SPS COST METHODOLOGY AND SENSITIVITIES

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INTRODUCTION

Accurate cost estimates for any advanced energy system are very difficult to develop. All such estimates require assumptions related to technological advancement over an extended period of time. Nevertheless, the evaluation of a potential system requires such estimates, and a number of cost estimates have been developed during the Solar Power Satellite (SPS) Concept Evaluation Program. The present summary paper will describe one such estimate for illustrative purposes. It should be noted that no official cost estimate exists for an SPS program at the present time.

Cost estimates for advanced systems must be considered from two perspectives. The first is the cost to achieve the initial operational unit. This cost includes research, engineering, demonstration, industrial and operational facility development, as well as the hardware and construction costs of the initial operating unit. The second is the cost to replicate the initial unit. The replication cost may vary as learning continues and productivity increases.

For the purpose of estimating costs, assumptions are required. The reference system as described in reference 1 serves as a general basis for the present estimate. Primary elements of the system are depicted in figure 1. These include the energy system consisting of the satellite and ground-receiving station or rectenna, a space construction facility located in geosynchronous orbit and a staging base located in low earth orbit; and a cargo launch vehicle and a cargo orbital transfer vehicle. Other system elements include personnel launch and transfer vehicles, launch and recovery facilities, and earth-based-production facilities. Each satellite is designed to deliver 5 gigawatts of power to an electrical utility network, and two satellites are assumed to be constructed each year for a period of 30 years resulting in a generating capacity of 300 gigawatts.

The program is assumed to consist of a number of phases. Each phase represents an increasing commitment of resources as confidence in the ultimate success of the program grows. The phases may be implemented serially although a degree of overlap may represent the most effective approach.

Reference 1. Reference System Report, Satellite Power System Concept Development and Evaluation Program, U.S. DOE and NASA, October 1978.

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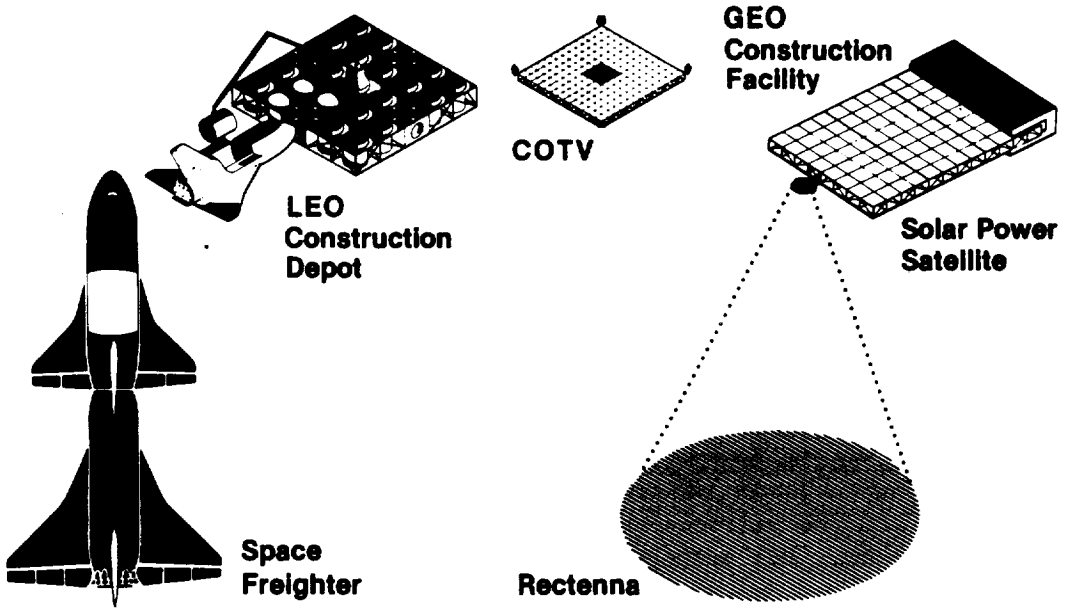
Figure 1

NASA Solar Power Satellite — Major Program Elements



Program Cost Estimates

The program phases with an estimated cost for each phase are presented in Table 1.

Table 1. Solar Power Satellite Program Cost Scenario in Billions of 1977 $

Phase	Cost
Research	.4
Engineering	8.1
Demonstration	23.0
Investment	57.5
First Unit	13.5
Total	102.5
Average Unit	11.5

It should be noted that the cost of the necessary environmental research program and social and economic studies are not included in Table 1. These costs would not affect the total cost nor the average unit cost to any great extent. They could, however, add significantly to the research phase of the program.

The total cost of the program through the first full-scale unit is estimated to be slightly over 100 billion dollars. The subsequent fifty-nine units are estimated to cost an average of 11.5 billion dollars per unit. A general description of each of the phases is given below.

Program Phase Descriptions

The research phase is designed to resolve critical technical issues which have been defined during the concept evaluation program. Approximately one-half of the estimated effort would be expended in ground laboratories and would emphasize such issues as the development of techniques for mass producing solar cells at acceptable costs. The remaining half of the effort would be devoted to specific space experiments which cannot be conducted in the laboratory. High voltage-plasma interaction typify the phenomena which cannot be adequately simulated in the laboratory.

The engineering phase would consist of a number of space projects which would allow the development of space construction techniques and the testing in space of engineering models or prototypes of various subsystems. Major cost elements include a multi-man space operation center in low earth orbit, a manned orbital transfer vehicle, a one megawatt solar array and transmitter, a liquid flyback booster for the Shuttle transportation system, and a number of subsystems such as the electric propulsion units.

The demonstration phase of the program is most difficult to define, and will have to evolve over a period of time. For the purpose of the present estimate, a system capable of delivering 100-200 megawatts of power from geosynchronous orbit to earth is assumed. This phase includes construction and support facilities at geosynchronous and low earth orbit and significant transportation system development and operations.

The investment phase involves the development of the capability to construct full-scale commercial energy systems. It includes the development and purchase of a transportation fleet, a full-scale space construction facility, launch and recovery facilities to handle daily launches, and industrial production facilities to mass produce solar cells, power amplifiers, and other high volume components.

The cost of the first production unit includes the satellite hardware costs (33%), the cost of transporting the hardware to the space construction facility (33%), the cost of space construction (11%), and the cost of hardware and construction of the ground rectenna (22%).

The average unit cost is seen to decrease somewhat after construction of the first unit. This reduction is related to an estimated reduction in space construction costs, as a function of learning, and a reduction in transportation costs.

Concluding Remarks

A total SPS program has been defined and costs for such a program estimated. The scope and complexity of the program, coupled with the necessity of projecting technology over a long period of time obviously limit the accuracy of such an estimate. Despite these difficulties, the cost estimates are useful as a reference for comparison with alternate approaches and as a guide for assessing the relative cost importance of the various program elements and components.

The cost estimates presented in table 1 were obtained from studies conducted by the Boeing Aerospace Company as part of the SPS Systems Definition effort.