GA–C23317

HIGH EFFICIENCY GENERATION OF HYDROGEN FUELS USING NUCLEAR POWER

for the period
February 1 through April 30, 2002

by

L.C. BROWN

Prepared under
Nuclear Energy Research Initiative (NERI)
Program. DE-FG03-99SF21888
for the U.S. Department of Energy

DATE PUBLISHED: SEPTEMBER 2002

GENERAL ATOMICS

DISCLAIMER

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High Efficiency Generation of Hydrogen Fuels Using Nuclear Power

Nuclear Energy Research Initiative (NERI)
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Technical Progress Report
February 1 through April 30, 2002

HIGHLIGHTS

- The scheme of processing the $HI/I_2/H_2O$ phase with phosphoric acid is being considered in addition to the reactive distillation scheme.

INTRODUCTION

Future nuclear reactors will operate at higher efficiencies and, therefore, at higher temperature than current reactors. High temperatures present the potential for generating hydrogen at high efficiency using a thermochemical process. Thermochemical cycles for the generation of hydrogen from water were extensively studied in the 1970s and early 1980s both in the U.S. and abroad. Since that time, thermochemical water-splitting has not been pursued in the U.S. at any significant level. In Phase 1, we reviewed and analyzed all available data to determine the process best suited to hydrogen production from the advanced nuclear reactors expected to be available in the next 20 to 30 years. The Sulfur-Iodine Cycle was selected for detailed study in Phases 2 and 3. In Phase 2, we investigated means of adapting this cycle to the heat output characteristics of an advanced high temperature nuclear reactor. In Phase 3, we are integrating the cycle and reactor into a unified hydrogen production plant.

OVERALL ASSESSMENT

The three participants: General Atomics (GA), Sandia National Laboratories (SNL) and the University of Kentucky (UK) all are working on Phase 2 tasks. Table 1 indicates the scheduled completion date of each task and actual completion date for completed tasks. Each organization participates, and to some extent in every task, but the lead organization is indicated on the task schedule, Fig. 1. The overall project is behind schedule. A no-cost extension to the period of performance will be requested.

STATUS, ISSUES AND CONCERNS

Phase 3

Develop Concepts for Auxiliary Systems (WBS Element 3.1)

A model of the thermal matching system is being modeled in Mathcad. The model considers both the case in which only thermal energy is provided to the process and the case where part of the thermal energy is provided from the reject heat of a Brayton power cycle.

Table 1
Summary of NERI Tasks — Phases 1–3

Identification Number	Milestone/ Task Description	Planned Completion Date	Actual Completion Date	Comments
1.1	Literature survey of new processes	Fri 2/25/00	Fri 2/25/00	Completed on schedule
1.2	Develop screening criteria	Fri 10/1/99	Fri 10/1/99	Completed on schedule
1.3	Carry out first round screening	Fri 3/10/00	Fri 3/10/00	Completed on schedule
1.4	Short report on conclusions	Fri 3/31/00	Fri 3/31/00	Completed on schedule
1.5	Carry Out Second Round Screening	Fri 6/2/00	Tue 5/9/00	Completed ahead of schedule
1.6	Write Phase 1 report	Fri 6/30/00	Fri 6/30/00	Completed on schedule
2.1	Carry out detailed evaluation of few processes to select one	Fri 1/26/01	Fri 1/26/01	Completed on schedule
2.2	Define reactor thermal interface	Fri 3/2/01	Tue 7/31/00	Completed behind schedule
2.3	Preliminary engineering design of selected process	Fri 3/2/01	Tue 7/31/00	Completed behind schedule
2.4	Develop flowsheet	Fri 6/29/01	Tue 7/31/00	Completed behind schedule
2.5	Conceptual equipment specifications	Fri 6/29/01	N/A	Work postponed to Phase 3 as task 3.3
2.6	Write Phase 2 Report	Fri 8/31/01		Work in progress
3.1	Develop concepts for auxiliary systems	Fri 6/28/02		Work not begun
3.2	Refine flowsheet	Fri 6/28/02		Work in progress
3.3	Conceptual equipment specifications	Fri 6/28/02		Work not begun
3.4	Size/cost process equipment	Fri 7/12/02		Work not begun
3.5	Evaluate process status	Wed 7/31/02		Work not begun
3.6	Write Final Report	Wed 7/31/02		Work not begun

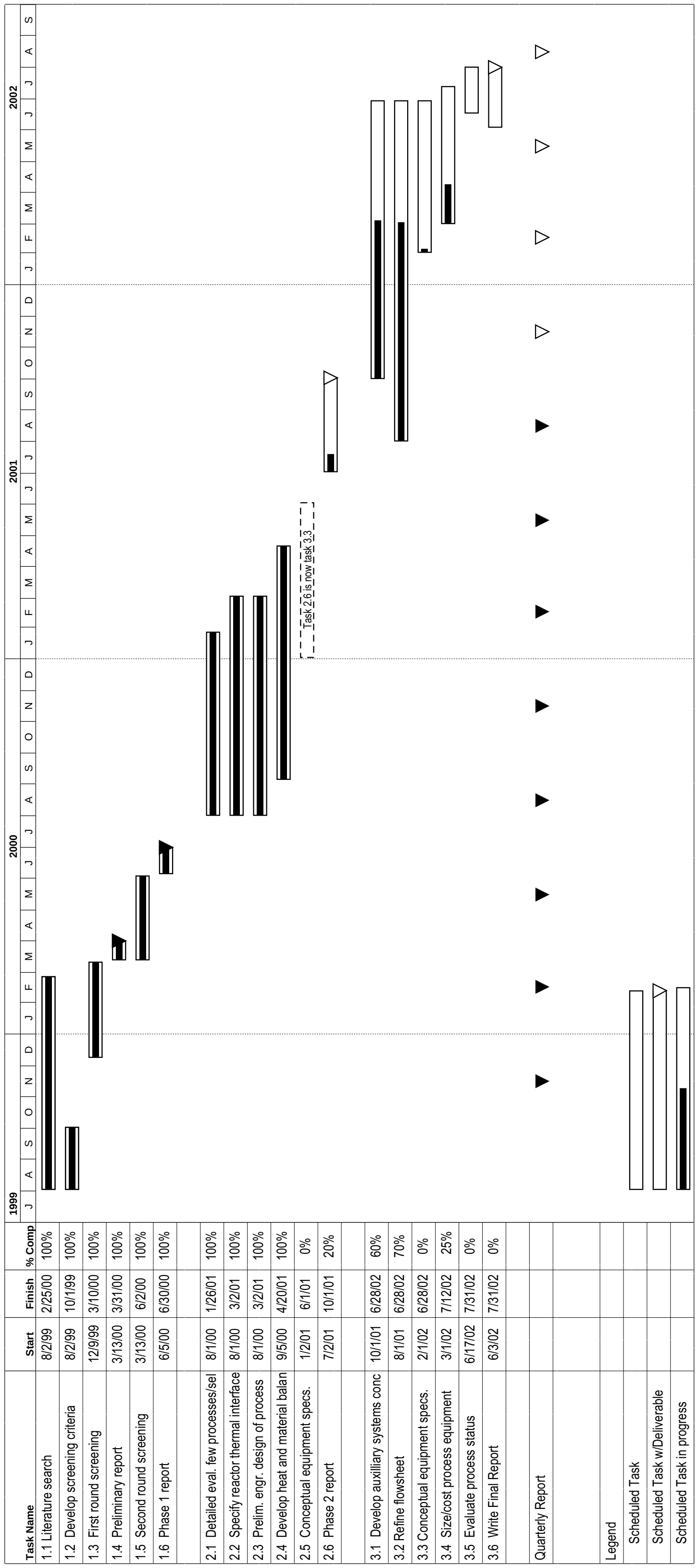

Fig. 1. Project schedule.

UNIVERSITY OF KENTUCKY GENERAL ATOMICS Sandia National Laboratories

Refine Flowsheet (WBS Element 3.2)

This task is progressing at UK and GA. Hydrogen is produced by reactive distillation of a mixture of hydrogen iodide, iodine and water according to the Knoche and Roth proposal. The ELECNRTL thermodynamic model being used to model the reactive distillation has convergence problems in the reactive distillation column. While continuing to work on this problem, the alternate method of contacting the mixture with phosphoric acid to generate pure hydrogen iodide is being revisited.

The alternative method extracts the water from the $HI/I_2/H_2O$ mixture allowing the HI and I_2 to be easily separated. The small amount of HI is decomposed at high pressure to produce hydrogen. In the original flowsheet, the water was removed from the phosphoric acid by vapor-recompression heated flash stages. The option of using the reject heat from a Brayton power cycle is being explored.

Conceptual Equipment Specifications (WBS Element 3.3)

This task has not started.

Size/Cost Process Equipment (WBS Element 3.4)

The size of the process equipment cannot be determined until the flowsheet is finished but we are far enough along to determine the costing elements that will be required. The costing methodology has been established and the calculations are being implemented using Excel spreadsheets. Once the final size of the equipment is determined, the costs will be quickly calculated from the size parameters.

Evaluate Process Status (WBS Element 3.5)

This task has not started.

NEXT QUARTER'S WORK

Work on tasks 3.1, 3.2 and 3.4 will continue.

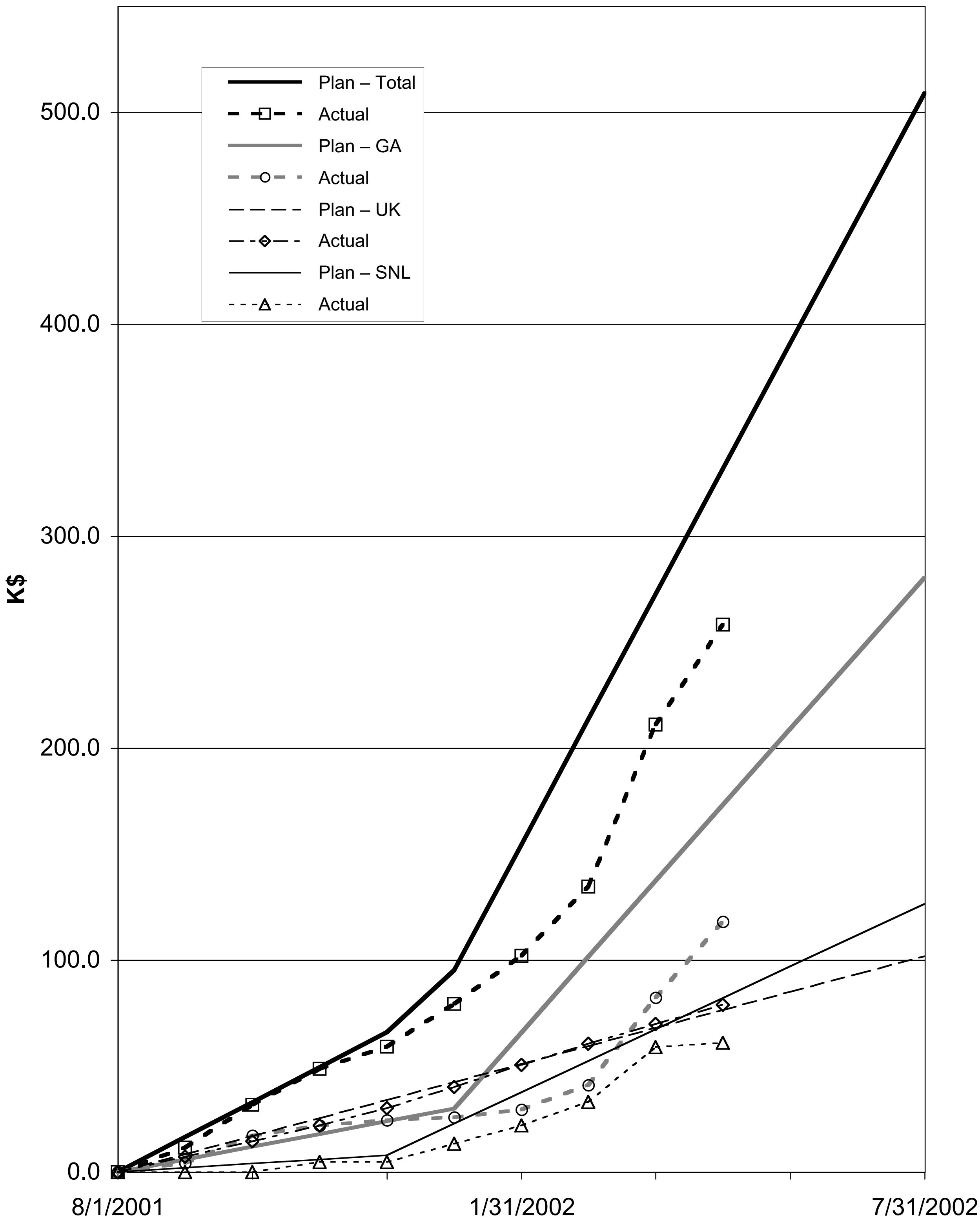

Fig. 2. Spending profile.