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RESOURCE DEVELOPMENT POTENTIAL - REVENUE GENERATION POTENTIAL ONLY A BALANCED APPROACH CAN LEAD TO DISTRICT ENERGY DEVELOPMENT

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ABSTRACT
Despite millions of dollars in exploration and drilling, and the identification of literally hundreds of high potential resource areas, few new geothermal district energy systems have been built in the United States over the past 25 years. A recent survey, looking into what was hindering such development, concluded that the development of new geothermal district energy systems was not going forward due to a lack of resource information and, in particular, a lack of exploration dollars to support confirmation drilling. But is this really the only or even the most critical need? It is the authors' contention that a lack of knowledge relating to the potential for revenue generation is as much or possibly even more of a problem than the lack of funds to carry out confirmation drilling. What is really needed is a balanced approach to "exploration," one that puts equal emphasis on determining revenue generation potential and resource development potential. And, in fact, a clear determination that revenue generation potential can support development and operation costs should be made prior to the substantial investment that must be made in most cases to confirm the existence of a viable geothermal reservoir. Such a determination would be a prerequisite for private investment, and should be a prerequisite for government support. How such a program should be structured and implemented is covered in detail.

1. INTRODUCTION
In the United States, the first geothermal district heating system was built in Boise, Idaho, in 1892. This system, known originally as the Artesian Hot and Cold Water Company and later as the Boise Warm Springs Water District, still serves the Warm Springs district of the city of Boise, Idaho, and has served as the catalyst for the development of the Boise, Idaho, capitol campus district system and a municipally-owned district energy system serving the downtown business district (Rafferty 1991). Throughout the western United States, numerous geothermal district heating systems were developed through the 1980s, and growth of many of these systems continues today (Lund, 1999). Of these, the systems in Elko, Nevada; San Bernardino, California; Klamath Falls, Oregon; and Boise, Idaho, are probably best known. Many of the systems built in the 1980s were a direct result of the oil crises of the 1970s, and the availability of extensive government programs that supported geothermal exploration, reservoir confirmation studies, and technical and economic feasibility studies. These programs included: U.S. Department of Energy Technical Assistance Grant Program, the Program Research and Development Announcement (PRDA), Program Opportunity Notice (PON), and the Industry-Coupled Program (Bloomquist 1986). In addition, a number of federal and state programs were in place throughout the late 1970s and early 1980s that also played a role in facilitating the success of geothermal district energy programs (Bloomquist 1986).

Growth of the geothermal district energy sector, however, has slowed dramatically since the mid to late 1980s, and although there has been some interest in areas such as Reno, Nevada, and Mammoth Lakes, California, in the 1990s, no new geothermal district energy systems have been developed since the late 1980s.

In 1991, the U.S. Department of Energy Geothermal Division received funding from Congress for what was to become known as the Geothermal Low-Temperature Resource Assessment Program (Wright, et al., 1992). This program was initiated primarily to help accelerate direct use geothermal development and specifically development of geothermal district energy systems. Working under the direction of the University of Utah Earth, Sciences and Resources Institute and the Oregon Institute of Technology, Geo-Heat Center, ten western states received funds to identify and, to a limited extent, characterize geothermal resources colocated with population centers. This work was performed by geologic teams in each of the states, and resulted in the identification of 271 colocated sites within the 10-state area. Identified sites represented a target population of over 7.4 million.

Based on the results of the study, the Oregon Institute of Technology Geo-Heat Center sent out letters to each of the 271 cities informing them of the presence of geothermal resources that could possibly be used to supply a geothermal district heating system. Of the 271 cities, the Geo-Heat Center received only one expression of interest. Obviously, knowledge of the existence of a potentially-viable geothermal resource was not enough to generate the kind of response that had been anticipated. If knowledge of a potentially-promising geothermal resource site in close proximity to a community or concentrated load center wasn't enough to generate significant interest, what was missing? For many geothermists, the answer was obvious—additional geological work needed to be done, including the drilling of well(s), to confirm the existence of a viable reservoir capable of supporting a district energy system. Based on this assumption, a ten-year plan for reservoir confirmation became part of the U.S. Department of Energy's strategic plan for the geothermal energy program with a recommended funding level for cost sharing the risk of reservoir confirmation and well drilling of $5,000,000 over the ten-year period. But would additional reservoir data be enough to generate a commitment to invest hundreds of thousands or even millions of dollars in the development of a district energy system? There still seemed to be a significant piece of information that would be missing—**would a geothermal district energy system be technically and economically viable**? Could such a system generate enough revenue to pay for the investment in wells, heat exchangers, distribution piping, and customer connections? Was it a question of a need for additional resource assessment or a question of the need for revenue assessment? In truth, most would probably conclude that both are vital and both, at least theoretically, equally necessary. If, on the other hand, the same question is put to those who must ultimately fund such projects, there is no question that revenue generation, i.e., the ability to be financially sustainable, is paramount. If this is, in reality, the case, then shouldn't investments in additional reservoir confirmation be contingent upon a positive finding that potential revenue will equal or exceed cost involved in developing the resource and constructing the distribution and utilization system?

If we can accept this assumption, then establishing an approach by which revenue potential can be best estimated becomes the quintessential question. Numerous attempts to develop a system capable of accurately estimating the technical and economic feasibility of a geothermal district energy system have been made. The first serious attempt was probably a computer model developed by the Pacific Northwest Laboratory in Richland, Washington, known as Geocity. However, work by Eliot Allen of Eliot Allen and Associates, "Preliminary Inventory of Western U.S. Cities with Proximate Hydrothermal Potential," (Allen and Shreve, 1980) and the development by the Washington State Energy Office of HEATPLAN must also be included. Unfortunately, these systems were incapable of generating numbers creditable enough to be given serious consideration by the development or financial community. All were, however, capable of, at a minimum, identifying sites that showed promise and that warranted additional analyses.

From the early 1980s to the present, numerous other models have been developed aimed at assessing the technical feasibility of geothermal district energy systems and the potential for such systems to generate sufficient revenues to cover debt, operation, and maintenance expenses and, at least in the case of private sector development, a reasonable rate of return on equity (Bloomquist, et al., 1999) (Lund and Lienau, 1997). The availability of such models provides the key to the development of a comprehensive and balanced program directed toward geothermal district energy development. A program must be iterative in nature when results from reservoir confirmation studies and revenue assessments lead to more and more detailed work until a decision can be made to proceed to resource development and system construction.

2. PROPOSED PROGRAM TO CATALYZE GEOTHERMAL DISTRICT ENERGY SYSTEM IMPLEMENTATION

There are, as was noted above, significant untapped low-temperature geothermal resources located near communities that could be used for geothermal district heating and/or district cooling. The following describes a proposed program for catalyzing the development of Geothermal Community Energy Systems (GCES). Key objectives of the program would be to:

1. rank the opportunities for GCES;
2. select communities for preliminary assessment;
3. conduct assessments in the highest-ranked communities; and
4. facilitate the implementation of GCES through outreach, technical assistance, and cost-shared feasibility studies and assessments, including drilling and reservoir engineering.

Studies of the potential of and barriers to implementation of geothermal community energy systems (GCES) have reached a number of common conclusions (Brookhaven National Laboratory, 1993) (Congressional Research Service, 1983), including:

- Many city and state leaders, electric utilities, building owners, and others who could be key stakeholders in implementing district energy systems are not aware of the potential benefits of these systems;
- Development of a new district energy system, particularly one implemented by the community as a whole, can be a complex, high risk undertaking, involving many institutional, technical, legal, and financial issues; and
- Local leaders and stakeholders usually lack important knowledge necessary to effectively implement district energy systems.

Key elements of the proposed program are designed to stimulate the use of geothermal energy resources by removing major barriers to implementation by local leaders and private sector developers, including lack of knowledge and experience. By educating them about benefits, providing them the tools to assess their current energy production systems, and helping them build a network of experts and practitioners, the proposed program would remove major road-blocks to successful implementation. This program could be the impetus for may local leaders to develop or facilitate private sector development of GCES in their community, increasing energy efficiency as well as benefiting the environment and local economy. This is a key strategy in the Canadian federal government's highly successful Community Energy Systems program operated by the CANMET Energy Technology Centre.

The proposed program also addresses the fact that in many cases the potential of the geothermal reservoir must be confirmed through additional drilling before detailed engineering on a GCES can be prudently undertaken. Such work could be done on the basis of federal/local cost share.

This proposed program is designed to bring communities to the point where they can confidently embark upon contract negotiations and detailed system design using local and/or private sector funding.

2.1 Program Elements

In order to achieve this goal, the following activities should be implemented:

1. Rank identified colocated opportunities in consultation with local, state, and federal geothermal experts.
2. Develop information tools on GCES, including a handbook and video.
3. Conduct screening evaluations of revenue generation potential in the highest-ranked communities using available computer models.
4. Implement outreach program to educate local leaders through workshops focusing on GCES.
5. Give local leaders a first-hand look at GCES via on-site visits to operating systems.
6. Facilitate the implementation of GCES through cost-shared feasibility assessments and assistance in overcoming institutional barriers.
7. Confirm reservoir potential through cost-shared well drilling and reservoir assessment.

These activities could be conducted in a phased and iterative program over several years.

Refine Ranking
Ranking of the opportunities is essential for a well-targeted, cost-effective program. Ranking should be established based on input from federal, state, and local geothermal experts. Such a ranking could be carried out using one of the computer models such as GEORANK developed for this purpose (Bloomquist, et al., 1985).

Experts in each of the relevant resource areas should be consulted to provide additional information and recommendations relative to ranking, such as information on new construction, planned development projects, or initiatives relating to geothermal development in the target communities.

Information Tools
Community interest in developing a GCES depends on a solid understanding of what a GCES can be, how it can be developed, and what its benefits are. A key element in the program would be the development of information products for getting the message out, effectively and efficiently, to community leaders and stakeholders. The primary products would be a Geothermal Community Energy Handbook and a video on geothermal community district energy.

Geothermal Community Energy Handbook. It is essential to create concise information on geothermal district energy to gain interest, expand awareness, and convey key information. One objective would be to develop a handbook and disseminate it through workshops, information and training sessions, and other avenues, as appropriate. This handbook would have dual uses as a stand-alone product that can be distributed individually, as part of a mailing, during a trade show or other event, or as part of the workshops and information sessions. The handbook would include information on:

- how Geothermal Community Energy Systems work;
- environmental and economic benefits;
- case studies; and
- process for evaluating the potential in any given community.

Video. A brief video should be produced to effectively convey basic information about GCES and the benefits from the community perspective. The video would be created focusing on how community energy systems work, how geothermal energy can be harnessed by communities, and what environmental and economic benefits can result. It could build on existing video information available from a number of sources. All of these communication tools would be cost-effectively produced by making maximum use of existing materials.

Screening Evaluations
An initial screening evaluation should be conducted of the top ranked opportunities. The screening evaluation should be designed to assess, quickly and cost-effectively, key variables crucial to the viability of a GCES. Costs of the screening assessments are estimated at approximately $10,000 to $15,000 per community. The assessment would include the following tasks.

Task 1 – Site Visit. The community shall be visited in order to:

1.1 Meet with community representatives to provide information about the evaluation process and to assess the level of interest and identify major potential stakeholders and key local issues relevant to a potential GCES.

1.2 Obtain data required for the community analysis, including a map of the downtown, data on power and fuel prices, data on building floor space, and other relevant information as available.

1.3 Conduct a "windshield survey" of the downtown to gather observational information on building use, the number of floors, and other aspects of major downtown buildings

1.4 Gather all relevant information related to the geothermal resource including location, depth, predicted or known temperatures and flows, ownership, accessibility, and preliminary estimates of cost to develop.

Task 2 – Loads and Distribution System. Heating and cooling loads and demand density should be identified using a model such as HEATMAP©.

2.1 Estimate the heating and cooling peak demands and annual energy requirements.

2.2 Map the estimated loads and identify areas with the highest development density.

2.3 Develop a preliminary thermal transmission and distribution network layout and pipe sizing.

Task 3 – Economic Analysis. The potential financial feasibility of a GCES should be evaluated, using the model to:

3.1 Estimate capital costs for:
- geothermal production
- back-up/peaking thermal production
- transmission to the community
- distribution within the community
- interface with buildings

3.2 Estimate operating costs for
- pumping at the geothermal wells
- pumping for transmission and distribution
- fuel for peaking thermal production in boilers
- personnel for operations, marketing, and management
- maintenance of production and transmission/distribution system components

3.3 Calculate the Internal Rate of Return on the required investment

Outreach
This program element should provide interactive dissemination of information about how GCES work, their environmental and economic development benefits, case studies, and how to evaluate GCES. This can be accomplished through workshops to which all of the target communities would be invited, creating an opportunity for detailed discussion and interactive learning.

Site Visits
Building on the previous elements, this program element places local leaders on the ground at actual GCES sites through study tours. These tours compliment the prior elements by putting a physical image together with the data and raw information. Participants should see the elements of GCES first-hand, examine working systems in action and be prepared to discuss with their local government peers how it was accomplished, how it has benefited other communities, and how it could benefit their own. This element of the program also provides an important opportunity for local leaders to make contacts that will be useful as some participants decide to pursue implementation of GCES in their communities. Visiting successful community energy systems helps local leaders understand the technologies, the community benefits, and how to make it happen.

Reservoir Confirmation
Based on the outcome of the preliminary modeling and a determination that thermal loads and thermal load densities are sufficient to generate a positive cash flow, additional reservoir confirmation studies, including confirmation drilling of

production and injection wells, should be carried out prior to initiating any additional technical and economic feasibility assessments or system design work. The reservoir confirmation program should be designed to establish reservoir temperature and production rates, water chemistry, production draw down, injection pressure, and location of production and injection areas relative to the GCES. This information will provide necessary inputs to a more detailed technical and economic feasibility assessment(s) as well as requirements needed for system design and eventual operation. Information derived from the reservoir confirmation will allow for calculations of well costs, pumping requirements, transmission systems length, material selection, potential requirements for back-up or peaking, and potential to meet various system growth scenarios. The cost of reservoir confirmation is extremely difficult to predict, but some guidance can be found in Small Geothermal Resources: A Guide to Development and Utilization (Dickson and Fanelli, 1990).

<u>Feasibility Assessments and Local Assistance</u>

This step takes the local official from education and training into partnerships for evaluation and implementation. Based on what they have learned and seen, some local leaders will be prepared to and want to take action to further assess the potential use of district energy in their communities and potentially implement a system based on the detailed evaluation. The program is designed to stimulate this activity by encouraging cost-shared partnerships between local governments and other entities, and guiding decision-makers through the process of a detailed feasibility study, community outreach, and consideration of financing and contractual issues.

The program would aid local leaders build a critical path toward implementation and leverage a resource network to guide them in this process. Communities for this step should be chosen on a competitive basis from among the screened communities.

Implementation of GCES is usually a complex undertaking from an institutional and contractual standpoint as well as technical and financial because it involves multiple stakeholders and participants. This program should provide comprehensive information and guide and assist communities in evaluating the opportunities and benefits of GCES in their community. This would help them overcome the institutional challenges and perform the essential planning, communications, marketing, engineering, and financing required for successful implementation.

A detailed feasibility study and associated community communications would be conducted if, based on the screening evaluation and reservoir confirmation program, a community remains interested in exploring the feasibility of a GCES. It is anticipated that the average total cost of a detailed technical and economic feasibility study and technical assistance would be a minimum of $75,000. The elements of the feasibility study and local assistance should include:

- quantification of the potential market for heating and cooling service;
- assessment of the costs of self-generation of heating and cooling;
- assessment of technology alternatives for thermal energy transmission and distribution;
- development of a preliminary distribution system lay-out and conceptual system design;
- conceptual design for back-up thermal storage and peaking capacity for the district heating and cooling system;
- capital costs for geothermal production, back-up/peaking thermal production, generation of cooling using geothermal heat (as appropriate), thermal storage (if applicable), transmission to the community, distribution within the community, and interface with buildings
- operation, maintenance, and management costs for the GCES;
- analysis of the economic feasibility based on alternative financing approaches; and
- communication with the community, key decision-makers, potential customers, and potential private sector partners regarding the GCES concept and its potential benefits.

<u>System Design Construction and Operation</u>

Only after the successful outcome of the reservoir confirmation and technical and economic feasibility studies should detailed design begin followed by construction and operation.

Many of the models that are now available for use in early preliminary assessments of revenue generation potential and technical feasibility have the capability of being used throughout the completion of technical and economic feasibility studies, design, and even operation as more and better information is made available. Building upon the capabilities of such a model will greatly reduce overall cost of doing the studies, ensure consistency in approach, and minimize the potential for overlooking critical components, costs, and decision points. The use of such a model also provides a means to evaluate various build-out scenarios and ensure that the piping network installed in early phases of a project will be capable of meeting future load growth (Bloomquist and Boyd, 2000 [in preparation]).

3. SUMMARY

Development of a geothermal community energy system is an iterative process with each subsequent step building on the information gained in the previous step or steps. The most attractive geothermal resource will not result in an economically viable GCES if thermal loads and thermal load densities cannot produce a positive cash slow and no GCES can even be seriously considered unless a viable geothermal resource capable of meeting system requirements is developable. A balanced and iterative approach reduces cost and risk, and ultimately is the only approach that will result in widespread development of successful geothermal district energy systems.

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