Will U.S. geothermal resources win a role in process plants?

Outside the U.S., the chemical process industries are already exploiting geothermal energy for several tasks. Now, the U.S. is moving toward similar applications.

☐ In Iceland, a diatomite filter-aid plant handles its drying operations with geothermal steam. A pulp and paper mill in New Zealand uses geothermal energy not only for drying but also for black-liquor evaporation and pulp digestion.

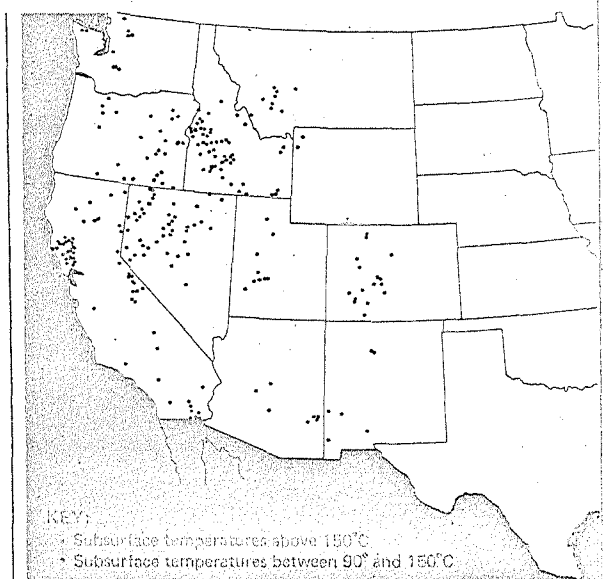
These two insular installations stand out from other facilities tapping hot subterranean fluids because the two are pioneering the large-scale use of the energy for process applications. In contrast, other ventures take advantage of geothermal fluids to generate electricity or to heat buildings.

However, the prospects of harnessing geothermal energy by the chemical process industries (CPI) for other than electrical and space-heating roles go far beyond these showcase systems (detailed in the box on the next page). Smaller CPI installations scattered around the world use or have used geothermal heat in the processing, for example, of boric acid, sulfur and seaweed. Proposed geothermal-heat applications include production of alumina and of heavy water. In addition, other proposals envision the recovery of minerals and chemicals from the geothermal fluids—see box on page 81.

All of the heating services—and many more CPI tasks—share one common trait: a need for considerable quantities of relatively-low-temperature (usually from 50 to 150°C) fluids. Such needs, and non-CPI chores such as space heating, will soon be satisfied by geothermal energy if a multipronged effort being spearheaded by the U.S. Energy Research and Development Administration (Washington, D.C.) proves successful.

WHY GEOTHERMAL ENERGY?—As shown on the map below, a prime attraction is that low-grade heat from geothermal resources is widely available in the U.S., particularly in Western states. Despite the greater attention now afforded to using geothermal resources for electricity generation (see *Chem. Eng.*, Mar. 5, 1973, pp. 40–41), which requires temperatures starting at about 150°C, lower-temperature geothermal resources are about equally abundant. "Identified and undiscovered" hydrothermal convection resources (where circulating water and/or steam transfers heat from depths to the surface) in the U.S. total 364×10^{18} cal at the wellhead for systems at 150°C or more and 346×10^{18} cal for systems from 90 to 150°C, according to the U.S. Geological Survey. (Each type of reserve exceeds the heat of combustion of 235 billion bbl of oil, or 50 billion tons of coal.)

Second, non-electrical use of low-temperature resources boasts greater utilization efficiency than electricity generation from higher-temperature geothermal resources. Efficiency in converting heat in wellhead geothermal fluid to electricity runs 8–20%, the USGS estimates, versus an average of 24% for process heat.



Source: U.S. Geological Survey

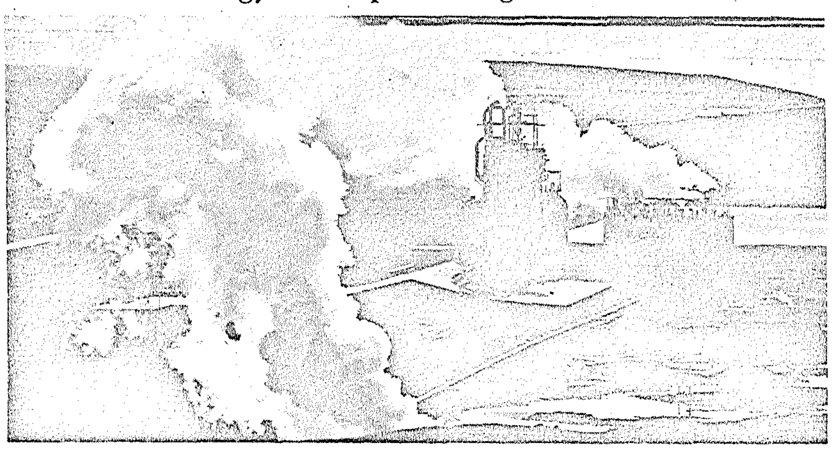
A third attraction for non-electrical tasks is fewer technical complications and risks in actually using the geothermal energy. Once this energy is brought to the surface, by well-production methods akin to those intensely studied for electrical end-uses, there's no electricity-generation cycle involved. Straightforward heat-transfer equipment is generally enough, albeit with close attention to choosing materials of construction that will resist the often brine-laden geothermal fluid.

Fourth, a typical non-electrical geothermal system is much smaller and thus far less expensive to build than a powerplant, making initial funding less troublesome. Payback is faster, too.

On the other hand, there is one prominent cloud on non-electric's horizon. The user installation must be situated quite near the geothermal resource, since heat can't be shipped very far. Few CPI facilities lie close enough to known resources to consider retrofitting to geothermal energy. That will demand the building of brand-new industrial complexes, in geothermal areas often rather remote.

The economics are also unproved;

Geothermal energy boasts processing successes



The two prime examples of plants now using geothermal energy for chemical-process-industries tasks both lie outside the U.S., in fact on opposite ends of the globe.

One is the Tasman Pulp and Paper Co. installation at Kawerau, New Zealand. Operating since the early 1960s, the integrated mill currently exploits saturated geothermal steam at about 175°C and 120 psi (this is flash-separated from water also in the local resource). Its most important end use is generation of clean, low-pressure process steam, for the kraft pulping step and also pulp/paper drying. Surplus geothermal steam passes to a 10,000-kW turboalternator, which provides part of the mill's electricity. Then, exhaust steam is fed to a pre-evaporator for black liquor.

The second showcase facility (see photo above) produces 25,000–30,000 tons/yr of diatomite filter aid. Started up in 1968 at Lake Myvatn in northern Iceland, the plant is owned by Kisilidjan H/F, a joint venture of the Icelandic government and Johns-Manville Corp. (Denver, Colo.). Here, geothermal steam first serves in the direct heating (to 85–90°C) of an 11–12%-solids slurry of diatomaceous earth, pumped from the bottom of the lake. After vacuum filtration turns out a higher-solids cake, geothermal steam acts as the heat source in four rotary tubular dryers, each having an evaporative capacity of about 5½ tons/h of water. Most of the 45 tons/h of 200°C steam consumed serves in this second step, after which the dried material proceeds to further processing. Operation has been smooth and successful, Kisilidjan reports. Without the benefit of low-cost geothermal energy, however, observers say the installation probably couldn't compete economically with diatomite production from the usual dry raw-material sources.

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it remains a paper-study prediction that the rising cost of fossil fuels in the U.S. will justify turning toward geothermal.

ERDA CONTRACTS—Though some geothermal advocates pooh-pooh the need for more engineering and economic feasibility studies—urging instead the immediate construction of commercial-size demonstration facilities—the latest initiative by ERDA indeed funds 19 such studies. The contracts, finalized within the past two months, have resulted from a Program Research and Development Announcement issued by ERDA earlier this year.

A half-dozen contracts address CPI applications, for raising process steam and providing low-temperature heating fluids. The remainder mostly cover space heating of commercial and residential buildings (widely practiced already at Klamath Falls, Ore., and Boise, Idaho, and even more so outside the U.S.); and applications in agribusiness, such as space, water and soil heating for greenhouses, animal husbandry and tree- and fish-farming.

The CPI studies, mostly in the $100,000–$125,000 range and scheduled for completion in 6–12 mo, are:

- Sugar-beet processing, by TRW Systems (Redondo Beach, Calif.), with additional support from Holly Sugar. California is the United States' largest beet-producing state, especially in its geothermal-rich Imperial Valley. Brines available there in the 150–195°C range could serve to generate steam for beet cooking.
- Fertilizer manufacture, by Westec Services, Inc. (San Diego, Calif.), with partial funding from Valley Nitrogen Producers. The main objective: learning how and where to retrofit the latter's existing ammonia plant, in the El Centro Valley area of California, to use geothermal heat from local resources.
- Refrigeration for food processing, by Aerojet Energy Conversion Co. (Sacramento, Calif.). Absorption-cycle refrigeration systems can be powered by geothermal heat, for freeze drying and similar uses.
- Seafood processing, by De Laureal Engineers, Inc. (New Orleans, La.). The potential lies in cleaning, steaming, cooking and refrigerating/freezing various seafood products, probably in a cascading system (where the same hot fluid passes from the highest-temperature initial service to others needing progressively lower temperatures). Campbell Soup Co.'s TRI Laboratories is providing technical assistance to the firm. Followup studies by De Laureal (not covered by the existing contract) might look into alumina and sugar-cane processing.
- Evaporation and crystallization, by Bechtel Corp. (San Francisco, Calif.). Its "multistage feed-and-bleed concept" for extracting heat from geothermal brines promises efficiency up to 85%, versus 35% extraction efficiency for single-stage systems.
- Industrial complexes, by DSS Engineers, Inc. (Ft. Lauderdale, Fla.). These would group, in a cascading arrangement, such heat-intensive industries as pulp-and-paper making and food processing.

RAFT RIVER COMPLEX—ERDA's

Idaho National Engineering Laboratory (Idaho Falls) has already conceptualized a $20 million–$30 million geothermally powered industrial complex, under its Raft River Geothermal Demonstration Project.

Much of the input geothermal energy, from a 150°C water resource at the as-yet-unindustrialized site, would first be used in a 5–10-MW_e powerplant (unusual because of the low temperature). Some geothermal fluid would also be flashed to steam and water, for use in a refrigeration plant (for a slaughterhouse), potato processing (peeling, cooking and drying), and manure processing (a complex flowscheme turning out protein feeds, silage and fertilizer). Water from the powerplant, or incoming 150°C water, might also serve for the refrigeration task.

Depending principally on the final powerplant design, the entire flow of geothermal fluid from these services, at somewhere between 70°C and 95°C, would then pass to a second set of non-electrical uses (a greenhouse, a feedlot, and fish and tree farms).

According to R. J. Schultz, manager of non-electric projects, INEL is currently holding preliminary talks with possible industrial participants. ERDA hopes to entice them with no-or low-cost geothermal energy for the first three to five years (after which ERDA would turn its initial energy-distribution role over to a private entity). It will take half a year, though, before all the legal and institutional entanglements can be ironed out and final participation contracts readied.

ERDA AIDS—Though each participant would provide its own capital funds, ERDA intends to help on that count, too, via its new geothermal loan-guarantee program.

Overseen by ERDA's San Francisco Operations Office, the program offers loan guarantees amounting to as much as 75% of the capital cost of various geothermal activities (*Chem. Eng.*, Aug. 16, p. 33). Program manager Mark Silverman says that non-electrical proposals would likely receive top priority for loans because of their near-term potential. Other strong points include low cost per project, and the promise of fast success and payback.

Yet another helping hand for geothermal development is ERDA's Geothermal Component Test Facility, operated by the University of California's Lawrence Berkeley Laboratory in the East Mesa section of the Imperial Valley of California. The facility cost slightly over $1 million and is just now being completed, reports Jim V. Davey, manager of non-electric geothermal utilization for the laboratory.

It offers industry and government a site to investigate hardware and processes, whether for electrical or non-electrical systems or both. Geothermal fluids of different temperatures and solids content are piped to four test pads. User charges can range from zero, to full-cost-recovery for ERDA.

(The geothermal wells at East Mesa actually lie on land belonging to the U.S. Bureau of Reclamation, and had been used until a few years ago to study desalting of geothermal brines, to generate fresh water to augment the flow of the Colorado River.)

OTHER PROJECTS—Outside the U.S. government, Oregon Institute of Technology has been a strong supporter of geothermal energy for non-electrical uses. Its Geo-Heat Utilization Center (funded by states in the region) has targeted most of its efforts toward space heating. Associate director John Lund points out, however, that studies are underway or planned also on various applications in the food industries, and identifies preheating heat-transfer fluids for particle-board processing as another potential outlet for local geothermal resources.

The Pacific Geothermal Food Desiccation Research Institute (Reno, Nev.) wants to build a plant at Brady Hot Springs, Nev., initially to dehydrate onions and chili peppers. Most of the about-165°C brine available at that site would heat drying air, but some would also generate on-site electricity. B. C. McCabe, Jr., a director of the Institute, adds that a special atmospheric-pressure freeze-drying scheme has been developed. Applicable specifically for geothermal energy sources, it would likely be exploited later on for, e.g., processing of potatoes. McCabe is now seeking construction funds for the plant under the ERDA loan-guarantee program.

Nicholas R. Iammartino

Are minerals also in geothermal's non-electric future?

Besides their potential role as a valuable energy source, geothermal brines are also being eyed for their minerals content.

Today's major project is in Iceland, where the government has completed feasibility studies for a two-part chemicals complex to be located at Reykjanes on the southern coast. The principal operation would process geothermal brine to turn out 200,000 tons/yr of industrial salt, 50,000 tons/yr of coarse fishery salt, 25,000 tons/yr of potassium chloride and 700 tons/yr of bromine. DSS Engineers, Inc., prepared the basic design (*Chem. Eng.*, Apr. 29, 1974, p. 164). The second operation, probably for implementation later, would draw on seawater, as well as the geothermal industrial salt, to yield myriad products such as sodium, chlorine, caustic soda, magnesium and hydrogen. A decision on this second stage is still a year or more off.

In the U.S., the Bureau of Mines has looked into minerals recovery from geothermal fluids, but taken no major steps. Last year, reports prepared for BuMines by Hazen Research, Inc. (Golden, Colo.) concluded that recovery of soluble saline constituents (e.g., sodium chloride and calcium chloride) would be impractical, but recovery of metals such as iron, manganese, zinc, lead and barium might be worthwhile. (During the 1960s, Union Oil Co. and Morton Salt Co. abandoned as uneconomical some projects aimed at producing potash and table salt, respectively, in the Imperial Valley of California. Japan has also had a salt-making venture fold.)