A Preliminary Analysis of the Distribution of Energy Usage at Goldstone DSCC

J. Lu
Systems Analysis Section

A survey has been conducted of energy used for space cooling, space heating, electromechanical and other functions, lighting, and electronics. Results show a preliminary estimated distribution of 46%, 24%, 18%, 6%, 5%, respectively, for the aforementioned categories. The percentage figure for electromechanical and other functions was done by elimination. The total primary energy consumption for Fiscal Year 1973 was known prior to undertaking this task.

I. Introduction

This article presents the results of a Network Operations Performance Analysis Task on identifying an energy usage pattern at Goldstone DSCC. The goal of this study was to understand those patterns such that: (1) a rational short-term energy reduction policy could be formulated, and (2) a consequent dollar savings in Goldstone operations could be obtained. The study was also useful as a preliminary energy usage model for long-term reduction of Goldstone's dependence on external energy sources.

Toward these ends, energy use was allocated into the following categories: space cooling, space heating, lighting, electronics, and electromechanical functions and all other uses (Ref. 1). Energy values for each of these categories were then determined for each site and each building at Goldstone. An expanded description follows.

II. Definitions

The category of space cooling included all air refrigeration[1] loads associated with each building at each Deep Space Station (DSS). These loads did not differentiate between rated capacities for comfort cooling or electronic equipment cooling. In addition, no evaporative coolers were considered, and only small heat pumps used primarily for comfort conditioning were included (Ref. 2).

The category of space heating included all electrical resistance heating units used for warming air for personnel comfort. An account of heating using liquid propane gas as the fuel source was included (Ref. 3).

Electronic loads were delimited to include only the energy used for control room electronics. This work was

[1]Here taken to mean no adjustment of relative humidity.

done by DSN Engineering prior to the initiation of this task (Ref. 4).

Lighting included all sources of interior and exterior illumination at the Pioneer, Echo, Venus, and Mars DSSs. Neither the Spacecraft Test Facility nor the Microwave Test Facility was included (Ref. 5).

Energy used for electromechanical functions and all other uses included all energy consumers not specified within the preceding four categories. Hence, the energy value, GJ or gigajoules (1 GJ = 0.948 × 10^6 BTUs), associated with this category was calculated by subtracting the energy used for the preceding four categories from the primary energy total of 115,000 GJ used in 1973 (Ref. 6).

III. Data

The basic tenets of data collection were that the data would be collected on a non-interference basis, and that there would be no special data-gathering instrumentation installed for this survey. Non-interference implied that the process of collecting data would disrupt neither the reliability of tracking nor the regular maintenance routines performed by Support Services personnel. Special instrumentation would have been required for measurements of currents flowing in selected busbars. Furthermore, cables were oftentimes so densely packed that instrumentation would have been useless in any case. For these and other reasons, data were collected in the following forms.

Energy used for lighting was broken into energy used for exterior lighting and energy used for interior lighting. In both cases, the energy used was calculated by counting the lighting wattages associated with each building at each site. An estimated number of hours of usage was then specified with the help of De Wayne Feasel and William Carman in Support Services at Goldstone.

There were, however, uncertainties as to the area under which such lighting intensities could be assumed constant. For example, lighting a 40-m^2 room could have 1614 lm/m^2 (150 fc) over an immediate work area of 10 m^2. This assessment was not recorded as a part of the lighting intensity survey. Hence, accounting for such factors necessitated an appropriate sampling of representative rooms. Avoidance of this procedure led to usage of aggregated floor areas. This particular procedure yielded unreasonable results. Thus it became apparent that a sampling of rooms would be necessary. If such an account were to be made, it seemed just as simple to count the lighting wattage directly. This was the method that was chosen.

The data used for space cooling energy were also collected from records maintained by Support Services at Goldstone. These records do not distinguish between cooling requirements for comfort and cooling requirements for electronic equipment. These data were then combined with average monthly usage times which accounted for air refrigeration loads turned off during weekends and during nine paid holidays per year. During summer, the percentage of capacity loading on air refrigeration tonnage[2] was assessed at 80%. Winter, fall, and spring were assessed at percentage loadings of 33%, 55%, and 55%, respectively.

Energy used for space heaters was collected in the form of power ratings at each building and each DSS for electrical heaters and average yearly usage in gallons at each site for liquid propane gas. The total electrical power delivered to resistance heaters was assigned full operating capacity during the nine-month period, September through May, when average monthly outdoor temperatures were less than indoor temperatures (21°C (70°F) Ref. 7).

Energy used for control room electronic equipment was given in power loads specified by DSN Engineering. An assumption was made that such equipment would be on at all times. Although such an estimate was made, energy usage still did not amount to a significant portion of the total energy picture.

Once again, energy used for electromechanical and all other functions was not considered except as an all-inclusive category to account for equipment not covered by the other four categories.

Although the hypothetical energy allocation scheme was useful as a tool for approaching this survey, there were areas where practical reality differed markedly from the conception. For example, the small heat pumps included in the space cooling category rightfully belonged in the space heating category when the weather was cold. Equipment cooling could be included in the category of electromechanical functions, and the unaccounted portion of liquid propane gas usage belongs more to space heating

[2]A measure of refrigerative capacity. One ton of refrigeration = 12.7 MJ/h or 12,000 BTU/h.

than to electromechanical and all other functions. Pioneer, Echo, and Venus are equipped with an assortment of fifteen boilers, twenty-nine space heaters, four hot water heaters and four cooking ranges, all of which consume liquid propane gas. For these reasons, one must consider the obtained distribution to be a preliminary sketch only.

IV. Results

The energy distribution obtained using the preceding data is summarized in Fig. 1. Although this distribution is a preliminary survey, three definitive statements can be made regarding energy usage at Goldstone.

(1) Air refrigeration consumes a major portion of the energy used in any one year.

(2) Additional lighting conservation measures will not yield significant savings in energy.

(3) Control room electronics equipment consumes only a small portion of the total energy.

V. Conclusions and Recommendations

These results reflect the distribution of energy usage collected from the Support Services Group at Goldstone between October 1, 1973, and February 1, 1974. The lines which separate the categories of energy use are not firm, and will require more detailed analyses to specify exactly where divisions are to be assigned. In particular, a more detailed account will have to be made of the various types of air refrigeration equipment and electromechanical equipment.

In the future, both an organizational chart and a uniform reporting system should be established for energy systems development. Ideally, a single category could be associated with a chain of documents. For example, a category such as solar heating designed by a person within a group from DSN Engineering is coordinated by a person within a group from DSN Operations and is maintained by a person within a group at Goldstone. It will be much easier to trace future energy systems development with such a tool.

References

1. Bourke, R. D., and Lu, J. Y., "Goldstone Energy Use Patterns," IOM 393.3-798, Oct. 9, 1973 (JPL internal document).

2. Lu, J., "Air Conditioning Loads on Space Cooling," IOM 393.3-883, Mar. 20, 1974 (JPL internal document).

3. Lu, J., "Space Heating Energy Use at Goldstone (Rev. A)," IOM 393.3-907, May 13, 1974 (JPL internal document).

4. Kroll, G., Casperson, R. D., Merrick, W. D., "DSN Air Conditioning System Upgrade Master Plan CY-72 through CY-77, Report A/C-771," Aug. 1, 1971, first issue (JPL internal document).

5. Lu, J., "Energy Used for Lighting at Goldstone," IOM 393.3-868, Feb. 27, 1974 (JPL internal document).

6. Rapp, R. A., "Annual Utilities Report to Management," National Aeronautics and Space Administration, Washington, D.C., July 10, 1973.

7. Lu, J., "Weather at Goldstone," IOM 393.3-881. Mar. 20, 1974 (JPL internal document).

8. Mechtly, E. A., "The International System of Units," NASA SP-7012, National Aeronautics and Space Administration, Washington, D. C., 1973.

9. Reichhardt, Jr., H., "Power Conservation Effort, Goldstone Complex," Philco Intra Company Memorandum, Mar. 7, 1972 (JPL internal document).

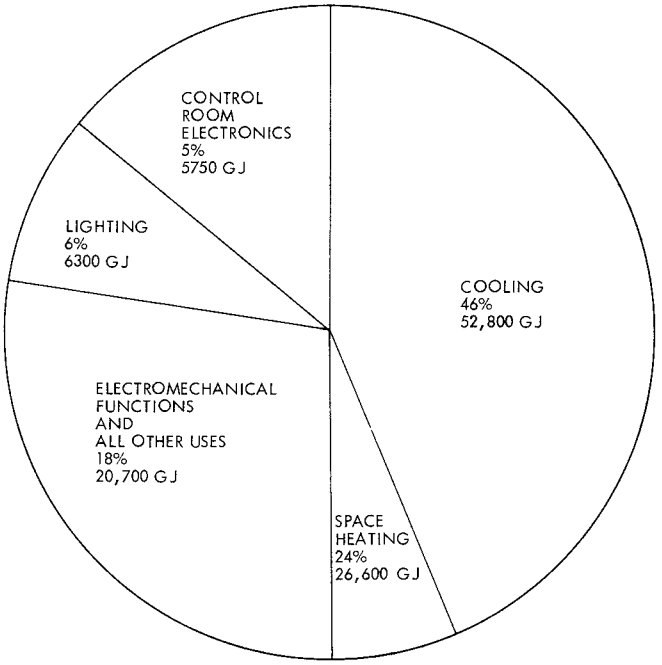

Fig. 1. Energy distribution by category for 1973

NASA — JPL — Coml., L.A., Calif.