MINUTES:
NINTH MEETING OF THE CENTERS FOR
THE ANALYSIS OF THERMAL/MECHANICAL
ENERGY CONVERSION CONCEPTS

Held at:
Barus and Holley Building
Brown University
Providence, R.I.

August 30-31, 1978

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MINUTES
of the
NINTH MEETING
of the
CENTERS FOR THE ANALYSIS OF
THERMAL-MECHANICAL ENERGY CONVERSION CONCEPTS

Held at
BROWN UNIVERSITY
Barus and Holley Building
Providence, Rhode Island 02912

August 30-31, 1978

Minutes prepared by
Ronald DiPippo
NINTH MEETING
OF THE
CENTERS FOR THE ANALYSIS OF THERMAL-MECHANICAL ENERGY CONVERSION CONCEPTS
BROWN UNIVERSITY
Barus and Holley Building
Providence, Rhode Island 02912
August 30-31, 1978

AGENDA

Wednesday, August 30:

8:30 - 9:30  Plenary session.

Arrangements and objectives of meeting: J. Kestin (Brown University).

9:30 - 12:00 Individual working sessions.

A. Instrumentation, Measurements and Controls
   J. Kestin (Brown University)
   J. T. Kuwada (Rogers Engineering, Inc.)
   J. F. Whitbeck (INEL)

B. Availability of Auxiliary Equipment
   R. DiPippo (Brown University)
   A. L. Floyd (City of Burbank)
   G. Simay (City of Burbank)

C. Waste Heat Rejection
   H. E. Khalifa (Brown University)
   R. C. Robertson (ORNL)
   E. Michaelides (Brown University)

D. Resource Characteristics: Exploration, Evaluation, and Development
   D. J. Ryley (Brown University)
   D. G. Elliott (JPL)
   J. F. Hermance (Brown University)

E. Economic Considerations
   P. F. Maeder (Brown University)
   C. H. Bloomster (BPNL)

12:00 - 1:00 Lunch. President's Dining Room, Sharpe Refectory.
Wednesday, August 30:

1:00 - 5:00 Individual working sessions.

F. Thermodynamics of Geothermal Energy Conversion Systems
   J. Kestin (Brown University)
   K. E. Starling (University of Oklahoma)

G. Environmental Considerations
   R. DiPippo (Brown University)
   R. F. Hartley (EPA - Cincinnati)
   R. C. Robertson (ORNL)

H. Hybrid Fossil-Geothermal Systems
   H. E. Khalifa (Brown University)
   A. L. Floyd (City of Burbank)
   G. Simay (City of Burbank)

I. Resource Characteristics: Exploration, Evaluation, and Development
   D. J. Ryley (Brown University)
   D. G. Elliott (JPL)
   J. F. Hermance (Brown University)
   J. T. Kuwada (Rogers Engineering, Inc.)

J. Economic Considerations
   P. F. Maeder (Brown University)
   C. H. Bloomster (BPNL)

Thursday, August 31:

8:30 - 10:00 Plenary Session on Sourcebook Outline and Scheduling

10:00 - 12:00 Individual workshop sessions.

K. Geothermal Steam Systems
   J. Kestin (Brown University)
   J. H. Eskesen (General Electric Co.)
   J. T. Kuwada (Rogers Engineering, Inc.)
   J. F. Whitbeck (INEL)
   R. H. Dart (INEL)

L. Summary and Criteria for Selection
   R. DiPippo (Brown University)
   A. L. Floyd (City of Burbank)
   G. Simay (City of Burbank)

M. Computer Codes for Cycle Optimization
   H. E. Khalifa (Brown University)
   W. L. Pope (LBL)

N. Resource Characteristics: Exploration, Evaluation, and Development
   D. J. Ryley (Brown University)
   D. G. Elliott (JPL)
   J. F. Hermance (Brown University)

O. Materials Selection Guidelines
   P. F. Maeder (Brown University)
   M. F. Conover (Radian Corporation)
   R. R. Reeber (DOE/DGE)
Thursday, August 31:

12:00 - 1:00  Lunch. President's Dining Room, Sharpe Refectory.

1:00 - 3:00  Individual working sessions.

P. Binary Fluid Systems
   J. Kestin (Brown University)
   J. H. Eskesen (General Electric Co.)
   K. E. Starling (University of Oklahoma)
   J. F. Whitbeck (INEL)
   R. H. Dart (INEL)

Q. Existing and Planned Power Plants
   R. DiPippo (Brown University)
   J. T. Kuwada (Rogers Engineering, Inc.)

R. Problems in Brine Utilization
   H. E. Khalifa (Brown University)
   R. R. Reeber (DOE/DGE)
   W. L. Pope (LBL)

Adjournment.
NINTH MEETING
OF THE
CENTERS FOR THE ANALYSIS OF THERMAL-MECHANICAL ENERGY CONVERSION CONCEPTS

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Wednesday, August 30:

1. Clifton B. McFarland opened the meeting, welcomed the participants, and briefly related the latest news relative to the pending reorganization within the Department of Energy as it is expected to affect the Division of Geothermal Energy. The upcoming moves are expected to focus all research activities under Energy Research, all engineering research and development under Energy Technology, and all commercialization activities under the new area Resource Applications. McFarland speculated that all geopressure studies would probably remain in Energy Technology, but that some of the hydrothermal activities may be shifted to Resource Applications. Although no one knows exactly when the reorganization will go into effect, it is believed imminent.

2. Joseph Kestin discussed the plan for the work of the meeting. He pointed out that the task of editing the submitted material is turning out to be more time-consuming than previously thought. Eventually a copy editor will be needed; an additional technical editor could be used now. He suggested that the material on existing geothermal power plants that has been written by R. DiPippo could be ready for a printer within two months, and that this could be a useful, stand-alone volume, not a part of the Sourcebook. If it could go to the printer in October, it could be "on the shelf" by March 1979. It would run to 300 - 350 pages.

Discussion then centered on the proposed chapters for Volume 1 of the Sourcebook which would focus on the particulars of energy conversion. There seems to be a need for a trade-off between early publication and a complete, logical sequence of chapters. In order to make an early publication date, the editors will have to use only those chapters which are in a ready condition in September/October. Waiting for all those chapters that are desirable to make a complete, logical package will delay publication by up to 6 months.

Most people agreed that some split was unavoidable and that the Sourcebook will lose its value if publication is unduly delayed. A suggestion was made that each chapter might be published as a separate monograph as each is completed. Kestin remarked that we would never achieve the hoped for impact of the Sourcebook under such arrangements. The level and scope of the Sourcebook were questioned. Will this be more like an encyclopedia than a sourcebook?

Kestin concluded this portion of the program by relating a few impressions he has gained during the course of the project. He remarked that geothermal power plants are developed step-by-step, rather than designed in a grand plan,
and that such plants are quite durable. Fears may have been exaggerated since the problems encountered so far have not been severe. The simplicity of the plants is their most important feature. Inherent reliability leads to low operating and maintenance costs.

McFarland related that it is often believed by upper management in both industry and government that geothermal energy for electric power is state-of-the-art; Licensing and institutional barriers are all that is holding up development. This view is based on foreign experiences. He prefers to take a different view. The quality of the resource is the key. There may be tens of thousands of megawatts in a given resource, but state-of-the-art technology will only yield a few hundred megawatts from that resource.

James T. Kuwada added that the situation may be deceiving because those plants which are in operation today have been located at the best resources. Sites have been very selectively chosen. There are a great many more sites that are less favorable, but which must be exploited soon if geothermal is to make an impact.

Paul F. Maeder urged more attention be paid to increasing the productivity of geothermal wells, perhaps by drilling wells of much larger diameters than is common now.

3. **Individual workshop sessions** were conducted in parallel, with the main participants for each session having been listed in the Agenda. Owing to the informal nature of the sessions, people often attended more than one session. These sessions continued for the rest of the day. The outcome of each and the status of each Sourcebook chapter are summarized in Table 1.
Thursday, August 31:

4. The status and schedule of each chapter of the Sourcebook came under scrutiny at the plenary session. The need for a stand-alone volume on existing plants was debated. Opinions were expressed both pro and con. Kestin was strongly in favor, stressing the uniqueness of the volume, its timeliness, and the state of preparedness of the material. McFarland agreed that the editorial staff should contact various publishers about printing arrangements and costs. Furthermore, Volume 2 of the Sourcebook will contain a condensed version (or update) of this stand-alone volume.

As the discussion proceeded on which chapters belonged to which volume, and what should be the order of topics, etc., it became clear that editorial decisions could not be made by a group of twenty. It was recognized that the ultimate responsibility for decisions of this type rests with the Brown editorial staff. Time constraints and the degree of readiness of the materials will be factors to be weighed.

Table 2 lists the state of affairs at this time. Everything shown is tentative, and subject to change pending final decisions. In order to facilitate the final editing tasks, Kestin will investigate the possibility of retaining a technical writing organization. Every effort will be made to produce the stand-alone volume on existing plants by March 1979 (in print), the Volume 1 of the Sourcebook by December 1978 (to the printer), and Volume 2 by March 1979 (to the printer).

5. More individual workshops followed and continued into the afternoon. The outcome of these may be found in Table 1.

6. The meeting was adjourned at the conclusion of the workshop sessions at about 3:00 p.m.

Respectfully submitted,

Ronald DiPippo
Adjunct Professor of Engineering (Research)
<table>
<thead>
<tr>
<th>Chapter</th>
<th>Main Author(s)</th>
<th>Editor</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resource Characteristics</td>
<td>Ryley</td>
<td>Brown staff</td>
<td>Geology portion - draft exists, needs considerable rework.</td>
</tr>
<tr>
<td></td>
<td>Ryley</td>
<td>Brown staff</td>
<td>Geophysics portion - draft exists, needs minor corrections.</td>
</tr>
<tr>
<td></td>
<td>Ryley</td>
<td>Brown staff</td>
<td>Prospecting portion - manuscript exists, needs typing, circulation for comments (geochemical methods needs writing).</td>
</tr>
<tr>
<td></td>
<td>Elliott, Ryley</td>
<td>Kestin, Starling</td>
<td>Wellflow portion - draft exists, needs very minor modification.</td>
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<tr>
<td></td>
<td>Ryley</td>
<td>Starling</td>
<td>Surface transmission portion - manuscript exists, needs typing.</td>
</tr>
<tr>
<td>Thermodynamics</td>
<td>Kestin, Starling</td>
<td>Starling</td>
<td>Draft exists, needs minor correction, binding and circulation.</td>
</tr>
<tr>
<td>Geothermal Steam Systems</td>
<td>Eskesen, Kuwada</td>
<td>Kestin</td>
<td>Draft exists, needs minor modification, retyping, binding and circulation.</td>
</tr>
<tr>
<td>Binary Fluid Systems</td>
<td>Eskesen, Whitbeck</td>
<td>Kestin</td>
<td>Draft exists, needs minor modification, retyping, binding and circulation.</td>
</tr>
<tr>
<td>Hybrid Fossil-Geothermal Systems</td>
<td>Floyd, Simay</td>
<td>Khalifa</td>
<td>Source material exists; draft needs writing.</td>
</tr>
<tr>
<td>Total Flow Systems</td>
<td>Austin</td>
<td>Ryley</td>
<td>Draft exists, ready for final preparation for printer.</td>
</tr>
<tr>
<td>Energy Conversion Equipment</td>
<td>Floyd, Simay</td>
<td>Brown staff</td>
<td>Draft exists, needs minor modification, retyping.</td>
</tr>
<tr>
<td>Criteria for Design Selection</td>
<td>Floyd, Simay</td>
<td>Brown staff</td>
<td>Draft exists, needs minor modification, retyping.</td>
</tr>
<tr>
<td>Waste Heat Rejection</td>
<td>Robertson</td>
<td>Khalifa</td>
<td>Source material exists; draft needs writing.</td>
</tr>
<tr>
<td>Environmental Considerations</td>
<td>Hartley</td>
<td>DiPippo</td>
<td>Source material exists; draft needs to be prepared directly from source material, retyping.</td>
</tr>
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</table>

*(continued)*
<table>
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<tr>
<th>Problems in Brine Utilization</th>
<th>Still uncertain</th>
<th>Some source material exists; draft needs writing.</th>
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<tbody>
<tr>
<td>Materials Selection</td>
<td>Conover, Reeber</td>
<td>Brown staff</td>
</tr>
<tr>
<td>Instruments and Control Systems</td>
<td>Whitbeck</td>
<td>Kestin</td>
</tr>
<tr>
<td>Economic Considerations</td>
<td>Bloomster</td>
<td>Maeder</td>
</tr>
<tr>
<td>Survey of Existing Geothermal Plants</td>
<td>DiPippo</td>
<td>DiPippo</td>
</tr>
</tbody>
</table>

Source material exists; draft to be prepared from Handbook.

Source material exists; draft to be prepared from source material.

Draft exists, needs minor modification, retyping.

Five reports exist; will be consolidated along with new material on Italy, Iceland, and USSR into a stand-alone book; summary to appear as part of Sourcebook, Volume 2.
TABLE 2 Organization of Material for the Sourcebook.

A. Electricity from Geothermal Sources throughout the World - A Survey of the Design and Operation of Geothermal Power Plants by R. DiPippo

An edited version of the following Brown University reports by R. DiPippo: CATMEC/9 (Japan), CATMEC/14 (United States), CATMEC/17 (New Zealand, Philippines, Indonesia), CATMEC/18 (Mexico, Central America), and CATMEC/21 (Summary, Rev. 1). Additional material will be written on Italy, Iceland and the Soviet Union.

B. A Sourcebook on the Production of Electricity from Geothermal Energy, Volume 1

The following chapters will definitely be included in this volume:
1. Introduction
2. Thermodynamics of Geothermal Energy Conversion
3. Geothermal Steam Systems
4. Binary Fluid Systems
5. Hybrid Fossil–Geothermal Systems
6. Total Flow Systems
7. Energy Conversion Equipment

The following chapters may be included in Volume 1 if the material is on-hand in time:
- Geothermal Well Flow
- Surface Fluid Transmission
- Waste Heat Rejection
- Environmental Considerations.

C. A Sourcebook on the Production of Electricity from Geothermal Energy, Volume 2

It is presently believed that the following chapters will constitute Volume 2:
1. Introduction
2. Geology, Geophysics and Geochemistry of Geothermal Sites
3. Problems in Brine Utilization
4. Materials Selection
5. Instrumentation, Measurements and Control Systems
6. Economic Considerations
7. Summary of Existing and Planned Power Stations

To the extent that the four chapters listed above do not appear in Volume 1, they will be included in Volume 2.