PHOTOVOLTAIC POWER SYSTEMS WORKSHOP

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The photovoltaic power systems workshop was divided into two groups. Their discussions concerned apparent deficiencies in NASA planning and technology development relating to a standard power module (25-35 kW) and to future photovoltaic power systems in general. Corollary conclusions and recommendations, although not stated, are believed to be obvious from the discussions.

The concerns of the workshop are listed in order of importance. It is significant that the two groups, functioning independently, reached similar positions.

A. <u>Have adequate system studies been done</u> -

1. <u>To establish guidelines for standardization</u>?

There is a need to develop design guidelines for commonality, modularity, materials, design options, etc., all of which are important to standardization and low cost. These guidelines should evolve in harmony from an identification of the technical problems associated with both near-term and far-term power systems, that is, from appropriate system studies.

2. <u>To establish a design that is flexible</u> -

a. <u>For adjusting to various user needs</u>?

Many future missions are being identified that would use large amounts of power. These missions involve diverse functions and diverse orbits, that is, diverse needs as regards a power system. A power module which hopes to "capture" many, if not most, of these missions should be sufficiently flexible in design to satisfy these diverse needs without inflicting undue penalties on any user.

b. <u>For incorporating technology advances</u>?

Many improvements in component and design technology can be postulated during the hopefully long life cycle of a standard power module. New users will want these improvements. The basic module design should be capable of accommodating improvements with a minimum of rework and new development.

c. For growing to larger size?

A power module design capable of growing in output would seem to be axiomatic with high mission capture rate over a long life cycle. As above, these higher output versions should be obtainable with a minimum of rework and new development.

3. To establish that the initial design (25-35 kW) is the right direction to evolve to the next generation (100-300 kW)?

It was indicated in the conference that the first power module should be an evolutionary precursor to the larger power systems which would follow. In order to achieve this, studies of the larger, more far-term systems should be performed.

B. Should a standard power system module be developed separately from a standard spacecraft?

If each subsystem of a complete spacecraft were developed separately as a standard module, the composite result could be chaotic. It seems possible that the necessary compatibility among subsystems, aimed of course at best meeting user needs, might best be achieved by development of a standard spacecraft.

C. Have proper approaches to cost reduction been identified?

1. What are the major cost elements?

Most of the cost attributable to a power system after it is in orbit is believed to be of nonhardware origin. Thus it may be that efforts to reduce cost could be more productive if they focused on nonhardware as well as hardware costs. Typical nonhardware costs are engineering and testing.

2. What are the relationships between component reliability, reliable design, and low cost?

Relaxation of component reliability requirements may be possible through fault-tolerant power system design. If so, how much relaxation might be possible and what is the cost reduction payoff? Certainly, "infant mortality" and generic failure requirements cannot be relaxed. Similar statements/questions could be posed regarding a maintainable design.

3. Can a large investment in development yield low recurring and life cycle costs?

A highly sophisticated design, thoroughly wrung out during development, might be able to utilize less reliable (less expensive) components and still achieve long power system life, yielding overall a low life-cycle cost.

D. Is energy storage avoidance being considered adequately?

Energy storage is the greatest technology hurdle for large power systems. High-energy-density batteries or other energy storage devices are a must if energy storage is to be included in large power systems without an exorbitant weight penalty. The history of high-energy-density battery development gives little cause for optimism about future prospects. System designs which avoid or minimize energy storage needs may be highly desirable.

E. Is attitude control being considered adequately?

Attitude control (including configuration management) is an important feasibility issue with large solar power systems. Solar array flexing is a major concern in this area.

F. Are thermal effects of heat rejection on solar array configuration stability being adequately considered?

Thermal control and heat rejection is a major design area. A good deal of emphasis in this area was evident and is considered appropriate. However, are the thermal effects on solar array configuration stability being adequately considered?

G. Is assembly of large power systems in space being considered adequately?

Large power systems (above about 50 kW in size) may have to be put in orbit by using more than a single launch and then assembled. The LSST (large space structures technology?) study purportedly is concerned with large solar array assembly in space but not with large solar power system assembly in space.

H. Is terrestrial photovoltaic work being factored into space power systems for possible payoff?

It is probable that the large amounts of money being spent to develop low-cost photovoltaic systems for terrestrial power will have some payoff for space use. It also seems probable that the differences between space and terrestrial requirements will eventually result in the terrestrial solar cells not being directly applicable to space. Thus, efforts should be undertaken to channel promising terrestrial developments into space-type solar cells.