COMPARATIVE HEALTH AND SAFETY ASSESSMENT OF THE SPS AND ALTERNATIVE ELECTRICAL GENERATION SYSTEMS

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A comparative analysis of health and safety risks is presented for the satellite power system (SPS) and five alternative baseload electrical generation systems: a low-Btu coal gasification system with an open-cycle gas turbine combined with a steam topping cycle (CG/CC); a light water fission reactor system without fuel reprocessing (LWR); a liquid metal fast breeder fission reactor system (LMFBR); a central station terrestrial photovoltaic system (CTPV); and a first generation fusion system with magnetic confinement. For comparison, risk from a decentralized "roof-top" photovoltaic system with battery storage (DTPV) is also evaluated. Quantified estimates of public and occupational risks within ranges of uncertainty were developed for each phase of the energy system on the basis of 1000 MWe average system output. A load factor of 70% was assumed for each system except the CTPV and DTPV for which 25% and 12% load factors, respectively, were used. Back-up energy systems were not included in the evaluation. More detailed system descriptions are provided in a companion paper.[1] Components of the analytical procedure are illustrated in Fig. 1. Also discussed in the paper is the potential significance of related major health and safety issues that remain unquantified.

For a comparative assessment that includes the more capital-intensive advanced technologies it is essential that risks from on-site construction and risks from both direct and indirect facility component production be evaluated. The latter indirect component production requirements (e.g., copper mining to produce electrical equipment) were obtained from 1972 input-output tables of the U.S. economy. As illustrated in Fig. 2, these indirect production risks comprise a significant fraction of the relatively large construction phase impact of the solar technologies. Although not shown, similar relative technology differences are obtained for non-fatal person-days-lost from occupational accident and disease.

The construction phase impacts, when averaged over an assumed 30-yr plant lifetime, bring the solar technology life cycle impacts to within the range of uncertainty of the quantified risks for the LWR, LMFBR, and fusion nuclear technologies (Fig. 3). The relatively large CG/CC risks per 1000 MWe-yr illustrated in Fig. 3 result primarily from public exposure to long-range transport of air pollutants (4-74 premature deaths; adapted from ref. 2), coal transport accidents, and coal mine disease and accidents. The relatively high risks of the DTPV system are related to the lower load factor and resultant higher material requirements, production risks for the storage batteries, and greater construction and maintenance requirements for the small, dispersed units.

In general, the more defined technologies (e.g., CG/CC, LWR) have a greater number of quantifiable risks and fewer unquantifiable risks. The opposite is true for the less-defined technologies (e.g., fusion, SPS). In contrast to the apparent public willingness to accept limited known risks of energy systems, recent experience with light water fission systems indicates that perceived major risks that are less quantifiable or predictable may restrict or completely halt energy system deployment if adequate assurances of very low impact probability cannot be given. For this reason potentially major, but unquantified, risks should be given prominence comparable to the quantified risks discussed above. Table 1 is a listing of potentially major unquantified issues identified for the seven technologies considered. Catastrophic events (i.e., events of low occurrence probability, but high impact per event) are included in the unquantified category because of the inherent difficulty in predicting occurrence rate and impact level. Furthermore, averaging expected catastrophic impacts over plant lifetime does not indicate the full significance of these potential events. Table 1 does not attempt to rank the unquantified issues, although, for example, potential radiation release from fission is expected to be greater than that from fusion.

A further perspective on the significance of relative technology risks is provided by Fig. 4, which indicates the range of annual occupational risks for 2000-2020 scenarios of energy production with and without the SPS system. A nearly constant total electrical energy capacity is assumed in this period for the scenarios (Table 2). Because of high construction and manufacture and low operation and maintenance impacts, the SPS scenario has higher initial, but lower final occupational health and safety risks, as compared to the scenario without SPS. The quantified public risks, in particular those from coal, would favor the SPS scenario with reduced conventional generation. However, the unquantified risks to the public in Table 1 restrict the delineation of definitive conclusions related to total scenario risks.

References

1. Samsa, M., *Cost and Performance Review,* SPS Program Review, Lincoln, NB, April 22-25, 1980.

2. *An Assessment of National Consequences of Increased Coal Utilization,* TID-29425, Feb. 1979.

Table 1. Potentially Major Unquantified Issues Identified

Solar Technologies (CTPV, DTPV, SPS)

1. Exposure to Cell Production Emissions
2. Hazardous Waste From Disposal or Recycle of Cell Materials
3. Chronic Low-level Microwave Exposure to Large Populations (SPS only)
4. Space Vehicle Crash into Urban Area (SPS only)
5. Exposure to HLLV Emissions (SPS only)

Coal Technologies (CG/CC)

(None Identified)

Nuclear Technologies (LWR, LMFBR, Fusion)

1. System Failure with Major Public Radiation Exposure
2. Fuel Cycle Occupational Exposure to Chemically Toxic Materials
3. Diversion of Fuel or By-product for Military or Subversive Uses (LWR, LMFBR only)
4. Liquid Metal Fire (LMFBR, Fusion only)

Table 2. Energy Scenario Baseload Capacities (GWe)

Year	LWR	CG/CC	LMFBR	SPS	Fusion	Total
2000	263	238	34	0	0	535
2020 (SPS)	188	71	78	200	11	549
2020 (W/O SPS)	213	159	140	0	37	549

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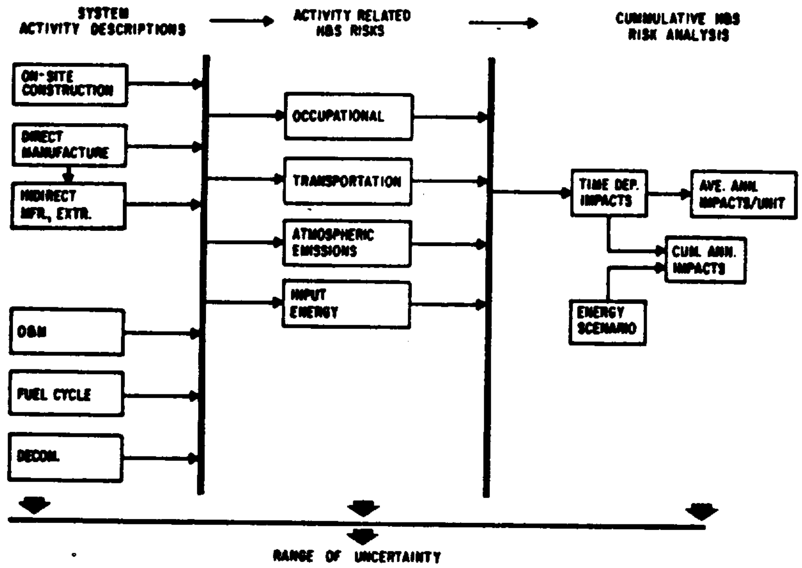

Fig. 1. Components for Comprehensive Energy Technology Health and Safety Risk Assessment.

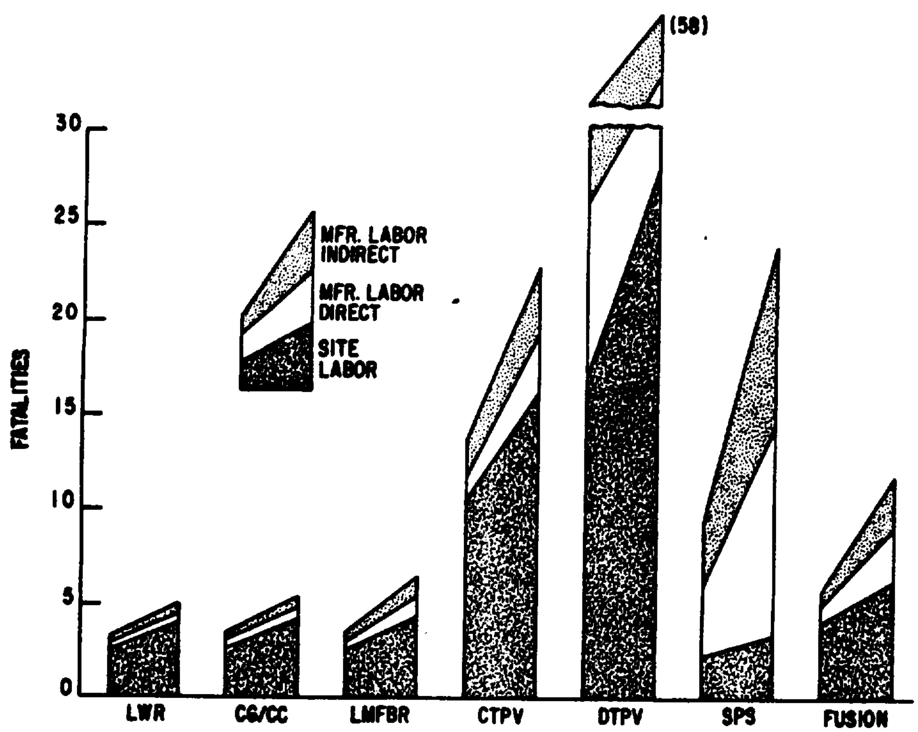

Fig. 2. Estimated Occupational Fatalities From Facility Construction and Manufacture for 1000 MWe Generation Capacity (Diagonal lines Represent Ranges of Estimates.)

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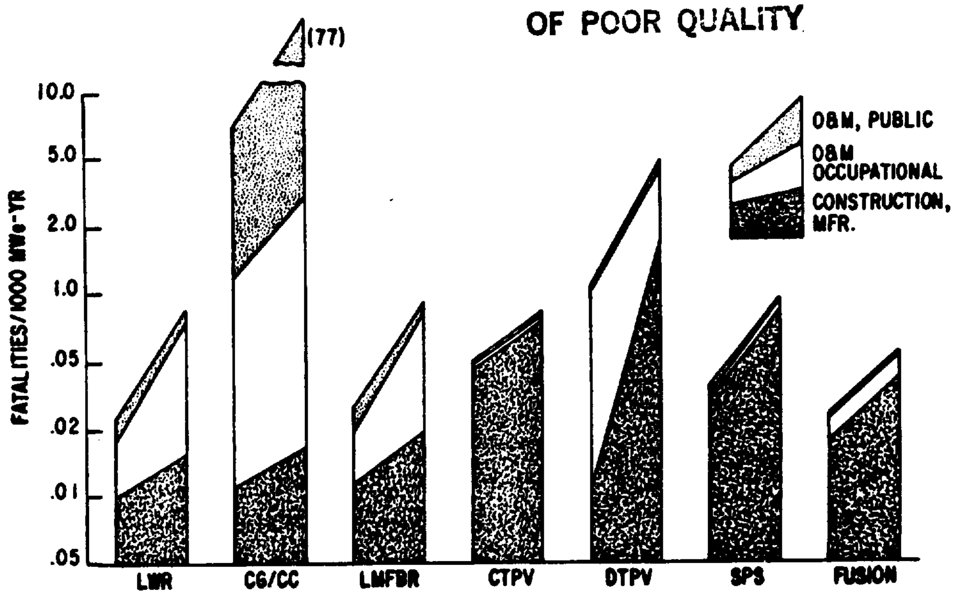

Fig. 3. Quantified Fatalities From Facility Manufacture, Construction, and O&M per 1000 MWe-yr (Diagonal lines represent ranges of estimates.)

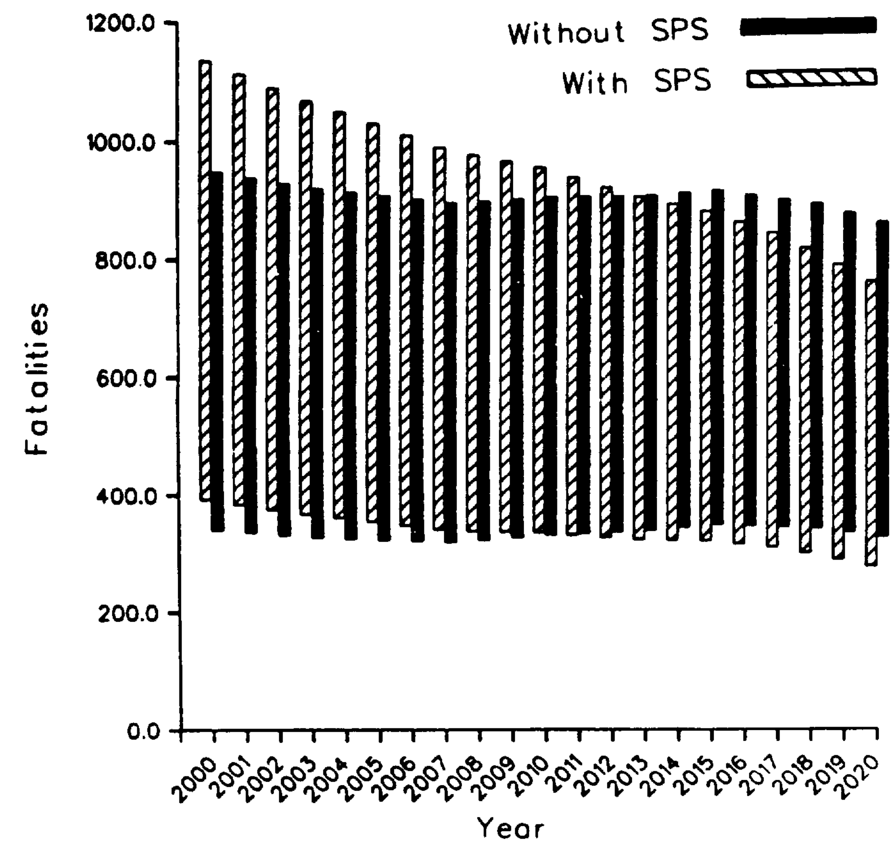

Fig. 4. Ranges of Quantified Cumulative Occupation Risks Related to a Scenario with Approximately Constant Electrical Generation With and Without SPS Implementation.