to operate a wind turbine. On Mars, it has to blow at about 30 meters/sec, or 98 feet/sec because the planet's atmosphere is extremely thin.

Figure 1. Wind turbine of 50 kW rated power in the arctic harsh environment. Source: Nunavut Wind Corp.

ALASKA WIND ENERGY PROJECT

At Kotzebue in rural Alaska, a Northwind 100 wind turbine prototype made by Northern Power Systems of Waitsfield, Vermont which collaborates with NASA, was installed. Kotzebue is located on the Bering Strait north of the Arctic Circle and is home to the tribal government of the Qikiktagrukmiut people, the original inhabitants of the area. Air is the only access to the region.

The Kotzebue Electric Association already uses 66 kWe turbines for electrical generation. The Northwind 100 turbine provides about 100 kWe of power. The turbine has been clocked at an even higher rate in Kotzebue's cold and hence higher density winds.

Compared to the usual 66 kWe models costing $75,000, the Northwind 100 model costing $250,000 is much more complicated with a lot more wiring and controls. It relies on sensors that monitor the wind then transmit information to a motor which rotates the entire encapsulated turbine to face the wind.

NASA, the Department of Energy, and Northern Power Systems helped the Kotzebue Electric Association purchase the $250,000 prototype turbine. NASA monitors the new turbine's functioning through a dedicated computer.

The Northwind 100 machine weighs 45,000 lbs, excluding the pilings which would add another 10,000 lbs, and is prohibitively heavy to use on Mars. In Alaska, the pilings were drilled into the permafrost. The cost of about $10,000/lb of payload is incurred to place a payload in low Earth orbit, make the generator and tubular tower still far too heavy to ship to Mars. The hope is the development of lower cost and heavy mass launch vehicles would make it possible.

A difficulty is that data from the NASA Viking and Pathfinder probes showed that the planet's ordinary surface winds do not blow strongly enough to drive wind turbines. But those missions did not visit the planet during a dust storm. Computer models and wind tunnel tests show that dust storms are accompanied by extremely high winds that would be strong enough to drive wind turbines, even at the speed needed in the thin Mars atmosphere.

A special turbine design would be needed on Mars: they need smooth blades to work efficiently and billowing dust could stick to the rotor blades or abrade them. The inner workings of a turbine generator would also have to be protected from the dust infiltrating and damaging them.

ANTARTICA COLD WEATHER WIND TURBINE PROJECT

At the USA Amundsen-Scott South Pole Station about six months of each year are engulfed in darkness. The South Pole's atmosphere and conditions mirror the conditions on Mars. The residents remain at the station for a set amount of time and have to grow their own food and bring everything needed for their station is analogous to the conditions on a Mars space station. It is not feasible to ship diesel oil to the South Pole, and that is the same for Mars. The base residents grow fresh fruits and vegetables, and recycle their waste. People at the South Pole station and a space habitat have to be careful to use electricity efficiently.

Designing and maintaining the wind turbines under extreme operating conditions, is the key to using wind power on a Mars mission.