Geothermal Heat Pumps: A Mid-Term Status Report on a $100 Million Public/Private Market Transformation Effort

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ABSTRACT

The Geothermal Heat Pump Consortium (GHPC) is a Climate Change Action Plan partnership. The Federal government pledged $35 million over seven years, to be matched by $65 million in private sector funding, to make "geothermal heat pumps" a significant component of the HVAC industry and avoid 1 – 1.5 million tons/yr. carbon equivalent/year. The original mission was to move the market from 40,000 units/year to 400,000 through a sophisticated, multi-faceted program addressing several market barriers simultaneously. This paper offers valuable "lessons learned." First, the original goal to achieve 400,000 unit sales/year by 2000 was too optimistic, given: (a) lack of rigorous market analysis to determine a realistically attainable growth rate; (b) lower-than-expected federal funding; (c) the collateral effects of utility industry restructuring; (d) low public awareness; and (e) weak infrastructure. Second, while geothermal heat pumps have historically seen most of their installations in the residential market, commercial/institutional market segments appear to have been more responsive to GHPC's programs. As a result, GHPC has adjusted its programs substantially to get the most bang for the limited market transformation buck. After a one-year period of program implementation, 1997 sales data indicate growth of over 20% compared to 1996, while heat pumps and central A/C experienced decline. Emergence of several other positive leading market indicators further provides evidence that the collaborative program is starting to transform the market.

Program Background And Goals

Geothermal heat pumps have been used in the United States for several decades. Around the mid-1980's, however, their use began to increase, as the result of support from rural electric and other utilities, the U.S. Department of Energy, the International Ground Source Heat Pump Association (IGSHPA), the Electric Power Research Institute (EPRI) the National Rural Electric Cooperatives Association.

In 1993, a U.S. EPA study comparing residential heating and cooling technologies identified geothermal heat pumps as generally having the lowest emissions of CO_2, SO_2, and NO_x among available electric, natural gas (including gas heat pumps) and oil technologies. EPA also found that geothermal heat pumps were economically competitive with other technologies on a life cycle basis, and that their owners liked them. EPA recommended a national private/public partnership to commercialize the technology, and included geothermal heat pumps in the ENERGY STAR program (L'Ecuyer, Hoffman & Zoi 1993).

DOE took the federal lead in the "National Earth Comfort Program" initiative, teaming with Edison Electric Institute (EEI), EPA, IGSHPA, NRECA, and EPRI in a $100 million market transformation effort. The electric industry was to provide $65 million in DSM program investments through 2001, while DOE pledged $35 million. EPA provided a grant for $1.3 million. The not-for-profit Geothermal Heat Pump Consortium (GHPC) was formed in late 1994 to coordinate the national effort and to funnel the federal grant resources. Recruitment of member utilities commenced

immediately. GHPC formed three operating committees to attack the major barriers to geothermal in the market: market infrastructure, first cost, and public awareness and confidence in the technology.

The participants set aggressive goals for GHPC. Surmising that current sales were around 40,000 units/yr, they set a program goal of 400,000 units/yr. – a ten-fold increase – by 2000 (this meant a compound annual growth rate >40%). This would achieve *market transformation,* defined as a national market penetration level sufficient to allow the technology to become self-sustaining in the market without the assistance of a government program. Proponents calculated that, if this goal were attained, national carbon emissions would be reduced by 1 to 1.5 million metric tons annually.

Bumps in the Road to Market Transformation

That original goal turned out to be overly ambitious, given issues that have been encountered in ramping up the National Earth Comfort Program. These include the analysis behind the goal itself; federal funding that was slower and lower than anticipated; utility industry restructuring; and lack of sufficient marketing resources within the geothermal industry to overcome the chronic problems of low public awareness and lack of sales and installation infrastructure.

Keeping Score: Baseline and Metrics

The program's aggressive goal of 400,000 annual sales in seven years made for great slogans, created a great deal of excitement in the utility and geothermal heat pump industries and helped motivate strong advocacy to win Congressional funding. However, no market analysis was performed to ascertain whether a ten-fold expansion of sales within a seven-year period was even possible, either from the perspective of market demand or market supply (the ability of manufacturers to keep up with growth). The annual compound growth rate demanded was in excess of penetration rates subsequently observed for other products that have faced much more favorable market conditions (Sachs 1998). It also did not account for a program ramp-up period and the lag times that would occur before market effects would be seen. In addition, no analysis was performed to ascertain whether 400,000 units/yr. represented a critical mass for market self-sustainability and an appropriate target for program sunset. This led to some tensions and statements of disappointment when 1996 sales appeared to be flat.

The lesson learned is that, while adoption of aggressive program goals can be a strong motivational factor and can help generate stronger budgetary support by Administration and Congressional policy makers, it is equally important to make sure that the goals are actually attainable. Otherwise, there is the danger that, even if the program is successful in initiating market transformation, it might be criticized and eventually down-funded due to a *perception* of failure because it cannot attain overly ambitious goals.

Show Me the Money!

As mentioned, DOE announced at the beginning of the Earth Comfort Program that it would commit $35 million to the overall effort. During 1994, EEI members and manufacturers worked successfully to win Fiscal Year (FY) 1995 Congressional funding. However, GHPC and its partners soon learned that getting Congressional appropriations for the program does not equate to instantaneous funding for GHPC!

Time Lags in the Federal Grants Process. While adept at obtaining Congressional funding, none of GHPC's key allies had much experience in obtaining funding from federal agencies, and therefore had unrealistic expectations with regards to program ramp-up. Procuring a large DOE grant took much longer than GHPC (or even DOE program management) anticipated. This wasn't accomplished until September 1995 – a few days before the end of the fiscal year. Similarly, EPA's smaller grant was not awarded until October 1995. This led to tensions with member utilities that had paid membership dues at the beginning of 1995, and which were not pleased that the program was not in full swing in early 1995.

There were two key lessons learned for any market transformation partnership relying on federal agency funding. First, don't plan from the assumption that funding automatically arrives at the beginning of a fiscal year in which Congress passes a budget. Rather, build realistic expectations as to when federal grant funding will arrive. Second, recognize that at this stage good grant writers are as important as good legislative experts, program designers and administrators.

Lower Funding than Anticipated. In addition to time lags in grant procurement, both the Congressional budgets for heat pump mobilization, as well as the yields to GHPC as a percentage of those appropriations, have been much lower than the $35 million DOE originally committed to in its grant to GHPC. To date, GHPC has received about 45% of the DOE funding stream projected at program outset (the pending FY98 grant may bring the percentage up to about 50%). The other resources have gone to geothermal heat pump programs and to DOE program "overheads." Despite these lower funding yields, GHPC has been held to the same program goals until recently, when DOE and program partners began to realize that the goals would need to be revised. The key lesson here is that a program with multiple partners requires strong communication, coordination and understandings from the outset. Program expectations must be calibrated to various funding scenarios, in order to minimize tensions and avoid perceptions that the program isn't working, when in fact it may be achieving a great deal with the resources provided.

Effects of Utility Industry Restructuring

The effects of utility industry restructuring on energy efficiency programs are well known. Not surprisingly, they have had a huge effect on the geothermal heat pump market, which has always relied on DSM programs, as well as on GHPC's market transformation program, which similarly relied on DSM to provide the bulk of the private sector's $65 million program investment. GHPC was to initiate up to 12 large major program "demonstrations" spread out across all regions of the United States, with each demonstration program leveraging several million dollars per year from the sponsoring utility.

Unfortunately, even as GHPC was hiring staff in early 1995, it became evident that, despite the strong interest of utilities in geothermal heating and cooling technology, restructuring would dampen their interest in major program demonstrations. Rebate programs were scaled back or canceled. Marketing staff were reassigned or let go. Marketing managers found it increasingly difficult to vie for upper management attention against such issues as whether the company would continue to exist, what its role in the market would be, or stranded assets. Some utilities felt unable to make multi-year commitments due to uncertainty over what they'd be allowed to do under deregulation. Thus, by 1996 GHPC learned that it would have to deviate from the original plan for large-scale utility programs as a central feature of the program.

Trials of an Emerging Industry – Low Awareness and Lack of Market Infrastructure

The prospects of reduced utility investments was a serious threat for the geothermal heat pump industry, which had long relied on those investments to make up for its own lack of resources relative to larger and more mature segments of the HVAC industry. Aside from the obvious effects of reduced or cancelled rebate programs on first cost, the industry was insufficiently capitalized to overcome the entrenched barriers of low public awareness and deficient market infrastructure without utility marketing and communications support.

"But I Don't Have a Geyser in my Yard." Lack of public awareness is always a problem with any new technology, and under-capitalization of the industry promoting it can severely lengthen its commercialization curve. For geothermal heat pumps, the challenge was even greater. Because the terms "geothermal" and "heat pump" each connote different technologies, it was inevitable that the technology would suffer from confusion and misidentification when people *did* hear about it. For many people, "geothermal" means tapping high-temperature ground reservoirs that provide sufficient energy to produce electricity. "Heat pumps," connotes air source heat pumps, GHPC found to score lower than competitive technologies in such critical areas as comfort and operating cost (GHPC 1996).

Some manufacturers and utilities had sought to overcome this confusion by using different terms for the technology. Variously, such terms as "earth-coupled heat pumps," "earth energy systems," "ground-coupled heat pumps," "ground source heat pumps," and "SystemGT"[1] were used. Rather than solve the problem, this proliferation of terms caused a Tower of Babel effect – a consumer could move about North America and hear several terms without realizing that they all referred to the same thing. Furthermore, GHPC-sponsored focus groups did not identify any existing term as particularly effective in the market. Thus, GHPC learned that the industry needed one effective, customer-tested term – even at the risk of initially adding to the Tower of Babel effect.

"Oh, You Don't Want *That!*" Although geothermal is a superior HVAC technology, its market success is dependent upon acceptance by key market influencers, just as other HVAC technologies are. If it is to succeed, mechanical contractors, engineers, architects, builders, and Realtors must not only be familiar with it, but also have the enthusiasm and skills to sell it as an upgrade. They must also overcome the additional barrier of finding and partnering with drillers and excavators to install the ground loop.

IGSHPA and geothermal heat pump manufacturers have developed and delivered training and certification to thousands of ground loop and mechanical installers over the years. However, while customers can obtain lists of certified loop installers from IGSHPA, many of the people on the list never became very active in the field. Only 11% of all HVAC contractors installed a geothermal heating and cooling system in 1997 (Skerl 1998). Among the 11%, the median installed only 5 systems. With such low participation and sales volume, one can expect customers to find it hard to find an experienced installer; if they do, the prices they face are likely to be much higher than what they would see in a more mature, higher-volume and more competitive market.

GHPC learned of cases in which DSM money was spent by the local utility to generate greater public awareness, only to have the effort result in unfulfilled leads. In addition, recent market research conducted by GHPC indicates that, among geothermal system owners, dealer service and reliability is rated lower than other aspects of the customer's system (e.g., comfort and low energy bills).

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[1] "SystemGT" and its associated markings is a trademark of Cinergy.

Thus, despite the fact that the National Earth Comfort Program has from the outset placed the highest priority on and devoted the most funding to increasing public awareness, continuing efforts to build infrastructure are absolutely necessary, no matter what the funding scenario is. Therefore, one of GHPC's challenges has been to augment market infrastructure as cost-effectively as possible in the face of tight budgets.

Quicker Acceptance in Commercial and Institutional Markets

GHPC discovered not long into the program that commercial markets offered as great opportunities as the traditional residential base. Furthermore, GHPC found that penetration of those markets was possible without large public awareness and communications budgets. In addition to lower energy bills, there were several technological and institutional reasons for this:

Fewer First-Cost Barriers

Experienced designers can often make commercial geothermal heat pump systems competitive on a first cost basis with conventional, high-efficiency technologies. For instance, innovative use of an open-loop configuration enabled the Galt House in Louisville, KY (the largest geothermal installation in the world at over 4,000 tons) to enjoy about a $500/ton first-cost advantage over alternatives (GHPC 1997a). Similarly, the Neff School in Manheim Township, PA found that a retrofit with geothermal would cost about one dollar/ft.^{2} less than the next best alternative (GHPC 1997b). Installation of ground loops in foundation pilings saved $100,000 in loop costs for hotel in New York (Sachs et al. 1998). In addition, geothermal reduces other building costs. Reducing roof load by down-sizing a cooling tower (hybrid system) or eliminating it altogether reduces the amount of support steel required. On the revenue side, smaller mechanical rooms allow geothermal building owners to translate more building space into revenues.

Lower Maintenance Costs

For many customers, especially public sector customers, lower maintenance costs are a key consideration. Research done for GHPC and ASHRAE reveals that, geothermal systems have substantially lower maintenance costs than conventional technologies – often the maintenance savings are as large as the energy savings, and they can reduce simple payback periods by as much as one-third (Cane et al. 1997). For many public sector institutions, lower maintenance costs allow public agencies to tolerate diminishing operations and maintenance budgets over time.

More Efficient Distribution and Greater Comfort

Since commercial geothermal systems typically employ many heat pumps distributed throughout the building, ducts are smaller and shorter. Often the only ductwork needed is for fresh make-up air required for indoor air quality. In addition, distributing heat pumps throughout the building facilitates local zone control, thereby enhancing comfort. It also allows simultaneous heating and cooling within the building, and recycling BTUs rejected from the cooled area to the heated area through the common loop.

Opportunities for Integrating Loads

Many commercial facilities offer additional opportunities to integrate loads through the ground heat exchanger. One striking example of this is the Skunk Creek Conoco in Minnesota Power Company's service territory. This combination gas station/convenience store/car wash handles many loads with one ground loop, including HVAC, reach-in and walk-in refrigerators and freezers, ice makers, hot water for the convenience store, hot water in the car wash, and even de-icing around the car wash. Integration the loads to allow recycling BTUs improves energy efficiency (GHPC 1997c).

Use of Life Cycle Analysis

Businesses tend to submit their investment decisions to more sophisticated analyses than homeowners. Use of life cycle costing provides the facility manager with a clearer picture of the long-term benefits of geothermal, since he or she can compare energy and maintenance savings over time with any first cost premium that may be incurred.

Pressure on Public Facilities to Cut Energy and Economize

Many public agencies are under pressure to cut expenses at their facilities, particularly federal agencies directed by Executive Order 12902 to cut energy consumption by 30% by 2005 relative to 1985. Geothermal heating and cooling can play a predominant role in achieving that goal – they also provide the benefit of allowing the agency to fulfill the additional requirement to utilize renewable energy to some degree. Following the success of a 4000-home retrofit of geothermal with other conservation measures at Fort Polk, LA, several additional military bases and non-Department of Defense agencies (such as the Post Office) have started adopting geothermal technology in facilities.

Fast Learning Curve

Geothermal is not hard for architects and engineers to grasp, given its similarity to a boiler/chiller or cooling tower system that employs water source heat pumps. In fact, geothermal heat pumps are basically extended-range water source heat pumps, and the ground loop can be seen as a straight substitute for the boiler and chiller or cooling tower.

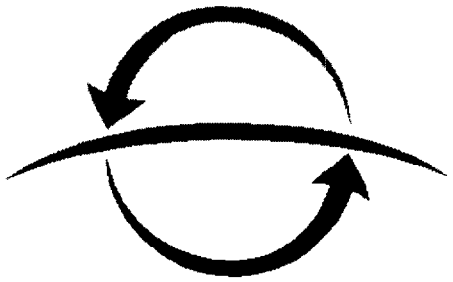
Adaptive Management: Adjusting to a Changed Market Landscape

From early on, GHPC has tried to maintain as much flexibility and responsiveness as possible. As a result, as market conditions have changed, GHPC has striven to make the appropriate program adjustments:

GeoExchange Brand Name

In 1996, GHPC performed market research on the issue of technology identification, in order to develop a brand name that the industry could rally around. We tested the many terms already used by various segments of the industry, and several new ones. The objective was to come up with a term, logo and tag line(s) that would help customers grasp the technology and that would someday be as ubiquitous and recognizable as the gas industry's blue flame. The focus groups indicated that, none of

the terms in use was very effective in clearly identifying the technology. A few new terms worked better. Subsequent trademark searches yielded "GeoExchange" as an effective term that was not currently in use. GHPC's creative team then produced symbols and tag lines to go with the term:



GEOEXCHANGE

Saving from the ground up.℠

Since some of GHPC's members wish to stress comfort as well as savings, GHPC offers an alternative tag line, "Comfort from the ground up." GHPC filed for protection of this branding package, which subsequently won a Pro-Comm advertising award in 1996 for its effectiveness in identifying the technology for customers.

As envisioned by GPHC, the GeoExchange brand has been eased into use by its utility and trade ally members over time. Many found it necessary to transition gradually from whatever terms they had used before, since they had invested in marketing those terms into various local and regional markets. For instance, GPU (a utility company in New Jersey and Pennsylvania) developed a radio spot to "announce" the new term. During 1997, many GHPC members began using the brand, and have not reported any significant transitional problems (probably due in large part to low customer awareness of the previous terms used in their markets).

Deployment of Smaller, Segment-Oriented Co-Funded Programs

Rather than solely emphasizing a dozen or so large utility programs (so-called "Major Demonstration Programs" calling for GHPC co-funding of $.5 to $1.5 million), GHPC has also co-funded a much larger number of smaller programs (GHPC co-funding of about $20,000 to $200,000). This approach has several advantages over a few large utility programs: a) smaller programs are more in scale with what most utilities are able to fund (several hundred thousand dollars total vs. millions of dollars per year); b) they spread market mobilization efforts across more markets, thereby better supporting the goal of creating a national market; c) they deliver more valuable products such as public awareness and program resource materials to other GHPC members more quickly; d) they allow GHPC to experiment with more innovative program designs and.

In addition, GHPC has made trade ally members eligible for co-funding opportunities,. GHPC now has 5 Major Demonstrations and over 20 co-funded programs operating or in start-up, covering a wide range of market segments and strategic approaches. Many of these target residential markets, including one (by Autumn Oaks) demonstrates an innovative integrated community water loop that is tied into the local water treatment plant as a heat source and sink. This new approach, and others like it that are emerging, actually enable GeoExchange to be installed at *lower* first cost than conventional

heating and cooling system infrastructure. In fact, the community loop is very similar to natural gas distribution lines, which uses very similar buried polyethylene pipes to feed each home. Rather than delivering a fossil fuel for combustion, however, it carries BTUs in water.

However, reflecting what GHPC has learned about opportunities in non-residential markets, many of the co-funded programs target key commercial and institutional market segments including offices, health care facilities, convenience stores, publicly owned buildings, schools. There is a TVA demonstration of a GeoExchange-heated aquaculture project in an agricultural school. Others increase local public awareness by installing GeoExchange in high-traffic facilities, such as nature centers and visitor centers, along with informational displays. For instance, the Lake Erie Nature Center outside of Cleveland co-sponsored by GHPC and FirstEnergy experiences over 125,000 visitors a year – all of whom can now view the GeoExchange display.

To address utility restructuring, many co-funded projects emphasize alternatives to rebates. One example is the innovative "chauffage" program by Delta-Montrose Electric Association, which is offering customers the entire geothermal system (loop and heat pump) and the *energy* for a flat monthly fee. Not only do builders see a lower first cost for GeoExchange homes (since the cost of the heating plant is taken out of the nominal price); customers enjoy heating and cooling comfort at a guaranteed monthly cost that includes system upkeep and maintenance as well as energy. Since it owns the system and charges a flat energy fee, Delta-Montrose has a clear incentive to make sure the system is designed, installed and maintained optimally. The emergence of innovative financing to replace rebates in reducing first costs has led to strong interest in a national leasing or loan program that can be accessed by home and business owners everywhere, with or without active participation by utilities.

GHPC's co-funded projects have produced significant market activity in several cases, and have provided GHPC with a rich set of consumer awareness and program resource materials. These have been widely distributed to GHPC members and to customers through GHPC's GeoExchange Information Center and Web page (below), thereby spreading the market mobilization benefits of GHPC's investments beyond the areas in which the co-funded programs are conducted.

Spreading the Word: GeoExchange Information Center

GHPC, with EPA's funding, has launched a GeoExchange Information Center through which customers can find information on the technology and GHPC member utilities and trade allies can request valuable marketing, communications and technical resources. The Center can be accessed in two ways: via high-visibility numbers (1-888-ALL-4GEO) and via GHPC's Web site at *www.geoexchange.org*. Both opened in Spring 1997, and activity has grown steadily ever since at a compound growth rate of nearly 20% per month over the first year. GHPC's Web site now experiences over 125,000 page "hits" per month.

GHPC has also worked to organize materials into comprehensive market segment kits. For instance, for the school market the kit includes a fact sheet, a video, several written case studies, and a list of known sites (there are over 400 in North America) with contact names wherever possible. GHPC member utilities and trade allies report that the segment kits make their job of promoting the technology much easier. Consequently, GHPC is continuing the development of segment kits for other segments, such as residential, hotels, office buildings, military housing, etc.

Trade Allies Leads Referral Service

An important practical function is disseminating leads. GHPC has the zip codes that member serves, so that when a customer inquires about the technology via phone, the Web, or at a trade show, GHPC can refer the customer to one or more trade allies. At the same time, GHPC sends the customer referral to allies. GHPC members that use the referral system have reported highly satisfactory results.

In addition, GHPC begun to post project referral databases for members in the "members only" section of its Web site. For instance, members can use a password to access a national school projects database that GHPC purchases on their behalf. The database lists jobs by state, giving vital information about the scope and size of the project (e.g., retrofit vs. new construction and budget), as well as contact information.

Referrals and lead generation not only make the process of getting customers together with providers much smoother; it also helps GHPC create direct benefits for its manufacturer and trade ally members, a function that could be sustained after the federal funding portion of the program is ended.

Strategic Outreach

Another facet of working directly with trade allies as well as utilities in a market segment-oriented approach is GHPC's strategic outreach program. GHPC hires segment experts to communicate GeoExchange benefits for their market segments. They exploit existing contacts, develop new leads, and respond to GHPC leads. Their mission is to help potential customers or market influencers (builders, developers, engineers, architects, etc.) become comfortable with GeoExchange. Their mission is NOT be to make direct sales, but rather to open up the door, qualify leads, and lay the foundation for trade allies to close deals.

Design Assistance for Commercial Markets

An essential complement to outreach for commercial and public sector markets is design assistance. While a customer's engineering firm could always seek formal training in geothermal design in response to a customer's interest, there are two major barriers to adoption. Typically, designers would rather not bother to get the training on something new when they are already aware of off-the-shelf solutions (especially if the training is on their own dime!). Even if they receive training, they often do not gain enough knowledge to account for all relevant factors when running a feasibility analysis, or enough confidence to actually apply GeoExchange in a real project.

GHPC has found that providing small grants (usually less than $8,000) to pay for industry design experts to mentor engineers in design has immediate benefits. First, the customer's architect or engineer gets a thorough education on geothermal system analysis and design. Second, the client sees that the GeoExchange industry is willing to invest in the project because we believe the technology will work for the client. Third, the designers see their own business advantage in learning the skills. Even though this program has been up and running for only about a year, GHPC is receiving very positive feedback, in that the vast majority of jobs are indeed going with geothermal. There are also instances in which engineers exposed to the program have begun to work on additional GeoExchange projects under their own initiative.

Strategic Alliances And Associations

GHPC has taken advantage of opportunities for strategic alliances with key trade groups and organizations. Again, many of these alliances focus on opportunities in commercial markets:

ASHRAE. GHPC has been able to take advantage of a pre-existing forum for geothermal at ASHRAE, Technical Committee 6.8. This committee has brought together many of the best minds in the commercial/institutional geothermal market. It has initiated key projects resulting in an up-to-date design manual (Kavanaugh and Rafferty 1997), a study on the environmental effects of ground loop antifreezes (Heinonen et al. 1997), the aforementioned maintenance study, and a compilation of case studies calculating the rate of return that geothermal represented for a set of nine buildings (Cane, Morrison and Ireland 1997). In addition, ASHRAE has worked with GHPC to promote a series of short design seminars to familiarize engineers with GeoExchange design. These activities have raised awareness and acceptance of geothermal among engineers.

American Institute of Architecture (AIA). GHPC has partnered with AIA on a national teleconference aimed at architects, and has recently designed a short seminar through which architects can earn continuing education credits. The early response of architects has been very positive, reflecting an increasing interest in "green" designs in that community.

Federal Energy Management Program (FEMP). GHPC and DOE labs have been working with FEMP to increase the use of GeoExchange at federal facilities. FEMP is currently finalizing a GeoExchange-specific RFP to pre-qualify ESCOs as GeoExchange installers. Successful bidders will be allowed to provide GeoExchange installations in federal facilities without having to compete for each job individually. Such streamlining will provide a strong incentive for federal facility managers to select GeoExchange as their preferred HVAC technology.

Ensure Multiple Uses for Field Performance Data to Stretch Technical Program Budgets

As mentioned above, GHPC has received much less federal support than originally anticipated, and one of the programmatic areas that has suffered has been in R&D projects, particularly in the development of new technologies. We have emphasized projects that address the short-term needs of the industry, particularly in the quickly expanding commercial and institutional markets

One type of project that results in multiple benefits, and therefore receives the majority of GHPC technical project funding, is field monitoring. GHPC is currently monitoring over a dozen facilities. These projects are yielding multiple benefits:

- They provide data on fuel and maintenance costs that will lead to the development of high-quality engineering case studies to be shared with the engineering and architectural communities, as well as with customers.
- The data will be turned over to GeoExchange software designers, in order to achieve much-need convergence and consistency across various software packages with regards to loop performance, heat pump performance, pump sizing, etc.
- In some projects, some R&D on different loop configurations or completion methods is being performed. For instance, at one school in Maryland, GHPC is comparing the

performance of thermally enhanced grout vs. that of standard grout within the same loop field.

- An unanticipated benefit of the monitoring projects is that they yield important lessons in system commissioning that are being used to ensure that GeoExchange systems work right.

GHPC has also conducted research to determine pumping head losses associated with high-density polyethylene (HDPE) pipes and fittings, so as to prevent circulation pump over-sizing, which can degrade overall system performance. GHPC is also currently funding work at University of Alabama to provide technical guidance on ventilation strategies, in order to ensure that indoor air quality standards are met without over-sizing loop fields. Technical projects like these are indispensable to marketing GeoExchange in non-residential markets, where high-quality, objective data is needed to demonstrate the technology's benefits.

Emphasis on Infrastructure Development

Given the fact that design and installation infrastructure is not well developed, GHPC supports six regional training centers, in Pennsylvania, Michigan, South Dakota, California, North Carolina, and Alabama. These centers build upon IGSHPA's ground loop installation training, bringing in such other elements as system sizing, integration with building envelope efficiency measures, correct installation ductwork, and sales training. GHPC has also initiated a forum (headed by IGSHPA personnel) through which IGSHPA and the regional training centers can cross-fertilize and coordinate their programs and activities.

In addition, GHPC has stressed regulatory outreach and education for ground water protection. As the technology emerges, regulators must establish regulations and licensing procedures that ensure ground water protection and installation quality. Four key products have helped this process. First, GHPC has supported a web site with all relevant state (and many local) regulations and licensing rules. Second, GHPC provided a grant to the National Ground Water Association (NGWA) to develop, consensus guidelines for vertical loop installations (McCray 1997). Third, EPA has developed a complementary guidance document on closed loop installations. Fourth, ASHRAE has produced an environmental assessment of loop antifreezes. Together, these sources help educate state and local regulators as to what geothermal heating and cooling is, and how it should be installed in order to maximize the environmental benefits. This has helped gain acceptance for geothermal in many markets that have been unfamiliar with the technology to date.

Prognosis

As mentioned above, GHPC received its federal grants in late 1995. Its sales surveys indicate that sales were flat in 1996 relative to 1995 (in fact, they were a little lower, due to the 4,000 unit installation at Fort Polk, LA in 1995). This is not surprising, given reduced utility DSM expenditures and the relative infancy of the National Earth Comfort Program. However, 1997 GHPC survey data indicate that GeoExchange unit sales increased a robust 22% compared to 1996 (in 1997, ARI estimates that sales of air source heat pumps and central air conditioners fell 6.5% and 1.5%, respectively). Thus, while the original program goal of 40% annual growth has not been achieved, there is some evidence in sales to suggest movement along the "S-Curve" of market transformation.

There are other positive leading market indicators. Confidential discussions with leaders in the industry suggest that at least two manufacturers had sales growth over 40% in 1997. One commented that the growth would have been higher if they had not been forced by labor shortages to stop taking orders in early November 1997. This raises the crucial issue of reasonable expectations about the pace of market transformation: there is only so much that an industry can do to expand in a given period of time. This needs to be worked into any market transformation program's goals. GHPC also has received a steady increase in inquiries at the Geothermal Information Center, as indicated above. Increases in inquiries will eventually lead to more sales downstream, albeit with a lag.

Also, more builders, architects and engineers are asking about the technology at trade shows, "because my customers are asking me about it." GHPC has experienced increased traffic at such trade shows as the annual National Association of Homebuilders (NAHB) convention and the annual ASHRAE meeting. At NAHB, geothermal homes won about 30% of the annual Energy Value in Housing Awards for the third year running (not bad for a technology that has less than 1% market share). At ASHRAE, interest is indicated by Technical Committee 6.8 meetings that have grown from 5-10 attendees to as many as 50, and the number of geothermal sessions has increased from 1or 2 per show to 4 or 5. Recent ASHRAE publications on geothermal have been strong.

Another indicator is the increase in the number of large organizations interested in geothermal. Centex Homes, McDonald's, Wendy's, Conoco, Texaco, Phillips 66, Insignia (the largest holder of multifamily units in the nation), JPI (the largest developer of *new* multifamily units), and several hotel chains have all initiated evaluation projects. In the public sector, the Department of Defense and the Postal Service have continued to see projects proliferate. The State Department has signed a Memorandum of Understanding, committing to the use of GeoExchange wherever feasible.

Combined with a strongly positive recent growth trend, GHPC is confident that these positive market indicators will continue to yield strong growth. GeoExchange technology has very good prospects to emerge as *the* logical next stage in the evolution of heating and cooling technology, and that GHPC's work, if carried to fruition, will result in a truly sustainable market by the middle of next decade.

Conclusions

Several conclusions already emerge from the Geothermal Heat Pump Consortium's work. These can help others developing voluntary, government-industry programs to carry out market transformation for niche products that can improve energy efficiency in the built environment:

1. Market transformation is more about markets than about technology. Care should be taken to understand all the market dynamics that present both opportunities and barriers to adoption of a new technology. While some product markets (such as some appliances) are relatively homogeneous, HVAC equipment enters market segments through very diverse channels that are influenced by diverse players. Thus, market segmentation and targeted market mobilization are essential. One must understand the dynamics in specific market segments to target the right people with the right programs and tools in order to have a strong impact. This goes well beyond simply determining where a particular HVAC technology is cost-effective, to understanding how key market players interact in the market, from their knowledge base how they come to accept and promote a new technology.

2. Commercial and institutional HVAC markets are easier to affect with limited resources than residential markets. As an industry trade group, GHPC has found that, on limited program budgets, commercial markets seem easier to influence than residential markets. First cost barriers are less pronounced for GeoExchange in some non-residential building types. But, just as importantly, market dynamics make it easier to attain greater penetration with fewer resources. The scale of individual projects is larger, and greater opportunities can be pursued through direct, one-on-one engagements. Individual customers often control large buildings and large numbers of buildings. Furthermore, non-residential sales are based more on objective, technical data that the trade group can readily assemble, and purchase decisions are typically based on more sophisticated analysis. Significant dissemination of information can be achieved very cost-effectively through industry groups representing key market influencers (e.g., ASHRAE or AIA) without the need for mass communications and advertising. Residential markets, on the other hand, are much more diffuse, with millions of individual decision-makers served by tens of thousands of HVAC contractors – both of which groups are often relatively unsophisticated compared to their non-residential counterparts. Residential markets therefore require more resources such as mass advertising and public education sustained over time in order to affect lasting market transformation.

3. Balance aggressive goals with attainability. Program goals must be set carefully and communicated clearly to all stakeholders. There has to be an understanding not only of market dynamics, but also of the natural constraints and limitations of any partnership organization that promotes the technology in the market without directly it. If goals are set too high, early disappointment based on unreasonably high expectations can threaten program continuation. On the other hand, if they are set too low, it may be hard to motivate players to gain a critical mass of support and funding.

4. Commitment to adaptive management is essential. Only the smallest and shortest duration programs have any promise of completion according to the original plan. Over time, resources, stakeholders, and their interests are all likely to change. While some changes are likely to be negative (such as the short-term effect of utility industry restructuring on the GeoExchange market or lower-than-expected federal funding), there are always new and valuable opportunities to be discovered. All participants must be committed to maintaining flexibility and to accepting route changes when detours are encountered.

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[2] References available from GHPC can be ordered by requesting the document number from the Geothermal Heat Pump Consortium. Call 1-888-333-4472 or send e-mail to *info@ghpc.org.*