INCREASING GSHP NUMBERS THROUGH INNOVATION, DEPLOYMENT AND ENTREPRENEURSHIP

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Abstract. Increasing the number of Ground Source Heat Pumps (GSHPs) requires a combination of looking at the successes of the past, identifying the cause of past failures and taking corrective actions by involving industry constituents. Innovation comes when traditional practices cannot be reconfigured to be successful and new approaches to system design are required. To simply argue that a ground heat exchanger replaces a cooling tower and boiler almost guarantees that no thought will be given to reducing costs from new indoor piping technology and materials and system modularization. Entrepreneurship comes about when industry people see that increasing GSHP numbers will occur when deficiencies in technology and/or business practices are changed. Deployment will occur when consumers are convinced by successful applications that the GSHP technology is fundamentally sound.

This paper will present examples of innovation, entrepreneurship and deployment methods of GSHP constituents that are increasing market share through a variety of new approaches using new thoughts and ideas as well as tried and proven methods. Critical to the process is that infrastructure and design tools be continually developed to meet new demands.

Key Words: ***ground source heat pumps, building energy systems, heating and cooling operation, ground-coupled systems***

1 INTRODUCTION

The GSHP industry has grown on a foundation of high efficiency supported by thermodynamic science (Halozan 2004). While this industry has enjoyed relatively good growth in a number of locations around the globe (Rybach 2005) it is still in its infancy when compared to other energy conversion technologies. Government and regulatory agencies have been characteristically cautious when business as usual is challenged by change. In a perfect world, change comes when it is necessary to correct technical and market imperfections and allocations by the State are made to the most productive alternatives based on the highest and best use of resources. It is safe to say that the attendees at this conference, because of their long and dedicated support to this technology, believe that GSHPs meet and satisfy the above criteria for change and allocation.

Many gathered at the conference will report on technology improvements with the strong-held belief that the quality of life for the world's population will improve as technology advances. It may not be the charge of this forum to advance political issues, but we must provide the strong technical basis to those who have assumed that responsibility. This paper is not a compilation of design methods and technology available from throughout the international community, but rather methods that have been reported on papers presented at the International Ground Source Heat Pump Association (IGSHPA 2007) Annual Conferences in the United States and other international meetings and published literature.

2 INNOVATION EXAMPLES

2.1 Integrated Design Software

A critical element in the design phase of a project is to have methods which allow building load analysis to be seamlessly integrated with internationally accepted ground heat exchanger design methods. Many times software programs require a full building analysis program to be integrated with ground heat exchanger design methodology in a multi-step procedure. Having a program of this type is particularly important in training programs to show that the integration of what is considered to be two technologies is straightforward and allows the designer to enter into an iterative process in selecting an array of different ground heat exchanger alternatives. The building thermal loads simulation program (eQuest 2003) is a freeware program that can be downloaded from the internet. An additional software program, also freeware, is available that integrates ground heat exchanger design (Liu and Hellstrom 2006) with the thermal loads program (Hirsch 2003). This building simulation model is coupled with the heat pump performance characteristics and the heat transfer characteristics (Hellstrom 2005) of the ground heat exchanger. This interactive design process combined with economic considerations allows designers the integrated tools to rapidly evaluate alternative designs. Individuals interested in GSHPs can get into the design process at no financial cost.

2.2 Reduced GSHP System Cost Using Decentralized Pumping and Field Layout

Major cost reductions in first and operating cost have been reported (Penn 2007) by the use of decentralized pumping, modular 20 kW ground heat exchangers, and simplified controls. First costs of the GSHP system were slightly lower than a conventional central system with a 30 to 40% reduction in operating cost (Penn 2007.) The benefits defined include:

- The GSHP system had the same first cost as a conventional central plant
- 30 to 40% less operating cost
- Cost control by the use of High Density Polyethylene (HDPE) for indoor piping to reduce corrosion control and the higher first cost of steel piping
- The use of individual circulating pump(s) for each zone heat pump allowing for better pump control and system redundancy
- Modular 250 kW well fields for system redundancy and field separation
- Reduced pumping energy for the indoor piping system
- Low purge flow (commissioning) and pressure required, resulting from multiple reduced pipe sizing in the header layout
- The use of 100 mm maximum header pipe size allows the use of smaller and less expensive pipe heat fusion equipment
- Small 100 mm bore holes with 25 mm loop piping

2.3 Electronic Delivery of Designer Training

The expense for training includes time away from the job, travel and lodging expense. A typical training program of three days results in reduced attendance and a 5-day work week missed. To minimize these costs, designer programs (IGSHPA

2008) are being delivered via a CD based instruction that includes instructional hard copies of materials used in conventional instruction plus a one-day Question and Answer session held at related professional meeting sites. There are a number of obvious advantages:

- Reduced expenses for the trainees
- More in-depth training by instructors who have integrated their best ideas into compact segments
- Safety is not a concern since all training is on a computer where visual images can be very directed and can be reviewed at the trainees pleasure
- Small groups in diverse locations can be managed simultaneously

Since the inception of this type of training, the number of trainees has increased by 48 and 51% from the base year of 2005 as shown in Table 1.

Table 1 Designer Training

Year	Trained	% Change	Certified	Grandfathered
2005	39		11	
2006*	79	51	26	
2007	84	54	4	
Past Three Years	204		41	
Since Inception	395		75	95

*Electronic Delivery Initiated

3 DEPLOYMENT

Deployment of an emerging technology is the artful approach of moving science and engineering, application and product delivery in a parallel program. No component of this parallel process is more or less important than the other. The participants at the conference do this knowing that governmental acceptance and their buy-in is critical in the face of alternate and competing technologies. The participants at this conference are fully aware of the obvious benefits of the GSHP technology in regards to its efficiency and its potential for slowing global warming. A critical element is the demonstrated growth of the industry. The following are measurable results and a little history of the growth trends.

3.1 Training Programs

Table 2 is a summary of training numbers as reported by IGSHPA. These numbers include training using materials developed by members of the IGSHPA staff and their member base.

Table 2 Installation Training

Year	Trained	Accredited
2005	542	518
2006	862	796
2007	883	813
Past Three Years	2287	2127
Since Inception	9631	8935

Since inception of the installation program, 9,631 installers have been trained with a majority of those in the US. It is safe to say that the number of these individuals installing at present is only a fraction of this number. What is important is the rate at which training is occurring. The data base shows that a majority of the trainers are highly experienced and have strong affiliation with the industry. The designer training numbers given in Table 1 are not included in Table 2.

3.2 Conferencing

Conferencing as a means of networking is an absolute requirement. Conferencing allows papers to be delivered, equipment to be exhibited, training to be delivered, installation standards to be reviewed, new design technologies to be peer reviewed and international perspectives to be presented. In regards to conferencing growth, Table 3 details conference numbers for the past three IGSHPA Annual Conferences.

Table 3 Conference Growth

Year	Conference Location	Number of Participants
2005	Stillwater, Oklahoma	241
2006	Albany, New York	382
2007	Oklahoma City	428

3.3 Training Programs

The IGSHPA is cooperating with a number of training programs outside the US and have initiated and completed Memorandum of Understandings (MOU). Sites include:

- Canada (Alberta) with the Northern Alberta Institute of Technology (NAIT)
- Korea with IGSHPA-Korea and the Korean Technical Center for Geothermal Energy (KCGE)
- China with IGSHPA-China

Information and content is being shared on the Accredited Installer course and Certified GeoExchange Designer program. Plans include the sharing of research and the development of a research agenda.

The Accredited Installer Course is a three day lecture/demonstration course with an exam. For information about the content of the program see: http://www.igshpa.okstate.edu/training/accredited.htm

The Certified GeoExchange Designer (CGD) is a training program with an examination reviewed by the training committee of the IGSHPA. The training and examination is delivered electronically. A one-day question and answer program is offered at selected sites where national conferences are being held. The one-day question and answer program will be offered via Micro Soft Live Meeting starting in the fall of 2008. For course content see: http://www.igshpa.okstate.edu/training/cgd.htm

3.4 Low Energy Buildings

After all is done on the thermal envelope, it becomes necessary to look at the HVAC equipment to evaluate what additional value comes from adding a GSHP system to the design of low energy buildings. Consider the following low energy project.

Central Oklahoma Habitat for Humanity (Hope Crossing Subdivision)

- 450 GSHP unit subdivision in Oklahoma City
- Single bore hole (214 meters depth)
- Bore hole located inside equipment room eliminating outdoor headers

- Single capacity heat pump
- High performance building envelope

The success of this project as reported in this conference was due in part by the active participation of the heat pump manufacturer throughout all phases of the project from beginning to end. It is not good enough to believe that all we have to do is build better heat pumps, but to participate in projects that have the potential to gain national and international acclaim because the application is to the economically disadvantaged

3.5 Military and Government Housing Development

US Department of Defense installation totals (Long 2008) for geothermal are given in Table 4.

Table 4 Department of Defense Totals

DOD Branch	Projects	(#) / (kW Capacity)	Annual Savings (kWh)
Army	193	9,534 / 79,319	77,748,424
Air Force	27	3,934 / 31,973	Insufficient Data
Navy/Marine Corps	44	7,679 / 71,768	80,546,656
Total	264	21,147 / 183,060	158,345,080

Locations are throughout the United States but concentrated in southern and coastal regions. Approximately 183,060 kW has been installed to date. Funding mechanism is from three sources; Energy Savings Performance Contracts (ESPC's), Utility Energy Savings Contracts (UESC's) and Energy Conservation Investment Program (ECIP). ESPC's make up 11% of the total, UESC's contribute 36% and other funding is 53%.

3.6 School Building Retrofitting

In retrofitting of school buildings, there are a number of considerations that need to be addressed that distinguishes this work from new construction. A successful school project team in the State of Missouri identified a number of significant issues that need to be addressed. One of the individuals was a school administrator (Vanderford 2007) and the other a GSHP installation company owner (Schoen 2007) who teamed together to retrofit more than 100 school buildings.

Their comments are as follows:
Construction and Bidding Considerations (SCHOEN 2007)

1. Electrical needs may be major depending on what type of system is being replaced. If it is fuel oil the cost of adding electrical capacity could be large. If roof top units are being replaced, electrical demand should be lower.
2. Gas water heating may be replaced by electric water to water heat pumps
3. Demolition of existing system may be a 10% cost addition
4. Asbestos removal
5. Saw cutting of sidewalks and relocation of other underground services need to be considered
6. Should consider the use of HDPE piping for new indoor piping.
7. Mechanical room for pumping requirements if needed – An alternative for reducing mechanical room sizing is load matched pumping using individual circulators for each heat pump (Penn 2008)

8. Design/Build is an attractive option to eliminate costs associated with two somewhat unrelated activities – geothermal heat pump design and site equipment demolition, removal and preparation
9. A large impediment at this time is the lack of GSHP experienced engineers

Common Sense Design (Vanderford 2007)
1. Replacing roof type units may result in lower electrical power demand
2. Using sophisticated DDC controls can result in excessive first cost with no apparent need for generated data
3. Communicating thermostats are simple and are about half cost of DDC systems
4. Fresh air requirements can be reduced by the use of new ASHRAE Standards
5. Indoor piping should be HDPE – eliminates corrosion, erosion and the need for water treatment
6. Staging smaller units or multiple capacity units can reduce consumption
7. Controlling start-up time and slightly over sizing equipment can eliminate the need for backup resistant heat
8. Early spring time (March through April) should be used to remove or add heat to balance annual ground thermal loads

3.7 Entrepreneurship

GSHP systems have a major difference in that addition to equipment being installed inside the building there is a major component that is in installed in the ground. A very large number of installing contractors do not have the experience or equipment to do the ground work and are reluctant to get involved in the higher up front costs associated with drilling/trenching, etc. As a result of this, manufacturers of water source heat pumps have developed subsidiary installation companies or alliances that allow them to control project costs. The more aggressive groups will have a team of system design professionals that include architects, engineers, and installation contractors for both indoor piping and outdoor ground heat exchangers.

Those companies which are fully integrated have more business, and in many cases, more competitive first costs. This is especially noted in the non-residential housing market and specifically in schools and government projects where there is not a large change in ownership and is governed by boards and national governmental policy. Light commercial buildings where the cost of professional and certified service technicians becomes noted at the bottom line is where the opportunity lies.

The opportunity is in the **SYSTEM**.

3.8 Technology Development

The GSHP industry has grown steadily from the strong commitment by this industry to:
1. Strengthen and evaluate State and National Installation Standards
2. Design piping networks for easy commissioning
3. Develop In-situ borehole thermal testing companies
4. Develop training programs and delivery
5. Support Government policy efforts (taxing and incentives)
6. Improve and update design materials including manuals and software
    - New design/installation manuals for residential and light commercial buildings (Remund 2007)
    - Integrated design software (Liu and Hellstrom 2006)

All of these have enjoyed success from international forums and conferences.

3.9 Program Growth in China

The growth of the GSHP market in China is very strong. Program growth is supported by a central government policy with ambitious expectations of installation in all provinces. One company (Ever Source 2005) reported growth that has exceeded 3,000,000 m^2 during the time period 2001 to 2004. The range of applications principally in Beijing included residences, office buildings, schools, hotels, commercial buildings, hospitals, banks, etc. A second company (Fan 2007) reported projects in excess of 10,000,000 m^2. Again, the range of building types and applications is large and represents a program of accelerated growth.

Single-well systems (Heng and Rybach 2005) have provided very large capacity and a relatively low cost where large amount of flowing ground water is available. Heat exchangers placed at the bottom of the boreholes are unique and very effective.

The accelerated growth of their market has resulted in the need for an increased number of training programs in China. The growth in 2007 is estimated (Xu, 2008) to be 3000 to 4000 MW or about 1 million USRT. Agreements are being made worldwide to meet this need. The international community needs to continue our collaboratively efforts in support of their market and installation goals.

4 REFERENCES

Ever Source Science & Technology Development Co. LTD. 2005. Beijing

Fan, Xin, 2007. Tsinghua Tongfang Environmental Co. IGSHPA Leadership Award IGSHPA Technical Conference & Expo. Oklahoma City. October 2007

Halozan, H. 2005. Heat Pumps and the Environment – 8th International Energy Agency Heat Pump Conference, Las, Vegas, June 2005

Hellstrom, G. 1991. Ground heat storage – thermal analysis of duct storage systems–theory. Doctoral thesis, University of Lund, Sweden.

Hirsh, J. 2003. Introductory Tutorial – eQuest/DOE-2.2.

Liu, X. and G. Hellstrom 2006. Enhancements of an Integrated Simulation Tool for Ground-Source Heat Pump Design and Energy Analysis. 10th International Conference on Thermal Energy Storage. Richard Stockton College of New Jersey. May 31-June 2, 2006

Long, B. 2007. Ground Source Heat Pumps in the US Navy. IGSHPA Technical Conference & Expo. Oklahoma City, October 2007

Penn, D. 2007. Marketing Geothermal to the End User. IGSHPA Technical Conference & Expo. Oklahoma City, October 2007

Rybach, L. 2005. The Advance of Geothermal Heat Pumps – Worldwide. IEA Heat Pump Center News Letter, 23(4)

Schoen, P. 2008. Personal Communication. Geo-Enterprises, Catoosa www.geo-enterprises.com

Vanderford, J. 2007. Marketing to Schools – IGSHPA Technical Conference & Expo. Oklahoma City. October 2007

Xu, Sheng Heng, Rybach, L. 2005. Proceedings World Geothermal Congress 2005 Antalya Turkey, 24-29 April 2005

Xu, Yunsheng “Shawn” 2008. Personal Communication. Institute for Environmental and Energy Technologies, University of Missouri 65211, USA