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DEVELOPMENT OF GEOTHERMAL POLICY IN THE UNITED STATES -WHAT WORKS AND WHAT DOESN'T WORK-

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ABSTRACT

Geothermal project characteristics and the conditions needed for success along with the various steps in developing a project are discussed. Geothermal policy in the United States started with the California Geothermal Resources Act of 1967 and the Federal Geothermal Steam Act of 1970. Various states followed defining a geothermal resource as either mineral, water, *sui generis*, heat or a combination of these. Federal incentives began with the Federal Energy Security Act of 1978 which included the Investment Tax Credits (ITC), followed by the Public Utility Regulatory Policy Act of 1979 (PURPA), and the Production Tax Credits (PTC). State incentives began with the Renewable Portfolio Standards in the 1990s, and various Renewable Energy Credits. Federal risk reduction policies to encourage geothermal development included the Geothermal Loan Guarantee Program in 1975, the Program Research and Development Announcement (PURDA), the User Coupled Drilling Program (UCDP), and the Program Opportunity Notice (PON) that provided funding for 23 direct-use projects in the late 1980s. More recently the American Recovery and Reinvestment Act of 2009 (ARRA) was funded to approximately $400 million for a variety of geothermal projects. To provide support to the various federal and state geothermal projects, the Geo-Heat Center at Oregon Institute of Technology was funded by USDOE Geothermal Technologies Office for over 30 years to provide technical assistance, preliminary feasibility studies and information dissemination of various successful projects throughout the United States.

GEOTHERMAL PROJECT CHARACTERISTICS AND WHAT IS NECESSARY FOR SUCCESS

Based on past experience the geothermal industry has learned that the following characteristics must be considered for a project to be successful (Lund, 2011):

- Every project is unique
- Simplicity is the key to operational success
- A strong promoter ("hero") is needed to develop each project (person and/or company)
- Resource characteristics determine the use and success or failure of a project
- Customers/market are needed to be successful
- Funding and cost are important
- Land, institutional, and environmental considerations play an important role
- Qualified persons/companies are needed
- The public/government/local concerns/ acceptance must be considered
- Cascading can improve economics

The resource temperature along with the flow rate and fluid chemistry will determine the best (economical) use of the resource. The following temperatures are general guide lines for the use of a resource along with the illustrations in Figure 1:

- >175^{o}C (350^{o}F) – flash steam electric power generation
- 100 to 175^{o}C (212 to 350^{o}F) – binary electric power generation

- 100 to 150°C (212 to 300°F) – industrial process energy/cooling
- 60 to 100°C (140 to 212°F) – space heating
- 30 to 60°C (90 to 140°F) – greenhouse and aquaculture pond heating
- 5 to 30°C (40 to 90°F) – geothermal heat pumps

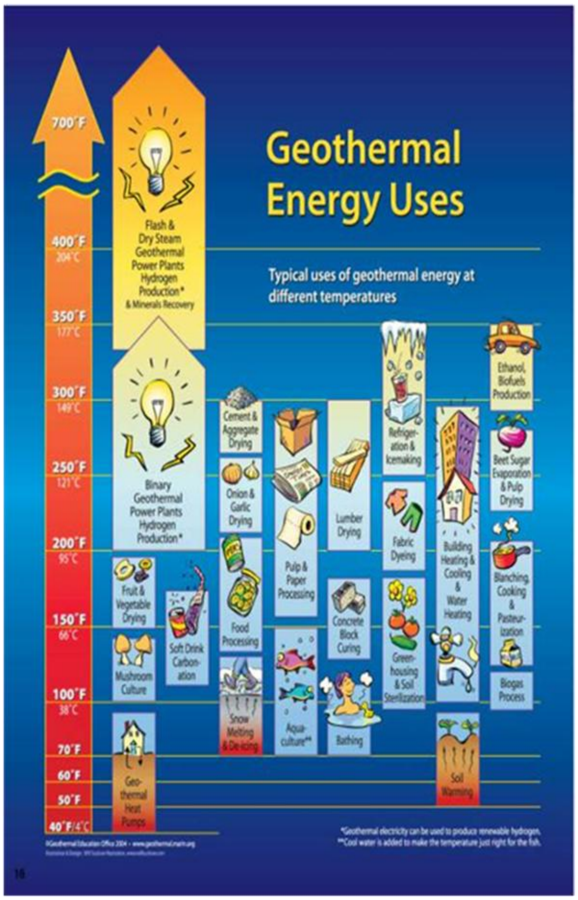

Figure 1. Geothermal Energy Uses (Geothermal Education Office).

A summary of the various factors needed to be considered (solved) for the success of a project are shown in Table 1.

NATIONAL ENVIRONMENTAL POLICY ACT

The National Environmental Policy Act (NEPA) of 1969 that became effective in 1970 was an environmental law that established a U.S. national policy promoting the enhancement of the environment and also established the President's Council on Environmental Quality (CEQ). NEPA's most significant effect was to set up procedural requirements for all federal government agencies to prepare Environmental Assessments (EAs) and Environmental Impact Statements (EISs). EAs and EISs contain statement of the environmental effects of proposed federal agency actions. The law applies to any project, federal, state or local, that involves federal funding, work performed by the federal government, or permits issued by a federal agency. Once a determination of whether or not a proposed action is covered under NEPA there are three levels of analysis that a federal agency may undertake to comply with the law. These three levels include: preparation of a Categorical Exclusion (CE), preparation of an Environmental Assessment (EA) and Finding of No Significant Impact (FONSI), or preparation of an Environmental impact Statement (EIS). If it is determined that a proposed federal action does not fall within a designated categorical exclusion or does not qualify for a FONSI, then the responsible agency or agencies must prepare an EIS. For geothermal projects, the EIS can require considerable time and funding to complete and is often contested, causing additional delays.

Table 1. Conditions Needed to be Considered for a Successful Project (Lund, 2011.)

	Flash	Binary	Direct-Use	GHP
Resource	XXX	XX	X	O
Ownership	XXX	XXX	XX	X
Permits	XXX	XXX	X	O
Environment	XXX	XX	X	O
Finance	XXX	XXX	XXX	X
Risks	XXX	XX	X	O
Expertise	XXX	XXX	XX	X
Market	XXX	XXX	XXX	XX
Hero/Leader	XX	XX	XXX	X
Transmission	XXX	XX	X	O
Public Acceptance	XXX	XX	X	O
Production Costs	XX	XXX	XX	X

XXX = Major X=Minor O=None

INITIAL EXPERIENCES IN PROMOTING AND DEVELOPING GEOTHERMAL PROJECTS

Two acts provided the initial framework for developing geothermal resources on public lands:

1. The California Geothermal Resources Act of 1967, and
2. The Federal Geothermal Steam Act of 1970.

Other western states followed suit over the years with the passage of their own geothermal acts – to establish a legal framework for leasing, exploration and development of geothermal resources – both for electrical power generation and direct-use.

The California Act of 1967 made the first attempt at defining geothermal resources:

> *"Geothermal resource" shall mean the natural heat of the earth, the energy, in whatever form below the surface of the earth present in, resulting from, or created by or which may be extracted from such natural, heat, and all minerals in solution or other products obtained from naturally heated fluids, bines, associated gases and stream, in whatever form found below the surface or the earth, but excluding oil, hydrocarbon gas, or other hydrocarbon substances.*

The Federal Geothermal Steam Act of 1970 and amended in 1988, defines geothermal as:

Geothermal steam and associated resources means:

1. *All products of geothermal processes, embracing indigenous steam, hot water and hot brines:*
2. *Steam and other gases, hot water and hot brines resulting from water, gas or other fluids artificially introduced into geothermal formations;*
3. *Heat or other associated energy found in geothermal formations; and*
4. *Any by-products derived from them.*

The resulting U.S. geothermal policies addressed the following issues in either legal (permitting, environmental, ownership, etc.) and/or financial (rent, royalties, taxes, grants, loans, etc.) terms:

1. Resource ownership and access
2. Regulations for the development and production of geothermal energy
3. Taxation (i.e., deduction of intangible drilling costs, and reservoir depletion allowance).
4. Financial incentives and risk reduction.

Requirements of the federal Geothermal Steam Act of 1970 resulted in the following issues:

1. The question of ownership at the federal level was not determined until 1977 and in California until 1981 in court cases;
2. These court cases determined that the geothermal resources are mineral in nature and belong to the mineral estate;
3. Thus, the federal government and the State of California claims geothermal ownership wherever it holds the mineral estate;
4. The creation of the Known Geothermal Resource Area (KGRA) – where competitive leasing was required, or designated by the US Geological Survey ;
5. Required an environmental assessment on all projects – either an EA (Environmental Assessment – minor) or an EIA (Environmental Impact Assessment – major).

The states followed with their own specific definition of geothermal resources. The definition varied from state to state:

- **Mineral resource** (Federal, California, Hawaii, New Mexico, Texas, and Nevada (if only used for heat content – classified as water otherwise),;
- **Water resource** (Alaska, Colorado, South Dakota, Utah and Wyoming);
- **Sui generis** – i.e. unique in itself: Idaho, Montana (governed by groundwater law), Washington (direct-use as ground water);
- **Water or mineral** (Oregon);
- **Heat** (North Dakota);
- **Steam, hot water, heat or mineral** (Arizona).

OREGON EXAMPLE

As an indication of how complicated geothermal rules and regulations can be, the Oregon classification system is as follows.

- If the water/steam is less than 250°F (120°C), then the use comes under the jurisdiction of the Oregon Department of Water Resources and is classified as "water".
- If the water/steam is over 250°F (120°C), then the use comes under the jurisdiction of the Oregon Department of Geology and Mineral Industries and is classified as "mineral".
- In addition, if the production well is over 2,000 feet (610 m) in depth, then the permitting comes under the Oregon Department of Geology and Mineral Industries – later changed to come under the jurisdiction of the Oregon Department of Water Resources.
- Now only injection wells over 2,000 feet (610 m) in depth, require permitting under the Oregon Department of Geology and Mineral Industries
- Ownership of the resources belongs to the owner of the surface estate.

ASSESSMENT OF GEOTHERMAL RESOURCES

To assist in the understanding and development of geothermal resources in the United States, the Geological Survey under the Department of Interior prepared several Circulars describing the geothermal resources by individual states. These data included reservoir thickness, volume, estimated temperatures and potential heat content. These Circulars were:

- Assessment of Geothermal Resources of the United States – 1975, Geological Survey Circular 726, edited by D. E. White and D. L. Williams. This publication included a listing of resources above 150^{o}C and also those from 90 to 150^{o}C.
- Assessment of Geothermal Resources of the United States – 1978, Geological Survey Circular 790, edited by L. J. P. Muffler. This publication include hydrothermal convection systems greater than 150^{o}C; systems from 90 to 150^{o}C; areas of favorable for discovery and development of local sources of low-temperature (<90^{o}C) geothermal water in the Western United States; and, thermal springs in the Central and Eastern United States.
- Assessment of Low-Temperature Geothermal Resources of the United States – 1982, Geological Survey Circular 892, edited by Marshall J. Reed. This publication included the estimated reservoir values and thermal energies of identified low-temperature geothermal resources in the Western United States, and low-temperature geothermal resources in the Central and Eastern United States.
- Assessment of Moderate- and High-Temperature Geothermal Resources in the United States, 2008, edited by Colin F. Williams, Marshall J. Reed. Robert H. Mariner, Jacob DeAngelo, and S. Peter Galanis, Jr., US Geological Survery Fact Sheet 3082.

ADDITIONAL FEDERAL LEGISLATIONS

The original Federal Steam Act of 1970 provided the following requirement for leases on Federal lands:

- Rent on non-KGRA federal land at $1.00/acre/year
- Rent on KGRA lands at $2.00/acre/year
- Rent increased to $3.00/acre/year after 6 years, only if designated a KGRA;
- Lease size; 640 to 2,560 acres (260 to 1,036 ha), with due diligence required (i.e. active exploration for a geothermal resource), with a maximum of 26,600 acres (10,350 ha), (later increased to 51,200 acres (20,700 ha)) leased in any state;
- Royalties for both electric and direct-use developments ranged from 10 to 15% on a net-back basis – either based on fossil fuel replacement or on actual sales.

The Federal Steam Act of 1970 was modified in 1974, 1980 and 1988 to address the need to provide incentives, reduce risk and thereby increase the competiveness of geothermal energy. This was intended to accelerate the leasing of federal lands. The royalty structure was also reduced as an added incentive as follows:

- For electricity production the royalties were:
    - 1.75% of gross proceeds for the first 10 years
    - 3.5% after 10 years
    - A portion of the fees were sent to local governments
- For direct-use the royalties were:
    - Annual fee per well between $100 and $1,000.

Other federal incentives included the Investment Tax Credits (ITC) enacted in 1978; The Public Utilities Regulatory Act of 1979 (PURPA); and the Federal Production Tax Credit (PTC) first applying to geothermal in 2004.

PURPA had the following requirements:

- Allowed for the first time the generation of electricity by non-utility companies, thus creating the private power industry;
- Required regulated utilities to purchase the output from these facilities at their avoided cost; and
- Required utilities to provide transmission and backup service at a reasonable rate.

As a result several hundreds of megawatts of new geothermal generation came on line during the 1980s.

The ITC was the first significant Federal tax provision under the Federal Energy Security Act of 1978. This act provided for deduction of intangible drilling costs and allowed for percentage reservoir depletion allowances. Intangible drilling cost deduction allowed a taxpayer investing in the drilling of a well for geothermal deposits to elect to expense the intangible drilling costs involved in the construction of the well in the same manner as an investment in oil and gas wells. Eligible intangible costs included such things as wages, fuel, repairs, hauling and incidental supplies that can represent a significant portion of field development expense. Unfortunately, slim hole temperature gradient and geochemical test wells and well as injection well costs were ineligible and must instead be capitalized with costs being recoverable only after production is established through depreciation (Bloomquist, 1986).

The percentage reservoir depletion allowance traditionally available to oil and gas was also extended to geothermal by the Energy Security Act of 1978. The Act provided for the percentage of gross income deductible for depletion, declining from 22% in 1978 to 15% for 1984 and years thereafter.

Two other tax credits were also provided by Congress in 1978, including the Residential Energy Credit and the Business Investment Credit. Both were later modified in 1980 under provisions of the 1980 Windfall Profit Tax Act (Bloomquist, 2003, and Bloomquist et al., 2008). The Residential Energy Credit allowed an individual taxpayer a credit for qualified renewable energy source expenditures made in conjunction with a principal residence. The amount allowed was 40% of the first $10,000 or a maximum of $4,000. This tax credit has unfortunately been eliminated. The Business Investment Credit provided a 15% tax credit for business investing in certain kinds of alternative energy property including geothermal. The percentage allowed was reduced to 10% and made permanent in 1992.

The Production Tax Credit (PTC) was first implement for wind and solar under the New Energy Policy Act of 1992, and later extended to closed-loop biomass and geothermal in 2004 (on a limited basis) and 2005 (on a full basis). For geothermal the initial tax credit was 1.8 cents per kW hour, available for five years and could be taken in addition to the business investment tax credit. More recently the tax credit was increased to 2.0 cents/kWh. It was one of the most important policy changed provided to the geothermal industry. However, a company could not take both the ITC and the PTC; they had to choose one or the other.

ADDITIONAL STATE LEGISLATIONS

A number of states also enacted tax incentives programs. These programs took the form of business tax credits, residential tax credits, property tax exemptions, sales tax exemptions and exemptions on public utility taxes. Some, but not all, of these programs also applied to eligible geothermal heat pumps installations.

The Renewable Portfolio Standards (RPS) were adopted in numerous states staring in the 1990s. These included provisions for:

- Ensuring a minimum amount of renewable energy is included in the portfolio of electricity resources for the state;
- Requiring retail electricity suppliers to include a minimum amount of their electricity supply from eligible renewable resources;
- Some states require that the amount of renewable energy come from specific resources such as solar PV, wind, geothermal, etc.,
- A typical requirement is: "20-20" – i.e. 20% renewable by 2020 (CO, HI, NM, DC), or "25-25" (IL, OR and MN), or "33-30" (CA).

Other state incentives include Renewable Energy Credits (REC), often referred to as "green tags" or "green certificates". These are provided by the state utility commission and have a market value of 1 to 2 cents/kWh. The RECs significantly improved the economic viability of a number of renewable generation technologies, including geothermal.

FEDERAL RISK REDUCTION PROGRAMS

A number of risk reduction programs to promote the development of geothermal projects in the U.S. were implemented by U.S.DOE-GTP starting in 1975 through the early 1980s. These included the Geothermal Loan Guarantee Program (GLGP) initiated in 1975, the Program Research Development Announcement (PRDA) initiated in 1976, the Program Opportunity Notice (PON) initiated in 1979, and the User Coupled Confirmation Drilling Program (USDP) initiated in 1980. The most ambitious program was the recent American Recovery and Reinvestment Act (ARRA) which started in 2009.

The GLGP provided the following:

- Loan guarantee for up to 75% of project costs with the federal government guaranteeing up to 100% of the amount borrowed;
- Encouraged new entrants into the geothermal market and enhanced competition;
- It was successful in furthering geothermal development in a number of locations including bringing direct-use and electrical generation projects on-line; and
- Amended in 1980 to allow for the granting of loans up to 90% of the total aggregate project cost providing that the applicant was an electric, housing or other cooperative or municipality; however, loans were limited to $100 million per project and no qualified borrower was to receive more than $200 million in loans.

The PRDA covered the following:

- Provided funds for detailed feasibility studies;

- Program directed at the completion of detailed engineering and economic feasibility studies of direct applications of geothermal resources; and
- USDOE targeted specific applications:
- Industrial process stem and moderate to low temperature heat for industrial plants (example: Honey Lake wood waste power plant in California);
- Agricultural, space, water and soil heating for greenhouses, grain drying, irrigation pumping and extraction of chemicals from agricultural produces;
- District heating and cooling for commercial-sized buildings or business complexes and residential development; and
- Mineral extraction. Process steam and moderate to low temperature heat for ore concentrating, leaching and flotation processes.

Solicitations for proposals were typically issued once or twice per years and grants were limited to between $100,000 and $125,000. Though generally considered to be successful, the program could have been significantly more successful if more emphasis had been place upon geologic, geophysical and other resource data as an integral part of the proposal evaluation process or if grants had provided monies for resource assessment as an integrated part of the program. The PRDA program was, however, closely tied to the USDOE Program Opportunity Notice Program (PON) described below.

The PON provided incentives for a number of geothermal direct-use projects:

- Provided opportunity for interested parties to propose direct utilization or combined electrical/direct application projects;
- Funded projects that would demonstrated single or multiple uses of geothermal energy;
- Applications included: space/water heating and/or cooling for residential and commercial buildings; agriculture and aquaculture uses; and industrial processing; and
- Grants were competitive and required cost share.
- The various projects funded included (Figure 2):
    - Heating of 5 schools
    - Heating of a hospital
    - Heating of a prison
    - District heating for 8 projects
    - 4 agribusiness projects
    - 3 industrial projects
    - 14 of 23 projects are still operating
- The most well known and successful systems are the district heating systems in Klamath Falls, Oregon, Elko, Nevada, and Boise, Idaho, several a total of almost 100 buildings.

Figure 2. The locations of the 23 PON projects.

The UCDP provided the following:

- It provided mainly for direct-use projects but did include some electrical generation projects;
- Cost sharing with industry for the confirmation of hydrothermal resources, such as siting drill holes, drilling and flow testing, reservoir engineering, and drilling of injection wells;
- Absorbed a portion of the risk associated with the confirmation of hydrothermal reservoirs in the initial stages;
- Developed an experienced infrastructure of exploration, reservoir confirmation and utilization engineering consultants, contractors and equipment manufacturers who would reduce reservoir confirmation risks in the future;
- Cost sharing – 20% if successful; 90% if not successful;
- The Raft River 5 MWe experimental project funded in part; and
- Loans up to $3,000,000.

Unlike the PON program that was directed primarily at direct application of geothermal energy, the Industry Coupled Program was designed to be a cooperative effort between the USDOE and industrial organizations engaged in geothermal exploration for electrical power generation. The program was initiated to foster development by providing for:

- Cost sharing with industry for exploration, reservoir assessment and reservoir confirmation; and
- The release to the public of geoscientific data that would increase the understanding of geothermal resources.

The program was never well publicized and when employed not particularly successful in meeting its intended objectives because release of geoscientific data had little impact on broader industry participation in geothermal development since most land positions were already well established (Bloomquist, 2003, and Bloomquist et al., 2008).

Several additional loan programs were authorized through provision of the Energy Security Act that passed Congress in 1980. These included Feasibility Study Loans, Reservoir Confirmation Loans, and System Construction Loans. The Reservoir Confirmation Loans Program was designed to replace the User Coupled Drilling Confirmation Loan Program to change the emphasis from direct-use projects to electrical generation projects. Despite passage and authorization by Congress, none of the loan provisions of the Energy Security Act were actually implemented because successive administration failed to request the need appropriations (Bloomquist, 2003, and Bloomquist et al., 2008).

The ARRA program of almost $400 million of 2009 was implemented to “jump-start” a variety of geothermal projects including (Figure 3):

- A total of $368.2 million was allocated for 148 geothermal projects such as;
- Rehabilitating wells, proving resources, installing power plants, direct-use projects, and geothermal heat pump projects;
- Specific projects include:
    - Innovative exploration and drilling projects ($97.2 million)
    - Coproduced, geopressured and low temperature projects, mainly electric ($18.7 million)
    - Enhanced geothermal systems demonstration projects ($44.2 million)
    - Geothermal data development, collection and maintenance ($33.7 million)
    - Ground source heat pumps ($62.4 million)
    - Cross cutting R&D ($111.9 million)
- The funding is ongoing.

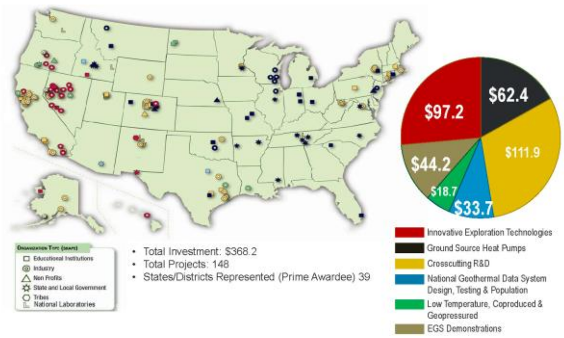

Figure 3. ARRA projects and funding (Milliken, 2011).

GEOPOWERING THE WEST PROGRAM

This program (GPW) was implemented by the UDOE-Geothermal Energy Program in 2001. The organization consisted of representatives from various federal organizations such as DOE, Idaho National Engineering and Environmental Laboratory, Scandia National Laboratories; National Renewable Energy Laboratory, and U.S. Bureau of Land Management, all the Western State energy offices, along with a number of research centers, trade and education associations such as the Geothermal Resources Council, Geothermal Energy Association, Geothermal Education Office, and the Geo-Heat Center. The main goals of the GPW program were:

- Contribute to the overall increased use of domestic renewable energy, as recommended in the National Energy Policy, by:
    - Doubling the number of states with geothermal electric power facilities from four to eight by 2010, and
    - Supplying the heat or power needs of 5 million Western homes and businesses by 2015.
- The program would pursue these goals by:
    - Bringing together national, state and local stakeholders for state-sponsored geothermal development workshops;
    - Working with public power companies and rural electric cooperatives to promote use of geothermal power;
    - Promoting increased federal use of geothermal energy;
    - Helping American Indians identify and develop geothermal resources on tribal lands; and
    - Sponsoring non-technical educational workshops.

The GeoPowering the West working groups had a number of meetings and implemented some of program objectives over approximately a five-year period and did accomplish some of the goals (i.e. there are now 8 states with geothermal electric power facilities); however, the goal of heating 5 million Western homes by 2015 may only be met with the help of geothermal heat pumps. All the Western states were funded by the program to implement local programs, and a few, such as Montana, Idaho, Utah, Colorado and California are still active in pursuing some of the goals proposed by the GPW program.

TECHNICAL ASSISTANCE PROGRAMS

One of the first, most successful and long-lived programs providing financial assistance to developers was the US DOE's Technical Assistance Grant Program.

The program intent was to provide assistance to potential developers of geothermal energy who had little or no expertise in the geothermal field in order to promote the rapid development of direct application resources. Assistance was provided to all public and private entities on a non- competitive, first-come, first-served basis. Assistance was available in resource assessment and/or preparation of technical and economic feasibility studies and was limited to 100 hours. Assistance was provided either by one of USDOE's technical center or by a consultant selected by the center. A secondary aim of the program was to establish expertise in the private sector consulting industry (Bloomquist, 2003, and Bloomquist et al., 2008).

Due to an increasing desire to involve more private sector consulting companies in the provision of technical assistance, the program was later scaled back with the technical centers being restricted to eight hours of direct assistance on any one project unless an exception was provided. Technical assistance continues to be available through the Oregon Institute of Technology Geo-Heat Center (GHC) with funds being made available through the USDOE. The program has been highly successful with numerous projects having been benefited by its ongoing availability. The initial work of the GHC included detailed state geothermal data basis and development status publications in 1979 for Alaska, Idaho, Montana, Oregon, Washington and Wyoming.

The Geo-Heat Center, established on the Oregon Institute of Technology campus in 1975, has been providing technical assistance to geothermal developers for over 30 years. This work has mainly been funded by USDOE Office of Geothermal Technologies. The Center staff has responded to assistance requests from all 50 states and over 60 countries. In addition to technical assistance for direct-use, small scale electric power and geothermal heat pumps, the Center staff have performed feasibility studies, implemented Task Ordering Agreements (TOA) for specific projects, provided information dissemination in the form of a Quarterly Bulletin and writing technical papers, maintains a website with over 1900 files that includes data on 12,000 wells and springs in 16 western states, and performs outreach by offering training, presenting papers at technical meeting and with site visits. As an example of activity on our website from 2008, the average hits per day were 11,000, the average users per day were 2,000 and the average downloaded pdf files per day were 4,000. Approximately 2/3 of the users were from the U.S., 10 to 15% were international requests, and the remaining from unknown sources.

CONCLUSIONS – WHAT WORKED AND WHAT DIDN'T WORK

Although all of the USDOE financial assistance programs, with the exception of ARRA and the technical assistance programs were terminated due to lack of congressional support, USDOE sometimes directly, but more commonly through one of the National Laboratories has continued to provide limited financial support. This support is generally directed to specific technologies, critical component development, resource exploration or demonstrations. Recent solicitations have been directed at for example small power plant demonstrations, critical power plant and well field components e.g. downhole pumps and enhanced evaporative cooling, direct-use applications and enhanced geothermal systems. All of these programs have required an industry cost share. Many of the initiatives, however, remain under-funded, and many projects have suffered from burdensome regulatory and administrative requirements (Bloomquist, 2003, and Bloomquist et al., 2008)).

Some states have also provided significant financial assistance; of these, California is by far the best example. Funding has come from geothermal royalties on state lands and the states' share of Federal royalties. Projects supported included for example, resource assessment, drilling, technical assistance, regulatory compliance, technology development and demonstration and enhanced injection. In a number of states, such as Oregon, New Hampshire and Nebraska, investor-owned and/or public utilities had established incentive programs directed at promoting geothermal heat pumps. Some states provide tax reductions for installing geothermal heat pump systems, mainly of the closed loop design. Starting in 2008 the USDOE provided tax incentives for geothermal heat pumps by providing a 30% tax credit for residential installations and a 10% tax credit for commercial installations.

An indication of the influence of USDOE geothermal programs on the development of direct-use projects is shown in Figure 4. Note the increase in energy on-line after the start of the PON and other direct-use program staring in 1975. A similar increase in electrical generation starting in 1975 influenced by USDOE GTP programs is shown in Figure 5.

One of the main problems with USDOE-GTP support of geothermal projects has been the variable funding over the years from a high of around $150 million (1980) to a low of $2 million (2007) as shown in Figure 6. Since around 1984 funding for the GTP has remained fairly constant at around $30 to $40 million annually. The only recent increase was for the ARRA program in 2009. In addition the emphasis of the USDOE-GTP R&D program, as in part directed by Congress, has changed annually. Some of the most resent emphasis are on Enhanced (Engineered) Geothermal Systems (EGS), Co-produced fluids from oil and gas wells, and Geothermal in Sedimentary Basins.

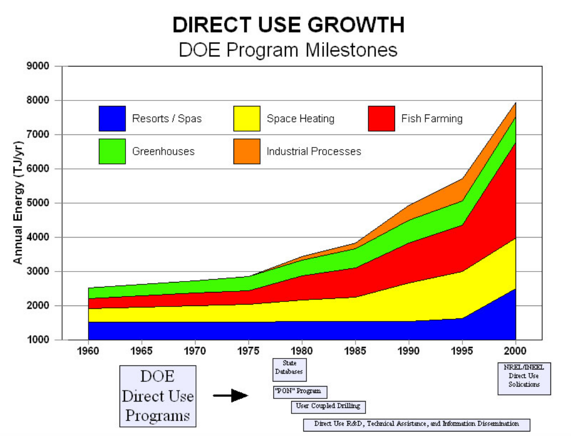

Figure 4. Direct-Use Growth with USDOE Programs 1960 to 2000.

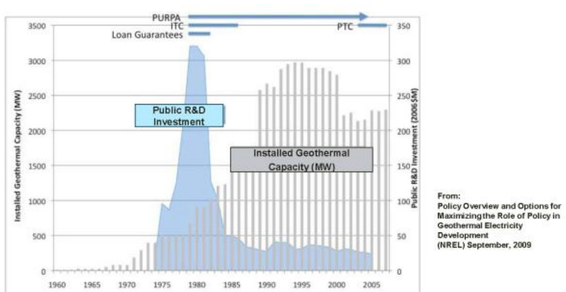

Figure 5. Installed electrical generation with USDOE program 1960 – 2008 (Milliken, 2011).

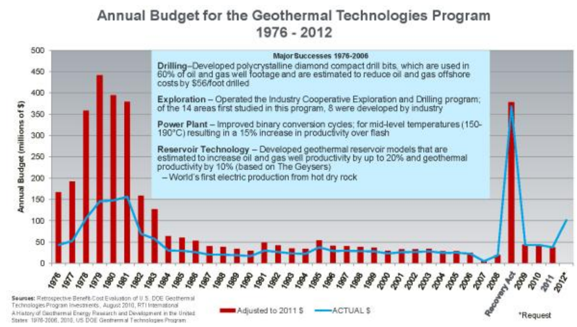

Figure 6. USDOE-GTP funding by year (Milliken, 2011).

Some of the other impediments to geothermal development are:

- Lack of reservoir insurance, however, a program of this type would tie up funds for up to 20 years, and the results are difficult to evaluate;
- Lack of public involvement and knowledge of geothermal energy (the "hidden" renewable resource);
- Leasing difficulties and time frame for leasing on federal lands, especially when the Forest Service is involved;
- Lack of recent emphasis on direct-use for small-scale developers;
- Transfer of the geothermal heat pump program to USDOE Building Technologies where it receives less emphasis;
- EAs and EISs are expensive and time consuming and often contested; and
- Information from USDOE funded projects is often limited or difficult to access for the information.

A summary of the major success for the GTP from 1976-2012 are:

- **Drilling** – Developed polycrystalline diamond compact drill bit, which are used in 60% of oil and gas well footage and are estimated to reduce oil and gas offshore costs by $56/foot drilled.
- **Exploration** – Operated the Industry Cooperative Exploration and drilling program; of the 14 areas first studied in this program, 8 were developed by industry
- **Power Plant** – Improved binary conversion cycles; for mid-level temperatures (150-190oC) resulting in a 15% increase in productivity over flash
- **Reservoir Technology** – developed geothermal reservoir models that are estimated to increase oil and gas well productivity by up to 20% and geothermal productivity by 10% (based on The Geysers)

– World’s first electric production from hot dry rock.

Other U.S. geothermal accomplishments include:

- Geothermal heat pumps is the fastest growing geothermal application with over 100,000 units installed annually and a total of over one million united installed – we are the worldwide leader;
- A number of universities have contributed to the education and development of geothermal resources along with have R&D programs including: Utah (EGI), Southern Methodist, Stanford, Oregon Institute of Technology, MIT/Cornell, University of Nevada – Reno, etc.
- Private industry has developed geothermal electric power as a worldwide leader, with over 3,000 MWe presently installed; and
- Geothermal energy is now mentioned along with other renewables (most of the time.)

U.S. renewable energy policy has continued to change over time in an attempt to best meet the needs of these emerging technologies. Geothermal has been the focus of numerous policy initiative directed at expanding the industry and bringing both electrical and direct applications on-line. Much of the early emphasis was placed on direct financial support in the form of loans, guaranteed loans, grants, government cost sharing or insurance. However, as Federal funding became less and less available the emphasis turned more towards creating markets for geothermal power and/or rewarding companies for success through production tax credits or direct monetary support. No matter what form policy takes, it is critically important that it provide a level playing field for all renewable (Bloomquist, 2003, and Bloomquist et al., 2008).

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