8.0 ECONOMIC ASSESSMENT

8.1 INTRODUCTION

After completing the conceptual designs for the Osiris and SOMBRERO power plants, cost estimates were made for the point designs, and cost scaling relationships were developed and incorporated into systems economic codes for the two power plants. These codes were then used to do parametric studies of the two designs to determine the cost of electricity (COE) as a function of design and operating parameters. The figure of merit used in our economic assessment is the constant dollar COE, which is dominated by the capital cost of the plant. The cost comparisons are most useful for identifying the most attractive operating space.

8.2 RESULTS FOR REFERENCE DESIGNS

Table 8.1 gives the capital costs, unit capital cost, and COE for the reference designs. The direct capital cost and COE of the SOMBRERO plant are nearly 20% higher than Osiris. The difference is largely attributable to the larger fusion power and gross electric power required by SOMBRERO to generate the same 1000 MWe output. In addition, the cost of the SOMBRERO reactor building is significantly larger than the Osiris reactor building due to locating the final optics 50 m from the target. The difference in the cost of reactor buildings is ~$110 M, which is about 40% of the total difference in the direct capital costs of the two plants.

8.3 RESULTS OF PARAMETRIC STUDIES FOR OSIRIS AND SOMBRERO

Parametric studies were carried out to determine the COE for different

- operating points (driver energy, chamber rep-rate, etc.),
- assumptions on target performance, and
- net electric power levels.

The COE as a function of driver energy is shown in Fig. 8.1 for both Osiris and SOMBRERO. For Osiris, the minimum COE occurs at a driver energy of 2.5 MJ. The rep-rate at E = 2.5 MJ is 16 Hz, which is probably too high for operation of the Osiris chamber. Increasing the driver energy to 3.5 MJ reduces the rep-rate to a manageable 8.6 Hz. The COE at this point is 5.37 ¢/kWh, only 2% higher than the minimum COE. The COE of the reference point design at E = 5 MJ is 5.61 ¢/kWh, less than 5% higher than the minimum COE and 3% higher than the 3.5 MJ case.

Table 8.1. Capital Costs, Unit Costs, and Cost of Electricity for Reference Designs (1991 $)

		Osiris	SOMBRERO
Direct Capital Costs			
20	Land and Land Rights	11.6	10.5
21	Structures and Site Facilities	137.6	276.1
22	Reactor Plant Equip.	504.3	615.5
23	Electric Plant Equip.	225.8	256.3
24	Turbine Plant Equip.	66.2	70.0
25	Miscellaneous Plant Equip.	18.5	19.9
26	Heat Rejection Systems	44.7	52.0
27	Driver Equipment	587.5	579.1
	Total Direct Cost	**1596**	**1879**
Indirect Capital Costs (M$)			
91	Construction Services and Equipment	192	225
92	Home Office Engineering and Services	83	98
93	Field Office Engineering and Services	96	113
94	Owners Cost	295	347
96	Project Contingency	391	461
	Total	**1057**	**1244**
Time Related Costs (M$)			
97	Interest During Construction	438	516
98	Escalation During Construction	0	0
	Total	**438**	**516**
Total Capital Cost (M$)		**3091**	**3639**
Unit Capital Cost ($/kWe-gross)		**2743**	**2678**
Unit Capital Cost ($/kWe-net)		**3091**	**3639**
Constant Dollar Cost of Electricity (¢/kWh)			
	Return on Capital	4.54	5.35
	Operation and Maintenance	1.00	1.25
	Fuel	0.02	0.02
	Decommissioning	0.05	0.05
	Total	**5.61**	**6.67**

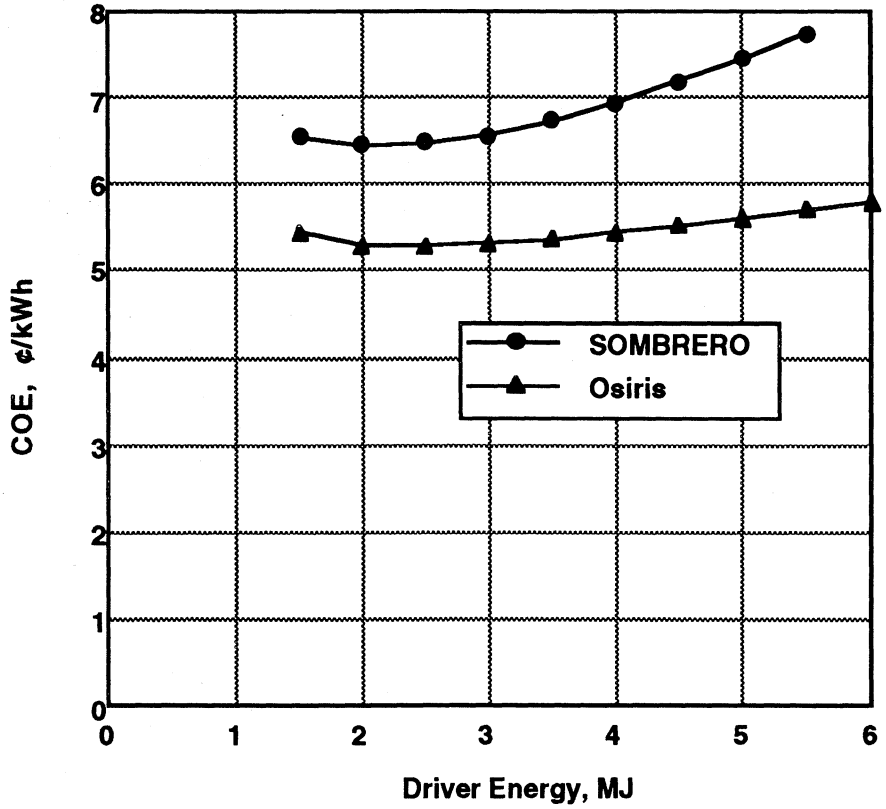

Fig. 8.1. COE vs. driver energy for 1000 MWe power plants.

For SOMBRERO, the minimum COE is 6.45 ¢/kWh, which occurs at a driver energy of 2.0 MJ. The rep-rate at E = 2 MJ is 15 Hz. We believe that the SOMBRERO chamber conditions could be reestablished at this frequency, although operating at this rep-rate puts additional stress on the target injection and tracking system. The COE of the reference point design at E = 3.4 MJ is 6.67 ¢/kWh, about 3% higher than the minimum COE.

The results of the parametric studies are summarized in Table 8.2. With optimistic target gain assumptions, the minimum COE is about 4-9% lower (Osiris result given first), and with conservative target gain assumptions, the COE is about 5-15% higher than the higher rep-rate design using base case assumptions. Increasing the net power to 1500 MWe reduces the COE by 17-15%, and reducing the net electric power to 500 MWe increases the COE by 43-38%.

Table 8.2. Summary of Results of Parametric Studies Constant Dollar COE (¢/kWh)

	Osiris	SOMBRERO
Reference Design	5.61	6.67
Higher Rep-rate Designs	5.37	6.45
Conservative Gain Curve	5.64	7.44
Optimistic Gain Curve	5.15	5.89
Lower Net Power (500 MWe)	7.69	8.88
Higher Net Power (1500 MWe)	4.48	5.49

8.4 CONCLUSIONS

In the context of the level of accuracy of our cost estimates, the 20% difference in the COE is not important enough to eliminate the KrF-driven design from further development. In fact, we note that the COEs for these designs are both quite competitive with cost estimates made for ARIES-I and ARIES-II magnetic fusion energy designs, which reported constant (1988$) dollar COEs of 8.11 ¢/kWh and 6.69 ¢/kWh, respectively.[18] While we have not done a careful comparison of the IFE designs with the MFE designs, it is interesting to note that the cost of the drivers (at ~$600 M) is on the same order as the $500 M sum of costs for the magnets ($339 M), current heating ($108 M), and energy storage ($51 M) for ARIES-I (ARIES costs in 1988$). The COEs for Osiris and SOMBRERO are higher than the projected COEs for the 1200 MWe Improved PWR (4.3 ¢/kWh) and 1200 MWe Advanced PWR (4.5 ¢/kWh), but they are competitive with the projected COE from future coal plants (5.8 ¢/kWh) and "best experience" present day PWRs (5.4 ¢/kWh).[19]