# SPS AND ALTERNATIVE TECHNOLOGIES COST AND PERFORMANCE EVALUATIONS

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An important consideration in the analysis of the Satellite Power System (SPS) concept for electrical energy production early in the twenty-first century is its expected generation cost in comparison with that for alternative technologies. This study uses, as a standard metric, the constant dollar levelized annual revenue requirement for production of a unit kilowatt-hour of electrical energy from each system as the basis for comparison. Levelized annual revenue requirement, expressed in mills/kWh, is essentially a discount factor weighted average unit cost of energy production which includes all components of capital recovery, fuel, and nonfuel operating cost projected over the facility's economic lifetime. A typical utility's weighted average cost of capital, exclusive of general inflation, was selected as the appropriate discount rate.

Analysis of future costs is complicated by the existence of large uncertainties about capital and fuel prices twenty to fifty years in the future. This uncertainty originates from three major concerns: 1) uncertain performance capabilities and capital costs for improved current, near-term, and advanced technologies, 2) uncertain future economic trends and their effect on energy demand, and 3) uncertain future regulations that may constrain certain fuel production or use. Each of these factors is accounted for in the analysis.

Table 1 displays the low, nominal and high capital costs projected for each technology for the year 2000. As shown, these costs derive from the direct and indirect capital cost estimates made as part of the technology characterization task by adding costs for contingencies, owner's expenses, and interest during construction. These additions result in a nominal 1978 costs. Projection of these costs to the year 2000 consider ranges of uncertainty in future environmental regulations, safety requirements and technological advances. Low year 2000 costs for coal and nuclear systems assume optimistic projections of future environmental and safety requirements, respectively. Low costs for the central station photovoltaic and SPS technologies assume a reduction in solar cell costs from the nominal \$37.80/m$^2$ (1978) to \$21.60/m$^2$ (1978). High year 2000 costs are driven primarily by uncertainties in achieving the currently estimated nominal costs as a result of technical and regulatory uncertainties.

Figures 1 and 2 show the ranges of installed generating capacity and fuel prices that result from uncertainties in future economic trends and energy demand. Values shown are derived from the results of the alternative futures scenarios task. Examination of Figure 1 indicates that only the high capacity growth scenario (scenario UH) is capable of accepting a full implementation of sixty SPS units by 2030 if the SPS is limited to no more than twenty-five percent of installed capacity for utility operational purposes. In the lower capacity growth scenarios, UI and CI/CI(d), the SPS implementation rate would need to be reduced to one-half or one-third the nominal rate, respectively, in order to satisfy the twenty-five percent criteria in 2030. Although reduction of the SPS implementation rate would also reduce the up-front investment costs necessary to support it, only about half of the investment costs would vary proportionately; the other half would remain unchanged. Thus, as the SPS implementation rate is reduced, up-front investment adds significantly to the average unit cost. As indicated in Table 1, reduced implementation could add as much as fifteen percent to the average unit cost, significantly offsetting potential major cost reductions, i.e., the sixty unit nominal year 2000 cost is comparable to the twenty unit low year 2000 cost for the SPS technology.

Figure 3 shows the ranges of levelized annual generation costs for SPS and the alternative technologies considered. The shaded area of each bar in Figure 3 represents the spread in nominal costs as a result of the spread of fuel price scenarios considered, except in the case of the terrestrial central station photovoltaic (TPV) where the range is defined by geographic location (Phoenix and Cleveland) and in the case of decentralized photovoltaics, where the indicated range is both location and design dependent. The low bound of each bar in Figure 3 represents the generation cost under the most favorable fuel price, location and/or design coupled with the low year 2000 capital cost. Conversely, the high bound represents the least favorable fuel price, location and/or design coupled with the high year 2000 capital cost.

Examination of Figure 3 leads to the following conclusions:

1. The SPS will have little chance of competing favorably, on a levelized cost basis, with improved conventional technologies over a wide range of fuel prices.
2. The SPS has a better chance of competing with near-term technologies, i.e. coal gasification/combined cost, high near-term technology cost assumptions.
3. The SPS may compete favorably with advanced technologies such as fusion, central station and decentralized photovoltaic. However, large uncertainties exist about the future costs of these systems.

Figure 4 shows the sensitivity of generation cost to variations in capacity factor for each of the central station technologies. The SPS, fusion and terrestrial photovoltaic systems are more sensitive to variations in capacity factor as a result of their higher capital intensity and essentially no variable fuel costs.

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Table 1

| | Conventional Coal | Light Water Reactor | Coal Gasification Combined Cycle | Liquid Metal Fast Breeder | Central Station Photovoltaic | Fusion | SPS Reference System—Silicone 60 Units | SPS Reference System—Silicone 30 Units | SPS Reference System—Silicone 20 Units | SPS Reference System—GaAl As 60 Units | SPS Reference System—GaAl As 30 Units | SPS Reference System—GaAl As 20 Units |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Unit Capacity (MWe) | 1,250 | 1,250 | 2 @ 625 | 1,250 | 200 | 2 @ 660 | 5,000 | 5,000 | 5,000 | 5,000 | 5,000 | 5,000 |
| 1978 Nominal Cost ($10^6$ $) | | | | | | | | | | | | |
| Direct | 452.1 | 486.0 | 537.4 | 702.9 | 117.5 | 1,533.2 | 11,073 | 11,073 | 11,073 | 10,035 | 10,035 | 10,035 |
| Indirect | 90.7 | 197.1 | 132.7 | 262.6 | 20.0 | 628.7 | 464 | 464 | 464 | 464 | 464 | 464 |
| Investment | - | - | - | - | - | - | 1,793 | 2,730 | 3,678 | 1,793 | 2,730 | 3,678 |
| Subtotal | 542.8 | 683.1 | 670.1 | 965.5 | 137.5 | 2,161.8 | 13,330 | 14,267 | 15,215 | 12,292 | 13,229 | 14,177 |
| Contingency | 38.0 | 54.7 | 60.3 | 106.2 | 17.9 | 389.2 | 2,133 | 2,283 | 2,434 | 1,967 | 2,117 | 2,268 |
| Owner's Costs | 53.5 | 68.6 | 66.5 | 93.2 | 15.3 | 229.6 | 463 | 497 | 529 | 428 | 460 | 494 |
| Interest During Const. | 51.9 | 83.9 | 65.1 | 131.8 | 8.7 | 358.9 | 772 | 826 | 831 | 711 | 766 | 820 |
| Subtotal | 143.4 | 207.2 | 191.9 | 331.2 | 41.9 | 977.7 | 3,368 | 3,606 | 3,844 | 3,106 | 3,343 | 3,582 |
| TOTAL 1978 Costs | 686.2 | 890.3 | 862.0 | 1,296.7 | 179.4 | 3,139.7 | 16,698 | 17,873 | 19,059 | 15,398 | 16,572 | 17,759 |
| 1978 Nominal Cost ($/KW) | 549 | 712 | 690 | 1,037 | 844 | 2,378 | 3,340 | 3,575 | 3,812 | 3,079 | 3,314 | 3,552 |
| Non-fuel O&M Costs (mills/kwh) | 3.1 | 2.3 | 2.7 | 3.0 | 3.4/4.6(b) | 7.3 | 5.6 | 5.6 | 5.6 | 5.6 | 5.6 | 5.6 |
| 2000 Costs (1978 $/KW) | | | | | | | | | | | | |
| Low | 647 | 886 | 813 | 1,291 | 731 | 2,378 | 3,139 | 3,374 | 3,611 | 2,874 | 3,109 | 3,346 |
| Nominal | 762 | 1,100 | 957 | 1,603 | 1,057 | 3,677 | 3,646 | 3,903 | 4,162 | 3,362 | 3,618 | 3,878 |
| High | 1,605 | 2,566 | 2,623 | 5,048 | 4,229 | (a) | 16,698 | 17,873 | 19,059 | 15,398 | 16,572 | 17,759 |
| 2000 Low/1978 Nominal | 1.18 | 1.24 | 1.18 | 1.24 | 0.87 | 1.00 | 0.94 | 0.94 | 0.94 | 0.94 | 0.94 | 0.94 |
| 2000 Nominal/1978 Nominal | 1.39 | 1.55 | 1.39 | 1.55 | 1.25 | 1.55 | 1.09 | 1.09 | 1.09 | 1.09 | 1.09 | 1.09 |
| 2000 Nominal/2000 Low | 1.18 | 1.24 | 1.18 | 1.24 | 1.45 | 1.55 | 1.16 | 1.16 | 1.16 | 1.16 | 1.16 | 1.16 |
| 2000 High/2000 Nominal | 2.11 | 2.33 | 2.74 | 3.15 | 4.00 | (a) | 4.58 | 4.58 | 4.58 | 4.58 | 4.58 | 4.58 |

(a) Physical Confinement not Proven

(b) Values for Phoenix/Cleveland

Figure 1

GROWTH OF ELECTRICAL ENERGY DEMAND WILL INFLUENCE RATE OF SPS IMPLEMENTATION

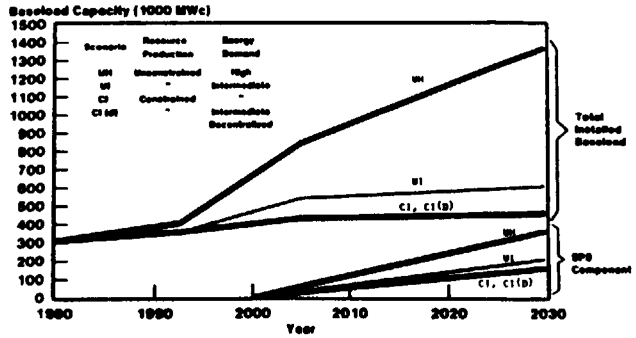


Figure 2

FUEL PRICE SCENARIOS SPAN A WIDE RANGE OF PROJECTIONS

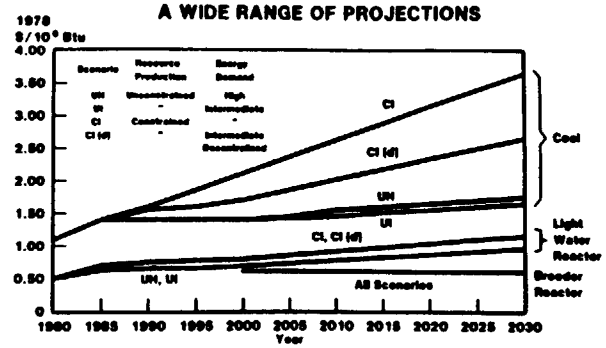


Figure 3

FUTURE CAPITAL AND FUEL PRICE UNCERTAINTIES RESULT IN A WIDE RANGE OF POSSIBLE GENERATION COSTS

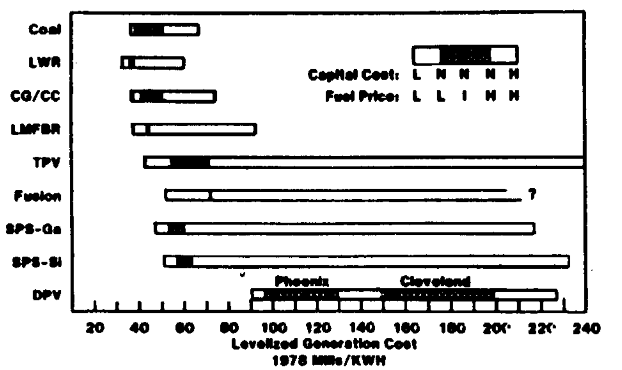


Figure 4

SPS, TPV AND FUSION GENERATION COSTS ARE MORE SENSITIVE TO CAPACITY FACTOR