

PROGRAM DEFINITION AND ASSESSMENT

An essential function related to management of the overall thermal energy storage program is that of program definition and assessment. The major emphasis in this activity is the implementation of a program level assessment of thermal energy storage technology thrusts for the near and far term to assure an overall coherent energy storage program. Included is the identification and definition of potential new thermal energy storage applications, definition of technology requirements, appropriate market sectors. This activity also includes the necessary coordination, planning and preparation associated with program reviews, workshops, multi-year plans and annual operating plans for the major lead laboratory tasks. SERI assessment tasks will be coordinated and integrated into this activity.

PROGRAM DEFINITION AND ASSESSMENT
OVERVIEW

Larry H. Gordon
NASA Lewis Research Center

The activities described in this program area assume that LeRC is performing the lead center function for the DOE Thermal Energy Storage Project and therefore, include those functions related to management of the lead laboratories. A primary emphasis is placed on the implementation of overall program definition and associated thermal energy storage system evaluations. In this context the objectives are: 1) to provide overall TES program guidance and 2) to ensure timely developments/demonstrations. To achieve these objectives, a competitive contract would be awarded which would consist of the following:

- a. Conducting a supporting analysis of the current program areas with major emphasis on solar thermal applications. Storage alternatives will be identified along with technology requirements. Value comparisons will be performed and commercialization requirements will be identified.
- b. Identifying new applications and their technology requirements. New storage concepts defined and economic evaluation will be performed. Suitable demonstrations will be recommended in those application areas offering potential for substantial ROI.
- c. Assuring overall integration and coordination of thermal storage developments with the appropriate DOE end-use divisions. This task will include assessments of technical progress, coordination of development goals, and milestones. Particular attention will be given to the impact of environmental requirements.

As shown in Figure 1, the Thermal Storage Program develops reliable, efficient, inexpensive storage technologies to support other DOE or private sector end-users in their substitution and energy savings missions. Within DOE this is accomplished by technology transfer agreements between STOR and the respective end-use divisions. The lead center is responsible for ensuring that the milestones, resources, and technology transfers are accomplished. Initially, an energy storage program assessment is performed for a particular application area. If this assessment indicates that thermal energy storage is competitive with respect to other storage technologies (batteries, flywheels, etc.), then the objective/goals can be defined for a project area. The lead laboratory provides the necessary management to implement the project and provide the necessary technology for transfer to the end-user.

Lead laboratory project structure generally takes a form similar to that shown in Figure 2. System studies are application oriented and consist of concept identification, technoeconomic assessments, and conceptual design studies. Concept development activities include development of storage concepts to the point of establishing the technical feasibility and assessing the concepts based on general application requirements. Establishing technical feasibility involves both concept feasibility studies and small-scale laboratory experiments.

The subsystem development phases culminates with technology readiness or technology validation for the storage subsystem. Activities include subsystem definition, engineering development, and subscale research experiments (SRE's). Throughout these various project phases continuous efforts are directed toward generic advanced technology and exploratory research studies thus providing a supporting research and technology base.

To examine how program/project assessments relate to and influence the project structure, let us use the electric utility application area as an example. Approximately four (4) years ago, an assessment of "Energy Storage Systems Suitable for Use by Electric Utilities" was made by Public Service Electric and Gas Company of New Jersey (ref. 1). The specific objectives of this program assessment for DOE (ERDA) and the Electric Power Research Institute were:

- o Identify the potential effect of energy storage on the electric utility systems of the United States.
- o Determine the status of development and the feasibility of commercialization of candidate energy storage technologies, and establish their key technical and cost characteristics.
- o Evaluate the relative merits of energy storage options on the basis of economic, operational, and environmental factors.
- o Identify research and development needed to advance the various storage technologies.

Based on this assessment, one of the major findings was that with sufficient off-peak energy available from baseload coal and nuclear capacity, energy storage could provide generating capacity for up to 17 percent of peak load demand (kW). An energy storage technology which was considered to be competitive with conventional pumped hydro was thermal energy. Hence, a DOE (ERDA) project was created for thermal energy storage in peak following electric utility applications. (See example inserts in Figure 1).

The first project assessment conducted as part of the system studies phase was performed by Bechtel Corp (ref. 2). For near-term utility applications it was felt that thermal energy storage could be easily "retrofitted" to existing power plants. However, the project assessment concluded that high capital costs and long retrofit downtimes negated the use of thermal energy storage. On a positive side, it was recommended that thermal energy storage might be attractive for "new construction" coal and nuclear power plant application. A second assessment for New Plant Thermal Energy Systems was performed by General Electric (ref. 3).

This "new plant" assessment was quite extensive and examined some 50+ technologies applicable to thermal energy storage subsystems. From this matrix, twelve (12) concepts were selected for a detailed technoeconomic assessment as shown in Figure 3. Conceptual designs of four selected TES system concepts were integrated into conventional base loaded plant designs. These concepts, as indicated on Figure 3, were as follows:

- a. A dual media, sensible heat, thermal energy storage integrated with a high sulfur coal power plant and supplying steam to a separate peaking power conversion system.
- b. An underground, high temperature water, thermal energy storage integrated with a high sulfur coal power plant and supplying steam to a separate peaking power conversion system.
- c. An above ground, high temperature water, thermal energy storage integrated with a Pressurized Water Reactor power plant and supplying boiler feedwater preheat.
- d. A dual media, sensible heat, thermal energy storage integrated with a Pressurized Water Reactor power plant and supplying boiler feedwater preheat.

Nevertheless, the bottom line of this assessment concluded that load leveling thermal storage is only marginally competitive with baseload, coal fired, cycling plants.

How the results of the Bechtel and General Electric assessments affected the "Peak Following Thermal Storage for Steam Electric Power" project is graphically shown in Figure 4. Based on the "negative" and "marginally competitive" assessments, the planned concept development and technology validation phase of the project were redefined. Future development activities for utilities will be directed toward compressed air energy storage (CAES). CAES incidentally, was also a competitive storage technology identified by the PSE&G Program assessment.

To further emphasize the scope of these assessments, an on-going program assessment for Solar Applications Analysis for Energy Storage will be reviewed by the Aerospace Corporation. In addition, the various project assessments required for TES in Solar Thermal Electric Power Applications will be reviewed by Sandia Laboratory Livermore. The importance of all of these assessments cannot be over-emphasized as a primary means of meeting the objectives of this Program Definition and Assessment activity.

Another input used to achieve the activity's objectives is to periodically have an independent review of the Thermal Storage Program. Specifically, for this program review, a committee was established and was charged to provide DOE/STOR and its management centers with a broad, objective review of the goals, content, and accomplishments of the Thermal Energy Storage Program. In this review, the committee was directed to:

- o Include all thermal energy storage subsystem technologies (containment, heat exchange, media, controls, and institutional constraints) and technologies for heat transport.
- o Exclude thermochemical heat pump storage subsystems.

And for consistency, the following definitions were noted:

Buffering Storage	1/2 to 2 hours
Diurnal Storage	2 to 12 hours
Long (Seasonal) Duration Storage	Greater than 12 hours
Near-Term Time Frame	1980 to 1985
Mid-Term Time Frame	1985 to 1990
Far-Term Time Frame	1990 and beyond

The review committee consisted of eleven (11) members representing a cross-section of state energy departments, academia, DOD, EPRI, and the National Research Council. Members or their representatives are listed in Figure 5. Prior to this meeting, specific questions to be addressed by the committee were generated. These questions, noted in Figures 6-7, will serve as the basis not only for discussion by the committee but also for open discussions throughout the two day program meeting. Responses will be reported in the proceedings for this program review.

REFERENCES

1. (PSE&G) Public Service Electric and Gas Company, An Assessment of Energy Storage Systems Suitable for Use by Electric Utilities, Volumes 1, 2, and 3, EPRI EM-264 ERDA E (11-1)-2501; Prepared for Electric Power Research Institute and Energy Research and Development Administration; Newark, New Jersey, July 1976.
2. Bechtel Corporation, Retrofitted Feedwater Heat Storage for Steam Electric Power Stations Peaking Power Engineering Study, CONS/2863-1; Final Report prepared for ERDA; Bechtel Corporation, Research and Engineering, San Francisco, California, October 1976.
3. General Electric Company-TEMPO, "Conceptual Design of Thermal Energy Storage Systems for Near-Term Electric Utility Applications", Volume 1, 2, DOE/NASA/0012-78/1, Final report prepared for DOE under contract DEN 3-12, October 1978.

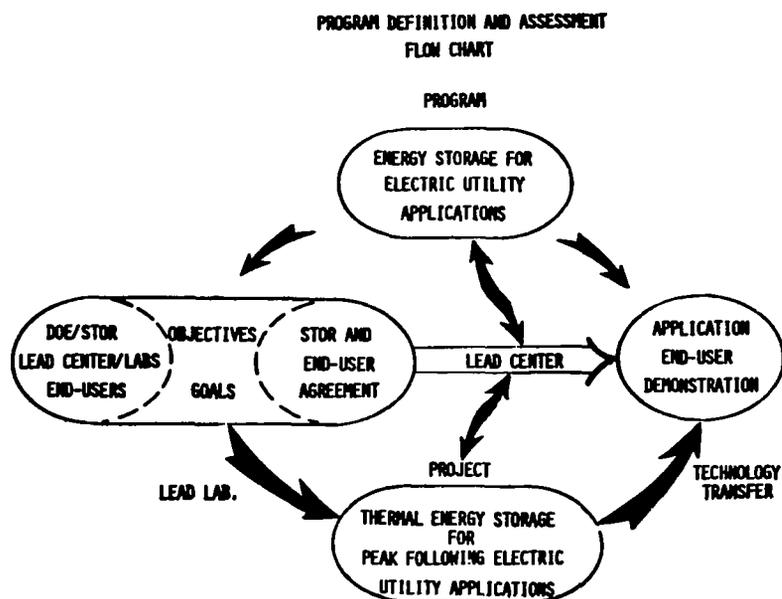
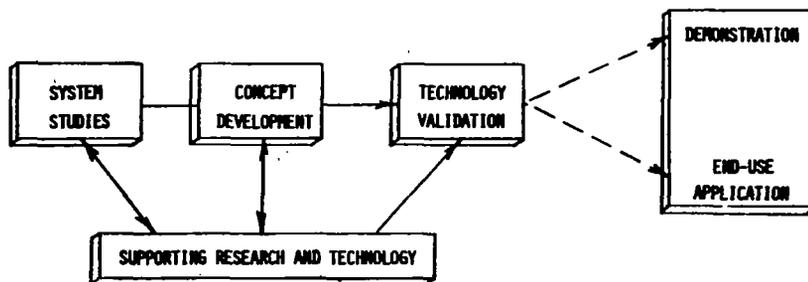


FIGURE 1



PROJECT STRUCTURE

FIGURE 2

NEW PLANT TES ASSESSMENT

(GENERAL ELECTRIC)

CONCEPTS

TYPE	MEDIUM	FEATURE	UTILIZATION
SENSIBLE HEAT	WATER	PRESTRESSED CAST-IRON VESSEL	FWH, SG
		PRESTRESSED CONCRETE AND WELDED STEEL PRESSURE VESSELS	FWH, SG
		CONCRETE-SUPPORTED CAVERN TANK	SG
		AIR-SUPPORTED CAVERN TANK	FWH
		AIR-SUPPORTED CAVERN TANK - STEEL LINED	SG
		AQUIFER	FWH
	WATER/STEEL	HEAVY WALLED STEEL CYLINDERS	FWH, SG
	OIL	DUAL TANKS	FWH
	OIL AND ROCK	THERMOCLINE TANK	FWH, SG
	OIL/MOLTEN SALT	TWO STAGE, DUAL OR THERMOCLINE TANK	SG
MOLTEN SALT	MOLTEN SALT	DUAL TANKS	SG
		DUAL TANKS	SG
PHASE CHANGE	SALT EUTECTIC	DIRECT CONTACT SYSTEM	SG

FWH - FEEDWATER HEAT
SG - STEAM GENERATION

FIGURE 3

PEAK-FOLLOWING THERMAL STORAGE FOR STEAM ELECTRIC POWER

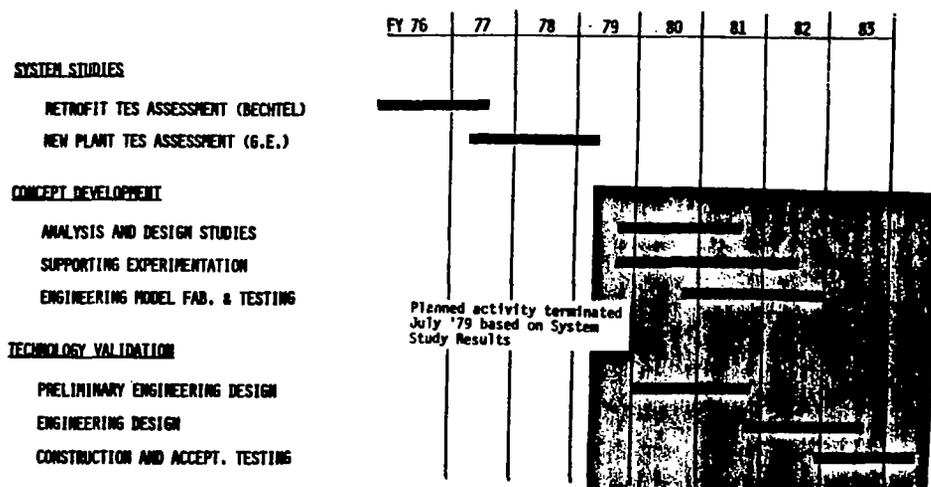


FIGURE 4

Philip Jarvinen	- Lincoln Laboratory
Andrew Kource	- U.S. Army
Michael O'Callaghan	- Massachusetts Institute of Technology
C. J. Swet	- Consultant, Thermal Storage
Milo Belgen	- Ohio Department of Energy
Henry Rice	- Nebraska Public Power
D. D. Wyatt	- National Research Council
Brian Swaiden	- U.S. Navy

FIGURE 5

TES REVIEW COMMITTEE

QUESTIONS:

1. IF STOR HAD TWICE THE FUNDING, WHAT PROGRAMS SHOULD BE INCREASED? WHAT NEW PROJECTS SHOULD BE INITIATED?
2. IF STOR PROGRAMS WERE REDUCED BY ONE HALF, WHAT PROGRAMS SHOULD BE REDUCED? WHAT PROGRAMS SHOULD BE DELETED?
3. ARE STOR PROGRAMS MISSION ORIENTED?
 - o DOES THE REVIEW COMMITTEE SEE REAL WORLD APPLICATIONS FOR ALL TECHNOLOGIES?
4. NEAR-TERM PROJECTS IN THE INDUSTRIAL, SOLAR THERMAL ELECTRIC, AND BUILDING HEATING/COOLING APPLICATION SECTORS REQUIRE HEAVY BUDGET OUTLAYS RESULTING IN DE-EMPHASIZING LONG-TERM, BASE TECHNOLOGY WORK.
 - a. DO WE HAVE A PROPER FUNDING BALANCE OF LONG-TERM VS. NEAR-TERM? IF NOT, WHAT SHOULD BE CHANGED?
 - b. IS THERE A PROPER FUNDING BALANCE AMONG THE NEAR-TERM PROJECTS?
 - c. DO YOU PERCEIVE AN ADEQUATE DEVELOPMENT TECHNOLOGY BASE THAT WILL LEAD TO DEVELOPMENT OF NEW TECHNOLOGY INITIATIVES IN THE FUTURE? IF NOT, WHAT SUGGESTIONS?
5. WHAT SHOULD STOR BE LOOKING FOR IN INTERNATIONAL COOPERATIVE PROGRAMS AND WHAT SHOULD STOR BE PROTECTING IN INTERNATIONAL NEGOTIATIONS?
6. WHAT ARE THE BEST MECHANISMS FOR TRANSFERING TECHNOLOGY TO THE COMMERCIAL BASE?
7. HOW DO WE DECIDE WHEN ACTIVITIES ARE READY FOR TRANSFER?
8. WHAT ARE YOUR OVERALL IMPRESSIONS OF THE PROGRAM:
 - o FOCUS, BALANCE, DIRECTION?
 - o TIMELINESS?
 - o USEFULNESS?
9. WHAT OTHER KEY QUESTIONS DO YOU THINK THIS REVIEW COMMITTEE SHOULD ADDRESS? DO YOU THINK THERE ARE BETTER WAYS TO RUN THIS REVIEW COMMITTEE?
10. DO YOU HAVE ANY SUGGESTIONS FOR IMPROVING THIS CONFERENCE AND OTHER INFORMATION EXCHANGE MEETINGS?

FIGURE 6-7