NASA-OAST PROGRAM IN PHOTOVOLTAIC ENERGY CONVERSION

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ABSTRACT

The NASA program in photovoltaic energy conversion includes research and technology development efforts on solar cells, blankets, and arrays. The overall objectives are to increase conversion efficiency, reduce mass, reduce cost, and increase operating life. The potential growth of space power requirements in the future presents a major challenge to the current state of technology in space photovoltaic systems.

INTRODUCTION

The OAST Office of Space Energy Conversion, formerly Space Power and Electric Propulsion, supports, guides, and directs programs to provide a power technology base that enables and/or enhances current and future activities in space exploration and utilization (figure 1). Within the Office of Space Energy Conversion, the Photovoltaic Energy Conversion program has the specific objective to improve conversion efficiency, reduce mass, reduce cost, and increase the operating life of photovoltaic converters and arrays. The program seeks to do so by developing and applying an improved understanding of photovoltaic energy conversion, and evaluating a broad range of advanced concepts for reducing cost and mass of photovoltaic systems.

PHOTOVOLTAIC ENERGY CONVERSION PROGRAM

Major thrusts of the program fall into three areas: (1) device research and technology; (2) low cost blanket and array technology; and (3) high performance blanket and array technology. Activities in device R&T include fundamental studies of radiation damage and annealing; development of high specific power cells; identification and demonstration of low cost technologies in cell fabrication; research on advanced devices such as the multiple bandgap cascade solar cell and surface plasmon converter; and finally, research on several types of concentrator devices such as spectro- and thermophotovoltaic converters. Low cost blanket and array activities include fundamental studies of solar cell interconnect welding, large area silicon solar cell development and a variety of planar and concentrator array approaches. High performance B&A work is at present focussed on

demonstrating reliable, space-qualifiable lightweight blanket and array technologies using the OAST 2-mil thin silicon cell. As future high performance, ultralight cells are developed, activities in this area are expected to evolve to incorporate them.

TECHNOLOGY CHALLENGES

Figure 2 is a summary of improvements in array specific power achieved over the history of the space program. Advances in array and blanket technology are presently under investigation which have the potential to enable array specific powers in excess of 150 W/Kg in the near term. A second goal within sight is demonstration of critical technology advances needed for 300 W/Kg array technology. Further advances are quite likely in the more distant future.

The trend in array specific cost over the past 20 years is shown in figure 3. It would appear that significant advances in cost-reducing technology must occur if the order of magnitude cost reduction goal is to be reached. The decreases in specific cost observed so far have resulted primarily from increases in array size during that period of time. Based on current estimates of the SEPS array specific cost, the NASA goal appears very ambitious. However, both increases in size and the introduction of new technologies can reasonably be expected to aid the drive toward lower cost. A number of studies have verified this view and the program will continue to explore promising approaches such as the cassegrainian concentrator identified in one such study.

Figure 4 shows the cumulative and annual amounts of photovoltaic power launched by NASA since the early 1960's. With the exception of Skylab, the annual rate has been on the order of 2-4 kilowatts per year, and is not expected to change much until the advent of large space stations, when multi-tens of kilowatt arrays will be required. Following that, it is possible to imagine the routine launch into LEO and other orbits of large arrays for various NASA, commercial, and military applications. Such a scenario presents a major challenge to our current technology base.

SUMMARY

The NASA-OAST program in photovoltaic energy conversion is a well-focussed, yet broadly based program designed to provide technological advances that enhance and/or enable current and future activities in space exploration and utilization. Significant improvements have been achieved in cell performance and in blanket and array specific power and lifetime. Technologies directed at reducing cost for large arrays have been identified; technologies for achieving high performance are currently under investigation. The trend toward high power requirements presents a major challenge to the current status of technology development in space photovoltaics.

SPACE POWER AND ELECTRIC PROPULSION PROGRAM CONTENT

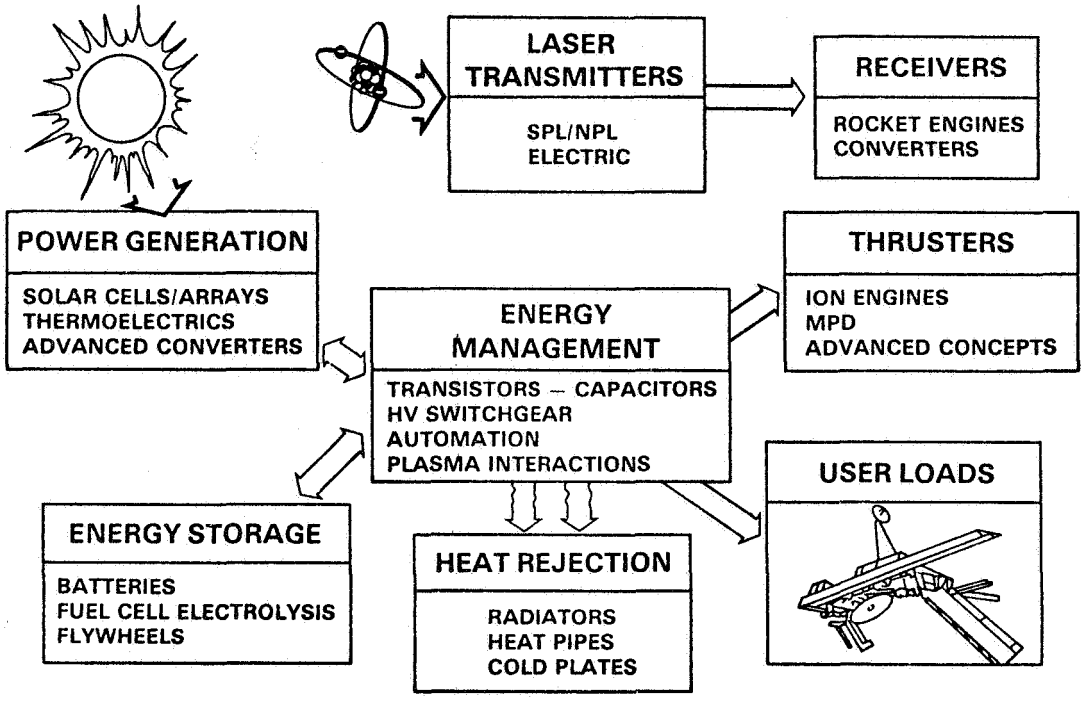

Figure 1

SPECIFIC POWER OF SOLAR ARRAYS

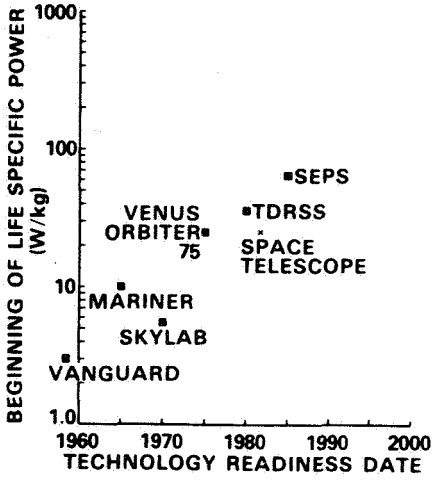

Figure 2

SPECIFIC COST OF SOLAR ARRAYS

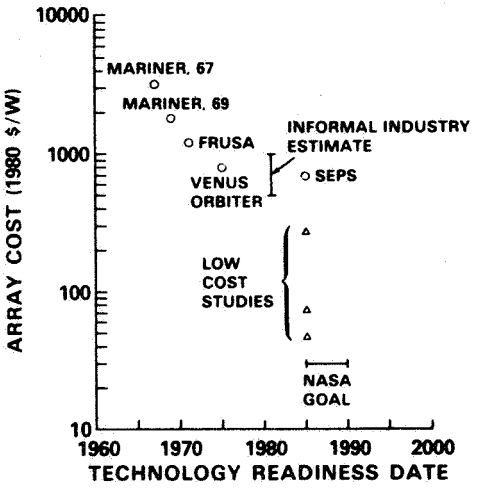

Figure 3

SOLAR POWER LAUNCHED BY NASA

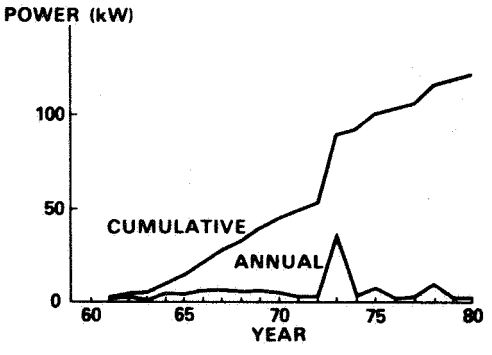

Figure 4