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Chairman

July 30, 1986

Honorable John S. Herrington
Secretary
U. S. Department of Energy
Washington, D.C. 20585

Dear Mr. Herrington:

Gas-Cooled Reactor Associates (GCRA) has been underway with a Project Definition Study in order to establish the scope of a one-module demonstration plant for the Modular HTGR. This Study has been in concert with the DOE funded HTGR Program that has been advancing the design, licensing and technology development for a reference four module plant.

The demonstration plant is proposed to be located at the Idaho National Engineering Laboratory and would be licensed by the NRC. It could be operational by the mid 1990's to support the deployment of commercial plants by the turn of the century. In addition to the conventional performance demonstration, the plant would be used to conduct a series of response to accident tests to demonstrate the system's passive safety and investment protection features and to support, as required, NRC's issuance of a design certification for a standard Modular HTGR system. Successful demonstration plant results will be crucial in establishing utility/investor/public confidence neccessary for the deployment of subsequent commercial plants.

In parallel with this Study, an effort primarily within GCRA has been underway to develop a Project Strategy Plan that addresses the proposed cost/risk sharing arrangements and the associated organization development to conduct such a Project. Particular attention has been directed to the development of a support arrangement from the utility industry. Key to the utility support arrangement is the formation of a utility consortium, including a partnership that will obtain the license, own and operate such a demonstration plant. Further, the utility project consortium will seek additional utility/user financial support through GCRA and EPRI in order to provide a major share of the financial support for such a Project.

The primary purpose of this letter is to indicate that efforts are ongoing within GCRA to establish such a utility consortium and to submit the attached draft Project Strategy Plan as the proposed implementation strategy for the Modular HTGR. In brief, the proposed strategy seeks to establish an affordable cost sharing and risk management arrangement between the utilities, the vendor participants and the federal government. Further, the strategy is based on a phased program whereby all parties are able to progressively justify or limit their financial commitment based on definitive decision oriented milestones.

DOE and the other prospective Project participants are requested to review the proposed Project Strategy Plan with the near-term goal of establishing a mutually supportable basis for each party's near-term Project development support and associated budget planning.

To that end, GCRA plans to generate at least $6 million of support for the HTGR Program from the utility industry in 1987. The proposed utility funded activities for 1987 have been defined and the proposed activities related to the ongoing DOE funded programs have been submitted to DOE. In summary, it is proposed that the utilities perform an expanded Program integration service to DOE, including the plant-level management of the reference plant design and licensing activities. In addition, utility funds would be provided to develop the design of the demonstration plant plus support ongoing Project development activities.

Obviously, these proposed activities and financial support plans in 1987 are meaningful only with DOE's support for the overall Project strategy, including HTGR Program planning for FY 1987 and budget proposals for FY 1988. Specifically, DOE's support is requested for the following:

1. Development, in cooperation with the utilities and the other Program participants, of a mutually agreed-upon Project Strategy Plan, with the attached draft offered as a start.

2. The proposed utility role in FY 1987, as summarized above.

3. Assuming sufficient budget resources from Congress in FY 1987, continue to support the completion of the conceptual design of the reference plant and the issuance of a licensability statement from the NRC.

4. Consistent with the proposed Project Strategy Plan, HTGR budget proposals for FY 1988 that include at least $38 million outlay in support of the Project and related technology development activities.

In addition to the utility and DOE support requirements for the Modular HTGR Project, vendor organization development and financial support will be required. Based on long-standing discussions with the vendor/AE participants in the HTGR Program, their plan is to form a Project Supply Company that will contract to provide the design, licensing support, manufacturing and construction management resources for the Project plus provide cost/risk sharing support consistent with the mutually agreed-upon Project Strategy Plan. Their confirmation of this plan is vital to both utility and DOE support interests for the prospective Modular HTGR Demonstration Project.

We look forward to follow-up discussions with you on our plans and proposals for the Modular HTGR.

Sincerely,

R. F. Walker

Richard F. Walker, Chairman & CEO
Public Service Company of Colorado
Chairman, Gas-Cooled Reactor Assoc.

Enclosure

Copies to:

Honorable Lando W. Zech, Chairman, and Members
Nuclear Regulatory Commission

Honorable Don Fuqua, Chairman, and Members
House Committee on Science & Technology

Honorable James A. McClure, Chairman, and Members
Senate Committee on Energy and Natural Resources

Honorable Tom Bevill, Chairman, and Members
House Appropriations Subcommittee on Energy & Water Development

Honorable Mark O. Hatfield, Chairman, and Members
Senate Appropriations Subcommittee on Energy & Water Development

Honorable Morris K. Udall, Chairman, and Members
House Subcommittee on Energy and Environment

Honorable Alan K. Simpson, Chairman, and Members
Senate Subcommittee on Nuclear Regulation

HTGR Program Participants

GCRA Members and Participants

GCRA 86-009
DRAFT

MODULAR GAS-COOLED REACTOR

PROJECT STRATEGY PLAN

-DRAFT-

Issued by:

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INTRODUCTION

The Modular Gas-Cooled Reactor (MGR) is an advanced reactor concept that offers the utilities and the Nation as a whole a most attractive second generation alternative for nuclear power.

The overall negative experience that has been realized with most large nuclear power plants has caused increased attention toward smaller, simpler plants. During the 1984-1985 time period, the joint industry/government High Temperature Gas-Cooled Reactor (HTGR) Program participants conducted an evaluation of small HTGR concepts with the objective of developing an innovative power plant design that is safe, reliable and economic with minimal public risk and greatly improved public acceptance.

The result of these activities was the selection of the 350 MWt MGR as a reference design concept for near-term development and deployment emphasis. Key distinguishing features of the MGR include:

1. The core size and power density are limited by design so that the fuel particle coatings retain the fission products to an acceptable degree under all licensing basis events, with decay heat removal being accommodated by the passive mechanisms of radiation, conduction and natural convection. This feature simplifies the overall concept, particularly the licensing and operations activities.

2. Major portions of an MGR nuclear island can be shop fabricated and assembled to nuclear standards, while the balance of plant can be largely manufactured and constructed to conventional fossil plant standards. These features improve productivity and reduce the plant construction schedule and field erection costs.

3. A plant can be constructed as a cluster of modules or the modules can be sequentially constructed to more closely match load growth requirements and the utility's financing constraints. This provides added flexibility and a reduction in financing risk.

Considering the overall climate of uncertainty for nuclear application within the U.S., the MGR, within the family of HTGR options, appears optimum for near-term deployment. If a major revival of the new light water reactors occurs in the U.S., the MGR may find its predominant market niche with small and medium sized utilities or with utilities having low load growth and/or financial constraints. Further, predominant applications may be for close-in siting, fossil plant repowering, cogeneration, and process heat. If a revival of the light water reactor industry is not forthcoming in the U.S., the MGR may be a vital nuclear alternative for some utilities that otherwise would rely on coal, purchasing power from small power producers or a shrinking supply of wholesale power. With this background of reality and view of the future, HTGR Program participants have established a solid consensus of support for the MGR.

Electric utilities in the United States have been actively involved in the development of gas-cooled reactors through their support of and participation in Gas-Cooled Reactor Associates (GCRA) since 1978, and in other utility organizations in prior years. Development of the MGR concept has resulted in a significant increase in the level of utility interest and involvement beginning in early 1985. This activity has been directed primarily toward the identification of an achievable strategy for developing the MGR concept into a viable commercial electricity generation option for future capacity additions.

The GCRA utilities recognized that it was very unlikely that either the federal government and/or the supply industry could mount an effort to commercialize the MGR in the current environment of funding restraints and perceived financial risks of nuclear power. However, the MGR appears to represent an attractive capacity addition option to complement the clean-burning coal technologies being developed for commercial application by the turn of the century. Although utility funds for research and development are also in short supply, the potential benefits of the MGR to the utilities and to the Nation as a whole are judged to warrant a priority effort to identify a means for providing this future option.

Indeed, the establishment of the institutional arrangements and the organizational commitment of resources required to develop the MGR concept into a commercial option in the current environment presents a major challenge that will require a concerted National effort. To that end, this Project Strategy Plan has been developed by GCRA as an initial basis for dialogue among the involved parties for establishing a National MGR Demonstration Project. The scope of the Project Strategy Plan includes a statement of Project objectives, a summary description of the proposed Project, the organizational development and management roles envisioned, the associated cost/risk sharing arrangements and recommended near-term actions in pursuit of the MGR Demonstration Project.

1.1 MODULAR GAS-COOLED REACTOR SUMMARY DESCRIPTION

The MGR design development process is being based on utility/user requirements, established by GCRA, and HTGR-unique licensing criteria that incorporate established requirements for protection of the public. A key objective of the HTGR Program is to gain acceptance of criteria that emphasize requirements rather than design selections. Table 1-1 summarizes key utility/user requirements that have been established to date. Ongoing assessments within the HTGR Program indicate that the reference plant design can meet these requirements.

The MGR concept builds on the substantial body of gas-cooled reactor experience in the United States and other countries. The MGR is described in detail in Reference 1, and will be only briefly discussed here. The foundation of the MGR is the coated microparticle fuel, proven through extensive operating experience in the United States and the Federal Republic of Germany. The fuel particles provide a high integrity barrier to radioactive fission products that retains the fission products where they are produced during power operation. The particles have been proven to maintain their integrity at temperatures far above normal operating conditions.

The fuel particles are incorporated within graphite fuel elements to form the reactor core. The result is stable nuclear characteristics, relatively low fuel temperatures during power operation, and the ability to absorb large amounts of energy with increasing core temperatures. The core is cooled by helium gas, which is chemically inert and transparent to the nuclear reactions taking place in the core. The design of the MGR builds on these properties to attain a system which will shut itself down following any incident in which an unplanned temperature increase occurs, with heat losses from the system preventing temperatures from exceeding levels damaging to the fuel. This response can be achieved even with the concurrent loss of the helium coolant.

The design analyses show that the passive safety characteristics described above can be maintained for power levels up to approximately 350 MWt (140 MWe). The apparent power cost penalties which would be associated with this relatively small unit size are compensated by simplifications in system design, construction, and operation. By reliance on the inherent characteristics of the reactor for addressing safety concerns, complex and costly active safety systems common to larger nuclear plants are unnecessary. Other economies of design are available as well, such as the use of a single helium circulator and steam generator. Because the loss of active cooling can be sustained without damage, there is no need for redundant main cooling loops.

The MGR primary system configuration is shown in Figure 1-1. The graphite reactor core is contained within an uninsulated steel reactor pressure vessel. Feedwater enters the steam generator at the bottom, passes through a helicle coil heat exchanger, and exits the vessel as superheated steam. The helium circulator at the top of the steam generator circulates helium between the reactor and steam generator through the coaxial cross duct connecting the two vessels.

TABLE 1-1

SUMMARY OF UTILITY/USER REQUIREMENTS
FOR MODULAR HTGR DESIGN

CRITERIA	UTILITY/USER REQUIREMENT
EQUIVALENT ANNUAL AVAILABILITY	
- TOTAL OUTAGE	20% MAXIMUM OVER LIFETIME
- SCHEDULED OUTAGE	10% MAXIMUM OVER LIFETIME
PLANT INVESTMENT PROTECTION	
- UNSCHEDULED OUTAGE	10% MAXIMUM OVER LIFETIME
- OUTAGES > 6 MONTHS	10% MAXIMUM OF UNSCHEDULED OUTAGES
- EXPECTED VALUE OF LOSS	< ANNUAL INSURANCE PREMIUM
- PROBABILITY OF REACTOR MODULE LOSS	$< 10^{-5}$/YR
SAFETY AND LICENSING CRITERIA	
- OVERALL CRITERIA	EXISTING NRC/EPA DOSE AND RISK CRITERIA
- EMERGENCY PLANNING CRITERIA	NO SHELTERING OR EVACUATION REQUIRED
SITING PARAMETERS	
- EXCLUSION AREA BOUNDARY RADIUS	425 METERS
- SEISMIC (GROUND ACCELERATION)	.3 g SSE/.15 g OBE
FUEL CYCLE	
- ENRICHMENT LEVEL	LOW, < 20%
- SPENT FUEL MANAGEMENT	ONCE-THROUGH THROWAWAY
ECONOMIC GOALS	
- BUSBAR POWER COST	AT LEAST 10% ADVANTAGE OVER COMPARABLY SIZED ADVANCED COAL PLANTS
- INSTALLED CAPITAL COST	< 2000$/KW (1986 DOLLARS)

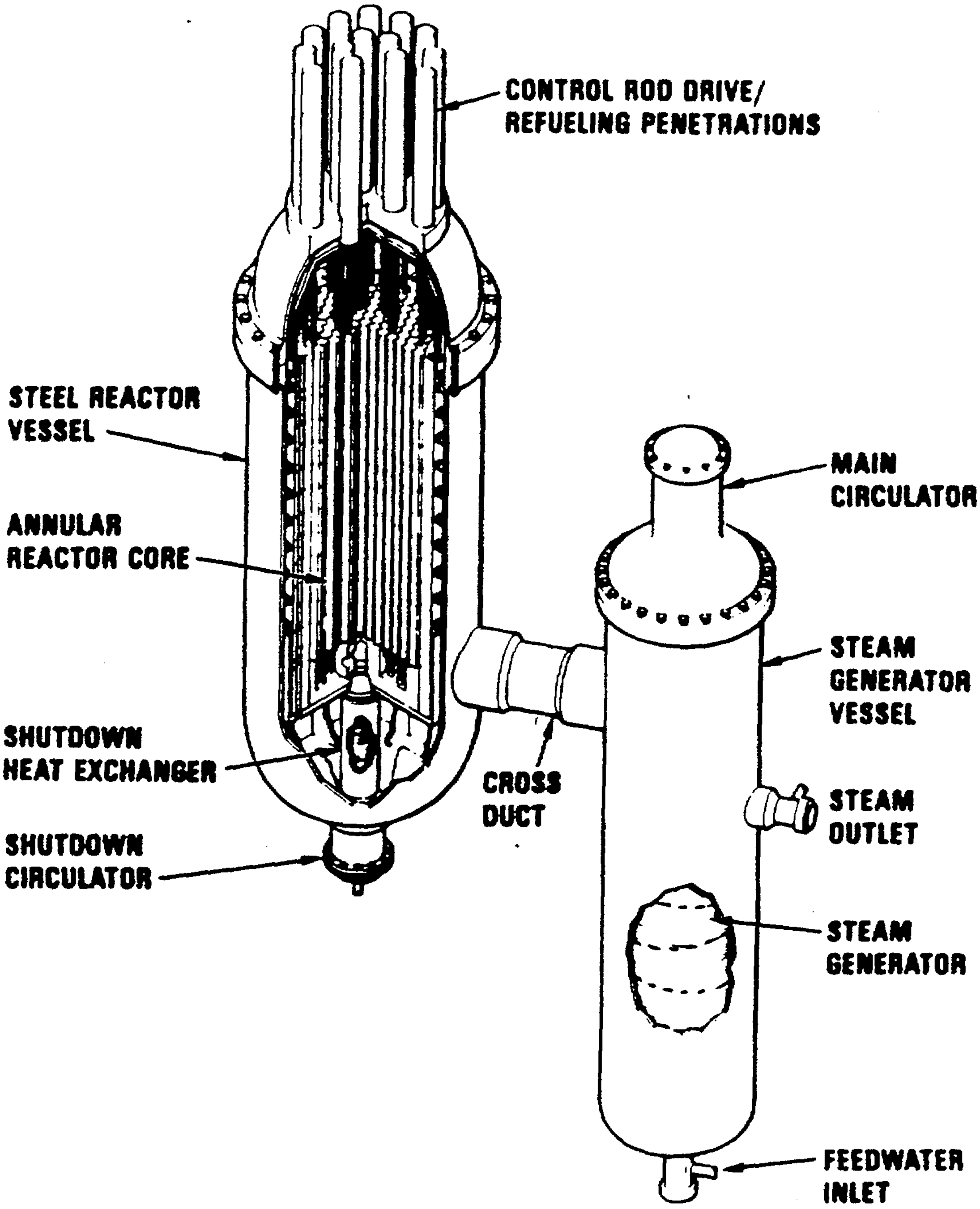


FIGURE 1-1 MGR PRIMARY SYSTEM CONFIGURATION

The primary system is supported below grade in a silo structure as shown in Figure 1-2. Heat from the reactor vessel is removed by the Reactor Cavity Cooling System (RCCS). The RCCS circulates outside air through panels suspended on the walls of the reactor cavity, removing heat by natural circulation under normal operation as well as accident conditions. This passive decay heat removal system integral to the structure provides a basis for designing, constructing, and operating the equipment and structures outside the Nuclear Island according to conventional power plant standards and practices.

1.2 PROGRAM/PROJECT ELEMENTS

The overall goal of the Program/Project is to establish safe, economic, commercial HTGRs as a viable electricity generation option with future potential for cogeneration and process heat applications. The major elements of the Program/Project are summarized below:

- REFERENCE PLANT - This activity is directed toward the design and licensing assessment of a reference commercial plant. The plant configuration selected contains four modules supplying steam to two turbine/generators operating in parallel, for a nominal net capacity of 550 MWe. The Reference Plant provides the basis to establish evaluated economics and licensability of the expected commercial plant. At present, the Reference Plant is the main focus of DOE's HTGR Program.

- TECHNOLOGY DEVELOPMENT - The technology required to design, license, construct and operate MGR plants is for the most part already available. It is envisioned that the modest additional technology development and confirmatory data required will be provided through the ongoing DOE funded program.

- DEMONSTRATION PLANT - The design, licensing, construction and operation of a one module, one turbine Demonstration Plant is the proposed approach to realize the evaluated basis for the Reference Plant and the associated technology. Establishing a Demonstration Plant as a Program element is treated herein as the conversion from the current MGR Program (first two elements) to a National MGR Demonstration Project (all three elements).

The commercial plant design and licensing activities will build on the Demonstration Project results, leading to the certification of a standard commercial unit. While this effort is the culmination of the ultimate Program/Project goal, it is not treated as part of the National MGR Demonstration Project since government support is not envisioned.

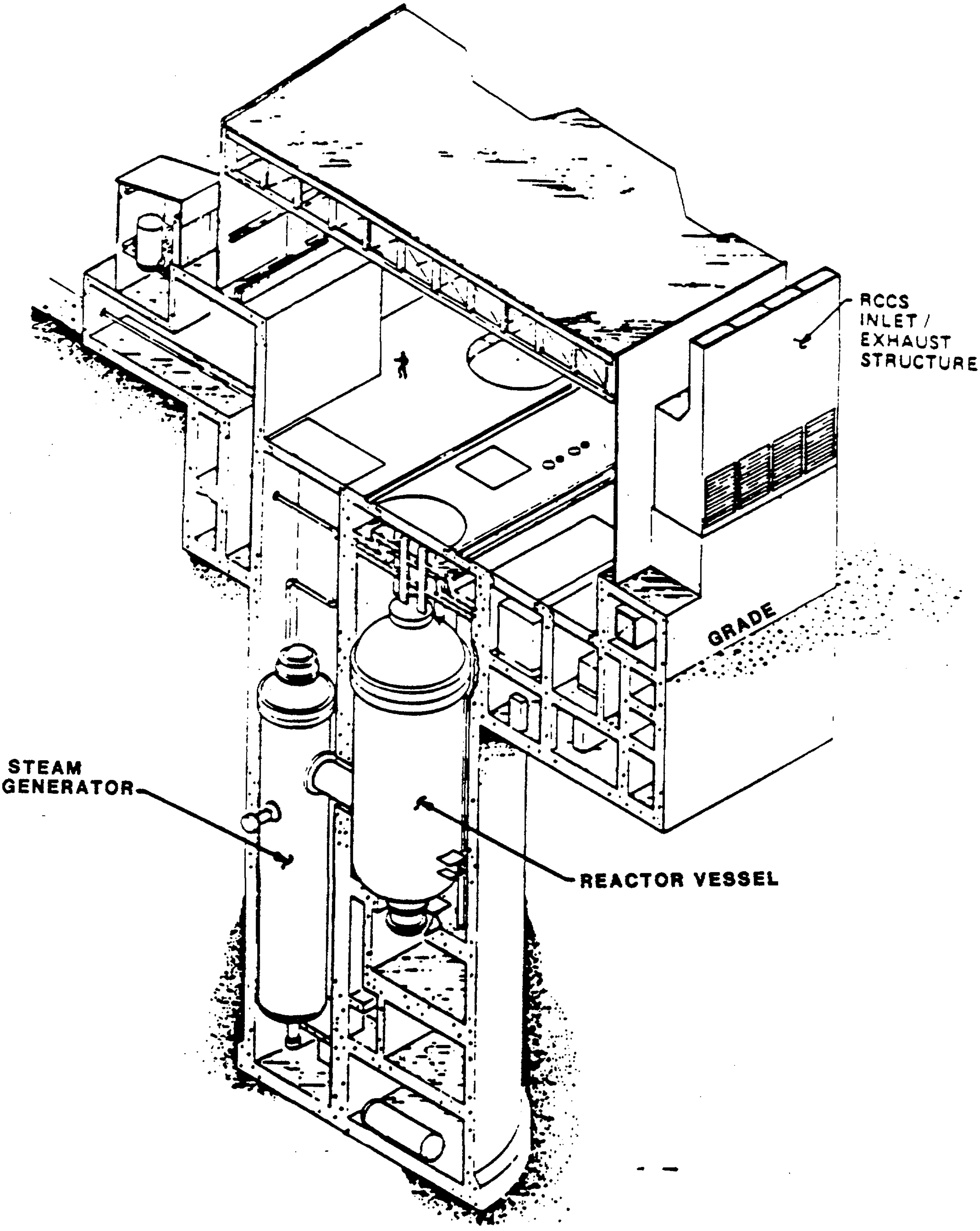


FIGURE 1-2 REACTOR BUILDING/REACTOR MAINTENANCE ENCLOSURE

SECTION 2.0

DEMONSTRATION PROJECT OBJECTIVES

As the HTGR Program concept selection process began to focus on a specific modular concept in late 1984, the means of commercializing the technology became a central issue. In early 1985, the GCRA Project Strategy Subcommitee was formed with members from the Management Committee and Technical Advisory Committee to evaluate the commercialization issue from a utility perspective. The need for and benefits of a Demonstration Project were discussed in detail by the Subcommittee. The results of those discussions are summarized in Reference 2.

In 1986, two additional utility subcommitees were formed to address key issues associated with a Demonstration Project. A Licensing Development Subcommittee consisting of utility personnel with nuclear licensing experience will support the licensing of the Project. A Utility Support Subcommittee will foster the development of utility funding and institutional support for the Project. Appendix A is a position paper developed by the Utility Support Subcommittee summarizing a utility perspective on the need for a utility initiative, and the benefits of a strong utility role in the Demonstration Project.

The MGR is being engineered to have the capability to withstand all licensing basis events without appreciable damage to the plant and with sufficiently low offsite radiation releases that the necessity for evacuation and sheltering plans for the public are precluded beyond an exclusion area boundary of 425 meters. While this capability may be fully understood and accepted by a small circle of technical professionals within the suppliers, utilities, regulators, etc., acceptance of this conclusion by a much broader community does not automatically follow. Demonstration through tests performed on a prototype unit would be a major factor in developing confidence in the MGR within the utilities, the regulators, the financial community, and the general public. This general acceptance is essential to the development and deployment of economically competitive commercial plants.

The overall objective of the Project is to design, license, construct, and operate a full scale, prototypical, standard module to demonstrate that the MGR is economic, licensable, and affords a high degree of investment protection. Without actual plant experience with a prototype, the utilities cannot be expected to have sufficient confidence to proceed to commercial units. Specific objectives of the Project are:

- DEMONSTRATE MGR-UNIQUE LICENSING PROCESS AND SUPPORT DESIGN CERTIFICATION OF THE STANDARD MODULE AND NUCLEAR ISLAND

  Through the Reference Plant development effort, a disciplined requirements based approach to licensing is being developed that should fully capitalize on the MGR's unique safety characteristics. This process will be put to practice and demonstrated through such a Project. In addition, if Project licensing issues, or Standard Nuclear Island design certification issues are identified which are not amenable to ready resolution via analysis or separate effects testing, the Project could be used to prototypically test the reactor module and Nuclear Island response to key design basis events as a potentially efficient and convincing supplement to the overall licensing process.

- DEMONSTRATE PLANT PERFORMANCE CHARACTERISTICS

  Albeit a one module plant, performance of a full scale reactor module and its interaction within the Nuclear Island and the overall plant will be demonstrated. In addition to the normal steady state power operation and anticipated transient demonstrations, design basis events may be demonstrated to verify inherent safety and investment protection features of the plant. This will provide the confirmatory basis for acceptance of design features without excessive margins often required when extrapolating from analyses and separate effects testing.

- DEMONSTRATE OPERATION AND MAINTENANCE ACTIVITIES

  The Project will provide for a demonstration of normal operation and maintenance (O&M) activities as well as identify and demonstrate O&M which might be required in the unlikely event of major equipment failures. This will provide feedback to the commercial plant design plus provide a strong basis for commercial plant O&M cost estimates. In addition, a reliability improvement program will be established as an integral part of the Project. Long-term operation will provide more extensive reliability data and early indication of problems which may arise with extended operation. Other potential benefits which may be derived from the Project include operator training for subsequent commercial plants and long term component and material surveillance.

- ESTABLISH BASIS FOR COMMERCIAL PLANT COST AND SCHEDULE

  The Project will provide first-of-a-kind experience with adapting modular fabrication techniques and separation of the Nuclear Island and Turbine Island portions of the plant. The cost and schedule experience in the overall design, licensing, fabrication and construction effort will serve as invaluable demonstration experience for prospective vendors and customers. Further, the Project will foster the development of one or more vendor/ supplier entities and related infrastructure for offering subsequent commercial plants (or at least nuclear islands).

Further, and perhaps most challenging, the Project must demonstrate whether and how the prospective participants can establish and implement a Project Plan. The Project Strategy Plan, presented herein, is a proposed framework toward that end.

SECTION 3.0

PROJECT DEFINITION STUDY SUMMARY

As the potential of the Modular Gas-Cooled Reactor became more apparent, GCRA began assessing means of demonstrating the concept. It was recognized that a supplementary benefit of the MGR was the potential for building a single module prototype unit at a much lower cost than the large HTGRs of earlier design. The Modular HTGR Demonstration Project Definition Study was initiated in mid-1985 to provide a detailed assessment of site, licensing, testing, cost, and schedule considerations for the design, construction, and operation of a single module prototype unit. Resources for the Study have been provided by incremental contributions from many of the GCRA utilities and cost sharing contracts by the Study participants.

The initial phase of the Study was completed in January, 1986, with results as summarized in Reference 3. Additional work was initiated to reassess the cost and schedule in more detail, and to develop a better understanding of the testing program. The final report for the Study is scheduled for completion by September, 1986, to be published as Reference 4. Accordingly, an update of this report will follow with input from the final Project Definition Study as well as inputs from the interactive discussions among the prospective Project participants. The primary conclusions are briefly summarized in the following sections.

3.1 SITING

In planning the Study, it was concluded that it would be more effective to perform the evaluation for specific sites rather than attempt to define an arbitrary generic site. Two basic types of sites were assessed:

- REPOWERING SITE - Connecting the module to an existing turbine/generator plant scheduled for retirement allows potential cost savings as well as a demonstration of the repowering capability of the MGR as a deployment mode. The Tennessee Valley Authority's Widows Creek Steam Plant in northern Alabama was used as a representative site.

- REMOTE SITE - Construction of the plant at a remote site could reduce the difficulty of licensing the Demonstration Plant particularly in light of the prospective testing to be performed. Two potential sites at the Idaho National Engineering Laboratory (INEL) were studied.

A cost savings of approximately $60 million (relative to a <u>total</u> Project cost of approximately $800 million) was identified as associated with the benefits of repowering.

However, this benefit must be weighed against reliability penalties during the test program which may result from the use of existing equipment, as well as limitations on long term operation as a power plant following testing. An additional site specific savings of $30 million for the Widows Creek Site was associated with differences in local labor rates and local productivity differences due to geography and climate.

The proposed New Production Reactor site and a site adjacent to the Test Reactor Area (TRA) were evaluated at INEL. Both can be considered remote sites, but the TRA site offered cost savings associated with the use of existing facilities and services. The savings that could be directly identified were about $25 million, with anticipation of additional savings during the test program from ready access to TRA personnel and facilities. Based on these considerations, the TRA site was chosen as the reference site for INEL.

Following review of the study results by GCRA and the Study participants, the INEL TRA site was selected as the reference for future program activities. It is anticipated that the site would be leased for the Project by the Utility Project Company discussed in Section 4.0.

3.2 LICENSING APPROACH

In assessing the licensing of the Demonstration Plant, it was recognized that there is a possibility of not having to formally license a Demonstration Plant that is constructed at the INEL (DOE) site. However, it was felt that the potential penalties of a formal NRC licensing of the Demonstration Plant would be justified by a greater confidence in licensing of subsequent commercial plants.

The licensing approach adopted for planning purposes is to obtain a Construction Permit and a Research and Development Facility (Class 104) Operating License. It is possible that a Class 104 license could be obtained to cover the testing phase of plant operation, with possible operating restrictions that could be lifted based on the results of the test program. At the completion of the testing program, the license could be amended to a Commercial Facility (Class 103) license.

3.3 TEST PLANNING

The test program as currently envisioned is expected to be performed over a period of approximately two years. The general objective of the testing, beyond qualification of the facility for power operation, is to effectively compress the operating time by inducing events that would not normally be expected to occur during a two year operating period, to support the program objectives discussed in Section 2.0. The operation and testing to be performed, discussed in detail in Reference 4, are divided into the following categories:

- PREOPERATIONAL TESTS - These tests address the capability of selected structures, systems, and components to meet performance requirements, to the extent they can be tested outside full plant service conditions. Successful completion of preoperational tests demonstrates that individual system performance is acceptable and the plant is ready for hot functional tests.

- BASELINE INSERVICE INSPECTION - These tests provide baseline data for comparison with future inservice inspection results.

- HOT FUNCTIONAL TESTS - The primary system will be operated at full power reactor gas inlet temperature, flow, and helium pressure with heat supplied by the helium circulator. In addition to primary system wear and vibration data, a first check on vessel heat losses and the operation of the Reactor Cavity Cooling System will be provided.

- FUEL LOADING - As fuel loading progresses, neutron flux monitoring results will be compared with predictions.

- STARTUP TESTS - Startup testing includes precritical, low power, and power ascension testing. Following verification of the core physics design, power is increased in steps to full power operation. Plant operating parameters will be verified to be within design limits, and response to load changes and reactor trips will be demonstrated.

- PERFORMANCE TESTS - These tests will subject the plant to less frequent events expected to occur during normal operation including turbine trip, circulator trip, etc.

- RESPONSE TO ACCIDENT TESTS - These tests are intended to demonstrate the inherent response characteristics of the module. Four basic categories of events are being addressed:

    1. Reactivity Transients
    2. Pressurized Cooldown
    3. Steam/Water Ingress
    4. Depressurized Cooldown

  These categories cover the performance of the key systems which provide safety and investment protection.

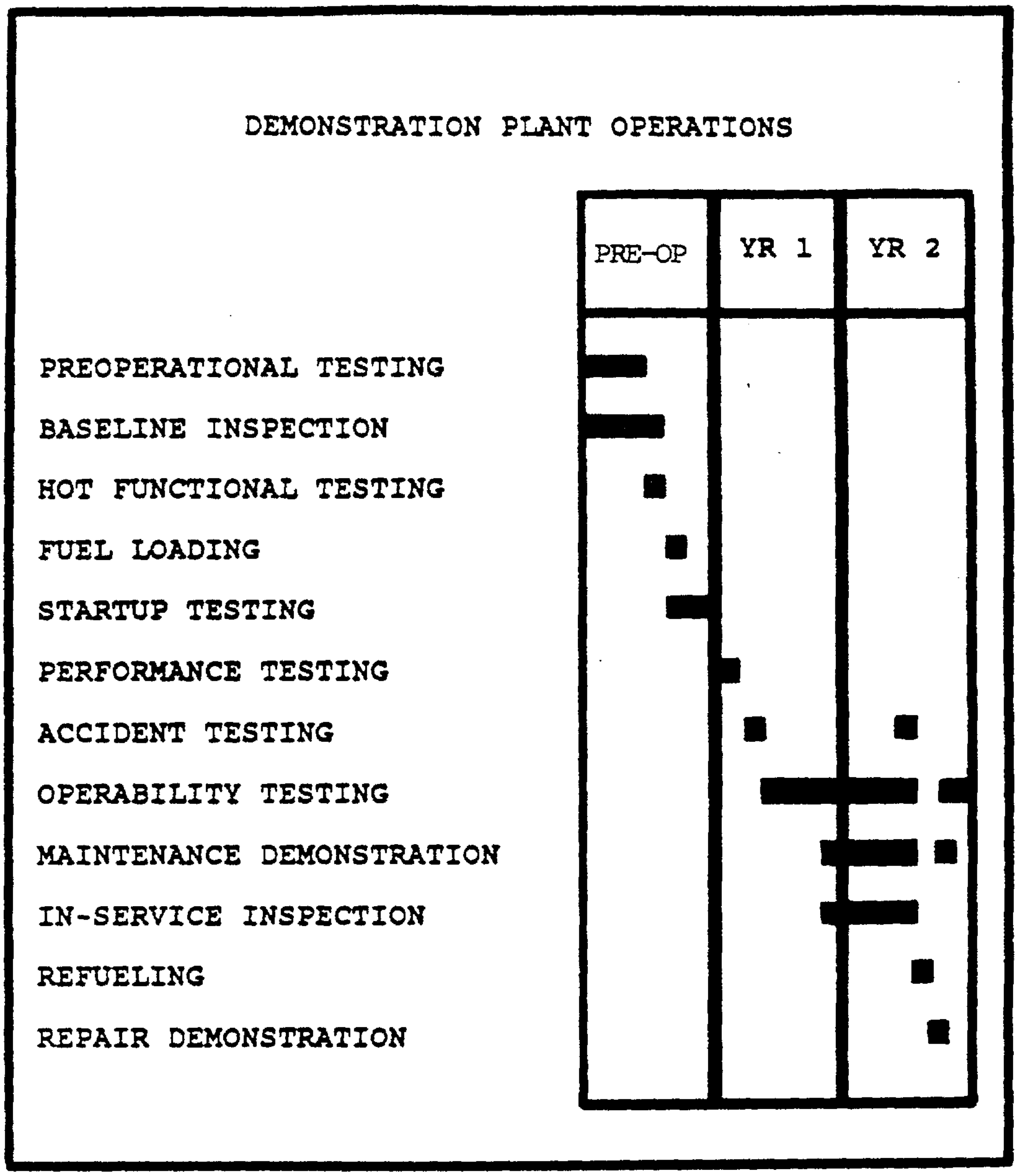


FIGURE 3-1 MGR PROJECT TESTING PLAN

The anticipated schedule for performing the testing program is illustrated in Figure 3-1. The data and experience gained during the test program are expected to provide a firm basis for the certification of subsequent commercial plants.

Although preliminary planning indicates that the response to accident testing will comprise only a small fraction of the total testing interval, the tests are a major element of the total Program. The tests to be performed have been developed based on a preliminary evaluation, and will be adjusted based on further evaluation of design and licensing issues as the Project proceeds. The ability to demonstrate the response to low probability events in a full scale plant without damage which would preclude subsequent long term operation is a key feature of the MGR. Demonstrating this capability is a vital element in the successful development of a commercial MGR which is economically competitive, and generally accepted by the utilities, the financial community, and the general public.

3.4 PROJECT COSTS

A cost estimate has been developed that covers all aspects of the Project from the design to completion of the test period. Costs for the design and licensing of the reference plant through preliminary design are included along with all supporting technology development costs. Project support activities such as licensing, plant operation during the test period, new fuel supply, and spent fuel disposal are also included. The costs were compiled into the following major cost components :

- DIRECT COSTS - The direct costs include factory material, site material, and site labor costs for both the Nuclear Island and the Energy Conversion Area of the plant. Factory material includes all factory fabricated equipment costs.

- INDIRECT COSTS - The indirect costs include home office design and licensing costs for the Reference Plant through a Preliminary Design Approval from the NRC, the total design and licensing costs for the Demonstration Plant, plus its construction management and field engineering services, and owner's cost. All operation and maintenance costs through the first two years of operation were included in the owner's cost.

- INITIAL FUEL - The initial fuel costs include the initial core and two reloads. Included in these costs are uranium, separation work, conversion, fabrication, shipping and spent fuel disposal.

- REVENUE - The revenue is for the first two years of operation and is based on a capacity factor of .35 and an electricity sale price of 20 mills/kWh (consistent with regional projections for non-firm power).

- CONTINGENCIES - Contingencies were developed based on a 20% contingency for the nuclear island related activities, and 10% for the energy conversion area activities.

- TECHNOLOGY DEVELOPMENT - The technology development activities include materials data base development including fuel, graphite and metals, fuel process development, fission product behavior and select component testing. Technology development requirements are specified and controlled through "Design Data Needs".

As indicated earlier, ongoing efforts include a detailed review of the costs developed during the first phase of the Project Definition Study. From preliminary reviews of the initial results, cost targets for the second phase estimate are shown in Table 3-1.

3.5 PROGRAM/PROJECT SCHEDULE

A detailed schedule has been developed for the Program/ Project elements discussed in Section 1.2. When the schedule was originally developed, it was based on an assumption of unconstrained funding available to the Program/Project. The resulting schedule was then adjusted (slipped one year) to reduce near term funding requirements to a level considered more achievable in the current environment. The resulting target schedule, including past work on the Program dating back to the beginning of 1984 is summarized in Figure 3-2, and discussed below:

- REFERENCE PLANT - The concept evaluation phase was completed in 1985 with the selection of the side-by-side steel vessel modular system with prismatic fuel. The Preliminary Safety Information Document (PSID) is on schedule for submittal to the NRC at the end of FY 1986. The NRC review of the PSID is scheduled to result in the issuance of a Licensability Statement at the end of FY 1987. This critical program milestone has been jeopardized by budget constraints and relative priorities within the NRC during 1986. Preliminary design activities based around the results of the Licensability Statement are scheduled to produce a Preliminary Standard Safety Analysis Report (PSSAR) by the end of 1989. With the PSSAR and other information from the Technology Development Program, the NRC is scheduled to issue a Preliminary Design Approval for the Reference Plant at the end of 1991. This will provide a basis for concluding that the Demonstration Plant is representative of a licensable commercial unit, and proceeding with the Demonstration Plant construction.

TABLE 3-1

-PRELIMINARY RESULTS-
SUMMARY COSTS FOR MGR PROJECT

COST COMPONENTS	1986 M$
• DIRECT COSTS	200
• INDIRECT COSTS	
- REFERENCE PLANT DESIGN & LICENSING	100
- DEMO PLANT DESIGN & LICENSING	150
- FIELD ENGINEERING & CONSTRUCTION MGMT.	35
- OWNERS COSTS, INCLUDING TESTING & O&M	60
• INITIAL CORE AND TWO RELOADS	52
• REVENUE FROM POWER GENERATED	-17
• CONTINGENCY	100
• TECHNOLOGY	90
TOTAL	770

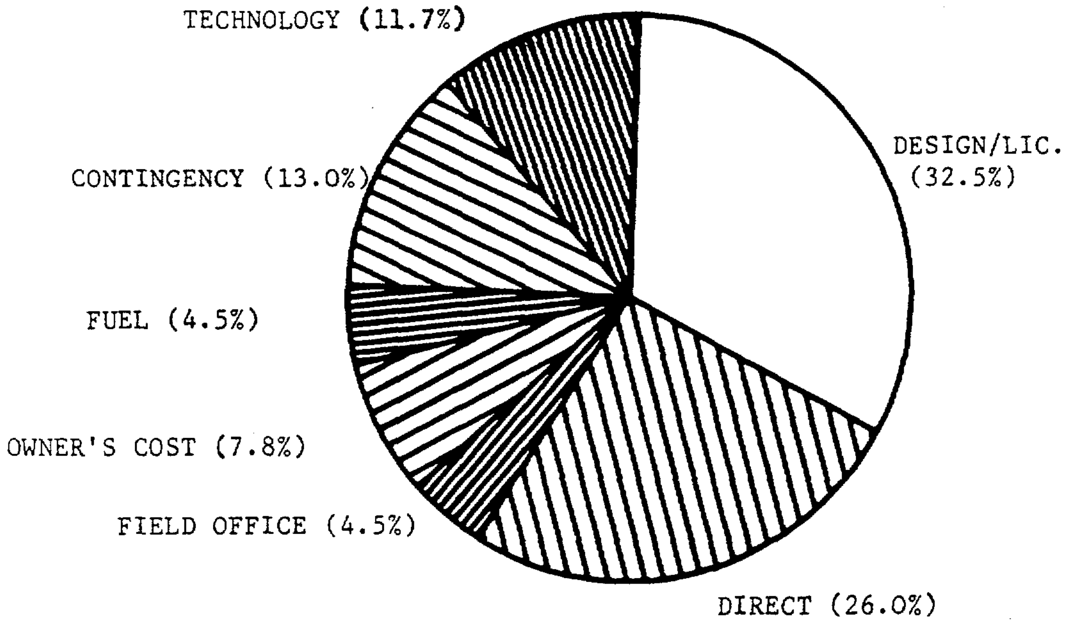
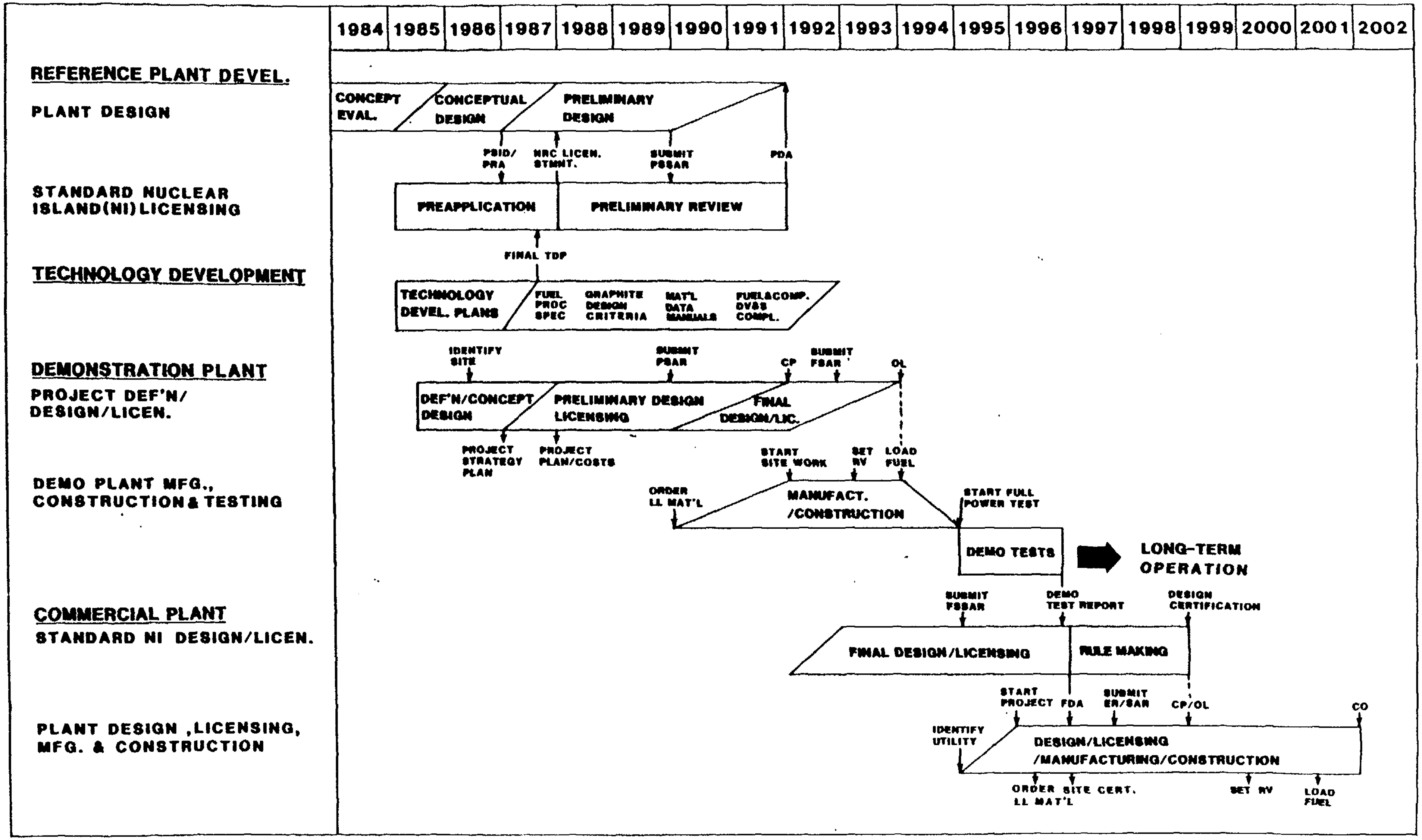


FIGURE 3-2

MGR PROGRAM/PROJECT TARGET SCHEDULE - COMMERCIAL PLANT OPTION #1



- TECHNOLOGY DEVELOPMENT - Technology development requirements are currently under review, with a final Technology Development Plan to be completed in 1987. Development activities will be scheduled to meet the needs of the overall Program/Project schedule.

- DEMONSTRATION PLANT - In concert with the Project definition and conceptual design, a Project Strategy Plan (this document represents an initial draft) is scheduled to be completed by the end of 1986. A detailed Project Plan including Project organizational structure and more definitive cost and schedule data are scheduled for the end of 1987. A Preliminary Safety Analysis Report and Preliminary Demonstration Test Plan are scheduled for completion at the end of 1989, approximately coincident with the order of long lead materials. Site work on the Project is scheduled to begin after the Construction Permit is issued by the NRC at the end of 1991. Final design and licensing work will proceed with the issue of a Final Safety Analysis Report in 1993, leading to an Operating License and fuel loading during 1994. The test program will be conducted during 1995 and 1996, followed by commercial operation of the Demonstration Plant. The critical path for the Demonstration Plant includes the design freeze of major system parameters, the detailed design, fabrication, and installation of the steam generator, completion of Nuclear Island systems, plant start-up, and testing. A secondary path with little float is the licensing process leading to the Construction Permit and subsequent construction of the silo to receive the reactor and steam generator.

- COMMERCIAL PLANT - The first commercial plant on the target schedule (Figure 3-2) is based on having the results of the demonstration tests to support NRC's Final Design Approval (FDA) and a projected two year design certification effort leading to a one-step license. It is recognized that this schedule coupling results in a hiatus of funding resources for the vendor's design and engineering manpower base. Accordingly, a more aggressive schedule for the first commercial plant may result that applies the conventional two-step license. The determination will be driven by the future experience for the Demonstration Plant and the commercial arrangements between the vendor and the customer.

3.6 COST PROJECTION TO MEET TARGET SCHEDULE

The detailed cost estimates were spread at a summary level to comply with the target Program/Project schedule presented in Figure 3-2. As indicated in Section 3.5, near-term budget constraints have been acknowledged in the development of the "target" schedule such that the projected cost increases are deemed supportable by budget resources. Accordingly, success in establishing Program/Project strategy but failure to achieve sufficient budget resources would necessitate further slippage of the schedule.

Also included in Table 3.2 are O&M cost and revenue projections through the year 2000, after which time the Project's net income is expected to be in equilibrium. The basis for the revenue projections are indicated on the bottom of the table. The low capacity factor in the first two years is related to the testing/demonstration activities which warrant the relatively low, non-firm electricity price. Afterwards, steady performance improvements are projected with a higher, firm price of electricity.

It is noted that <u>all</u> the costs in support of the Project are included in Table 3-2. However, subsequent costs in support of MGR commercialization, namely final design and certification plus manufacturing facility investments have not been included. Further, associated costs that support advanced HTGR technology development and other application work are not included.

Proposed cost sharing arrangements in support of the Project are addressed in Section 4.3.

TABLE 3-2

\- PRELIMINARY -

MGR PROJECT COST SCHEDULE PROJECTION

COST ELEMENTS	87	88	89	90	91	92	93	94	95	96	97	98	99	00	TOTAL THRU '96
DIRECT COSTS	-	-	-	7	37	66	57	26	7	-	-	-	-	-	200
INDIRECT COSTS															
- REF. PLANT DES. & LIC.	12	15	25	25	23	-	-	-	-	-	-	-	-	-	100
- DEMO PLANT DES. & LIC.	2	5	7	11	13	36	36	30	10	-	-	-	-	-	150
- FIELD ENG. & CONST. MGT.	-	-	-	-	3	9	12	8	2	-	-	-	-	-	34
- OWNERS COSTS	3	3	3	4	4	5	5	5	14	14	14	13	13	13	60
INITIAL CORE & RELOADS	-	-	-	2	-	7	9	11	13	10	11	11	11	11	52
REVENUE	-	-	-	-	-	-	-	-	(9)	(9)	(31)	(37)	(43)	(49)	(18)
CONTINGENCY	2	5	6	8	14	22	20	14	6	3	-	-	-	-	100
TECHNOLOGY	14	22	20	18	12	4	-	-	-	-	-	-	-	-	90
TOTAL (1986$)	33	50	61	75	106	149	139	94	43	18	(6)	(13)	(19)	(25)	768
CURRENT $ @ 4%/YR	33	53	68	85	123	182	175	124	59	26	(9)	(20)	(30)	(42)	926
CAPACITY FACTOR									.35	.35	.50	.60	.70	.80	
ELECTRICITY PRICE ($/KWH)									.02	.02	.05	.05	.05	.05	

SECTION 4.0

PROJECT STRUCTURE

This section presents the proposed organizational development and related roles, the approach to financial commitment management and the associated cost/risk sharing arrangements.

4.1 ORGANIZATION DEVELOPMENT AND ROLES

There are three major parties to the prospective Demonstration Project: the utility/users, the vendor/suppliers and the federal government (including DOE and NRC). As discussed later, major organizational development is envisioned within the utility/user industry and the vendor/supplier industry in order to conduct the Project.

Before major commitments and progress on the Project can be expected, it is imperative that the three parties establish mutually supported Project objectives and strategy for Project implementation (draft proposed herein). Further, an ongoing forum must be established whereby the principals from each of three parties can routinely convene to review progress as an input for their respective ongoing budget commitments, plus mutually resolve policy/budget issues, as required.

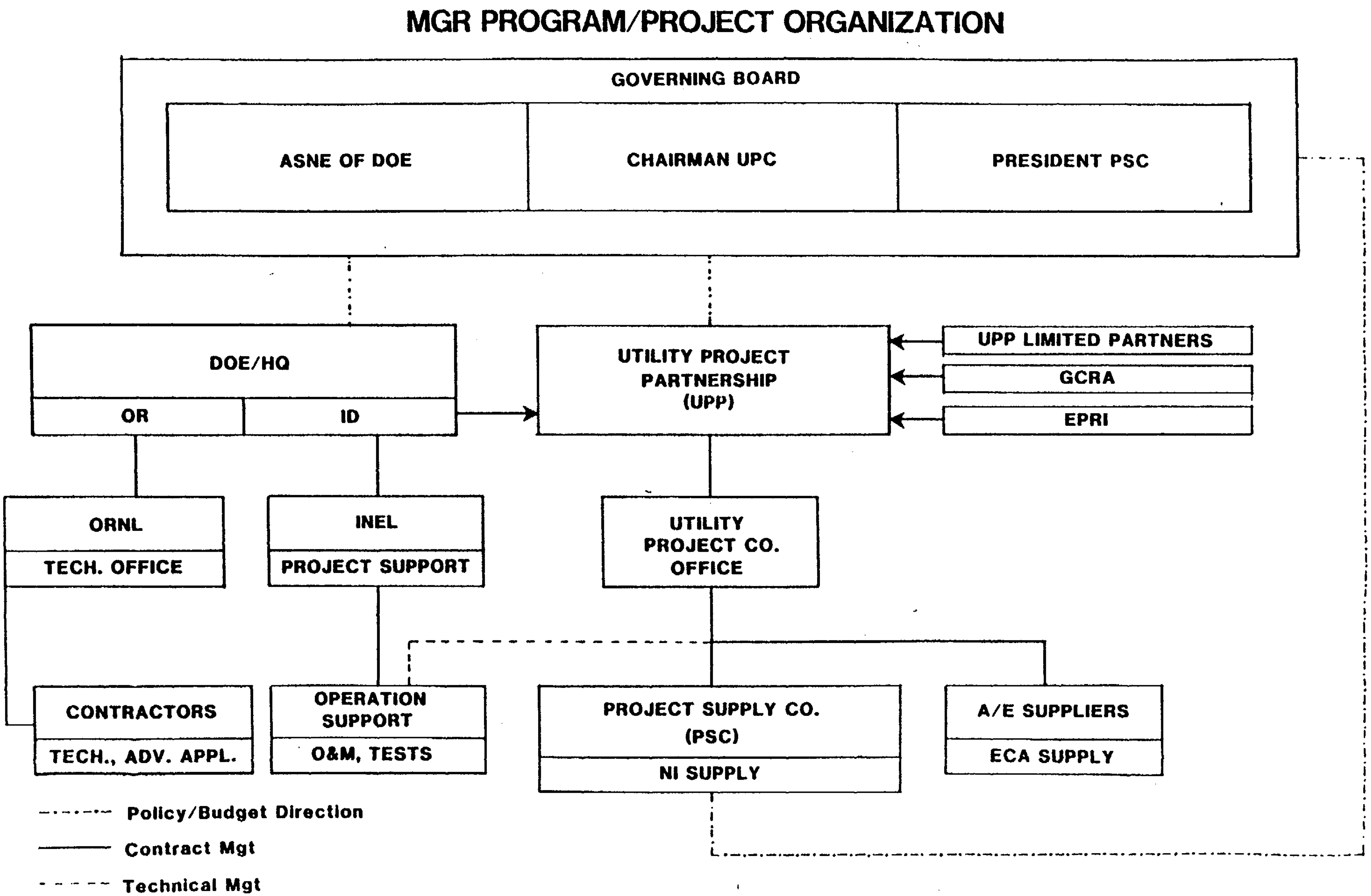
An MGR Project Governing Board is proposed to serve this function that would be constituted by: the Assistant Secretary of Nuclear Energy at DOE, the chairman of the utility owner company (discussed later) and the president of the supply company (also discussed later). The Governing Board would meet at least twice a year to the convenience of the respective budget cycles plus as required to resolve policy/budget issues. All decisions must be mutually supported with the recognition that the party(ies) having the greatest cost and risk exposure on any issue will have the greatest decision making influence. The Governing Board members will communicate Board actions to their respective organizations that will implement such actions according to the management arrangements previously agreed to by the Governing Board.

The proposed MGR Program/Project organization is presented in Figure 4-1. The following discussion addresses key developments needed to support this organizational arrangement.

4.1.1 Utility/User Organization Development and Role

Central to the utility/user industry support for the Project and the overall Project management issue is the entity that will obtain the license, own and operate the Demonstration Plant. The approach for such an entity is to establish a

FIGURE 4-1


MGR PROGRAM/PROJECT ORGANIZATION
GOVERNING BOARD
ASNE OF DOE
CHAIRMAN UPC
PRESIDENT PSC
DOE/HQ
OR
ID
UTILITY PROJECT PARTNERSHIP (UPP)
UPP LIMITED PARTNERS
GCRA
EPRI
ORNL
TECH. OFFICE
INEL
PROJECT SUPPORT
UTILITY PROJECT CO. OFFICE
CONTRACTORS
TECH., ADV. APPL.
OPERATION SUPPORT
O&M, TESTS
PROJECT SUPPLY CO. (PSC)
NI SUPPLY
A/E SUPPLIERS
ECA SUPPLY
Policy/Budget Direction
Contract Mgt
Technical Mgt

Utility Project Partnership (UPP) as a limited R&D partnership for the single purpose of demonstrating the MGR concept. UPP members would be a subset of GCRA and would consist of 5 to 10 utilities. The partnership approach to the utility owner entity recognizes the absence of any single utility (or regional utility group) as a prospective owner. Further, locating the Project at INEL necessitates such a partnership approach since there is no host nuclear utility in the immediate region. While there are complications in the organization and management arrangements, the partnership effectively spreads the cost and risk and provides key flexibility for adding and/or dropping members as conditions change over time within the UPP members.

The following structure has evolved from discussion among the utilities considering membership in the partnership. The general partner of UPP would be a non-profit Utility Project Company (UPC) that would be jointly owned by the initial UPP limited partners. Per the discretion of the UPC members, additional limited partners may be added to UPP on a case basis. Candidates may include U.S. or foreign Project investors that are not able to participate in UPC. In any event, UPC would be responsible for developing cooperative arrangements with foreign utility/user organizations.

The major fraction (approximately 50%) of the utility/user financial support is expected through the UPP limited partners. In return, UPP partners would receive their pro-rata share of returns from the Demonstration Plant that may result from its sale and/or revenue generation through electricity sales.

As general partner, UPC members have direct management responsibility and control of the UPP which translates to lead management responsibility and control for the Project. This added responsibility and risk would be compensated by a royalty arrangement and/or favored terms and conditions on subsequent commercial MGR plant(s). These arrangements will be developed by the principals of UPC and the vendor/supplier entity (discussed in Section 4.1.2).

All utility/user members of UPP would also contribute to the Project as members of GCRA, which would continue as a vehicle for raising broad utility/user financial support for the Project. Twenty to thirty utility/user companies in GCRA are envisioned (beyond the UPP utility members) that would generate approximately 25% of the utility/user financial support. For each utility/user, the contribution would be based on an electric revenue formula and fixed with no open-ended risk. In return, all GCRA members would receive full disclosure of the Project related experiences and reports and participate in the management and technical advisory support of the Project.

The final 25% of the utility/user financial support would be sought from EPRI. This support would be contracted to UPP and negotiated on a fixed commitment basis. Such support is consistent with EPRI's current role in demonstrating advanced coal technologies. In return, EPRI members would receive select Project reports and EPRI staff would participate in the management and technical advisory structure of the Project.

A summary of the respective contributions and benefits for UPC members, UPP members, GCRA members and EPRI is given on Table 4-1. The organization arrangement within the utility/user industry to support the MGR Project is depicted on Figure 4-2.

4.1.2 Vendor Organization Development and Role

A stated objective of the MGR Demonstration Project is to establish a capable vendor entity to sell and service subsequent commercial plants (or, at a minimum, nuclear islands and their fuel supply. The approach to fulfill this objective that has evolved over the past year envisions such vendor development through the near-term formation of a single purpose Project Supply Company (PSC) that will consolidate the design and engineering, licensing support, critical manufacturing and construction management activities for the Demonstration Plant (or again, at a minimum, its nuclear island). Included in the PSC's near-term scope is the reference plant (or nuclear island) design, engineering and licensing support through the Preliminary Design Approval from the NRC. This assures commonality of the reference plant and demonstration plant designs and therefore optimum applicability of the Demonstration Project results.

Upon Project Plan agreement by all parties, the PSC would provide financial support to the Project through out-of-pocket cost based contracts for indirect cost elements of the Project. Further, any cost overruns to achieve completed, quality deliverables for each contract period will be shared by the PSC. For direct cost elements of the Project,such as components and systems, the PSC would provide fixed price contracts to effect increased cost/risk sharing support for the Project. The PSC could supplement U.S. capabilities and resources with foreign vendors and suppliers through cooperative joint venture and/or licensee arrangements.

Based on the Demonstration Project experience, at least one commercial vendor entity would evolve. The vendor(s) would complete the final design for commercial plant(s), obtain a design certification for their respective standard nuclear island(s), provide unique manufacturing facilities and offer commercial plants (or, at a minimum, nuclear islands).

Ownership of the design(s) and related technology is a major issue to be addressed within the formation agreements of the PSC principals as well as between PSC and the major sources of financial support, namely DOE and the utilities.

TABLE 4-1

SUMMARY OF UTILITY/USER SUPPORT STRUCTURE

UPP LIMITED PARTNERS

PROVIDE	RECEIVE
- PROJECT MANAGEMENT	- PROJECT CONTROL, PROJECT RISKS, EXPERIENCE
- OPERATING STAFF SUPPORT	- OPERATOR TRAINING
- "FIXED" $S THROUGH GCRA BASED ON REVENUE FORMULA	- FULL DISCLOSURE OF PROJECT REPORTS, DRAWINGS, EXPERIENCE
- "FIXED" $s THROUGH LIMITED PARTNERS IN UPP	- PRO-RATA PROCEEDS FROM DEMO PLANT

INCREMENT FOR UPC MEMBERS (ADDITIVE TO UPP ABOVE)

- "OPEN" $s THROUGH UPC GENERAL PARTNERSHIP (SHARED BY UPC MEMBERS)	- TO BE NEGOTIATED ROYALTIES FROM COMMERCIAL PLANTS

GCRA

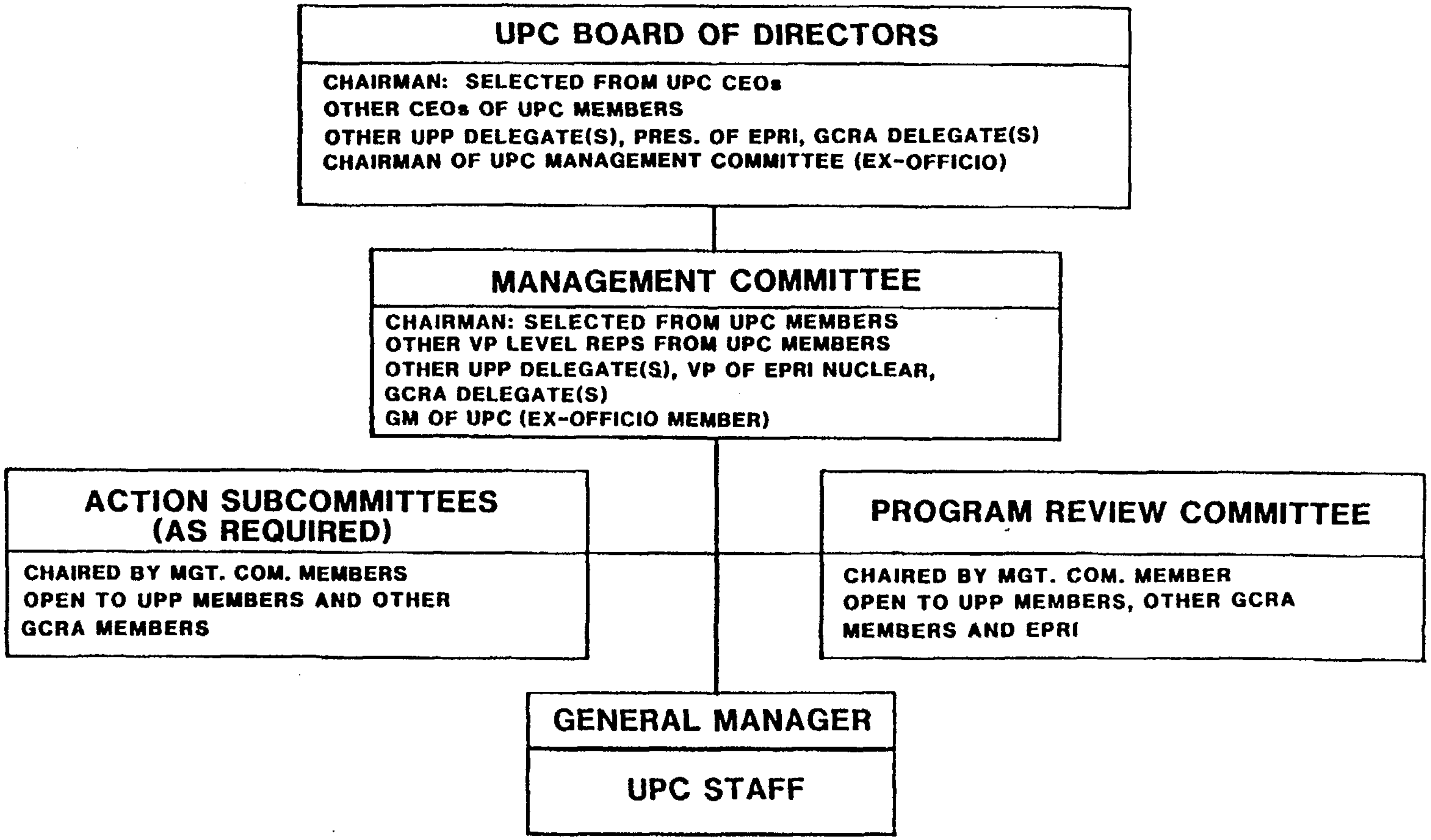
- PROJECT MGT./TECH. ADVISORY SUPPORT	- PROJECT PARTICIPATION (SEE ORGANIZATION CHART)
- FIXED R&D $s BASED ON REVENUE FORMULA (OR NEGOTIATED CONTRIBUTION)	- FULL DISCLOSURE OF PROJECT REPORTS, DRAWINGS, EXPERIENCE

EPRI

- PROJECT MGT./TECH. ADVISORY SUPPORT	- PROJECT PARTICIPATION (SEE ORGANIZATION CHART)
- R&D SUPPORT TO COMPLEMENT DOE'S TECHNOLOGY DEVEL. PROGRAM	- SYNERGISM BENEFITS FOR FSV AND OTHER EPRI PROGRAMS
- "FIXED" PROJECT $s TO COMPLEMENT UPP AND GCRA PROJECT SUPPORT	- SELECT PROJECT REPORTS AND EXPERIENCE SUMMARY

FIGURE 4-2

UTILITY ORGANIZATION FOR MGR PROJECT



4.1.3 Federal Government Role

Recognizing the government based risks associated with the development and deployment of any nuclear power system, it is imperative to establish stable government policy and financial support for the MGR Project. At present, these risks stem primarily from an interralated web of issues, e.g. uncertain regulatory process, the ever-increasing budget pressures and the poor political appeal currently associated with support for nuclear power.

Since the demise of the Clinch River Breeder Reactor Project, the role of the federal government in the development and demonstration of advanced reactors for civilian applications has been in tumultuous transition. The attitudes within DOE and Congress have varied from no role to dominant role. While efforts continue within DOE and related Congressional Committees to evolve a policy and strategy for supporting advanced reactor deployment, expectations are generally low absent a catalyzing initiative from the private sector. GCRA's MGR Project Definition Study and draft Project Strategy Plan (presented herein) were specifically directed to address these issues. The following sections discuss the proposed supporting roles for DOE and the NRC in the MGR Demonstration Project.

4.1.3.1 DOE Role

As the lead government agency for the development of nuclear power, DOE is responsible for developing and addressing related policies associated with a National Program to develop and demonstrate the MGR. In particular, this requires the inter-agency rationalization of DOE's role and financial support, the intra-agency cooperative activities to coordinate the overall federal government's support, and the government-based international cooperative activities in support of MGR development, demonstration and deployment.

To date, the gas-cooled reactor program within DOE has not received priority policy and therefore budget support in their annual budget proposals to Congress. As a result, a significant effort has been required from the major private-sector participants working with key Congressional supporters to sustain DOE's financial support for the program. The resultant DOE program has been closely coordinated with the program participants with ongoing efforts to establish a firm basis for increased DOE policy and budget support. This year, the effort is strengthened by the Project initiative (presented herein) plus the post-Chernobyl increasing National attention and support for passively safe reactor concepts, such as the MGR.

Assuming receptivity to the MGR Project initiative and an aggressive private-sector role that will minimize the cost and accelerate the termination of DOE's development program for gas-cooled reactors, the following programmatic role for DOE is proposed in support of the MGR Demonstration Project:

- Provide primary support and oversight management for technology development as specified and controlled through "design data needs". As "lead lab", ORNL would provide the lead technical management of the technology development programs for DOE, including integration of other related technology development programs (e.g., foreign, EPRI, etc.) plus the integration of advanced HTGR technology development and application programs.

- Through the Project Definition Phase (see Section 4.2), provide primary support for reference plant design and licensing development. Management control will continue to be partitioned between DOE, the Plant Design Control Office (PDCO) - a contractor/subcontractor based extension of DOE, GCRA and various committees, task forces, etc.

- Beyond the Project Definition Phase, provide cost sharing support and oversight management for reference plant and demonstration plant development. Cost sharing is based on a fixed 50% of agreed-upon estimates or actual costs, whichever is less.

- Provide specific support associated with the Demonstration Project at INEL:

  - No-cost lease for INEL site and related facilities;

  - Decontamination and decommissioning for demo plant;

  - Initial core plus two reloads of uranium and SWUs at cost.

4.1.3.2 NRC Role

As the nuclear safety regulatory agency, NRC's role is to establish and conduct an efficient, stable licensing process. In light of the past negative experiences with the regulatory process and the prospects for a greatly reduced licensing effort for the MGR, NRC's role is most crucial to the MGR Project's success.

Efforts within NRC to address the licensing of advanced reactors have begun through a disciplined, top-down approach that should capitalize on the MGR's passive safety features. Further, a recent policy statement has been issued by the NRC (Reference 5) that is compatible with the MGR safety philosophy and proposed approach to licensing.

Given that a National MGR Project initiative is established, the following role at NRC is proposed:

- Provide budget priority to support licensing reviews associated with Project schedule.

- Continue support of developing top-down licensing process and MGR-unique licensing criteria.

- Waive Project's licensing fees through the demonstration period.

- Support Class 104 License application and waive provision on allowable operating cost fraction devoted to energy sales.

4.2 PROJECT PHASES

Recognizing the obvious uncertainties associated with the MGR Demonstration Project, there must be very clear hold points on budget approvals to evaluate programmatic progress as well as calibrate to the external impacts of changing players, budget priorities and related world events. On the other hand, there must be sufficient long-term commitment, albeit conditional within the context of the preceding sentence, from the Project principals in order to implement the Project. Accordingly, a carefully paced schedule of programmatic activities and phased commitments must be developed.

The conventional programmatic structure for any nuclear demonstration project envisions the following phases:

- Project Definition

- Detailed Design and Licensing

- Manufacturing, Construction, Testing

- Commercialization

Table 4-2 applies this structure to the MGR and the proposed time interval and key milestones for each phase, with added emphasis on Phase I - Project Definition. Progressive financial commitment to the venture is proposed as follows:

- Phase I continues the current annual budget review and commitment. Exposure is obviously limited at the expense of the time and attention given to the budget process

- Phase II is accommodated by an agreed-upon, long-term Project Plan established, among other things, in Phase I. Accordingly, an implicit multi-year financial commitment is in effect. However, during Phase II, all Parties must be able to progressively justify or limit their financial commitment based on

TABLE 4-2

HTGR DEMONSTRATION PROJECT PHASES

PHASE I - PROJECT DEFINITION (THRU 1987)

- CONCEPTUAL DESIGN AND EVALUATED ECONOMIC BASIS ESTABLISHED FOR REFERENCE PLANT
- LICENSING BASIS ESTABLISHED THROUGH PSID REVIEW AND NRC ISSUANCE OF LICENSABILITY STATEMENT
- CONCEPTUAL DESIGN AND BASELINE COST ESTIMATE ESTABLISHED FOR DEMONSTRATION PLANT
- PROJECT DEFINITION, INCLUDING COSTS, LICENSING PLAN, TEST PLAN & SITE ESTABLISHED
- PROJECT STRATEGY PLAN, INCLUDING COST/RISK SHARING AND MANAGEMENT ARRANGEMENTS ESTABLISHED
- UTILITY HOST (UPP & UPC) AND SUPPORT ARRANGEMENTS ESTABLISHED
- VENDOR/SUPPLIER/AE TEAMING (PSC) AND SUPPORT ARRANGEMENTS ESTABLISHED
- DETAILED PROJECT PLAN (SCOPE, COSTS, SCHEDULE) ESTABLISHED AS BASIS FOR PROJECT COMMITMENT

PHASE II - DETAILED DESIGN AND LICENSING (1988 → 1991)

- PRELIMINARY DESIGN APPROVAL ISSUANCE FROM NRC FOR REFERENCE PLANT
- CONSTRUCTION PERMIT ISSUANCE FROM THE NRC FOR DEMONSTRATION PLANT
- FIXED PRICES ESTABLISHED FOR MAJOR COMPONENTS AND/OR SYSTEMS IN DEMONSTRATION PLANT

PHASE III - MANUFACTURING, CONSTRUCTION, AND TESTING (1991 → 1996)

- MANUFACTURING AND CONSTRUCTION COMPLETED
- OPERATING LICENSE ISSUANCE FROM THE NRC FOR DEMONSTRATION PLANT
- STARTUP AND DEMONSTRATION TESTS COMPLETED

PHASE IV - COMMERCIALIZATION

- COMMERCIAL PLANT FINAL DESIGN ESTABLISHED THROUGH FSSAR REVIEW BY NRC AND ISSUANCE OF FDA AND DESIGN CERTIFICATION
- COMMERCIAL ORDER(S) COMMITTED

the annual success of definitive milestones and the continued support of the other parties. Multi-year contract commitments will be treated on a case basis between the respective parties involved. Government support stability would be strengthened by multi-year budget authority from Congress, albeit continued annual budget appropriations.

- Phase III necessitates a multi-year financial commitment from all parties to mutually support the remaining fixed price, risk sharing contracts to complete the Project. At this stage, multi-year Congressional appropriations would be necessary for the remaining government financial support. Provisions for termination and/or limitation of financial support commitments will be treated on a case basis.

- Phase IV presents a fresh approach to the buyer/seller relationship for nuclear power financial commitment and risk sharing. These terms will develop with the success or failure of the Demonstration Project.

In summary, the Project Strategy Plan intends a progressive financial commitment based on progressive Project success.

4.3 COST AND RISK SHARING ARRANGEMENTS

The most central issue with the MGR Demonstration Project is establishing an agreed-upon framework for cost/risk sharing and the attendant management roles. The proposed arrangements presented herein envisions shared funding between the utilities and DOE through Phase III whereby the utility share is progressively increased. Cost/risk sharing arrangements with the prospective Project Supply Company (PSC) are envisioned through their respective contract arrangements. For Phase IV, the cost/risk sharing arrangements will be negotiated between the prospective vendors and users.

The proposed phased funding framework between the utilities and DOE is presented in Table 4-3. In summary, 100% in Table 4-3 indicates total cost/risk responsibility, 50% indicates a capped cost sharing whereas 50+% indicates cost sharing responsibility and risk management responsibility. The underlying principles of this framework are:

- DOE is responsible for providing the technology development, consistent with the agreed-upon Project Plan which is based on the "design data needs" established in Phase I of the Project.

- For the balance of Phase I, DOE provides the funding and oversight management for the reference plant design and licensing activities.

TABLE 4-3

FUNDING SOURCES FOR MGR PROJECT

COST ELEMENTS	PHASE I UTIL.	PHASE I DOE	PHASE II UTIL.	PHASE II DOE	PHASE III UTIL.	PHASE III DOE
	PERCENT FUNDING FROM UTILITIES AND DOE DURING:					
● REFERENCE PLANT						
- DESIGN & LICENSING INTEGRATION MANAGEMENT	100	0	100	0	NA	NA
- DESIGN & LICENSING DEVELOPMENT	0	100	50+	50	NA	NA
● DEMONSTRATION PLANT						
- PROJECT MANAGEMENT	100	0	100	0	100	0
- DESIGN & LICENSING	100	0	50+	50	50+	50
- MANUFACTURING & CONSTRUCTION	NA	NA	NA	NA	50+	50
- STARTUP & DEMONSTRATION TESTING	NA	NA	NA	NA	100	0
● TECHNOLOGY SUPPORT	0	100	0	100	0	NA

- For Phase II and III, DOE's cost sharing for the Project, other than the technology development, is capped at 50% of the mutually agreed-upon cost estimate established in the Project Plan during Phase I or the actual cost, whichever is less.

- The utilities (through UPP/UPC) are responsible for their own Project management and owner's cost.

- For the balance of Phase I, the utilities provide the funding for the Demonstration Project development activities plus a plant-level integration service to DOE for the reference plant design and licensing activities.

- For Phases II and III, the utilities provide at least 50% of the funding for the Demonstration Project, including the reference plant design and licensing development activities. Further, the utilities provide the risk management for these activities through their cost/risk sharing contract arrangements with PSC.

For Phase IV, a vendor entity for commercial plants must evolve that will provide financial support and risk sharing for the commercial plant design, certification and associated manufacturing facility investments in concert with a utility/user customer(s) prepared to order a commercial plant(s).

Applying the cost sharing framework of Table 4-3 to the total cost projection of Table 3-2 results in the cost sharing projection given in Table 4-4 and summarized on Table 4-5.

TABLE 4-4

- PRELIMINARY -

COST SHARING PROJECTION FOR MGR PROGRAM/PROJECT

TOTAL COST PROJECTION (See Table 3-2)	87	88	89	90	91	92	93	94	95	96	TOTAL
1986 $	33	46	59	75	106	150	144	94	43	18	768
CURRENT $ @ 4%/YR	33	48	64	85	123	183	182	124	59	26	926
RESOURCE PROJECTION ('86M$)											
UTILITY/USER	6	12	20	28	44	68	65	41	25	11	320
PROJECT SUPPLY CO.	1	3	4	6	9	15	14	14	7	7	80
DOE	26	35	37	42	52	67	63	39	11	-	368
TOTAL ('86M$)	33	50	61	75	106	149	139	94	43	18	768
RESOURCE PROJECTION (CURRENT M$)											
UTILITY/USER	6	12	22	31	51	83	82	54	34	16	392
PROJECT SUPPLY CO.	1	3	4	6	11	18	18	18	10	10	100
DOE	26	38	42	47	61	82	74	51	15	-	435
TOTAL (@ 4%/YR)	33	53	69	85	123	182	175	124	59	26	926

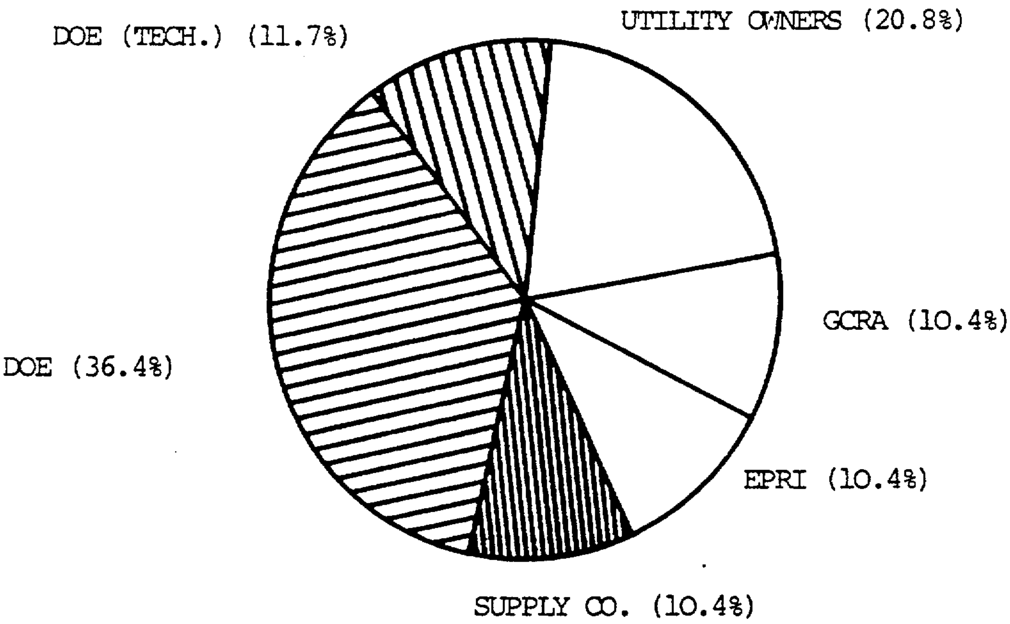
TABLE 4-5

FUNDING TARGETS FOR MGR PROJECT

	UTILITIES	PSC	DOE	TOTAL
• PHASE I (1987)	6	1	26	33
• PHASE II (1988-91)	104	22	166	292
• PHASE III (1992-96)	210	57	175	443
TOTAL	320	80	368	768

UTILITIES

	OWNERS	GCRA	EPRI	TOTAL
• PHASE I (1987)	2.5	2	1.5	6.0
• PHASE II (1988-91)	53	25	26	104
• PHASE III (1992-96)	111	47	52	210
TOTAL	166	74	80	320



SECTION 5.0

NEAR-TERM ACTION FOR 1986/1987

The most critical near-term action needed on the prospective MGR Project is DOE review and consideration of the Strategy Plan (presented herein). Assuming receptivity to the basic approach, a senior level forum of DOE, GCRA and the major Program participants must be convened and sustained to establish a mutually agreed-upon Project Strategy Plan. For discussion here, this group will be referred to as the MGR Strategy Committee (MGR/SC). While success cannot be ordained or scheduled, it is obvious that the earlier this group is formed and functioning, the better.

The first agenda item for the MGR/SC is the organizational arrangements and management roles for the overall MGR Program in FY 1987. This subject has been active for months and numerous proposals and working documents are available for immediate consideration. The proposed organization/management arrangement in concert with the long-term strategy (presented herein) is presented in Figure 5-1.

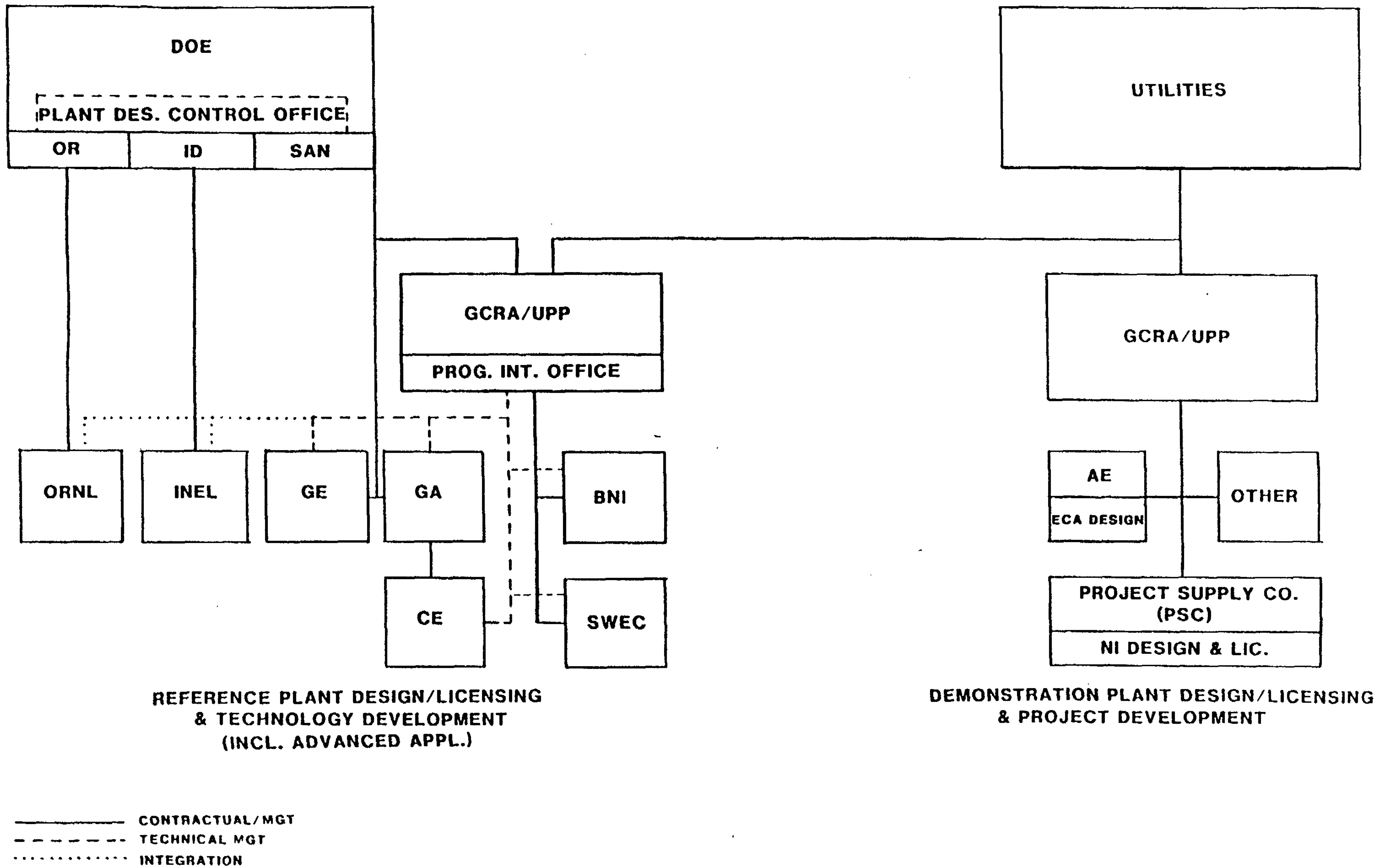
While most of the structure and management arrangements indicated on Figure 5-1 are obvious, there are several points to emphasize:

- During FY 1987, UPP will be established and effect a transition from a GCRA-based staff to a "utility owners" based staff.
- The utilities will strengthen their current coordination support role to DOE via a Program Integration Office with emphasis on the integration of plant-level design and licensing activities.
- The Plant Design Control Office will continue to strengthen the system-level and component technical management and nurture the coalescense of an effective Project Supply Company (PSC).
- During FY 1987, PSC will be formed and be in a position to take a contract to support the Demonstration Plant design and licensing activities.
- A different entity (AE and/or utility) outside of PSC may have a contract to support the Demonstration Plant's Energy Conversion Area.

It is noted that the proposed technical scope for FY 1987, particularly for the DOE funded activities, is basically

FIGURE 5-1

MGR PROGRAM/PROJECT ORGANIZATION FOR 1987



established. The major uncertainty deals with the level of available resources to be appropriated from Congress. However, there are several key scope items related to the development of the proposed Project Plan that must be resolved, e.g. integration of the Demonstration Plant into the Technology Development Plan.

The next agenda item for the MGR/SC is the organizational arrangements and management roles for FY 1988 and beyond. Further, DOE plans for submitting a request-for-proposal must be structured to complement the emerging, mutually agreed-upon Project Strategy Plan.

Other key MGR/SC agenda items for achieving an agreed-upon Project Strategy Plan include:

- The ownership and protection rights of Project related information, past and future
- The appropriate use of DOE's "Applied Technology" stamp
- Cooperative arrangements with foreign countries, including government-to-government, utility/user-to-utility/user and vendor/supplier-to-vendor/supplier
- The PSC's cost sharing arrangements

Assuming a Project Strategy Plan is achievable, the next key agenda item for the MGR/SC is the structure and content of the MGR Project Plan (MPP). The MPP will constitute a controlled, baseline of scope, cost and schedule to implement the Project. Key supporting plans within the MPP include:

- Licensing Plan
- Design Plan
- Technology Development Plan
- Management Plan

In each case, the supporting plans must integrate the ongoing Reference Plant and Technology Development activities with the Demonstration Plant. The agreed-upon Project Plan and associated organizational development in concert with a successful Licensability Statement from the NRC is the culmination of Phase I - Project Definition. Its success and content will dictate the nature of commitment to Phase II implementation by the respective Project participants.

SECTION 6.0

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MODULAR GAS-COOLED REACTOR

THE NEED FOR AND BENEFITS OF A STRONG UTILITY ROLE IN THE DEVELOPMENT AND DEPLOYMENT OF THE MGR

GCRA UTILITY SUPPORT SUBCOMMITTEE

JULY 1986

PREFACE

The GCRA Utility Support Subcommittee was authorized by the GCRA Management Committee in January 1986 to foster expanded utility participation in the development of the Modular Gas-Cooled Reactor. The membership of the committee is listed below:

Vince Boyer (Chairman)	Philadelphia Electric Co.
Dale Bradshaw	Tennessee Valley Authority
Merwin Brown	Pacific Gas & Electric Co.
Dave Ellis	Arizona Public Service Co.
Ken Matson	Public Service Electric & Gas Co.
Milt McBride	Public Service Co. of Colorado
Larry Teply	Idaho Power Co.

APPENDIX A

CONTENTS

1.0 INTRODUCTION

It has been generally accepted within the utility industry that the majority of future capacity additions will be natural gas, coal, or nuclear plants. However, although natural gas generation technology is well established, and a number of promising clean burning coal technologies are being pursued in the United States through demonstration projects, no comparable activities are currently under way for the nuclear option.

Recent utility experience has included large uncertainties in load growth, coupled with negative experiences in completing and operating the current generation of nuclear plants. This experience may well eliminate the option of adding more nuclear capacity for many utilities if large Light Water Reactors are the only choice. The net result would be a near monopoly of new capacity additions by coal burning technologies. In addition to the potential future problems associated with environmental issues surrounding coal-fired generation, over-reliance on a single source of electricity generation could present serious future problems, both for individual utilities and the Nation as a whole.

Responding to these concerns, the utilities of Gas Cooled Reactor Associates (GCRA) are actively exploring means of establishing the Modular Gas-Cooled Reactor (MGR) as a future generation option. The MGR concept has been developed to address the anticipated realities of future capacity addition. However, translating the MGR from a conceptual design to a viable generation option presents a major challenge. This paper summarizes the considerations and conclusions of GCRA regarding the ways and means to address this challenge.

2.0 HISTORICAL PERSPECTIVE

The early development of commercial nuclear generation in the United States was characterized by a number of successful demonstration projects. Many of these projects were made possible by the combination of government support and industry support and direction stemming from the Power Reactor Demonstration Program. The evolutionary development of the technology was then pursued primarily by the private sector.

The Light Water Reactor (LWR) moved relatively quickly through the developmental phase due in large part to the technological base associated with submarine propulsion available in the mid 1950's. The oldest currently operating US commercial nuclear power plant, the Yankee Nuclear Power Station, was authorized in 1956, and began commercial operation in 1961. Several other LWR projects were successfully completed in the early 1960's, providing sufficient confidence for industry to procede with design evolution without need for additional government support. Although faced with significant barriers to future deployment, the history of LWR development contains many examples of highly successful projects, and currently provides approximately 15 percent of total US electrical generation.

The early Liquid Metal Reactor (LMR) development was also supported by a technology base developed for submarine propulsion. The Experimental Breeder Reactor EBR-I, a federally funded and directed project, was the first nuclear power plant to generate electricity, beginning operation in the mid 1950's. The EBR-II followed, beginning operation in the mid 1960's, and continuing operation today. The Fermi plant was successfully completed as an industry project under the power Reactor Demonstration Program, but was shut down due to a shortage of funding required to subsidize its continued operation. The continued development of LMR technology was pursued by the federal government. Subsequent to the construction of EBR-II, the program was directed away from demonstration power plants toward base technology and component development activities. The Fast Flux Test Facility was constructed as a fuel test bed, and thus provides no electrical generation. Although operation continues, the large annual operating costs threaten to close down the facility in the near future. A subsequent demonstration plant, the Clinch River Breeder Reactor, was abandoned in the face of multi-billion dollar funding requirements.

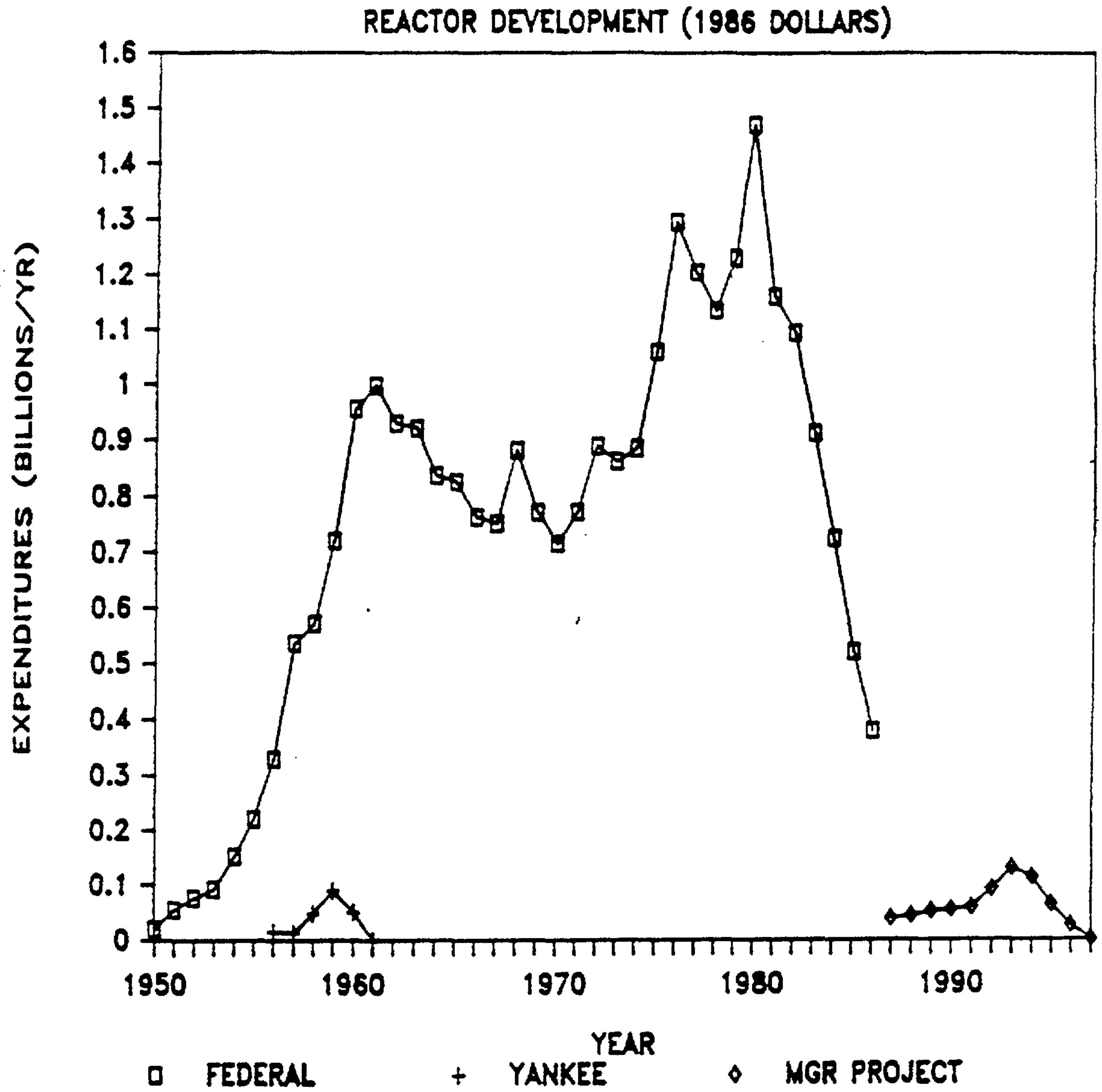
The High Temperature Gas-Cooled Reactor (HTGR) Technology was originally developed in England via the Dragon project. Its major introduction to the United States was through the 40

MWe Peach Bottom Unit 1 plant, within the Power Reactor Demonstration Program. The Peach Bottom plant was completed in 1965, and operated very successfully for nine years prior to being shutdown in 1974. The Fort St. Vrain plant (design rating 330 MWe) was completed in 1975, and continues in operation today. Although the operating history to date has been disappointing, primarily due to water inleakage effects, much of the experience has been positive from the standpoint of providing a technology base for future HTGR development. A substantial majority of the funding and management direction for the development of HTGR technology in the US has been provided by the private sector.

The primary thrust of federal advanced nuclear development in the United States from the mid 1960's onward was directed toward the development of the Liquid Metal Fast Breeder Reactor (LMFBR). The magnitude of the funding expended by the federal government for nuclear reactor research and development is illustrated in Figure A-1. The majority of federal expenditures shown were directed toward liquid metal technology. The actual expenditures for the Yankee Nuclear Power Station and the projected expenditures for an MGR Demonstration Project are also provided for comparison. All values are shown in 1985 dollars for consistency.

FIGURE A-1

CIVILIAN NUCLEAR R&D EXPENDITURES



3.0 CURRENT CONDITIONS

The current environment for new nuclear electric generating capacity additions is highly uncertain. The Light Water Reactor technology, which has reached an advanced state of commercial application in the United States, has encountered problems on a number of fronts that have translated into a strong resistance to future orders in many utilities. Meanwhile, advanced concepts have not been demonstrated, and no plans are currently in place for projects to bring advanced nuclear power technology to the marketplace. An assessment of current conditions for a number of specific issues are discussed below.

- TECHNOLOGY DEVELOPMENT - From the preceding chart, it can be seen that a large amount of funds have been expended for civilian nuclear power reactor development by the federal government. The total expenditure to date is in excess of $26 billion in current dollars. If the cost of money is included at 4 percent per year above inflation, the net present value of the cash flow exceeds $50 billion. The great majority of these funds have been directed toward the development of liquid metal technology. While voluminous technical data and reports have been generated, the EBR-II with a net output of 20 MWe is the only currently operating liquid metal cooled power plant in the United States. After expenditures of tens of billions in current dollars, commercial deployment still awaits identification of a concept and design and construction of a prototype plant.

- PROJECT ORGANIZATION - The history of nuclear technology in the United States contains many examples of successful demonstration power reactor projects in the 1950's and 1960's. A common trait of these projects was a well defined objective and a focused organization with the authority to effectively manage the project. The legal and political environment that surrounds nuclear power today is considerably more complex than conditions that were present in the 1950's and 1960's. While this will certainly make a project more difficult to manage today, it also increases the need for a focused, effective management organization. The majority of the successful demonstration projects in the past have been managed by industry with varying degrees of project management involvement by reactor vendors, architect engineers, and utility organizations.

- PROJECT FUNDING - If industry is to take the lead in managing a project, it is not unreasonable to expect industry to provide a majority of the funding. This was in fact the case in the industry led projects of the 1950's and 1960's. Also, reactor vendor organizations accepted major risks in the early LWR commercialization phase through fixed price turnkey projects. However, it is unrealistic to expect any single utility to fund, or any single supplier to cofund or accept the risk for a demonstration nuclear power plant in light of the experience of the last two decades in the United States. The currently perceived risks associated with regulatory acceptance of a new technology and licensing basis are too high. However, It is also unrealistic to expect the federal government to totally fund and accept the open end risk for an industry led project in light of current budget restrictions.

- UTILITY GENERATION NEEDS - Based on discussions among GCRA utility participants, and the results of a poll conducted among United States utilities [1], a number of general observations can be made about future utility capacity addition preferences. Recent negative experiences with schedule delays and cost growth for large capacity additions have in many cases led to partial exclusion of capital expenditures from the rate base. These effects have been compounded by major departures in load growth rates from the predictions of the early 1970's. The net effect has been a greater interest in smaller incremental capacity additions and a greater premium for short capacity addition lead times. The Modular Gas-Cooled Reactor [2] has been specifically designed to address these needs.

- UTILITY OPERATIONS NEEDS - Recent utility nuclear construction and operating experience has been characterized by substantial pressure on management structures. These pressures have developed from the demanding quality assurance requirements associated with constructing and maintaining the complex safety systems required for current generation plants. Also, the major financial risks associated with potential loss of the plant due to specific events or regulatory actions pose a serious problem. This experience points out the need for a strong utility involvement in the development, construction and operation of future nuclear plants. In addition, the experience also illustrates the major benefits of system simplicity and more forgiving response characteristics for future nuclear plant designs. The MGR program is specifically directed at these concerns through system design and utility involvement in the development of the technology.

- HTGR TECHNOLOGY INDUSTRY STATUS - At present, many of the key personnel involved in the design, construction, and operation of the highly successful Peach Bottom I demonstration HTGR remain actively involved through GCRA or the DOE program. The same can be said for the prismatic fuel technology demonstrated at Fort St. Vrain and a foundation of the MGR concept. However, it is unlikely that this technology base can survive in any meaningful form in the current environment. Thus it is reasonable to expect that this future power generation option will be lost to the utilities in the very near future absent a well focused and supported Demonstration Project.

Many of these issues were considered by the GCRA Subcommittee on Project Strategy [3], and were factored into the implementation of the Project Definition Study managed by GCRA. A summary of the results of the initial phase of the project definition is provided in reference [4].

4.0 BENEFITS OF A STRONG UTILITY ROLE

As the ultimate owner of Modular Gas-Cooled Reactors, utilities will be required to effectively manage the operation and maintenance of the plants through their operating lifetime. During that time, it can be expected that significant modification and repair of plant equipment will be required. Two key elements will be required to effectively perform this function:

1. The utility owners must have experienced personnel with a detailed understanding of the plant and its requirements.

2. The development of the MGR must proceed with a detailed understanding of long term operating requirements.

To date, the Program has addressed these elements through information exchanges with the GCRA utility committees. However, the effectiveness of this process is limited because of time limitations and other job responsibilities of the committee members. As the Program moves toward the demonstration phase, the need for detailed utility review and understanding will expand. The active, full time involvement of a significant number of utility personnel will be essential to a meaningful utility role.

In the existing commercial nuclear industry, a number of examples can be found where the early and active involvement of the utility industry has lead to solid performance. As a case in point, utility participation in the design and construction of the Yankee Nuclear Power Station has resulted in very successful long term plant operation. In addition, the expertise developed in that project was transferred to other later plants in the region, and made a substantial contribution to the successful operation of those plants as well.

The capabilities needed by the utilities to support the deployment of the MGR as a commercial power plant must include management as well as technical expertise. The formation of a utility project consortium to represent the participating utilities in a strong project management role is seen as an effective means of establishing this expertise within the utility industry for the MGR. The large nuclear construction program of recent years provides an experienced base of utility project management and licensing personnel for staffing the utility project consortium as the Program moves toward a Demonstration Project.

In addition to their own experience, seconded utility personnel will be able to draw directly on the experience of others within their respective companies. This input can be expected to significantly reduce the number of problems experienced during the initial operation of the demonstration plant. This is of particular importance to the MGR Development Program, since the nuclear island of the demonstration unit is intended to be an exact replica of the commercial units to follow. If problems require significant redesign, modification and retesting of the demonstration unit may be required.

As an additional practical consideration, it is generally accepted that the federal government will not totally fund an advanced power generation demonstration project. In general, this means a major contribution from industry will be required. For a nuclear plant, the perceived commercialization risk is sufficiently high that the supply industry is unlikely to provide a major portion of the funding. A strong utility management role will be required if the utility industry is to accept a major share of the funding and risk of a Demonstration Project.

For the reasons discussed above, a strong, central utility involvement in the management of the MGR is considered an essential condition for a successful Program. In order to perform this role, sufficient time must be allowed to establish an effective organization structure and for the personnel to develop a detailed understanding of the technology. In addition, as the concept moves toward the preliminary design phase, the need for timely, detailed assessments of design features will expand. While GCRA has effectively represented the utility interests to date, more direct utility involvement from the prospective utility owner(s) is appropriate in the future.

5.0 SUMMARY AND CONCLUSIONS

From the considerations discussed in the previous sections, the following conclusions can be reached:

- Coal may be the only major generation option for many U.S. electric utilities if the current load growth environment continues.

- Over-reliance on a single source of electricity generation could present serious future problems.

- The MGR concept is particularly well suited to the expected future generating capacity needs of a substantial fraction of the U.S. electric utilities.

- The inherent response characteristics and resultant system simplifications of the MGR directly address utility operational and financial risk concerns with current generation nuclear plants.

- The U.S. HTGR option will be lost in the current environment absent an industry initiative.

- The most effective way to commercialize nuclear power technology is through a demonstration project.

- The majority of the successful civilian nuclear power demonstration projects have been managed by industry.

- A strong central role for the utilities in the development of the MGR is an important prerequisite for effective management and operation of future commercial MGR plants.

- It is unrealistic to expect that any combination of a single utility and potential supplier would fund a demonstration nuclear power plant.

- The federal government cannot be expected to totally fund an industry managed project.

The industry initiative being developed by GCRA and its member utilities is designed to address these issues and identify an effective means of establishing the MGR as a viable future capacity addition option.

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