1.0 INTRODUCTION

1.1 BACKGROUND

In the fall of 1990, the Department of Energy's Office of Fusion Energy funded two industrial/university teams of fusion scientists and engineers to conduct parallel studies on a project entitled "Inertial Fusion Energy (IFE) Reactor Design Studies." The studies concluded in March 1992, and the results of the W. J. Schafer Associates (WJSA) team, which consisted of Bechtel, General Atomics (GA), Textron Defense Systems (formerly Avco Research Lab), and the University of Wisconsin, are reported here.

1.2 OBJECTIVES AND SCOPE OF THE STUDIES

The primary objective of the of the IFE Reactor Design Studies was to provide the Office of Fusion Energy with an evaluation of the potential of inertial fusion for electric power production. The term *reactor* studies is somewhat of a misnomer since these studies included the conceptual design and analysis of all aspects of the IFE power plants: the chambers, heat transport and power conversion systems, other balance of plant facilities, target systems (including the target production, injection, and tracking systems), and the two drivers.

The scope of the IFE Reactor Design Studies was quite ambitious. The majority of our effort was spent on the conceptual design of two IFE electric power plants, one using an induction linac heavy ion beam (HIB) driver and the other using a Krypton Fluoride (KrF) laser driver. After the two point designs were developed, they were assessed in terms of their 1) environmental and safety aspects; 2) reliability, availability, and maintainability; 3) technical issues and technology development requirements; and 4) economics. Finally, we compared the design features and the results of the assessments for the two designs.

1.3 DESIGN PHILOSOPHY

Early in the project, our team developed several new ideas for chamber concepts to a preliminary level. The downselection to the two designs described in this report was based on a set of weighted selection criteria established by our team. After screening out obviously unfeasible or uneconomical concepts, the following criteria and weightings were used:

Technical Issues	50%
Environmental and Safety	30%
Economics	20%

The two designs that we selected are the HIB-driven Osiris reactor, and the KrF laser-driven SOMBRERO reactor. (SOMBRERO is an acronym for **SO**lid **M**oving **BRE**eder **R**eactor.)

Technical Issues. Our judgments on technical issues were based on our assessment of credibility that the physics, engineering, technologies, materials, and processes needed for the concepts to function as conceived would be available by the time the systems are commercialized, 40 years or so from now. Clearly, the current state of the art for some of the key subsystems is far from what is required for a commercial power plant. We have, however, identified technology development programs or design alternatives to address the critical issues associated with each design. Many of the issues can be addressed with analyses or non-nuclear experiments of modest duration and cost.

Environmental and Safety. As the reader will discover, both of these designs have very attractive environmental and safety features (see Chapter 5). This is the result of using only low activation materials for the first walls, vacuum chambers, and breeding blankets, and minimizing the tritium inventory and controlling its leakage.

Economics. The economic characteristics, although not given a high priority in the selection process, have turned out to be attractive in comparison to previous IFE and MFE designs (see Chapter 8). This is largely due to two factors: 1) the high safety ratings of the designs allowed us to cost the power conversion and plant facilities on a non-nuclear basis and 2) innovation in the design of the drivers led to a higher efficiency (and thus lower operating cost) for the KrF driver and lower capital cost for the HI driver than previous design concepts.

For the most part, we feel that we have met the goals we set for ourselves at the start of the study and have developed IFE power plant design concepts that are technically credible and have attractive safety and economic features.

1.4 STUDY GUIDELINES

The DOE provided a set of study guidelines at the start of the project.[1.1*] These guidelines are reproduced in Appendix A for completeness. Some of the key ground rules are listed here.

Net Electric Power. The base case designs were to have a net electric power of 1000 MWe, typical of large central station electric power plants built today. In the economic evaluation, we examined the impact on cost of electricity of 500 MWe and 1500 MWe plants (i.e., ± 50% from the base case).

Target Gain. Target performance was given in terms of target gain as a function of incident driver energy for direct and indirect drive targets. Based on the information supplied, we selected direct drive targets for the laser system and indirect drive for the HIB-driven plant.

* References are given at the end of each chapter.

We did not attempt to evaluate the credibility of the information that was supplied by the Target Working Group of the Study Oversight Committee, which was made up of distinguished members of the fusion community. We accepted this as input information to the study. We are aware of the honest difference of scientific opinion on the credibility of some of the gain curves and assumptions associated with driver irradiation geometry, beam uniformity, etc. It was not within the scope of our work to judge or debate this information.

Economic Assumptions. The economic assumptions listed in the study guidelines were modified to correct some inconsistencies and errors. The economic assumptions given in Chapter 8 were agreed to by the Oversight Committee.

1.5 ORGANIZATION OF THE REPORT

This report contains two volumes: Volume 1 – Executive Summary and Overview, and Volume 2 – Designs, Assessments, and Comparisons.

VOLUME 1 - EXECUTIVE SUMMARY AND OVERVIEW

Volume 1 contains a brief executive summary and an overview of the two designs. The main sections of the overview correspond to the chapters of Volume 2, which are described below.

VOLUME 2 - DESIGNS, ASSESSMENTS, AND COMPARISONS

Volume 2 is organized along the same lines as the study was itself.

Description of the Designs. Chapters 2 to 4 contain the detailed descriptions of the designs. Chapter 2 is devoted to the Osiris HIB-driven power plant. It begins with an overview of the design (Section 2.1) and then proceeds with more detailed descriptions of the chamber (2.2), power conversion and plant facilities (2.3), and concludes with a description of the HIB driver (2.4). Chapter 3 provides a description of the SOMBRERO laser-driven power plant. The organization of Chapter 3 parallels Chapter 2, beginning with an overview (3.1), description of the chamber (3.2), power conversion and plant facilities (3.3), and concludes with the KrF laser design (3.4). Chapter 4 describes the target systems for both plants. This chapter describes target production (4.1); target injection, tracking, and beam pointing (4.2); and target heating during injection (4.3).

Assessments of the Designs. Chapters 5 to 8 are assessments of the designs. Chapter 5 covers the environmental and safety assessment for SOMBRERO and Osiris and provides a detailed comparison of the results. Chapter 6 contains the reliability, availability, and maintainability (RAM) assessments. Chapter 7 identifies technical issues and makes an assessment of technology development needs and priorities. Chapter 8 contains our economic assessment of the two designs and a detailed comparison of the results.

Comparison of the Designs. Chapter 9 compares the operating characteristics of the two designs and the results of the assessment studies.

Conclusions and Recommendations. Chapter 10 contains a summary of our conclusions and recommendations.

Appendices. The appendices contain supporting information relative to the design studies including the study guidelines (Appendix A), information on the procedure used to select the two reactor concepts (Appendix B), more detailed descriptions of two reactor concepts that were considered in the preliminary phases of the study but were not selected for the detailed conceptual design and assessment phases (Appendices C and D), additional detail on remote maintenance (Appendix E), and the results of a survey of study participants comparing various aspects of the two designs (Appendix F).

1.6 REFERENCE FOR CHAPTER 1

1.1 R.C. Davidson, C.C. Baker, R.O. Bangerter, E.C. Brolin, D.R. Cohn, D.L. Cook, D.J. Dudziak, D.B. Harris, R.A. Krakowski, T.E. Shannon, W.E. Stacey, C.P. Verdon, "Inertial Confinement Fusion Reactor Design Studies Recommended Guidelines," (Sept. 1990).