Half-Month Solar Thermal and Electric Storage System for a Lunar Environment.

Majid Naji[1,] Michel A. Duguay[2]
1: COPL, Department of Electrical Engineering, Université Laval, Ste-Foy, Quebec,
majid.naji.1@ulaval .ca
2: COPL, Department of Electrical Engineering, Université Laval, Ste-Foy, Quebec,
mduguay@gel.ulaval.ca

If an astronomical station (mainly an observatory) is built one day on the Moon there will be a need to keep it at a minimum temperature, likely in the vicinity of zero degree Celsius, in order to keep its computers, electronics components…functional, and keep the optical, mechanical components and interior environment in a constant temperature.

The solar thermal storage unit proposed here will supply both heat and electricity to the lunar astronomical station right through the very chilly (minus100 °C) half-month lunar night. We describe a system for storing solar energy in thermal form in lunar rock over a 15-day period and for its recovery during the half-month lunar night in the form of guided infrared radiation and electricity from thermoelectric or thermovoltaic devices. The proposed system is illustrated in Fig. 1. An array of holes is drilled into lunar solid rock in order to house resistive heating elements operating at a maximum temperature of about 800 degrees Celsius. At this temperature lunar rock with high olivine content will still be in solid form. Twenty-centimeter wide trenches are dug into the lunar rock and define a lithic thermal storage volume that has a truncated conical shape. The base of the cone is 60 cm in diameter at a depth of 7 meters, while the top surface is 2 meters in diameter. At 800 °C this truncated conical volume stores about 21 Gigajoules of thermal energy. The thermal heat loss through the base of the cone is about 0.8 kW, while the thermal loss through the conical sides is about 4 kW.

Assuming 30% efficient photovoltaic solar panels with a 1.35 kW/sq. meter insolation we calculate that about 60 square meters of panels would be required in order to charge up the storage unit and to compensate for the thermal conduction losses. When the storage unit temperature is 500 °C a 10-cm hole in the lunar rock will emit about 150 Watts of infrared radiation, which can be guided by a hollow reflecting waveguide to a chosen target, such as a computer housing or a telescope mirror. Assuming an IR transmission of 75% through the guide, this infrared could be converted to electricity in future thermovoltaic cells with an efficiency of about 5% and generate about 6 watts of electricity. At higher storage temperatures more electricity will be generated. Thermoelectric devices could also be used to convert about 5% of the thermal energy to electricity.

This generated electricity also can be used for the electronic and control parts of the station.

The same type of system could be adapted to an Astronomical station on Mars. The infrared would be useful for keeping the temperature of the Mars based observatory (optical and Radio) greenhouses and of living and control quarters at an acceptable level.

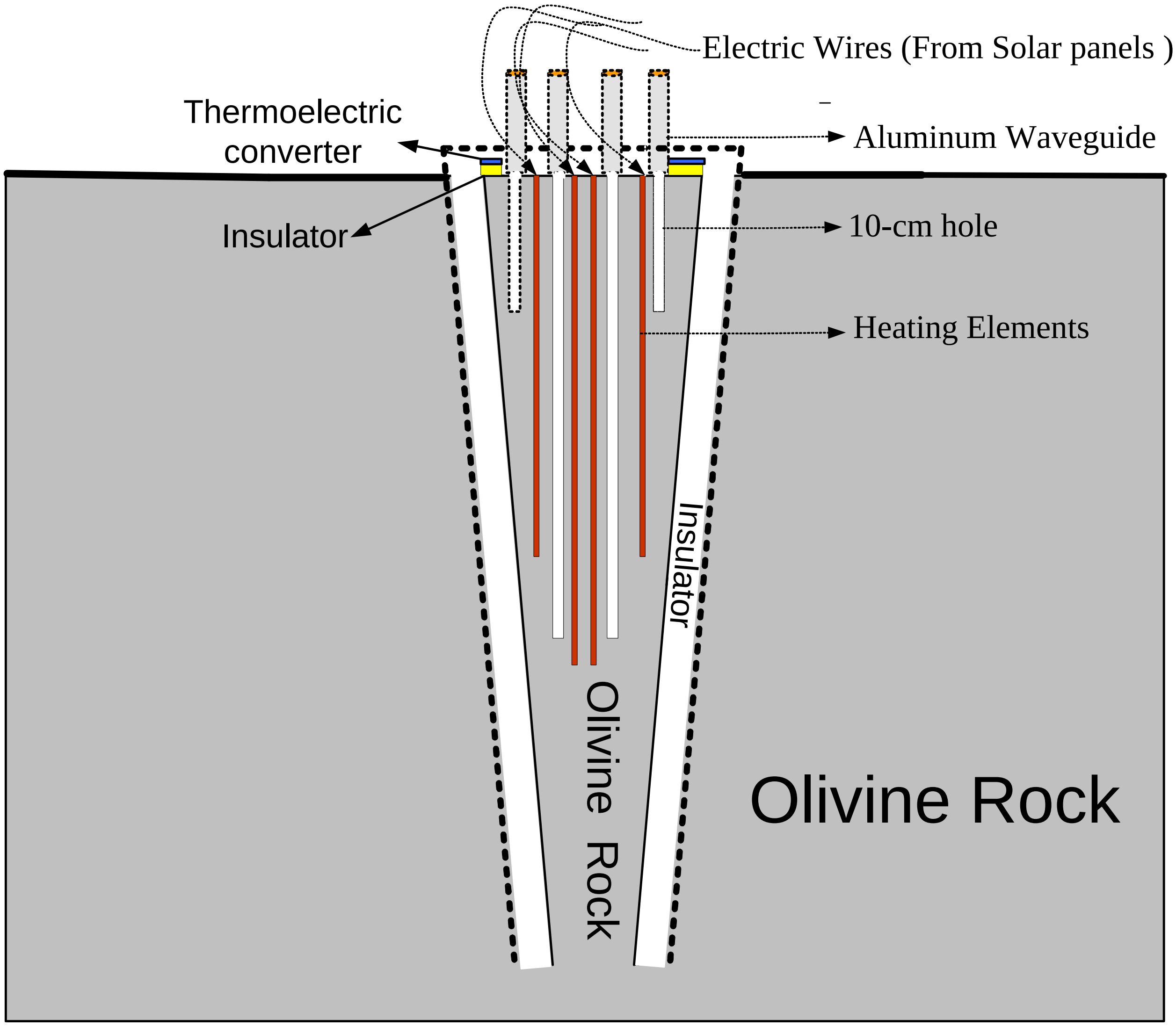

Figure1

References:

1) Michel A. Duguay, Philippe Faucher and Francis Pronovost (2004) Nested multicomponent lithic thermal energy storage and electrical generation system. US Provisional patent application, Sept.27th.

2) Geoffrey A. Landis and Joseph Appelbaum (1991), Photovoltaic Power Options for Mars, Space Power, volume 10, No.2, pp225.

3) Geoffrey A. Landis, 1997, Photovoltaic Power for the Moon, NASA Glenn Research Center, http:// powerweb.grc.nasa.gov/pvsee/programs/solarmoon.html

4) J. Appelbaum, G.A. Landis and I. Sherman (1993), Solar radiation on Mars, Solar Energy Vol.50, No.1, pp. 35.

5) J.M. Clawson, A. Hoehn, L.S. Stodieck and P.Todd (1999), AG-Pod - The Integration of Existing Technologies for Efficient, Affordable Space Flight Agriculture, 29th International Conference on Environmental Systems Denver, Colorado July 12-15.

6) Geoffrey A. Landis (1989), Solar power for Lunar night, 9th SSI/Princeton Conference on Space Manufacturing, Princeton, NJ, 10-13 May 1989

7) Anthony Zuppero, Geoffrey A. Landis (1991), Mass budget for mining the moons of Mars, The Second Annual Symposium of the University of Arizona /NASA Space Engineering Research Center for Utilization of Local Planetary Resources
8) B.D. Fables, W.H. Poisl (1991), Refractory materials from lunar resources, The Second Annual Symposium of the University of Arizona /NASA Space Engineering Research Center for Utilization of Local Planetary Resources.
9) Linda Voss (2002), Space Power, http://science.nasa.gov/headlines/2002/03sept_spacepower.htm
10) James R.Bolton (1995), The Photochemical conversion and storage of solar energy: An historical perspective, Solar Energy Materials and Solar Cells 38, pp543-554.
11) L.M. Fraas, W.R. Pyle and P.R. Ryason (1983), Concentrated and piped sunlight for indoor illumination, Applied optics, Vol22, No. 4, 15 February.