DOE/SF/02034-T26

Gas-Cooled Reactor Associates

HIGH-TEMPERATURE GAS-COOLED REACTOR (HTGR)

LONG-TERM PROGRAM PLAN

OCTOBER 9, 1980

High Temperature
Gas-Cooled Reactor Program

DISCLAIMER

FY 1981 HTGR PROGRAM
SUMMARY-LEVEL PROGRAM OUTLINE
(REVISION 10/10/80)

MASTER

INTRODUCTION

Presented herein is a summary-level outline of the proposed HTGR Program Plan for FY 1981. The effort described in the plan is that to be supported by the Department of Energy (DOE). The purpose of this outline is to provide an initial basis for FY 1981 planning by all HTGR Program participants. After further development, this outline will also provide the basis for evolving the detailed FY 1981 HTGR Program Plan.

BACKGROUND

In early FY 1980, GCRA, with the support of Program participants, assisted DOE in the development of a summary-level plan for the conduct of the HTGR Program. This plan, the HTGR Lead Project Identification Plan, was adopted as a basis for the HTGR Program in February 1980.

As defined in the HTGR Lead Project Identification Plan, the principal thrust of the FY 1980 effort was to investigate four technology options identified by program participants as potentially viable candidates for near-term demonstration. Included were the Gas Turbine system (HTGR-GT), reflecting its perceived compatibility with the dry-cooling market, two systems addressing the process heat market, the Reforming (HTGR-R) and Steam Cycle (HTGR-SC) systems, and a more developmental reactor system, the Nuclear Heat Source Demonstration Reactor (NHSDR), which was to serve as a basis for both the HTGR-GT and HTGR-R systems as well as the further potential for developing advanced applications such as steam-coal gasification and water splitting.

To provide a basis for evaluation, the FY 1980 plan provided for a detailed technical and economic assessment of the four lead project options and an extensive interface with potential users of the technology to identify interest. Further, studies were initiated to identify market dimensions for the dry cooling and process heat applications, the latter effort including an assessment of the emerging synfuels technology.

The efforts over the eight-month period of February through September have resulted in considerable progress with regard to improving the focus of the HTGR Program. Obvious in this context is the elimination of the HTGR-GT as an option for early deployment. While water utilization studies conducted through HEDL have indicated a large potential market for near-dry and wet/dry cooling, the economic advantage of the gas turbine at 850°C is not presently compelling. Further, technical issues arising from postulated turbine failure accidents imply longer term development.

Progress with regard to process heat applications has been equally significant but less conclusive than in the case of the HTGR-GT. To characterize the process heat market, two market studies were undertaken during the seven-month period of the investigation. A study by General Energy Associates, under contract to GCRA, addressed the overall characteristics of the process heat market and provided a further breakdown by utility service area. A companion study by ORNL addressed the potential process heat market specifically available to the HTGR-SC. The results of these studies can be summarized as follows:

- The process heat market is substantial, amounting to some 17.9 quads (projected for 1980) exclusive of electricity.
- About 73% of input energy is in the form of oil and gas, approximately 6.2 million barrels per day of oil equivalent.
- Direct heat and process steam requirements are approximately equal with requirements for temperatures less than 500°F (43%) and temperatures from 500-1000°F (34%), comprising 77% of the total process heat market.
- The market is dispersed, with only 779 of the 335,346 plants included in the data base requiring 100 MWt or greater heat input and only 1841 requiring 50 MWt or greater heat input.
- While relatively small in number, large facilities (greater than 50 MWt) use over half of the total energy consumed in the process heat energy sector.
- Energy availability requirements are high, typically above 90%.

In addition to the process heat market studies, PACE completed an assessment of the synfuels market under contract to GAC. A substantial potential HTGR market was projected, with 44 synfuels plants projected for deployment by 2000 and 201 by 2020. These facilities are of particular interest to the HTGR program in view of their compatible size and temperature requirements, deployment timing, probable siting characteristics, and the projected capability of the HTGR to greatly improve coal utilization. The synfuels projections developed by PACE were confirmed through an independent study which was conducted by TRW under contract to GCRA. The TRW study also projected a range for the number of HTGR plants which would be deployed to serve the synfuels market based upon environmental constraints and energy impact requirements for the synfuels industry.

The FY 1980 application studies addressed two HTGR configurations which were identified as potential matches to the process heat market, the HTGR-SC and the HTGR-R. The results of the technical studies include the following:

- The HTGR-SC applied to process steam/cogeneration is technically acceptable and offers favorable economics over large central, fossil-fired cogeneration plants; however, the projected market is limited by the large size of the heat source and the limited capability to store and distribute energy.
- The limitations of the HTGR-SC for process heat applications may be overcome by coupling the 750°C nuclear heat source with sensible energy distribution and storage using a medium such as molten salt.
- The HTGR-SC applied to baseload electric applications is both technically and economically acceptable and engenders continued utility interest. In view of that interest and the strong commonality in technical and institutional issues, the HTGR-SC may offer a minimum cost path to process heat applications.

- Available time and resources proved insufficient to adequately address the HTGR-R. Major open issues remain regarding the basic design configuration, operating parameters, and associated economics.

- Both the 750°C and 850°C nuclear heat sources appear to have substantial potential for coupling with synfuels facilities.

In addition to the configurations described above, the NHSDR was examined as a more developmental path to HTGR demonstration. In concept, the NHSDR combines demonstration of both the HTGR-GT and HTGR-R technologies with additional potential for even higher temperature applications. As a result of the study, the NSHDR was found to be unsuitable as a lead project in its proposed configuration for the following reasons:

- HTGR-GT studies have not yet provided sufficient justification for development.

- While the size and cost of the NHSDR were of commercial scale (fixed in accordance with HTGR-GT demonstration needs), prospects for investment recovery through commercial operation were minimal due to the noncommercial configuration and projected mission in advanced systems development. Accordingly, minimal bases exist for utility/user interest and financial support.

FY 1981 SUMMARY-LEVEL PROGRAM DESCRIPTION

The stated objective of the DOE HTGR Program is the development of technology for the most important HTGR applications. A high priority during FY 1981, therefore, will be to confirm the substance of that Program so as to assure that it is both necessary and sufficient to provide the required support.

In the establishment of a supportive technology program, key elements which must be addressed are as follows:

- Studies must be conducted to identify important HTGR applications and to evaluate their potential in the context of market opportunities, utility/user interest, and national objectives.

- Based upon the configurations and operating characteristics projected for selected applications, Technology Program requirements must be identified to support development, verification, and ultimately licensing of components and systems comprising the facilities of interest.

- In the context of limited resources, sufficient analysis and evaluation must be accomplished so as to prioritize technology elements in accordance with programmatic and technical criteria.

To accomplish the above, the HTGR Program in FY 1981 will be organized in a logic structure as depicted in Figure 1. The principal elements of the Program are described as follows:

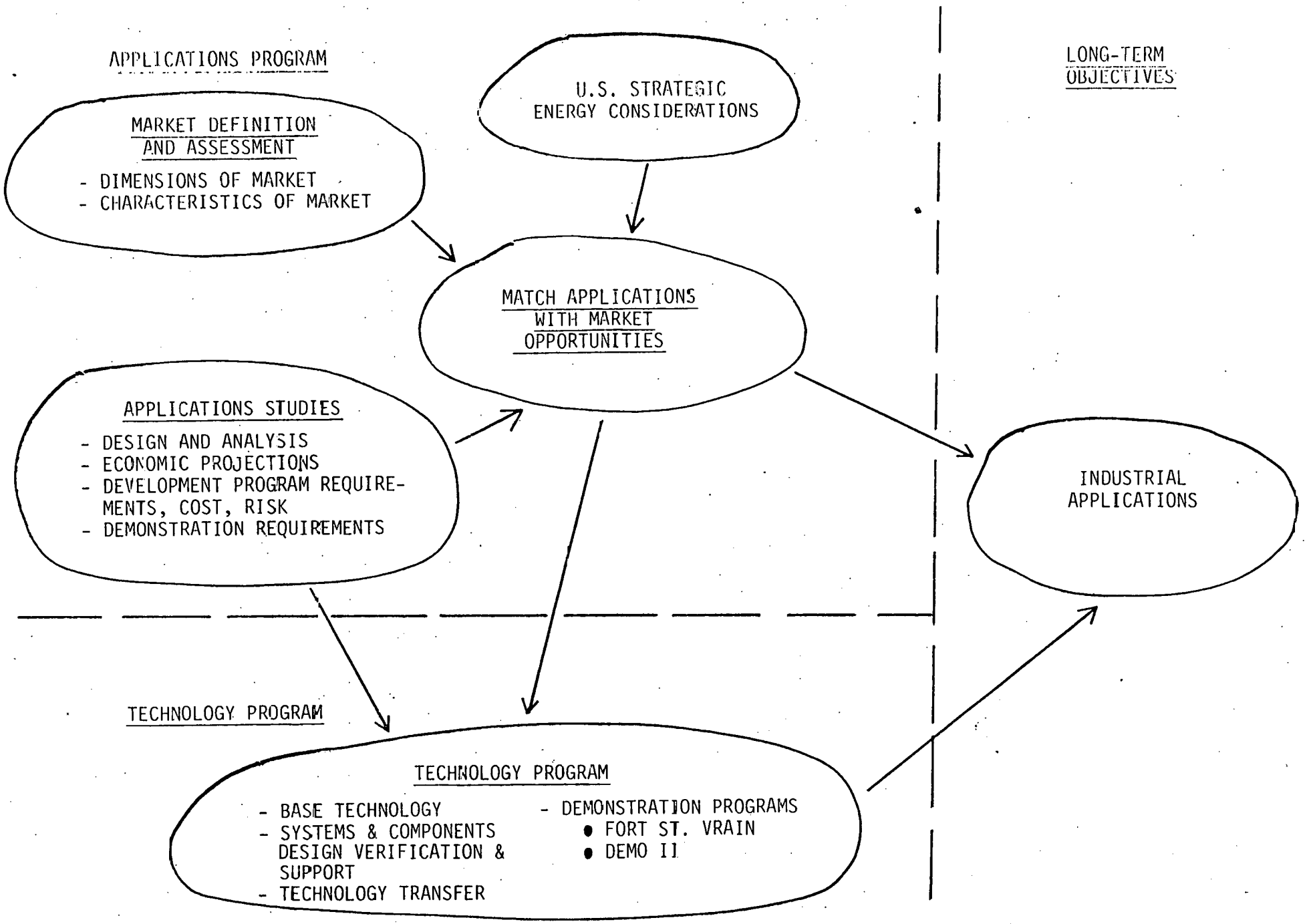


FIGURE 1 OVERALL PROGRAM LOGIC ELEMENTS

10/10/80

Market Definition and Assessment

Market evaluations to date have typically emphasized dimensions (sizes) of the projected market but have provided inadequate insight with regard to market characteristics (size and distribution of users, temperature requirements, etc.). Indications from FY 1980 results are that the latter are of perhaps greater importance with regard to process heat market accessibility. Accordingly, the FY 1981 program will continue the work initiated during FY 1980 to portray the various HTGR markets both in terms of dimension and characteristics. Coupled with the application studies described below, the market studies will provide a basis for matching potential HTGR markets with the most appropriate HTGR configuration.

Application Studies

Through the HTGR Application Studies, information regarding specific HTGR configurations is developed in sufficient scope and depth to provide a basis for evaluation against other HTGR configurations and against competing technologies. These studies, along with studies characterizing market opportunities, will provide a basis for decisions regarding development and, ultimately, deployment priorities. The Application Studies further provide a basis for identifying design data needs and for focusing Technology Program activities.

Included in the scope of the application studies are the following:

- Sufficient design and analysis to define principal plant features and to provide a basis for reliable cost estimates.
- Estimates of plant capital and product costs in sufficient depth to facilitate comparison with alternatives.
- Identification of design data needs and timing as input to the establishment of Development Plans for applications of interest.
- In the case of HTGR applications which are to be supported by the Technology Program, the establishment of a reference design which will be subject to configuration control when procedures are available. Additional development of the reference design will be undertaken as required to focus the Technology Program.
- Identification of demonstration requirements.

Figures 2, 3, and 4 depict potential matches between the various HTGR configurations and their potential markets. Reflecting the results of the FY 1980 effort, the major part of FY 1981 Program will address the process heat, synfuels, and unconventional electrical generation (cogeneration and load-following) markets. Reflecting the above market emphasis, technical emphasis will center upon the 750°C NHS for process steam and sensible energy storage and the high-temperature (850-950°C) NHS incorporating reformer technology.

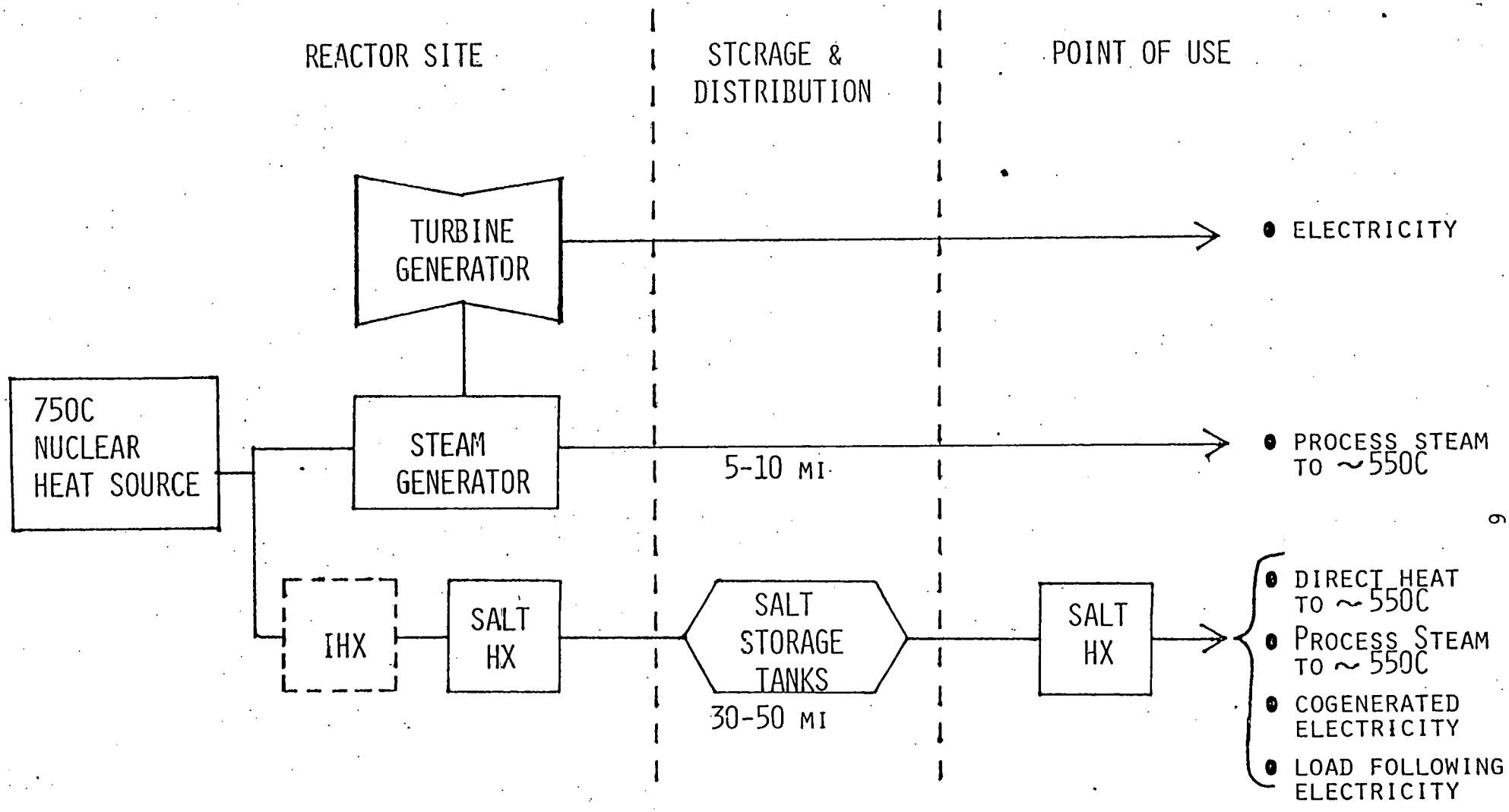


FIGURE 2 750C HTGR APPLICATIONS

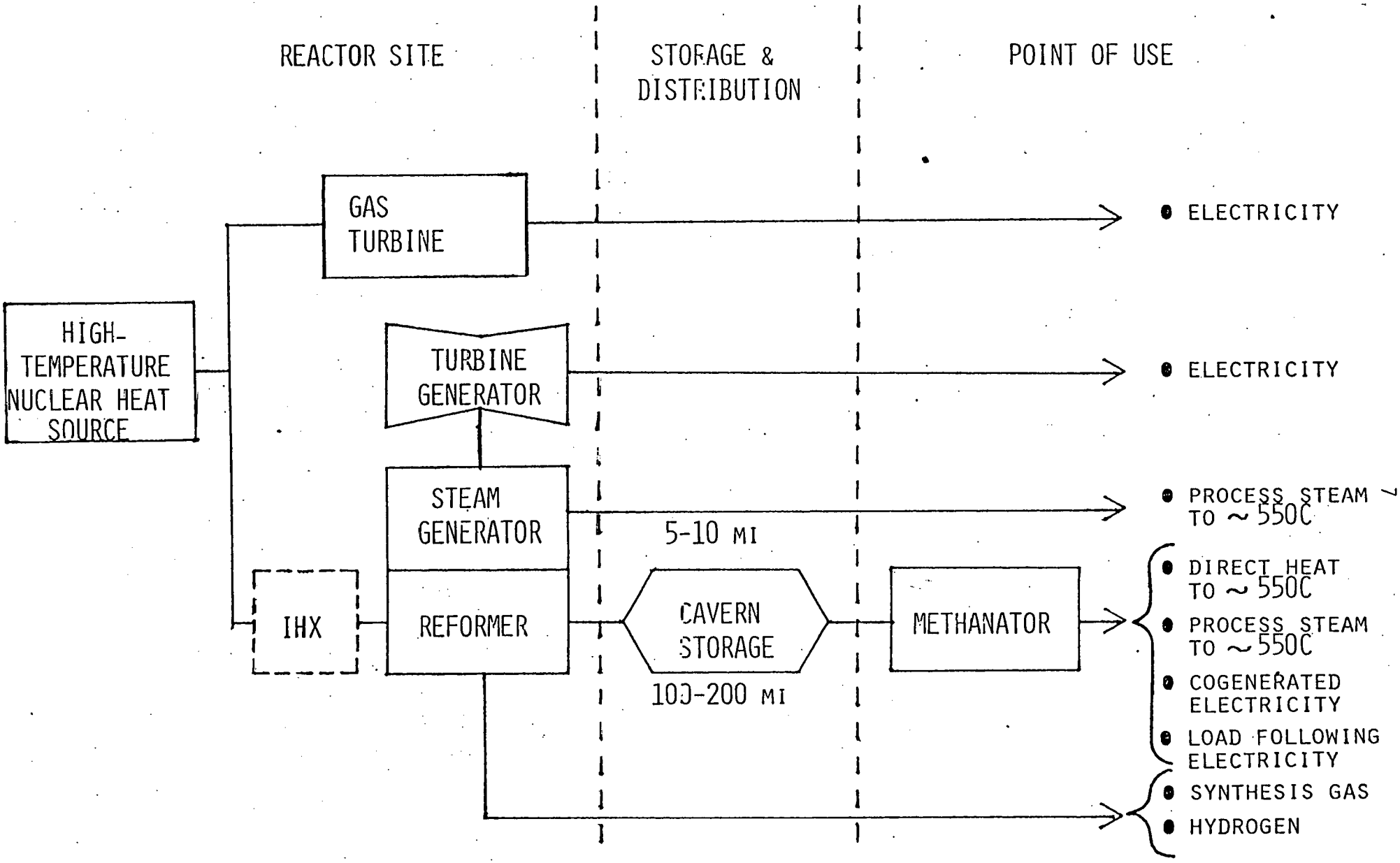


FIGURE 3 HIGH-TEMPERATURE HTGR APPLICATIONS

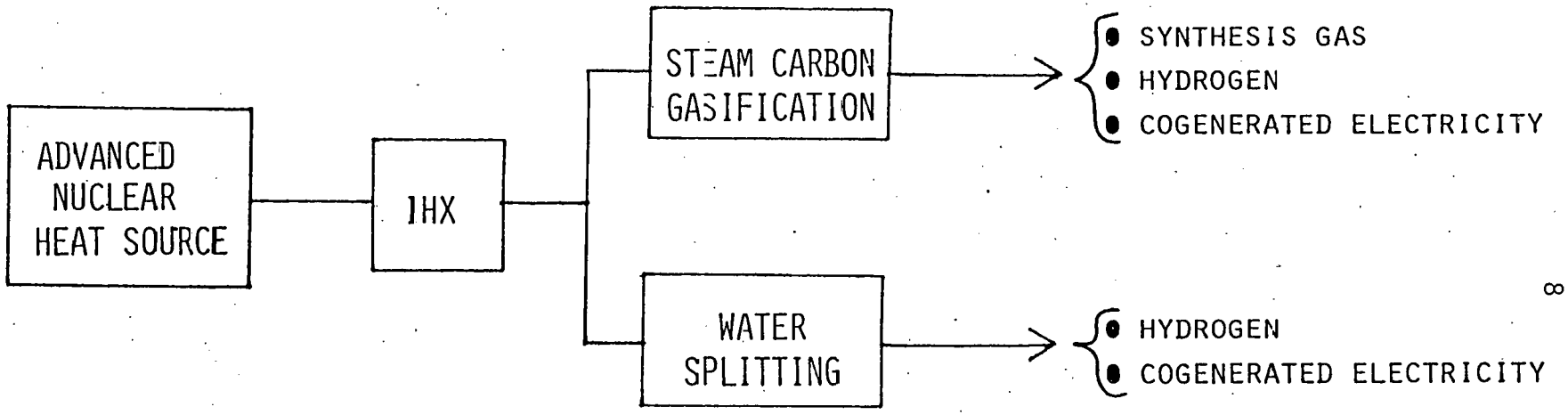


FIGURE 4 ADVANCED HTGR APPLICATIONS

Technology Program

The HTGR Technology Program is guided by the findings of Application Studies and further focused by safety and licensing activities. The Technology Program provides the reservoir of information from which technical and economic aspects of various applications may be gauged and, in addition, is central to identifying the costs and schedules associated with development efforts required to deploy candidate systems. The Technology Program further includes the HTGR Program activities at the Fort St. Vrain demonstration plant and the transfer and utilization of information from related external programs. The Technology Program is oriented toward the early resolution of technical issues that may restrain the potential for HTGR contributions to important sectors of the potential market.

The following outgrowths of Application Studies conducted in FY 1980 provide the basis for programmatic guidance to the HTGR Technology Program:

- Major process heat and future synthetic fuel markets may exist for the HTGR in temperature regimes compatible with 750°C HTGR plant technology.

- An even broader market potential may exist for HTGR plants operating in an 850°C temperature regime, and such plants appear to have the potential to evolve to even higher temperature applications (950°C).

Accordingly, the approach taken to structure the FY 1981 Technology Program has as its basis the continuation of activities to characterize design and development requirements for HTGR plants in 750°C and 850°C regimes with additional work to support meaningful assessments of the potential for achieving 950°C operating levels. For the purposes of FY 1981 planning activities, and until redirection occurs as the result of findings within Application Studies, reference plant configurations are as described in the "HTGR Steam Cycle/Cogeneration Application Study: Interim Report" for the 750°C temperature regime and in the "HTGR Reformer Application Study: Interim Report" for the high-temperature regime. For the reformer plant, emphasis is on 850°C core outlet temperature and the use of an intermediate heat exchanger. Priority is given to the resolution of the critical issues identified for these plants in the interim reports noted above. Review and coordination meetings for major areas of work will be conducted in the first quarter of FY 1981 to assist in uniformly focusing contractor work on program objectives within this framework.

A key activity within the Technology Program during FY 1981 is directed at defining the current status of HTGR technology and the effort remaining before that technology can be assumed by industry for the most important HTGR applications. The results of these efforts are termed Technology Program Baseline, which will be developed in a three-step process:

1. Based on the reference plant configurations described in the interim report, Design Data Needs will be identified.

2. From the Design Data Needs (which also serve as guidance for FY 1981 programs), Development Plans will be produced which describe system and component development strategies and identify major testing facilities in addition to associated costs and schedules.

3. From this body of information, recommendations regarding allocations and priorities will be provided and appropriate work areas to be supported by DOE will be established. The result will be a carefully defined body of work which will be committed in accordance with an appropriate schedule and allocated resources. This carefully defined effort will comprise the Technology Program Baseline.

In a parallel process, an extensive evaluation of management techniques appropriate to the needs of the HTGR Technology Program will be conducted. It is intended to integrate the experience derived in the first quarter FY 1981 effort to focus program activities with the planning framework established through the Development Plans to determine the requirements for a management system and a plan for its implementation.

In summary, the focal planning activity for the HTGR Technology Program is centered on establishing Development Plans for the reference plant configurations identified in FY 1980 Application Studies. These Development Plans will provide:

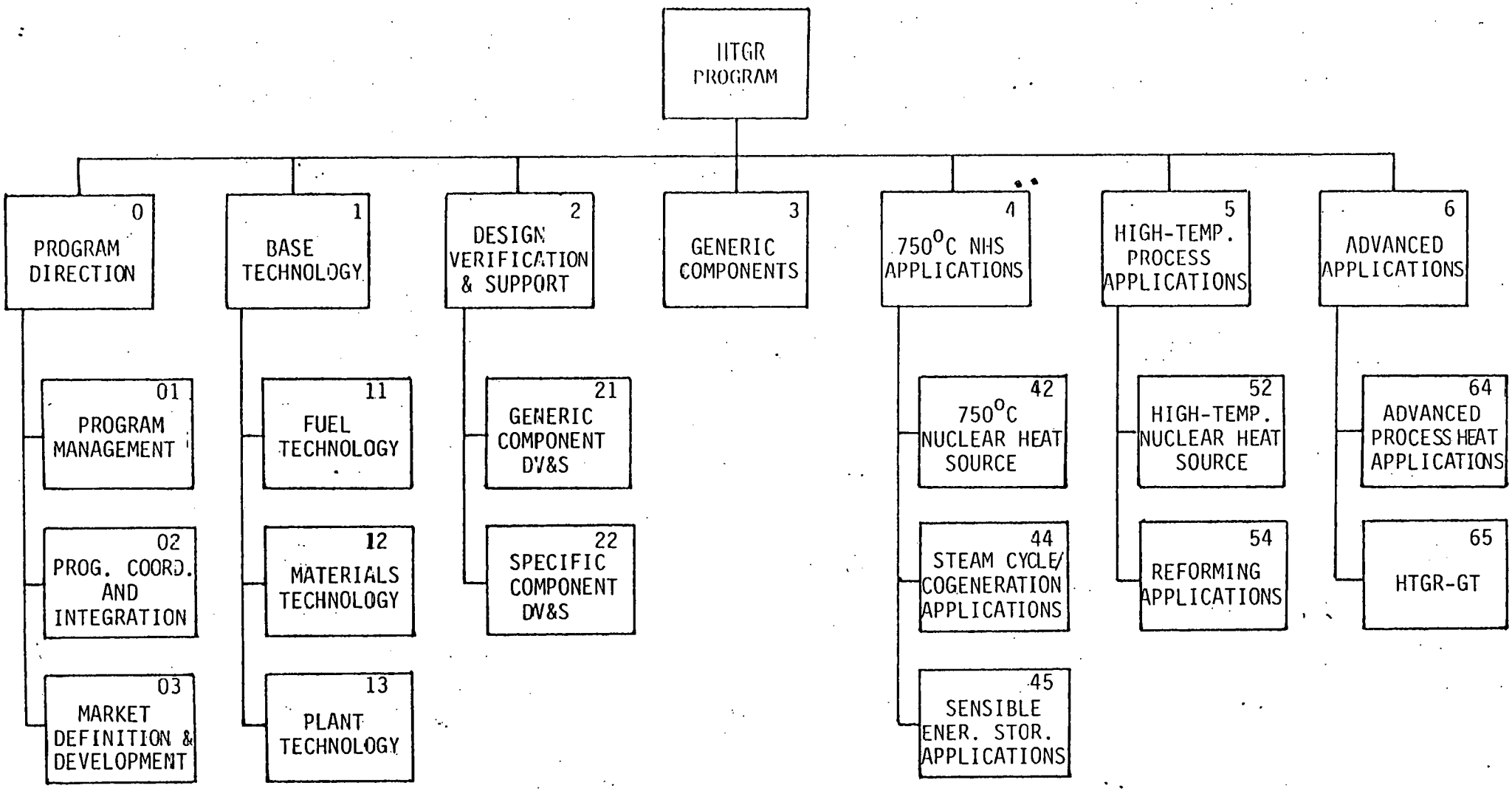
- Reference plans and points of departure for evaluating candidate systems identified in FY 1981 Application Studies as they evolve.
- The basis for allocating resources to Technology Program activities such that agreed-upon priority issues are emphasized.
- The basis from which the HTGR Technology Program Baseline can be evolved.

FY 1980 WORKSCOPE OUTLINE

Based upon the previously described program logic and structure, a Work Breakdown Structure (WBS) (Figure 5) and summary-level task descriptions have been developed and are presented within this section. It is intended that these be utilized by all Program participants for the planning and development of detailed work plans which will be used for the reporting and control of these activities.

SCHEDULE BASIS

Table 1 provides a schedule outline which should be used for Technology Program planning. As a first-order assumption, the depicted schedule is intended to be broadly representative of that which might pertain to 750°C and high-temperature lead plant applications.



HTGR PROGRAM
SUMMARY-LEVEL WORK BREAKDOWN STRUCTURE

Rev. 0
10/15/80

TABLE 1

Schedule Outline

I. Program Definition - 81

- Identify application priorities
- Identify priorities for development/deployment
- Establish Technology Program Baseline

II. Project(s) Definition - 82

- Prepare decision package
- Complete long-term definition and plan
- Define international arrangements

III. Plant(s) Design - 83-87

- Complete design and licensing in detail sufficient to support decision for plant(s) construction
  - PSAR/EIR
  - Design of long lead components
  - Detailed cost and schedule based upon actual equipment cost and delivery dates
- Construction permit (or equivalent in 1987)

IV. Construction and Startup - 88-93/95

- Complete design and construction
- Obtain operating license
- Start up tests and begin operations

V. Demonstration - 94/96-2000

- Demonstrate lead plant
- Effect transition to commercial status
- Continue follow-on applications

WBS 01: PROGRAM MANAGEMENT

Work Summary:

Program Management comprises the planning and management of HTGR Program technical activities at and below the participant level.

Work Statement:

The efforts of HTGR Program participants in the planning and management of technical programs and related functions are included within the scope of this task. It excludes Program Coordination and Integration activities at the program summary level which are defined within WBS Element 02. Typically included within the scope of this task are the following:

- Development of detailed program plans and work plans at the participant level and below in support of the objectives and approach identified in the Summary-Level Program Plan.
- Provision of schedule and resource estimates for planned activities.
- Management of technical programs in accordance with established plans.
- Provision of required reports and documentation.

WBS 1 consists of supporting subtasks as follows:

GC01 - Program Management (GCRA)

Comprises management of GCRA technical activities.

GA01 - Program Management [General Atomic Company (GAC)]

Comprises technical management of the GAC Applications, HTGR Plant Technology, and HTGR Fuel Technology Programs.

GE01 - Program Management [General Electric Company (GE)]

Comprises technical management of the GE Gas-Cooled Thermal Reactor Program and the GE Advanced Gas-Cooled Nuclear Reactor Materials Evaluation and Development Program.

OR01 - Program Management [Oak Ridge National Laboratory (ORNL)]

Comprises technical management of the ORNL High-Temperature Gas-Cooled Reactor Program.

Cost Summary:

	GCRA	GAC	GE	ORNL
DOE				
Private				
Total				

Schedule/Milestone Summary:

1.	Status Reports	Monthly
2.	Initial program plan submittal	10/80
3.	Program plan update in accordance with Summary-Level Program Plan	12/80

MILESTONE RESPONSIBILITY																									
MILESTONE / WBS	1	2	3																						
GC01	P	P	P																						
GA01	P	P	P																						
GE01	P	P	P																						
OR01	P	P	P																						

KEY: P = Primary S = Supporting R = Review

WBS 02: PROGRAM COORDINATION AND INTEGRATION

Work Summary:

Program Coordination and Integration comprises assistance to DOE in the definition of the HTGR Program at the summary level and in the coordination and integration activities required for its execution. It further includes the input of user perspective to program technical activities and assistance to DOE in the evaluation of program technical results.

Work Statement:

WBS 02 currently includes the following supporting subtask:

GC02 - Program Coordination and Integration (GCRA)

GCRA activities in support of Program Coordination and Integration are organized into four supporting elements of work which are described as follows.

Program Definition

Program Definition includes those activities directed to the establishment of overall HTGR Program objectives and strategy and the development of summary-level program plans. It further includes coordinating activities related to development of supporting program plans. Specific activities include the following:

- Objectives and Strategy Development - Conduct studies and investigations to support the identification of HTGR Program objectives. Develop and evaluate HTGR Program strategy options.

- Program Planning - Coordinate the development of summary-level HTGR Program plans to achieve program objectives within the context of available resources. Coordinate the development of supporting program plans by other program participants.

Program Review and Control

Program Review and Control includes development, implementation, and maintenance of systems and procedures to meet DOE Performance Measurement System/Cost and Schedule Control System objectives and requirements. It further includes the development of program integration and configuration control procedures. Specific activities include the following:

- Performance Measurement - Conduct management system reviews and analyses to determine technical progress. Evaluate system effectiveness and monitor cost relationships. Make timely recommendations to DOE to maintain cost and schedule control.

- Program Integration - Develop procedures for program integration and interface relationships. Coordinate the development of an integrated reporting system and work breakdown structure.

- Configuration Control - Develop a procedure for configuration control and document through appropriate standards and specifications.

Technical Coordination and Evaluation

Technical Coordination and Evaluation includes assistance to DOE in the coordination of the HTGR Program at the summary level. It further includes utility/user perspectives as input to technical activities and assistance to DOE in the evaluation of program technical results. Specific activities include the following:

- Technical Coordination - Assist DOE in the technical coordination of the HTGR Program as defined in the summary-level HTGR Program Plan and in supporting participant plans. In particular, assist in further defining and coordinating technical interfaces among program participants.

- Utility/User Requirements - Provide the utility/user perspective regarding technical issues and requirements. Document these perspectives in the form of functional specifications, topical reports, etc.

- Technical Evaluations - Assist DOE in evaluating the technical results of the HTGR Program from the utility/user perspectives.

Licensing Coordination

Licensing Coordination includes coordinating activities related to the development of safety, licensing, and environmental plans. It further includes utility/user review and evaluation of safety, licensing, and environmental information. Specifically included are the following activities:

- Safety and Environmental Assessment - Identify and investigate major safety issues in the various HTGR applications of interest and appraise DV&S requirements for resolution of these issues and for the licensing of the HTGR.

- Licensing Interface - Develop and maintain an appropriate interface with participants. Plan and conduct periodic meetings to present licensing positions and to evaluate safety and licensability of applications under consideration. Maintain a current perspective of NRC plans for regulation of the nuclear industry resulting from TMI and review any future research activities the agency plans in support of HTGR safety.

- Utility Interface - Maintain a technical interface with participating utilities on siting and licensing of HTGR systems.

Cost Summary:

	GCRA
DOE	
Private	
Total	

WBS 03: MARKET DEFINITION AND DEVELOPMENT

Work Summary:

Market Definition and Development includes the program effort required to identify and characterize potential HTGR markets. In FY 1980, primary emphasis was placed upon determining market size. In FY 1981, additional emphasis will be placed upon evaluation of market characteristics which impact accessibility. Also included within this task are GCRA activities in the development and maintenance of an active interface with utilities/users.

Work Statement:

Investigations will be conducted to identify potential HTGR markets and to characterize those markets in terms of size and accessibility. Particular emphasis will be placed upon those markets which are important to national energy goals, i.e., displacement of oil and gas.

During FY 1980, emphasis was placed upon market identification and growth projections through 2020. A principal conclusion of that effort was that while the industrial and synfuels markets offer significant potential, market characteristics which bear upon accessibility are a key element to be considered. Unit plant size, geographic distribution, capacity factors, availability requirements, and operating parameters are examples of such characteristics.

During FY 1981, characteristics such as the above will be further explored and matched against proposed HTGR applications. Specifically included in these investigations will be the industrial process heat market, the synthetic fuels market, and the load-following electrical generation market.

In the course of these investigations, applications will be identified for detailed application and/or site specific studies to be conducted under WBS Elements 4 and 5.

The following subtasks are included within the context of this WBS element:

GC03 - Market Definition and Development (GCRA)

Under this subtask, GCRA will conduct activities which are summarized as follows:

- Develop and maintain an active interface with utilities/users with a potential interest in HTGR applications. Plan and conduct periodic technical meetings with utility/user technical advisory committees. Develop appropriate support from other utility/user organizations into the HTGR Program.
- Evaluate current experience with central station cogeneration and district heating projects in the U.S. and Canada.
- Subcontract for specialized studies regarding industrial process heat and/or synfuels market characteristics.

GA03 - Process Applications Evaluations [General Atomic Company (GAC)]

Under this subtask, GAC will:

- Conduct further studies to identify and evaluate the process heat energy market.
- Identify preferred HTGR system characteristics for identified markets and establish scenarios for deployment.
- Evaluate cost and benefits for deployment.

GE03 - Market Definition and Assessment [General Electric Company (GE)]

Under this subtask, GE will:

- Establish application-specific factors that impact HTGR configurations and estimate the total projected market for each application of interest through 2020.
- Estimate market penetration as a function of product cost for applications of interest.

OR03 - Application and Project Assessment [Oak Ridge National Laboratory (ORNL)]

Under this subtask, ORNL will:

- Evaluate the relative merits of energy distribution via steam transport, heat transfer salt, thermochemical pipeline, and coal gasification techniques.
- Conduct further evaluations of HTGRs for synthetic fuels applications.

WBS 11: FUEL TECHNOLOGY

Work Summary:

This task includes activities performed by Program Contractors to develop and qualify the fuel for application in HTGR plants. Included is the development of fuel processes, fuel materials, fuel cycles, and fission product/coolant chemistry.

Current work is focused on the identification and resolution of critical issues associated with the selection and demonstration of the reference LEU/Th fuel cycle. Priority is assigned to those technology areas necessary to demonstrate the fuel cycle for 850°C applications. This task further includes scoping work essential to defining a program for demonstrating the reference fuel performance in the 950°C temperature regime. The program is structured to provide an orderly selection of the reference fuel cycle through carefully selected and thoroughly reviewed criteria.

Work Statement:

The work included in this task includes the development of fuel fabrication processes; fuel design, testing, and analysis; and fuel fission product/coolant chemistry. Currently, this task includes the following:

GA11 - Fuel Technology [General Atomic Company (GAC)]

Under this supporting subtask, GAC will perform the following work:

- Fuel Process Development

  This work is directed toward establishing, characterizing, and qualifying LEU fuel fabrication processes and equipment for advanced HTGR fuel. This work is in support of the reference LEU/Th fuel cycle selection and places emphasis upon establishing process feasibility for the LEU fissile kernel and improved coatings for the LEU/Th fuel for the advanced, high-temperature application (850°C). Quality control techniques are being developed on a priority basis to improve the detection of defective particles, since defective particles are a major contributor of in-core fission product release.

- Fuel Materials Development

  This work is directed toward the design, testing, and analysis of candidate fuels in support of the selection and confirmation of the reference fuel. Priority tasks include in-pile and out-of-pile fuel testing to characterize performance under normal and off-normal conditions; and fuel performance model development work for predicting fission product release under these conditions. This work area also includes the development of fuel design and engineering data and fuel product specifications which are essential for supporting interfacing activities with fuel manufacturing, licensing, and core design.

- Fuel Cycle

  This task emphasizes the establishment of criteria for the reference LEU/Th fuel cycle through evaluation of critical fuel cycle parameters such as mass flows, costs, enrichments, etc. The task provides a necessary interface between reactor core designs, fuel development, and fuel manufacturing by evaluating the acceptability of a given fuel cycle. This includes fuel cycle cost studies, long-range strategy development, and fuel cycle transitional analysis from LEU/Th to HEU fuel cycles.

- Fission Product/Coolant Chemistry

  Work under this task is directed toward providing the necessary analytical and experimental data base in the areas of fission product release and transport and coolant impurities interactions with primary circuit components. Primary emphasis is placed upon LEU fuel performance evaluations and predictions in support of core design efforts and the reference fuel selection process. The impact that water ingress and subsequent fuel hydrolysis has on fission gas release is assigned a high priority.

OR11 - Fuel Technology [Oak Ridge National Laboratory (ORNL)]

Under this supporting subtask, ORNL will perform the following:

- HTGR Fuel Chemistry

  Primary work areas include basic studies of fission product transport through reactor core/primary circuit materials and place emphasis on improving the data base for LEU fuels which is deficient in many of these areas. The work includes fission product sorption/desorption on steam generator alloys and core graphite, tritium transport, and actinide metal diffusion. These broad-based fission product chemistry studies provide a necessary experimental data base for analytical studies in support of core design, licensing, and safety activities.

- HTGR Fuels

  Under this category at ORNL, both fuel materials development and process support work is being performed. In the area of fuel materials, the major efforts emphasize post-irradiation examination of fuel irradiation experiments. The unique hot-cell examination facilities allow a more quantifiable evaluation of fuel particle performance than other available facilities in the U.S. Several joint U.S./FRG tasks under the Umbrella Agreement are also being conducted, again primarily because of the unique post-irradiation examination facilities. Fuel process development work is focused on a few key areas and is aimed at attaining a better understanding of the underlying physical principles controlling either the process or product performance. Emphasis is placed on the LEU-fissile fuel particle, and this work will aid in the reference fuel selection process.

Contractor workscopes will be reviewed and coordinated in meetings to be held during the first quarter of FY 1981.

Cost Summary - WBS 11:

($1000s)	Fuel Process Dev.	Fuel Materials Dev.	Fuel Cycle	Fission Product/ Coolant Chemistry	Totals
GAC	1346	1850	377	920	4493
(Cap. Equip.)	(645)	(90)	(0)	(80)	(815)
ORNL	400	630	--	410	1440
(Cap. Equip.)	(0)	(172)	(--)	(66)	(238)
Totals	1746	2480	377	1330	5933
(Cap. Equip.)	(645)	(262)	(0)	(146)	(1053)

Milestones:

0.	Issue Reference Fuel Selection Criteria (FY 1980 Milestone to be reviewed during FY 1981)	10/80
1.	Establish fuel cycle parameters for preliminary fuel cycle selection	1/81
2.	Issue fuel design data needs report	3/81
3.	Define the fuel technology baseline and test facility requirements	3/81
4.	Complete LTR on fuel performance under hypothetical accident conditions	8/81
5.	Document LEU-fissile kernel process status	9/81
6.	Select reference fuel	9/81

MILESTONE RESPONSIBILITY

WBS \ MILESTONE	0	1	2	3	4	5	6
GA11	P	P	P	P	P	P	P
OR11	R	R	R	S	R	R	S
GCO2*	R	R		R	R		R

KEY: P = Primary S = Supporting R = Review

*GCRA activities performed under WBS 02 workscope.

WBS 12: MATERIALS TECHNOLOGY

Work Summary:

This task includes activities performed by Program Contractors to characterize and qualify materials for application in HTGR plants. Included is the development of graphite, ceramic, and metallic materials. This work is focused on the early resolution of feasibility issues with priority assigned to the reference indirect cycle plant with 850°C core outlet temperature. It further includes scoping work essential to defining a program for the development of materials suitable for application in 950°C temperature regimes. It is structured to provide for a thorough progression of materials data base acquisition through the temperature and environmental regimes encountered in the most important HTGR applications. This work is coordinated through the activities of the Materials Coordinating Committee and specialist coordinators to support the design data needs identified for reference applications.

Work Statement:

Materials technology is divided into Graphite Materials Development and Metallic and Ceramic Materials Development:

Graphite Materials Development

This work is directed toward characterization and qualification of candidate graphite materials for the HTGR core and reactor internals. This includes determination of mechanical and creep properties relevant to the environment and loading histories; characterization of environmental effects such as irradiation and coolant chemistry (oxidation); definition of materials behavior to system loads such as variations in gas pressure and seismic events; and the definition of materials availability and fabricability.

GA12 - Materials Technology Graphite [General Atomic Company (GAC)]

Under this task, GAC will:

- Investigate fuel block graphite.
  - PIE on specimens from OG-5 for effects of irradiation on dimensional stability.
  - Develop non-linear, multiaxial material behavior model.
- Investigate core support floor block graphite.
  - Evaluate alternate materials to PGX, including the German material ASR-1RG, as one means of resolving oxidation problems.
  - Continue characterization of PGX to oxidizing environment.

- Investigate graphites for core support posts and seats.
  - Develop triaxial failure stress models and multiaxial fatigue models.
  - Perform mechanical properties tests on 2020 to develop statistically significant data sets in support of graphite design criteria.
  - Develop acceptance test criteria.
  - Evaluate the German graphite V-483-T as an alternative to 2020.
- Investigate graphites for permanent side reflectors.
  - Evaluate replacement to the reference HLM which is no longer commercially available.

OR12 - Materials Technology - Graphite Development [Oak Ridge National Laboratory (ORNL)]

Under this task, ORNL will:

- Conduct graphite creep irradiations at Oak Ridge Research Reactor (principally on fuel element graphite).
  - Complete capsule irradiations at 600°C and 900°C.
  - Design capsule for 1250°C.
- Conduct graphite irradiation stability experiments at High Flux Isotope Reactor (principally fuel element and reflector materials).
  - Irradiate capsule at 900°C (six cycles).
  - Irradiate capsule at 500°C (five cycles).
- Fracture mechanics studies (principally fuel element and core support post materials).
  - Characterize stress/strain and microstructure preparatory to the use of acoustic measurement methods.
  - Incorporate the use of Weiball statistical methods for data correlation.
- Graphite oxidation studies (principally fuel element and core support post materials
  - Evaluate ASR-1RG German graphite.
  - Evaluate strength loss due to oxidation.
  - Theoretical treatment of oxidation kinetics.

Metallic and Ceramic Materials Development

This work emphasizes the characterization of materials for applications in the highest temperature regimes of the HTGR. Included are work tasks to quantify the effects of creep fatigue, thermal aging, reactor coolant impurities, and surface and wear phenomena. In addition, work is conducted to establish fabrication and joining processes relevant to the parts and components unique to the HTGR.

GA12 - Materials Technology - Metallic and Ceramic Materials Development [General Atomic Company (GAC)]

Under this task, GAC will:

- Provide materials property data on candidate metals and ceramics for use in HTGR environment up to 850°C.
- Evaluate material candidates for use up to 950°C.
- Coordinate activities with other contractors through the Materials Coordinating Committee.

To this end, the materials program at GAC includes tests to provide data on:

- High-temperature strength/fracture toughness behavior of alloys and welds.
- Fatigue and creep-fatigue behavior of alloys at service conditions.
- Thermal aging behavior.
- Ceramics strength and toughness.
- Friction/wear behavior of metals/coatings.
- Primary coolant gas corrosion (carburization) behavior of alloys.
- Design data correlations for IHX materials.
- Properties of experimental cast thermal barrier cover plates.
- Criteria for tube buckling under external pressure.

GE12 - Materials Technology - Metallic and Ceramic Materials Development [General Electric Company (GE)]

Under this task, GE will:

- Conduct screening creep, precision creep, and mechanical properties tests on alloys/coating systems in the temperature range of 750°C to 1050°C.
- Evaluate thermal stability and coolant corrosion of alloy/coating systems in the temperature range of 750°C to 1050°C.

OR12 - Materials Technology - Metallic and Ceramic Materials Development [Oak Ridge National Laboratory (ORNL)]

Under this task, ORNL will:

- Conduct mechanical property tests of leading commercial alloys for high-temperature applications: Inconel 617, Hastelloy X, and Hastelloy N.
- Conduct studies on corrosion mechanisms and the effects of fission products such as tellurium and cesium.
- Conduct impact testing of PCRV liner steels.

Since a given material may be used in several different components and since efficienct use of laboratory resources requires that workscopes be defined by type of material and type of test, it is seldom meaningful to assign a distinct relationship to a given task and the resolution of a particular materials issue. The Materials Coordinating Committee (or specialist group in the case of graphite) provides the forum for interpreting program objectives and priorities and coordinating workscopes for efficient utilization of equipment and the timely resolution of issues. Contractor workscope definition will be refined in the first quarter of FY 1981.

Cost Summary - WBS 12:

($1000s)	Graphite Development	Metallic & Ceramic Materials Development	Totals
GAC	1288	2167	3455
(Cap. Equip.)	(55)	(230)	(285)
GE	--	1632	1632
(Cap. Equip.)	--	(250)	(250)
ORNL	1150	1200	2350
(Cap. Equip.)	(100)	(85)	(185)
Totals	2438	4999	7437
(Cap. Equip.)	(155)	(565)	(720)

Schedule/Milestone Summary - WBS 12:

1.	Design data needs presentations	11/80
2.	Report on strengthening materials used in fuel elements	12/80
3.	Define materials technology baseline	3/81
4.	Report on external pressure tube buckling criteria	6/81
5.	Report on cast thermal barrier coverplates	8/81
6.	Report on feasibility and program to achieve 950°C	9/81
7.	Report feasibility of coating/cladding systems on IHX tubes	9/81

MILESTONE RESPONSIBILITY

WBS \ MILESTONE	1	2	3	4	5	6	7
GA12	P	P	P	P	P	P	P
GE12	R	R	P	S	S	P	P
OR12	R	S	P	S	S	P	P

KEY: P = Primary S = Supporting R = Review

WBS 13: PLANT TECHNOLOGY

Work Summary:

This work task embodies those activities oriented at analytical methods development, safety and reliability, engineering technology and technology transfer. This work is generally applicable to multiple plant applications as well as multiple components and sytems within a plant. The focus of these activities is to support the identification and resolution of key technical constraints and uncertainties fundamental to the HTGR. These activities address the development of basic engineering criteria unique to the HTGR. Such criteria are essential to the determination of the feasibility of the various candidate HTGR applications and contribute to the identification of Design Data Needs.

Work Statement:

This work may be divided into four major categories:

- Methods Development
- Engineering Technology Development
- Safety and Reliability
- Technology Transfer

Methods Development

This work entails the development and maintenance of computer codes, analytical models, and solution schemes necessary for the development and verification of methods and technologies required for the HTGR.

GA13 - Plant Technology - Methods Development [General Atomic Company (GAC)]

Under this task, GAC will:

- Develop computer programs and methods used in the design of the HTGR and verify these to meet regulatory licensing requirements.
- Emphasize development of methods to aid the solution of important design issues on the HTGR applications:
  - Core seismic analysis.
  - Fuel element dynamic stress analysis.
  - Primary loop acoustic vibrations.
  - Design methods for straight tube heat exchangers.
  - Water ingress to reactor primary systems.

GE13 - Plant Technology - Methods Development [General Electric Company (GE)]

Under this task, GE will:

- Develop methods required to assess the HTGR in process heat applications and identify requirements for system and component design and development.
  - Systems dynamics codes with models for direct and indirect cycle systems.
  - Systems optimization codes directed at reforming.

OR13 - Plant Technology - Methods Development [Oak Ridge National Laboratory (ORNL)]

Under this task, ORNL will:

- Make improvements to the ADINA finite element code for use on PCRV.

Engineering Technology Development

This work involves engineering technology development in the following areas:

- Structures
- Heat Exchangers
- Systems
- Mechanical Design

The nature of this work is to extend or develop engineering design tools and criteria through analytical and empirical methods where existing capability is inadequate.

GA13 - Plant Technology - Engineering Technology Development [General Atomic Company (GAC)]

Under this task, GAC will:

- Complete long-term behavior analysis for offset core PCRV and develop an approach for pressurized crack analysis.
- Establish new fuel block graphite design criteria.
- Evaluate applications and identify controlling loads and properties for thermal barrier materials.
- Initiate upper and lower plenum air flow tests following successful completion of water flow tests.
- Perform heat exchanger flow tests, including finned tube heat transfer and pressure drop test.

- Perform heat exchanger structural tests, including fretting and wear and helical bundle seismic tests.
- Specifications for heat exchanger materials tests, including creep/fatigue, extended life creep rupture, and properties of weld materials.
- Participate in development of ASME ISI code and evaluation criteria.

Safety and Reliability

The focus of this work is to collect the data and develop the methodology to describe the HTGR response to hypothetical events required for the licensing process. The methodology and data base also permit probabilistic assessments of plant reliabilities.

GA13 - Plant Technology - Safety and Reliability [General Atomic Company (GAC)]

Under this task, GAC will:

- Ensure that HTGR generic design features meet applicable safety and licensing criteria.
- Develop safety, reliability, and availability data for HTGR components and systems.
- Start boron migration analysis and test program to study recriticality under a core heat-up event.
- Develop methodology and evaluate design changes required for enhanced safety and investment protection.
- Evaluate NRC proposed siting criteria (NUREG-0625).
- Issue LTR on maximum hypothetical fission product release model.

Technology Transfer

Technology transfer pertains to those activities directed at assuring the utilization of information emanating from outside the DOE-sponsored HTGR Program. It includes the effort to analyze data collected in the French CEA program prior to its termination and project support of work under the Umbrella Agreement with the FRG. Also in this category is the effort to assimilate experience with the Fort St. Vrain installation into the data base for the large HTGR. Assessments of means to extend component design lives based on observed operating histories and the surveillance of Fort St. Vrain fuel performance are also in this area of work. Additional activities to be pursued in FY 1981 are reviews of other government-sponsored programs, particularly those within the Department of Defense, to determine if developmental materials used in those applications may complement the HTGR Program.

GA13 - Plant Technology - Technology Transfer [General Atomic Company (GAC)]

Under this task, GAC will:

- Continue analysis on tests performed at CEA, primarily thermal barrier tests and core flow distribution tests.
- Continue the Fort St. Vrain surveillance program on plant performance and preparations for the second fuel segment examination.
- Assist in the set-up of an additional sub-program area (materials) under the Umbrella Agreement.
- Complete the Fort St. Vrain reliability improvement programs now under way:
  - Component cycle life.
  - Single loop operation.
  - Moisture removal from the thermal barrier.

GE13 - Plant Technology - Technology Transfer [General Electric Company (GE)]

Under this task, GE will integrate and coordinate the GE program with other U.S. HTGR programs:

- Fort St. Vrain operating and performance data for control rods, steam generators, turbocompressors, and instrumentation.
- Maintain cognizance of HTGR programs in Germany, Switzerland, and Japan.

Cost Summary - WBS 13:

($1000s)	Methods Development	Eng. Tech. Development	Safety & Reliability	Technology Transfer	Totals
GAC	899	670	326	797	2692
GE	150	--	--	140	290
ORNL	110	--	--	--	110
Totals	1159	670	326	937	3092

Schedule/Milestone Summary - WBS 13:

1.	Design data needs presentation	11/80
2.	Complete HX tube grid performance tests	12/80
3.	Input to development plans	3/81
4.	Define mathematical model for graphite oxidation	6/81
5.	Complete FSV fuel surveillance robot development	8/81
6.	Revised fuel block design criteria	9/81
7.	Issue evaluation of thermal barrier design for candidate applications	9/81
8.	Develop reformer systems dynamics and optimization codes	9/81

MILESTONE RESPONSIBILITY

WBS \ MILESTONE	1	2	3	4	5	6	7	8
GA13	P	P	P	P	P	P	P	R
GE13	R	R	P	R	R	R	R	P
OR13	R	R	P	R	R	R	R	R

KEY: P = Primary S = Supporting R = Review

WBS 21: GENERIC COMPONENT DESIGN VERIFICATION AND SUPPORT

Work Summary:

This task comprises the experimental and developmental work necessary to support the evolution and verify the design adequacy of components described in WBS 3. It further includes the planning, analysis and design of test fixtures and rigs, and the validation and interpretation of test results. This work is focused on the early resolution of priority issues common to HTGR applications under consideration.

Work Statement:

The scope of this element includes testing and verification activities conducted by HTGR Program contractors on the following components and systems:

- Reactor vessel (PCRV) components.
- Neutron and region flow control.
- Fuel handling system.
- Reactor service equipment and storage wells.
- Reactor internals components.
- Reactor core engineering.
- Helium service systems.
- Core auxiliary cooling system.
- Gas waste system.

GA21 - Generic Component Design Verification and Support [General Atomic Company (GAC)]

Under this task, GAC will:

- Conduct tests on reactor vessel components.
  - Mechanical and thermal tests of ceramic core support post pads.
  - Resiliency and fluid ingress tests on fibrous insulation.
  - Vibration test on thermal barrier assemblies.
- Conduct tests on neutron and region flow control parts.
  - Prepare test plan for control and orifice assembly tests.
  - Verify thermal stability of in-core flux measurement instrumentation.

- Issue test plan for fuel handling equipment.
- Complete bayonet tube scoping tests for the core auxiliary heat exchanger.
- Conduct component screening and evaluation tests of advanced core support floor designs.
- Verify fuel element analysis methods.
  - Issue report on RWG 1 and 2 experiments.
  - Plan Fort St. Vrain fuel element impact testing.
  - Complete 2-D analysis specimens from RWG 2 and 3.
- Review data needs for core nuclear DV&S and develop necessary program.
- Prepare a plan to obtain information required for core thermal and flow design.
- Prepare a plan for fuel element corrosion and DV&S plan for control rods, plenum elements, and reserve shutdown material.
- Continue program for resolution of core fluctuation issue.
  - Issue report on potential solutions.
  - Complete 2-D fluctuation computer code.

OR21 - Generic Component Design Verification and Support [Oak Ridge National Laboratory (ORNL)]

Under this task, ORNL will:

- Conduct work preparatory to PCRV model test.
  - Develop capability to apply circumferential prestressing.
  - Develop a liner system suitable for a PCRV model test.
- Conduct an HTGR physics program to address:
  - Axial fuel zoning and temperature distributions.
  - Fuel management influences on peak temperatures for 950°C.
  - Core temperature fluctuations.
  - Control rod worth and control requirements for a PBR.
- Conduct shielding program tasks oriented at:
  - Radiation streaming through the large coolant holes in the lower core region.

- Determination of boron shielding requirements.
- Determining the effects of core support posts on the radiation levels at hot plenum thermal barrier.

- Conduct work to adapt the GCFR Core Flow Test Loop (CFTL) to the HTGR Program.
  - Develop outline of CFTL applications.
  - Design and fabricate fixtures and specimens for steam-graphite oxidation tests.

Cost Summary - WBS 21:

($1000s)	Generic Component DV&S
GAC	1866
(Cap. Equip.)	(--)
GE	--
(Cap. Equip.)	(--)
ORNL	1510
(Cap. Equip.)	(977)
Total	3376
(Cap. Equip.)	(977)

Schedule/Milestone Summary - WBS 21:

1.	Develop outline CFTL application	10/80
2.	Design data needs presentation	11/80
3.	Input to development plans	3/81
4.	Report on thermal barrier component tests	3/81
5.	Report on potential solutions for core fluctuations	6/81
6.	Verify fuel element stress analysis methods	8/81
7.	Design and fabricate hardware for steam-graphite oxidation tests at CFTL	8/81
8.	Analytical methods for core fluctuations	9/81
9.	Screening tests and evaluation of advanced core support designs	9/81
10.	Develop PCRV model circumferential prestressing capability	9/81
11.	Report on radiation levels to hot plenum thermal barrier	9/81

MILESTONE RESPONSIBILITY																							
MILESTONE / WBS	1	2	3	4	5	6	7	8	9	10	11												
GA21	R	P	P	P	P	P	R	P	P	S	S												
OR21	P	R	P	R	R	R	P	P	R	P	P												
GE21	R	R	P	R	R	R	R	R	R	R	R												

KEY: P = Primary S = Supporting R = Review

WBS 22: SPECIFIC COMPONENT DESIGN VERIFICATION AND SUPPORT

Work Summary:

This task comprises the testing work necessary to support the design evolution of key components and systems of plants being studied under Work Elements 4, 5, and 6. It also includes the planning, analysis, and design of test specimens, fixtures, and rigs, and the validation and interpretation of test results. Work in the category is focused on the early resolution of priority technical issues.

Work Statement:

Components currently identified in this category are steam generators, circulators, intermediate heat exchangers, and reformers. Where substantial work is subcontracted, the scope of the design verification and support activities is identified in the contract and reported under this work element. This category includes the planning and execution of work such as:

- Circulator bearing and seal tests.
- Steam generator air flow tests.
- The demonstration of fabrication technologies such as the feasibility of tubesheet fabrication for all heat exchangers and tube cladding processes for the IHX.

GA22 - Specific Component Design Verification and Support [General Atomic Company (GA)]

Under this task, GA will conduct DV&S of specific components.

GE22 - Specific Component Design Verification and Support [General Electric Company (GE)]

Under this task, GE will conduct DV&S of specific components.

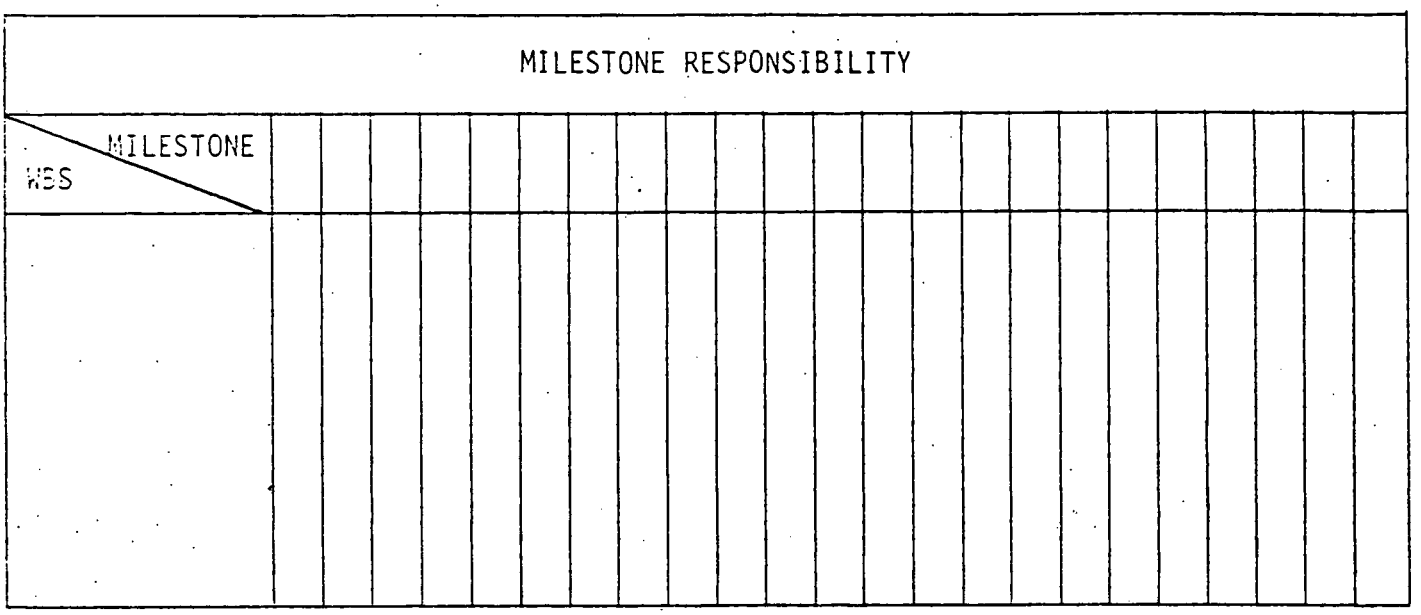
ORNL22 - Specific Component Design Verification and Support [Oak Ridge National Laboratory (ORNL)]

Under this task, ORNL will conduct DV&S of specific components.

Cost Summary - WBS 22:

GA	
GE	
ORNL	
Totals	TBD

Schedule/Milestone Summary - WBS 22:



KEY: P = Primary S = Supporting R = Review

WBS 3: GENERIC COMPONENTS

Work Summary:

This task comprises the definition and evaluation of HTGR components and systems which are broadly applicable to multiple applications. Information to be developed will be that required as input to WBS Elements 4, 5, and 6 and that required to serve as a basis for a comprehensive assessment of Technology Program requirements. Reference designs will be established and maintained for generic components and systems to provide a basis for the establishment of Data Needs Packages and Development Plans. It is specifically noted that additional design definition for some components is an integral part of the resolution of priority issues.

Work Statement:

Work Element 3 includes the definition and evaluation of HTGR components and systems which are broadly applicable to multiple HTGR applications. Currently included in this category are the following:

- Reactor vessel (PCRV) components
- Neutron and region flow control
- Fuel handling system
- Reactor service equipment and storage wells
- Reactor internals components
- Reactor core engineering
- Helium service systems
- Core auxiliary cooling system
- Gas waste system

Generic components and systems will be defined in sufficient detail to establish preferred configurations and to facilitate technical and economic evaluations. These activities comprise an input to application studies described in WBS Elements 4, 5, and 6. Additional, more detailed design and analysis will be undertaken as required to establish design data needs for selected systems and components.

As a means of focusing the Technology Program, reference designs will be established for generic components and systems. The range of applicability will be identified as an element of the reference design definitions. Upon establishment of configuration control procedures, the reference generic component and system designs will be subject to those procedures. As an interim assumption, generic system and component designs enveloping the Steam Cycle/Cogeneration and HTGR-R applications will be utilized as a reference.

Based upon the reference designs, Data Needs Packages will be prepared as input to the establishment of Development Plans and the subsequent identification of a Technology Program Baseline (see WBS Elements 1 and 2).

WBS Element 3 consists of supporting tasks by HTGR Program participants which are summarized as follows:

GA3 - Generic Component Design (General Atomic Company)

Under this supporting task, General Atomic Company will:

- Provide generic component and systems designs as input to the application studies to be undertaken within WBS Elements 4, 5, and 6.
- Establish and maintain reference designs for generic components and systems.
- Develop a Data Needs Package for generic components and systems to include:
  - Identification of design data needs ordered by systems and components.
  - A critical path schedule identifying required dates for data needs.
  - A recommended priority for each data need in accordance with a uniform procedure to be developed by HTGR Program participants.
- Assist in the establishment of Development Plans based upon the generic components and systems Data Needs Package and in the identification of a Technology Program Baseline.

GE3 - Generic Components (General Electric Company)

Under this supporting subtask, General Electric Company will investigate major issues affecting the use of the prismatic core HTGR for high-temperature and advanced process heat applications. Included will be:

- Review of reactor vessel components.
- Assess the ability of the prismatic core to operate at 950°C.
- Assess the impact of prismatic core temperature rise limitations.

Cost Summary:

(Later)

Schedule/Milestone Summary:

(Later)

WBS 42: 750°C NUCLEAR HEAT SOURCE

Work Summary:

This task includes further definition and evaluation of an HTGR Nuclear Heat Source which is designed to operate in the temperature range approximating 750°C. The 750°C Nuclear Heat Source has broad application to Steam Cycle/Cogeneration and Sensible Energy Storage configurations of the HTGR. The information developed within this task, in part, comprises input to WBS Elements 44 and 45.

Work Statement:

The effort included within this task is generally applicable to all HTGR configurations which employ the 750°C Nuclear Heat Source. It comprises specific input to WBS Elements 44 and 45. Currently this task includes the following:

GA42 - 750°C Nuclear Heat Source (General Atomic Co.)

Under this supporting subtask General Atomic Co. will:

- Conduct design activities in sufficient detail to establish the preferred configuration of the 750°C Nuclear Heat Source and to facilitate technical, economic, and institutional evaluations.
- Provide the Nuclear Heat Source design and associated cost estimates as input to WBS Elements 44 and 45.
- Perform further investigations regarding priority technical issues associated with the 750°C NHS including water ingress, graphite stresses, and thermal barrier acoustic interactions.
- Conduct studies addressing Nuclear Heat Source options regarding enhanced safety, reliability, and maintainability.
- Conduct studies required to further the understanding of NHS performance, margins, dynamics, and control characteristics.
- Support the development of licensing positions.
- Identify technical, institutional, and licensing issues and conduct additional, more detailed design of selected systems and components (e.g., circulator) to facilitate development of a design Data Needs Package, Development Plans, and a Technology Program Baseline.
- Establish and maintain a 750°C NHS Reference Design.
- Develop a Data Needs Package for the 750°C NHS Reference Design as input to WBS Elements 44 and 45.
    - Identification of design data needs ordered by systems and components for the Nuclear Heat Source.

- A recommended priority for each data need in accordance with a uniform procedure to be developed by HTGR Program participants.

- Assist in the establishment of Development Plans based upon the 750°C NHS Data Needs Package and in the identification of a Technology Program Baseline.

- Provide appropriate input to periodic and planned documentation of program results.

Cost Summary:

(Later)

Schedule/Milestone Summary:

(Later)

WBS 44: STEAM CYCLE/COGENERATION APPLICATIONS

Work Summary:

This task includes the definition and evaluation of 750°C HTGR applications in which the reactor thermal energy is utilized for production of high-quality steam (2500 psi, 1005°F). Information to be developed will be that required to evaluate specific applications in the context of market opportunities and to serve as a basis for a comprehensive assessment of Technology Program requirements. A reference design will be established and maintained to serve as a basis for the establishment of Data Needs Packages and Development Plans. Excluded from this task are specific design and evaluation activities addressing the 750°C nuclear heat source which are included within WBS Element 42 and generic components which are included within WBS Element 3.

Work Statement:

Work Element 44 comprises the definition and evaluation of HTGR applications in which the 750°C nuclear heat source is utilized for production of high-quality steam (2500 psi, 1005°F). Design of the 750°C nuclear heat source is included in WBS Element 42. Design of generic components is included in WBS Element 3.

Integrated plant designs will be produced for specific applications. Design activities will be conducted in sufficient detail to establish preferred plant configurations and to facilitate technical, economic, and institutional evaluations. Additional, more detailed design will be undertaken as required to establish design data needs for selected systems and components. In completing these activities, maximum use will be made of existing data developed through prior studies.

As a means of focusing the Technology Program, a reference design will be established and maintained. Upon establishment of configuration control procedures, the reference design will be subject to those procedures. As an interim assumption, the reference design will be that documented in the Steam Cycle/Cogeneration Application Study: Interim Report.

Based upon the reference design, Data Needs Packages will be prepared as input to the establishment of Development Plans and the subsequent identification of a Technology Program Baseline (see WBS Elements 1 and 2).

Results of these application studies will be documented through a comprehensive update of the HTGR Steam Cycle/Cogeneration Application Study: Interim Report. Additional documentation will be provided through appropriate supporting topical and periodic reports.

WBS Element 44 consists of supporting tasks by HTGR Program participants which are summarized as follows:

GA44 - HTGR-Process Steam/Cogeneration (General Atomic Company)

Under this supporting task, General Atomic Company will:

- Support agreed-upon application studies for detailed evaluation. Included for consideration are the following typical applications:
  - Process steam/cogeneration as applied to large industrial users.
  - Process steam/cogeneration as applied to the development of new industrial energy parks in which the energy mix evolves from a high fraction of electricity generation to a high fraction of process steam.
  - Process steam/cogeneration as applied to selected synfuels applications (oil shale, tar sands, coal gasification, coal liquefaction).
- Conduct design activities in sufficient detail to establish the preferred plant configuration and to facilitate technical, economic, and institutional evaluations. Maximum use will be made of existing data available from prior studies.
- Using input from WBS Elements 3 and 42, develop nuclear steam supply system cost estimates as input to overall capital and product cost estimates to be produced within task GC44 (below).
- Support the development of licensing positions.
- Identify technical, institutional, and licensing issues and conduct additional, more detailed design of selected systems and components (e.g., steam generator) to facilitate development of a design Data Needs Package, Development Plans, and a Technology Program Baseline.
- Establish and maintain a Steam Cycle/Cogeneration Reference Design.
- Develop a Data Needs Package for the Steam Cycle/Cogeneration Reference Design to include:
  - Identification of design data needs ordered by systems and components for the nuclear steam supply system incremental to that provided within WBS Elements 3 and 42.
  - A critical path schedule identifying required dates for data needs.
  - A recommended priority for each data need in accordance with a uniform procedure to be developed by HTGR Program participants.
  - Identification of demonstration requirements necessary prior to unassisted commercial deployment.
- Assist in the establishment of Development Plans based upon the Steam Cycle/Cogeneration Data Needs Package and in the identification of a Technology Program Baseline.

- Provide input to a comprehensive update of the Steam Cycle/Cogeneration Application Study: Interim Report and provide additional periodic and topical reports as required for documentation of results.

GC44 - Architect/Engineering Services - Steam Cycle/Cogeneration Applications (GCRA)

Under this supporting task, GCRA will provide Architect/Engineering services as required to:

- Assist in evaluation of alternate plant configurations and parameters.
- Define the balance of plant (BOP) in sufficient detail to support technical, economic, and institutional evaluations.
- Produce a reliable and consistent BOP cost estimate and integrate that estimate with those provided by others to produce overall plant capital and product cost projections.
- Define and evaluate, as appropriate, energy distribution and utilization systems.
- Develop capital and product cost estimates for competing technologies on a consistent basis for comparative purposes.
- Provide appropriate input to the establishment of the Data Needs Package and Development Plans for Steam Cycle/Cogeneration applications.

Cost Summary:

(Later)

Schedule/Milestone Summary:

(Later)

WBS 45: SENSIBLE ENERGY STORAGE APPLICATIONS

Work Summary:

This task includes the definition and evaluation of 750°C HTGR applications in which all or part of the reactor energy is stored and/or transported in the form of sensible heat through a medium such as molten salt. Information to be developed will be that required to evaluate specific applications in the context of market opportunities and to serve as a basis for a comprehensive assessment of Technology Program requirements. A reference design will be established and maintained to serve as a basis for the establishment of Data Needs Packages and Development Plans. Excluded from this task are specific design and evaluation activities addressing the 750°C nuclear heat source which are included within WBS Element 42 and generic components which are included within WBS Element 3.

Work Statement:

Work Element 45 comprises the definition and evaluation of HTGR applications in which all or part of the reactor energy is stored and/or transported in the form of sensible heat through a medium such as molten salt. Design of the 750°C nuclear heat source is included in WBS Element 42. Design of generic components is included in WBS Element 3.

Integrated plant designs will be produced for specific applications. Design activities will be conducted in sufficient detail to establish preferred plant configurations and to facilitate technical, economic, and institutional evaluations. Additional, more detailed design will be undertaken as required to establish design data needs for selected systems and components. In completing these activities, maximum use will be made of existing data developed through prior studies.

Assuming positive results from the above, a reference design will be established and subsequently subjected to configuration control procedures when implemented. Data Needs Packages will be prepared as input to the establishment of Development Plans and the subsequent iteration of the Technology Program Baseline (see WBS Elements 1 and 2) to support these applications.

Results of these application studies will be documented through the development of a Sensible Energy Storage Application Study Report which will include definition of the reference design. Additional documentation will be provided through appropriate supporting topical and periodic reports.

WBS Element 45 consists of supporting tasks by HTGR Program participants which are summarized as follows:

GA45 - Sensible Energy Storage Applications (General Atomic Company)

Under this supporting task, General Atomic Company will:

- Support agreed-upon application studies for detailed evaluation. Included for consideration are the following typical applications:

- Central station cogeneration in which electricity is generated at the reactor site and process energy is distributed to a remote location(s).

- Satellite cogeneration in which all reactor energy is transported to a remote location(s) and electricity is generated locally to maximize use of low-grade heat otherwise wasted.

- Coupling with selected synfuels applications (oil shale, tar sands, coal gasification, coal liquefaction).

- Load following.

- Conduct design activities in sufficient detail to establish the preferred plant configuration and to facilitate technical, economic, and institutional evaluations. Maximum use will be made of existing data available from prior studies. In particular, the extensive molten salt data base developed by ORNL in conjunction with the Molten Salt Reactor Experiment will be utilized to the maximum extent.

- Using input from WBS Elements 3 and 42, develop nuclear heat source cost estimates as input to overall capital and product cost estimates to be produced within task GC45 (below).

- Support the development of licensing positions.

- Identify technical, institutional, and licensing issues and conduct additional, more detailed design of selected systems and components (e.g., He/salt heat exchanger) to facilitate development of a design Data Needs Package, Development Plans, and iteration of the Technology Program Baseline.

- Assuming positive application study results, establish and maintain a Sensible Energy Storage Reference Design.

- Assuming positive results from application studies, develop a Data Needs Package for the Sensible Energy Storage Reference Design to include:

  - Identification of design data needs ordered by systems and components for the nuclear heat source incremental to that provided within WBS Elements 3 and 42.

  - A critical path schedule identifying required dates for data needs.

  - A recommended priority for each data need in accordance with a uniform procedure to be developed by HTGR Program participants.

  - Identification of demonstration requirements necessary prior to unassisted commercial deployment.

- Assist in the establishment of Development Plans based upon the Sensible Energy Storage Data Needs Package and in the iteration of the Technology Program Baseline to support these applications.

- Provide input to an Application Study Report addressing Sensible Energy Storage applications and provide additional periodic and topical reports as required for documentation of results.

GC45 - Architect/Engineering Services - Sensible Energy Storage (GCRA)

Under this supporting task, GCRA will provide Architect/Engineering services as required to:

- Assist in evaluation of alternate plant configurations and parameters.
- Define the balance of plant (BOP) in sufficient detail to support technical, economic, and institutional evaluations.
- Produce a reliable and consistent BOP cost estimate and integrate that estimate with those provided by others to produce overall plant capital and product cost projections.
- Define and evaluate, as appropriate, energy distribution and utilization systems.
- Develop capital and product cost estimates for competing technologies on a consistent basis for comparative purposes.
- Provide appropriate input to the establishment of the Data Needs Package and Development Plans for Sensible Energy Storage applications.

Cost Summary:

(Later)

Schedule/Milestone Summary:

(Later)

WBS 52: HIGH TEMPERATURE NUCLEAR HEAT SOURCE

Work Summary:

This task includes further definition and evaluation of an HTGR Nuclear Heat Source which is designed to operate in the temperature range approximating 850-950°C. The High Temperature Nuclear Heat Source has broad application to reforming configurations of the HTGR and is a basis for extrapolation to advanced HTGR applications. The information developed within this task, in part, comprises input to WBS Elements 54, 64, and 65.

Work Statement:

The effort included within this task is generally applicable to all configurations of the HTGR which employ the High Temperature Nuclear Heat Source. It comprises specific input to WBS Elements 54, 64, and 65. Currently this task includes the following:

GA52 - HIGH TEMPERATURE Nuclear Heat Source (General Atomic Co.)

Under this supporting subtask General Atomic Co. will:

- Conduct design activities in sufficient detail to establish the preferred configuration of the High Temperature Nuclear Heat Source and to facilitate technical, economic, and institutional evaluations.
- Provide the Nuclear Heat Source design and associated cost estimates as input to WBS Elements 54, 64, and 65.
- Conduct studies required to further the understanding of NHS performance, margins, dynamics, and control characteristics.
- Support the development of licensing positions.
- Identify technical, institutional, and licensing issues and conduct additional, more detailed design of selected systems and components (e.g., circulators) to facilitate development of a design Data Needs Package, Development Plans, and a Technology Program Baseline.
- Establish and maintain a High Temperature NHS Reference Design for Reforming applications.
- Develop a Data Needs Package for the High Temperature NHS Reference Design as input to WBS Element 54.
    - Identification of design data needs ordered by systems and components for the Nuclear Heat Source.
    - A recommended priority for each data need in accordance with a uniform procedure to be developed by HTGR Program participants.

- Assist in the establishment of Development Plans based upon the High Temperature NHS Data Needs Package and in the identification of a Technology Program Baseline.
- Provide appropriate input to periodic and planned documentation of program results.

Cost Summary:

(Later)

Schedule/Milestone Summary:

(Later)

WBS 54: REFORMING APPLICATIONS

Work Summary:

This task includes the definition and evaluation of high-temperature HTGR applications in which a portion of the reactor thermal energy is utilized for production of synthesis gas through the use of reforming technology. Information to be developed will be that required to identify preferred plant configurations, to evaluate specific applications in the context of market opportunities, and to serve as a basis for a comprehensive assessment of Technology Program requirements. A reference design will be established and maintained to serve as a basis for the establishment of Data Needs Packages and Development Plans. Excluded from this task are specific design and evaluation activities addressing the High-Temperature Nuclear Heat Source which are included within WBS Element 52 and generic components which are included within WBS Element 3.

Work Statement:

Work Element 54 comprises the definition and evaluation of HTGR applications in which a portion of the energy produced by the High-Temperature (850°-950°C) Nuclear Heat Source (NHS) is utilized to convert a steam-methane mixture to synthesis gas (H_2 and CO) using the reforming process. The synthesis gas can subsequently be employed as a distribution medium for stored reactor energy (Thermochemical Pipeline) or can be used as feedstock for a chemical process such as synfuels manufacture from coal. Design of the High-Temperature NHS is included in WBS Element 52. Design of generic components is included in WBS Element 3.

Integrated plant designs will be produced for specific applications. Design activities will be conducted in sufficient detail to establish preferred plant configurations and to facilitate technical, economic, and institutional evaluations. Additional, more detailed design will be undertaken as required to establish design data needs for selected systems and components. In completing these activities, maximum use will be made of existing data developed through prior studies.

Key issues to be addressed within the context of the Reforming Application Study include the following:

- Configuration of the Nuclear Heat Source - Principal options being addressed are direct vs. indirect cycle reforming, secondary pressure vessel configuration (indirect cycle-steel vessels vs. PCPV), and primary and secondary heat exchanger design options.

- Nuclear Heat Source operating parameters - Core outlet temperatures of up to 950°C are presently under consideration. Other key parameters to be investigated include reformer/steam generator crossover temperature and core temperature rise.

- Evaluation of the Reforming HTGR for application to a wide range of potential market opportunities in the areas of energy distribution (Thermochemical Pipeline and related applications) and integrated chemical process (coal gasification and liquefaction, shale oil recovery, synthesis gas production, etc.

In addressing the issues identified above, the Reforming Application Study will comprise three principal elements to be conducted in parallel: Nuclear Reforming Design and Evaluation, Nuclear Reforming Applications Screening, and Nuclear Reforming Utility/User Applications.

The Nuclear Reforming Design and Evaluation element will principally address configurational issues and will provide an input to the selection of operating parameters. Additionally, the capital cost data to be developed will provide a basis for extrapolation to various applications as an input to computing total product costs. Within this element, designs will be developed for both the direct cycle and indirect cycle versions of the HTGR-R on the basis of open cycle reforming. Included in the study will be the Nuclear Heat Source (NHS) and the balance of plant (BOP) through the reformers and steam generators. The turbine plant and piping to the nuclear site boundary will also be included. Representative input and output parameters will be selected so as to provide a consistent basis for comparison. From a basic design point in the case of each configuration, parameters of interest, notably including core outlet temperature, reformer/steam generator crossover temperature, and core temperature rise, will be extrapolated over a range of interests. The extrapolation will take into account performance effects as well as major design impacts on systems and components (e.g., materials changes, lifetimes, etc.). Through the use of coordinated Architect/Engineering support, the direct and indirect cycle designs will be evolved on a consistent basis of safety and reliability and cost estimates will be developed using consistent economic ground rules. In addition to providing the basic data required to address configurational issues, the capital cost estimates resulting from this element will be a basis for extrapolation to various specific applications to be considered in other elements. Parametric data to be developed will form a basis along with application requirements for selecting operating parameters.

A second principal element to be included within the Reforming Application Study is Nuclear Reforming Applications Screening. Within this element, a wide variety of potential applications will be addressed. Notable examples are various coal gasification and liquefaction processes, oil recovery from shale and tar sands, synthesis gas production from light hydrcarbons, Thermochemical Pipeline concepts and others. Based upon existing data, a coordinated effort will be undertaken to identify high-interest candidates and to set priorities. For selected processes, in-depth investigations will be conducted to evaluate process systems and subsystems and to determine the potential impact of substituting HTGR-derived energy. Key elements to be addressed are conventional and nuclear energy interfaces with the process, process modifications required, present and planned use of waste streams, etc. Based upon these investigations, projections will be made regarding the feasibility of incorporating HTGR-R derived energy and the impact on product cost, resource requirements, environmental impact, etc. The effort described within this element of the Reforming Application Study will be coordinated with Application Studies addressing the Steam Cycle/Cogeneration (WBS 44) and Sensible Energy Storage (WBS 45) concepts so as to derive a common basis for comparison. Data regarding conventional processes will also be developed on a consistent basis for comparison.

The third principal element of the Reforming Application Study is Utility/User Applications. Within this element, specific utilities/users will be identified which have an interest in a site-specific study. Primary candidates for such studies

currently include Public Service Electric and Gas Company and a three-party combination of Idaho Power and Light Company, Utah Power and Light Company, and Idaho Nuclear Engineering Laboratory. Once identified, the scope of the site-specific studies will be similar in concept to the detailed screening studies described above. The additional element to be introduced, however, will be the context of an actual site coupled with its specific requirements on the integrated system. As before, these studies will be coordinated with WBS Elements 44 and 45 and will also consider competing conventional technologies.

In completing the above described studies, it is recognized that a high degree of consistency will be required in the various comparisons to be made. Further, a consensus must be reached regarding the priorities for applications screening and a basis must be provided to avoid unplanned duplication of effort. To effect these requirements, a coordinating committee will be established under WBS Element 1 to develop uniform economic ground rules and to provide a forum for coordinating respective participant efforts.

As a means of focusing the Technology Program, a reference HTGR-R design will be established and maintained. Upon establishment of configuration control procedures, the reference design will be subject to those procedures. As an interim assumption, the reference design will be the 850°C Indirect Cycle HTGR-R which is documented in the HTGR-Reforming Application Study: Interim Report completed during FY 1980.

Based upon the reference design, Data Needs Packages will be prepared as input to the establishment of Development Plans and the subsequent identification of a Technology Program Baseline (see WBS Elements 1 and 2).

Results of these application studies will be documented through a comprehensive update of the HTGR-Reforming Application Study: Interim Report initially completed during FY 1980. Additional documentation will be provided through appropriate supporting topical and periodic reports.

WBS Element 54 consists of supporting tasks by HTGR Program participants which are summarized as follows:

GA54 - 850°C Synfuel Applications [General Atomic Company (GAC)]

Under this supporting subtask, GAC will

- Advance the integrated plant design of the 850°C Indirect Cycle (IDC) HTGR-R as required to facilitate technical, economic, and institutional evaluations in the context of specific applications and to permit continued assessment of key technical issues.

- Extrapolate the 850°C IDC HTGR-R design and cost estimates to 950°C. The extrapolation will take into account major impacts on plant performance, systems and components (material changes, component lifetimes, etc.), plant optimization parameters, and other similar factors.

- Participate in a cooperative effort to design and evaluate a 950@C Direct Cycle version of the HTGR-R. The design and evaluation effort will be conducted in sufficient detail to indicate potential advantages or disadvantages relative to indirect cycle configurations. The results of this study will be used to

determine the levels of effort which could be directed to these respective options in FY 1982 beyond. GAC input to this evaluation process will include the core design, PCRV layout, major balance-of-plant requirements and consideration of safety issues.

- Participate in a coordinated study of potential reforming applications to industrial process heat and synfuels development.

- Using input from WBS Elements 3 and 52, develop cost estimates in areas of design responsibility as input to overall capital and product cost estimates to be produced within task GC54 (below).

- Support the development of licensing positions.

- Identify technical and licensing issues and conduct additional, more detailed design of selected systems and components (e.g., IHX) to facilitate development of a design Data Needs Package, Development Plans, and a Technology Program Baseline.

- Establish and maintain an HTGR-R Reference Design.

- Develop a Data Needs Package for the HTGR-R Reference Design to include:

  - Identification of design data needs ordered by systems and components for the Nuclear Heat source incremental to that provided within WBS Elements 3 and 52.

  - A critical path schedule identifying required dates for data needs.

  - A recommended priority for each data in accordance with a uniform procedure to be developed by HTGR Program participants.

  - Identification of demonstration requirements necessary prior to unassisted commercial deployment.

- Assist in the establishment of Development Plans based upon the HTGR-R Data Needs Package and in the identification of a Technology Program Baseline.

- Provide input to a comprehensive update of the HTGR-Reforming Application Study: Interim Report and provide additional periodic and topical reports as required for documentation of results.

GE54 - Application Studies [General Electric Company (GE)]

- Participate in a coordinated study of potential applications of the HTGR-R to industrial process heat and synfuels development.

- Participate in a cooperative effort to design and evaluate a 950°C Direct Cycle version of the HTGR-R. The design and evaluation effort will be conducted in sufficient detail to indicate potential advantages and disadvantages relative to indirect cycle configurations and will be used as a basis for determining the level of resources to be allocated to those respective options in FY 1982. GE participation will include reformer design and overall systems integration using input provided by GAC.

- Provide appropriate extrapolations of the 950°C Direct Cycle design to other design points of interest.

- Develop cost estimates in areas of design responsibility as input to overall capital and product cost estimates to be produced within task GC54.

- Support the development of licensing positions.

- Identify technical and licensing issues and conduct additional, more detailed design of selected systems and components (e.g., IHX) to facilitate development of a design Data Needs Package, Development Plans, and a Technology Program Baseline.

- Contribute to the development of a design Data Needs Package for the HTGR-R Reference design.

- Assist in the establishment of Prioritized Development Plans based upon the HTGR-R Data Needs Package and in the identification of a Technology Program Baseline.

- Provide input to a comprehensive update of the HTGR-Reforming Application Study: Interim Report and provide additional periodic and topical reports as required for documentation of results.

GC54 - Architect/Engineering Services - Reforming Applications (GCRA)

Under this supporting subtask, GCRA will provide Architect/Engineering services as required to:

- Assist in evaluation of alternate plant configurations and parameters.

- Define the balance of plant (BOP) in sufficient detail to support technical, economic, and institutional evaluations.

- Produce reliable and consistent BOP cost estimates and integrate those estimates with those provided by others to produce overall plant capital and product cost projections.

- Define and evaluate, as appropriate, energy distribution and utilization systems.

- Develop capital and product cost estimates for competing technologies on a consistent basis for comparative purposes.

- Provide appropriate input to the establishment of the Data Needs Package and Development Plans for HTGR-Reforming applications.

OR54 - Application and Project Assessments [Oak Ridge National Laboratory (ORNL)]

Under this supporting subtask, ORNL will

- Participate in the evaluation of the HTGR with respect to synfuels and industrial process heat applications.

- Provide a liaison with ongoing activities within ORNL fossil energy programs.

Cost Summary:

(Later)

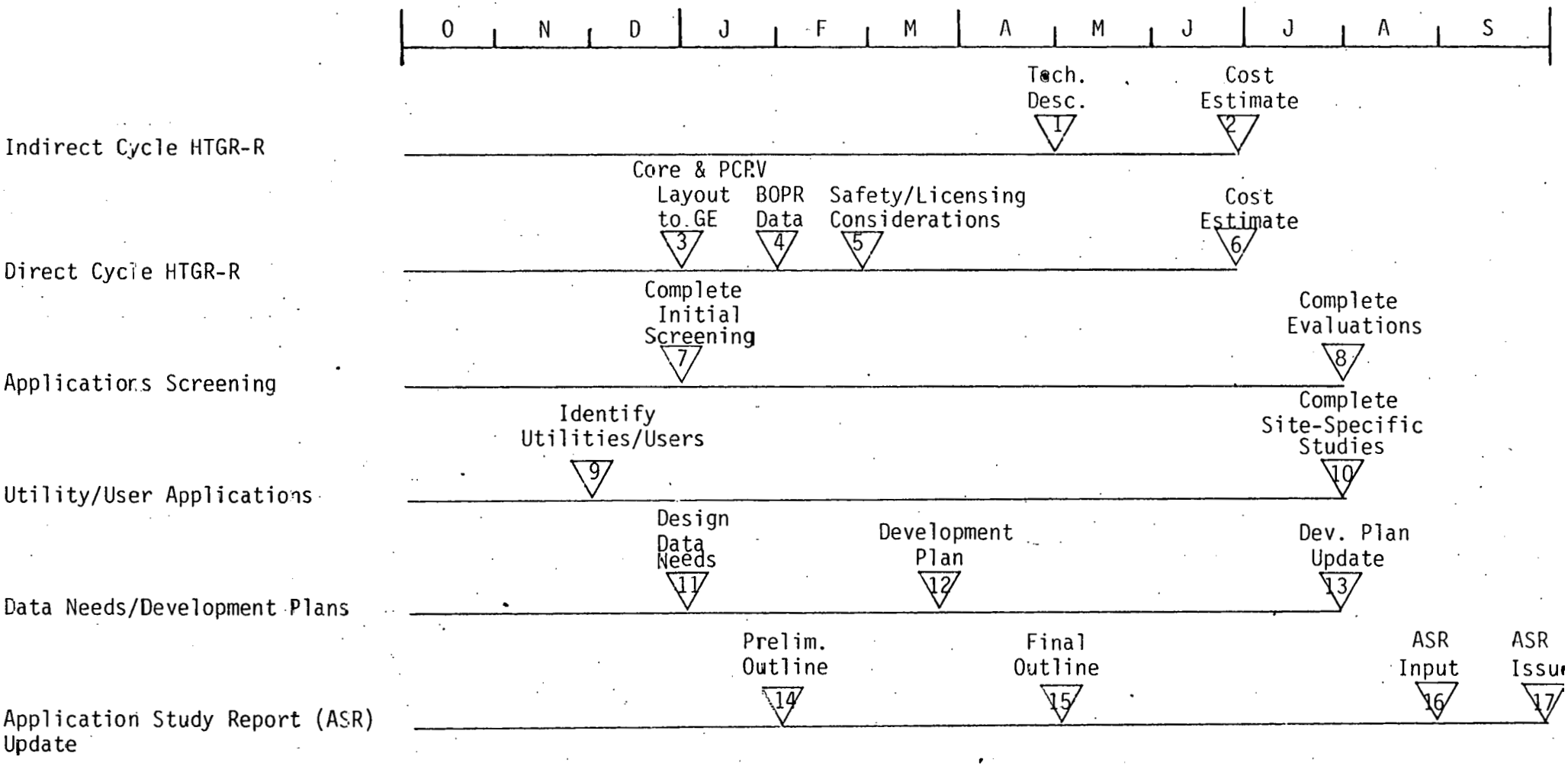
Schedule/Milestone Summary:

1.	Issue Technical Description Document	4/81
2.	Provide cost estimate for HTGR IDC	6/81
3.	Provide core and PCRV layout to GE	12/80
4.	Provide BOPR input data to GE	1/81
5.	Provide primary system safety and licensing considerations	2/81
6.	Provide cost estimate for HTGR-R DC	6/81
7.	Complete initial screening	12/80
8.	Complete initial evaluations	7/81
9.	Identify utilities/users for site-specific studies	11/80
10.	Complete site-specific studies	7/81
11.	Identify design data needs	12/80
12.	Complete development plan	3/81
13.	Complete development plan update	7/81
14.	Issue Application Study Report (ASR) preliminary outline	1/81
15.	Issue ASR final outline	4/81
16.	Provide ASR input	8/81
17.	Issue ASR	9/81

MILESTONE RESPONSIBILITY

MILESTONE / WBS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
GA54	P	S	P	P	P	S	P	P		S	P	P	P	S	S	P	S
GE54	R	R	R	R	R	S	P	P		S	P	P	P	S	S	P	S
GC54		P		R	R	P	R	R	P	P	R	R	R	P	P	P	P
OR 54							S	S		R	S	S	S	S	S	P	S

KEY: P = Primary S = Supporting R = Review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Tech. Desc.
1
Cost Estimate
2
Indirect Cycle HTGR-R
Core & PCRV Layout to GE
3
BOPR Data
4
Safety/Licensing Considerations
5
Cost Estimate
6
Direct Cycle HTGR-R
Complete Initial Screening
7
Complete Evaluations
8
Applications Screening
Identify Utilities/Users
9
Complete Site-Specific Studies
10
Utility/User Applications
Design Data Needs
11
Development Plan
12
Dev. Plan Update
13
Data Needs/Development Plans
Prelim. Outline
14
Final Outline
15
ASR Input
16
ASR Issu
17
Application Study Report (ASR) Update

WBS 64: ADVANCED PROCESS HEAT APPLICATIONS

Work Summary:

Within this task, information will be developed regarding the definition and evaluation of advanced process heat applications of the HTGR such as Steam/Carbon Gasification, Water Splitting and other process heat applications which do not utilize a reformer.

Work Statement:

Through this effort, advanced process heat applications of the HTGR will be investigated in summary level detail as a means of assessing their future potential and the estimated timing for their introduction. The results of this effort provide input to the establishment of long term Technology Program goals.

The following are included within WBS Element 64:

GA64 - 950°C Synfuel Study [General Atomic Company (GAC)]

Under this supporting subtask, GAC will:

- Develop technical information regarding the steam/carbon gasification and water splitting processes.
- Prepare design concepts for a 950°C IHX.

GE64 - System Application Studies [General Electric Company (GE)]

Under this supporting subtask, GE will:

- Evaluate the water splitting process for H_2 production with regard to design, schedule, and cost definitions and the identification of technology needs.

GC64 - Architect/Engineering Services - Advanced Process Heat Applications (GCRA)

Under this supporting subtask, Architect/Engineering services will be provided under subcontract to GCRA during FY 1981 to support the definition and evaluation of selected advanced HTGR process heat applications. The scope of this task will include balance of plant (BOP) and process plant design, layout, and cost estimate support for advanced HTGR applications such as steam/carbon gasification, thermochemical water splitting and other process heat applications which do not utilize a reformer. The purpose of this task is to provide a common basis for plant cost evaluations such that the potential of advanced systems can be identified and factored into the HTGR program plan and logic.

Cost Summary:

(Later)

Schedule/Milestone Summary:

(Later)

WBS 65: HTGR-Gas Turbine

Work Summary:

Within this task critical technical, licensing, and development issues specific to the HTGR-GT concept will continue to be addressed and assessed during FY 1981. These issues and their possible impact on HTGR-GT plant design, cost, and performance data will be identified.

Based upon the above, a projection will be made of the time period when the HTGR-GT may be expected to have sufficient economic attractiveness to begin to make significant penetrations into the general marketplace.

Work Statement

The design of the HTGR-GT plant will be assessed with respect to the consequences of postulated turbomachine failure modes. Included in this task are efforts to better define the actual failure sequence and time frame, the resulting transient condition, and its effect on plant design or safety. Design changes which accommodate these transients or sufficiently reduce their probability will be considered. The objectives of this task are to identify issues, recommend solutions, and establish a licensing position. The impact of any design changes will be assessed from a plant cost and performance standpoint to permit evaluation of the modified HTGR-GT plant commerical potential.

The above described effort will include the following supporting elements:

GA65 - HTGR-GT [General Atomic Company (GAC)]

Under this supporting subtask, GAC will:

- Investigate modifications to the HTGR turbomachine design which will prevent or mitigate the consequences of potential turbine failure accidents.
- Investigate other system and component modifications which will mitigate the effects of potential turbine failure accidents in the HTGR-GT primary system.
- Improve analytical models to better characterize the results of potential failures.
- Assess the results of the above studies in terms of plant and product costs and risks. Provide an assessment regarding the commercial potential and timing for the HTGR-GT.

GC65 - Architect/Engineering Support - HTGR-GT (GCRA)

Under this supporting subtask, Architect/Engineering services will be provided under subcontract to GCRA during FY 1981 to furnish engineering, design, and cost estimating services for the balance of plant (BOP) of the HTGR-GT. Activities will be limited primarily to review of key licensing concerns for the HTGR-GT and evaluating their impact on BOP design and capital costs. Work will continue to support the HTGR-GT market evaluation efforts, including the assessment of HTGR-GT performance improvements and dry and wet/dry cooling tower design developments.

Cost Summary:

(Later)

Schedule/Milestone Summary:

(Later)