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GEOTHERMAL HEAT PUMP PROFITABILITY IN ENERGY SERVICES

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Prepared for
U.S. Department of Energy
Idaho Operations Office

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DISCLAIMER

Geothermal Heat Pump Profitablity
in Energy Services

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EXECUTIVE SUMMARY

If geothermal heat pumps (GHPs) are to make a significant mark in the market, we believe that it will be through energy service pricing contracts offered by retailcos. The benefits of GHPs are ideally suited to energy service pricing (ESP) contractual arrangements; however, few retailcos are thoroughly familiar with the benefits of GHPs. Many of the same barriers that have prevented GHPs from reaching their full potential in the current market environment remain in place for retailcos. A lack of awareness, concerns over the actual efficiencies of GHPs, perceptions of extremely high first costs, unknown records for maintenance costs, etc. have all contributed to limited adoption of GHP technology. These same factors are of concern to retailcos as they contemplate long term customer contracts.

The central focus of this project was the creation of models, using actual GHP operating data and the experience of seasoned professionals, to simulate the financial performance of GHPs in long-term ESP contracts versus the outcome using alternative equipment. We have chosen two case studies, which may be most indicative of target markets in the competitive marketplace:

- A new 37,000 square foot office building in Toronto, Ontario; we also modeled a similar building under the weather conditions of Orlando, Florida.
- An aggregated residential energy services project using the mass conversion of over 4,000 residential units at Ft. Polk, Louisiana.

Our method of analyses involved estimating equipment and energy costs for both the base case and the GHP buildings. These costs are input in to a cash flow analysis financial model which calculates an after-tax cost for the base and GHP case. For each case study customers were assumed to receive a 5% savings over their base case utility bill. A sensitivity analysis was then conducted to determine how key variables affect the attractiveness of a GHP investment.

Why Should the Retailco Offer the GHP Rather than the Standard Technology?

The simple answer is because it is a much better investment! Internal rates of return were 28% for GHP system, the conventional air conditioning system in the base case office building, if offered to the customer under an energy service pricing contract, would earn an IRR of just 9%. Table E-1 presents the results of the case studies.

Table E-1
Case Study Results

Case Study	Contract Term	ESCO Equity Investment	Net Present Value Cash Flow	ESCO Internal Rate of Return
Toronto Office Bldg..	10 years	$71,200	$155,200	28%
Orlando Office Bldg.	10 years	$84,200	$192,000	30%
Fort Polk Residences	20 years	$3,150,000	$17,450,000	28%

Sensitivity of Results

The sensitivity analysis found that two key inputs had the greatest impact on the retailco's IRR: energy service price and installed cost. The most important of these is installed cost because the retailco has less control over this input than the energy service price which it has discretionary control. Conversely, the retailco's IRR is relatively nonsensitive to three inputs: maintenance cost, contract length, and finance interest rate.

Conclusions

This case study used real geothermal heat pump operating data and highly reliable base case modeled data to examine the applicability of a GHP system as an energy service offering for commercial buildings and large scale aggregated residences. The GHP system proved to be an excellent investment, providing an expected internal rate of return of a least 28% for contract periods up to 20 years while still reducing equivalent customer bills by 5%. Conversely, for office buildings, a five year contract can be offered which provides a 23% IRR to the retailco, still an attractive investment. Additional return on investment can be achieved if the retailco can integrate the HVAC design with the building plan early in the design process.

The primary risk in this business venture is cost over runs for the loop portion of the system. Significant risk can be minimized by incorporating thorough design and project management principles.

INTRODUCTION

With the advent of competition in the U.S. wholesale and retail energy markets, the landscape for the successful promotion of geothermal heat pumps (GHPs) is changing rapidly. The days of utilities offering large ratepayer funded incentives to subsidize GHPs incremental cost are quickly coming to an end, as these companies seek to reduce costs and improve operations. Favorable regulatory treatment for demand side management investments is also ending as state commissions revise rules to deal with the competitive marketplace.

At the same time, a new market for energy services seems to be evolving. This market combines the very large energy commodity markets ($280 billion), the efficient energy equipment market ($45 billion); the equipment maintenance markets ($100 billion); and the design and installation services markets ($10 billion). Many customers are actively seeking to purchase bundled energy services as they increasingly outsource non-core functions of their businesses, and marketers are creatively structuring offerings to differentiate themselves in an increasingly crowded field. Since no single company has more than a 5% share of this huge market, the opportunity for gain is tremendous.

Given this impending competition in the electric power industry the U.S. Department of Energy retained a consulting team led by Barakat & Chamberlin to investigate the potential positions that GHPs might take in the new energy market. Ancillary issues include which market participants might have incentives to promote GHPs, what barriers might exist to GHP adoption, how will the economics of GHPs be affected, and under what deal structures might GHPs flourish.

The approach taken to the project included several tasks which may be summarized as follows: an investigation into the investment motivations and requirements of electric utilities, the various components of soon-to-be formerly vertically integrated utilities, and energy service companies; the construction of models, using as much "real life" data as possible, to explore the financial results of using GHPs in different potential arrangements between the energy companies and customers; and the assessment of risks incurred by different parties. Also included in the scope of the project was the identification of market participants with high potential to adopt GHPs as part of their offerings, and the creation of presentation materials suitable for meeting with the identified high potential market participants.

This report summarizes the findings of the project. It includes an overview of the market participant motivations and investment requirements, a description of potential areas of interest for each participant, and case studies of two of the more promising market offerings. Also included are a description of the financial models created, and appendices with information and analyses gathered and performed during the course of the project.

WHY WOULD A UTILITY OR ESCO INVEST IN A GHP PROGRAM?

Virtually all utilities in the U.S. are restructuring their operations in order to better cope with impending competition. Some utilities, especially municipals and coops, are likely to remain structured as regulated utilities that provide added retail energy services to customers. In the next five years, many of these will also prefer to sell their own generation to their current customers as well, as opposed to simply acting as a common carrier and selling their commodities on the open market.

The majority of investor-owned utilities are likely to structure themselves quite differently than the vertical monopoly model of past years. Most utilities are creating independent (unregulated) retail companies (retailcos). These retailcos intend to provide a wide variety of energy services (including energy and energy related equipment) to their customer base, which may include their service territory and beyond. Utilities are also spinning off their generation businesses. The unregulated generation business (genco) will try to maximize the profits they can receive from their existing investments. This may include selling generation directly to customers, to intermediaries (brokers and marketers), and to power pools. The retailco and the genco may be affiliated in some cases; in others, they will be completely separate.

The distribution and transmission elements of the utility are likely to be the only regulated part of the business. The prices they charge will be set with and by regulators, and will be based at some level on performance of the "wireco". They may be interested in selling more kWh; however, regulatory structures may be implemented to reduce or eliminate their benefits from selling more kWh. Wirecos may also be told by regulators to limit the amount of customer-oriented programs they may provide. The distribution company may offer energy efficiency services, for example, based upon statewide funds targeted for that purpose.

The strategies employed by traditional energy service companies (ESCOs) are also changing in response to the more open market for energy. ESCOs, who have traditionally performed energy efficiency upgrades under performance guarantee contracts, are now adding commodity energy and other services to their portfolio of services. Essentially, it is becoming difficult to distinguish between the retailco affiliates of traditional utilities and the new full service ESCOs.

Opportunities for GHP Programs

Each new company within the energy services and electricity market will have its own unique perspective on GHPs, and each has a different set of potential rewards and risks. A snapshot is provided below in table form. A discussion regarding each perspective follows.

Company Type	Motivations for GHP Program	Potential Rewards	Potential Risks
Traditional Utility Structure (generation, distribution, and retail functions are intact -- primarily munis and coops)	Increased electric sales; improved load factor; loyalty if long term energy contracts are signed	Improved revenue stream in winter; could lower cost structure due to improved load factor.	Chance that the investment in heat pumps will be stranded if regulation changes. Customers may choose alternate suppliers.
Utility Distribution Company	Increased electric sales; improved load factor; could free up constrained distribution feeders	Increased profit if regulatory incentives are compatible with GHP growth. Possible rewards for efficiency program implementation	Value of heat pump loads may be small. Money to support a marketing program may not exist, or may be prohibited.
Unregulated Generation Company	Very limited on a stand-alone basis	---	---
Unregulated Retail Energy Services Company, no electricity sales	Additional high quality "comfort" solution; fits with performance contracting model. Lower maintenance costs.	Competitive advantage over other ESCOs not experienced with GHPs; more savings potential which improves project economics.	Paybacks can be long; increases the up-front capital needed; less "track record" with technology.
Unregulated Retail Energy Services Company, includes electricity sales	As above, plus potential increase in electricity sales and plant utilization (if affiliated)	As above, plus potential for higher margins on electricity sales versus selling to the open market.	As above, plus the generation may have higher value in the future in sales to other customers.

Traditional Utility Strategy

As mentioned above, competition in the electricity and gas markets is changing utility structures. A number of utilities are "defending" the regulatory status quo, although their ranks are reduced daily. The municipal utilities and coops may be the only group that, over the next five years, can still operate in a similar manner as in the past. While the munis and coops are certainly affected by competition, many believe they can hold on to much of the "domain" as a local provider, if their costs are very competitive.

These "publics" and a few other IOUs are still reducing any extraneous expenditures. Spending on DSM programs and education is likely to continue dropping. However, these utilities may see benefits in load growth through GHPs, and may be particularly interested in using energy services as a method to secure long-term contracts with customers.

The federal government has initiated "area wide" contracts under which utilities may contract with government owned facilities to provide energy services across a broad geographic area without the normal time consuming contracting process. Also, some states are including provisions in their restructuring protocols for the formation of statewide funds to continue investment in demand side management activities. These funds will most likely be administered by state agencies and utilities and others may submit bids to secure funding for programs including GHPs and other technologies. Both of these initiatives provide vehicles for traditional utilities to continue the promotion of GHPs in pursuit of their traditional goals.
A GHP program could be a stand-alone approach such as promoting their use in a new residential sub-division or in new commercial and institutional buildings. The utility may assist with engineering assistance, seminars, marketing communications, low cost loans, or comfort guarantees. They will likely count on their local trade allies to conduct most of the work in specifying and installing the equipment itself.

Generating Revenues and Profits

Traditional utility programs are likely to concentrate efforts on electricity sales and load shaping. Since trade allies are likely to reap any benefits of the technology sales and service, the utility can gain benefits on the commodity side. GHPs can provide added revenue where natural gas heating can be replaced and where cooling can be added. In addition, the GHP may provide opportunities for enhanced customer loyalty, leading to greater sales.

Any efforts to assist utilities in starting or expanding such programs must be carefully targeted. The time frame for such programs is quite limited, and the risks of losing the commodity portion of sales for these utilities is quite high.

Conclusions

Municipals, coops and some investor owned utilities may continue to see benefits from promotion of GHPs for the traditional reasons. Load factor improvement for vertically integrated utilities can be quite a power financial carrot. Likewise, increasing electric sales can lower average supply costs and increase revenue and profitability (at least temporarily). The economic benefits and costs in these situations are well understood by most organizations and therefore, the team concluded that a focused investigation was not necessary.

Unregulated Generation Company Strategy

The genco is under fierce competitive pressure to keep their costs low and their volumes high. Gencos typically have very lean organizational structures, and will avoid retail activities that are time consuming and customized. They will provide a number of financial tools to help modify the risk of price fluctuations. However, it is very unlikely that a genco will be interested in demand-side technologies. Therefore, we conducted no detailed investigation of the economics of GHPs for gencos.

Utility Distribution Company Strategy

The distribution company may see specific benefits from the loads that a GHP program generates. Distribution companies are likely to improve their profitability from two activities: lowering their costs, and increasing the flow of kWh over their system without creating new capacity bottlenecks. A GHP program, when designed properly, can provide improved system utilization leading to higher profits.

The specific regulatory regime a wireco operates will determine how feasible and attractive GHP programs may be, and at this point, the regulatory guidelines have yet to be constructed. However, there is strong sentiment among some influential parties that all incentives for distribution companies to sell more energy be removed. Another trend in regulation of these entities is performance incentives for items such as cost control and customer satisfaction. GHP programs could conceivably contribute to both of these goals, thus increasing the company's profitability. However, since these rules have not been written, the benefits would be impossible to calculate. Therefore, we have only taken a cursory look at the potential financial implications of load factor improvements. This can be found in the Appendices of this report.

Unregulated Energy Service Company Strategies, *No Commodities*

Utility energy service affiliates, or retailcos, have been created at a very rapid rate in the past year. Retailcos typically have broad charters, and therefore have many more product and service ideas than they have resources to chase them. Out of hundreds of options, those products and services that promise the highest long-term return on investment, match the corporate strengths, and position well against competitors should be chosen for development. The line between retailcos and ESCOs is very fuzzy in our current market, and they can be considered essentially the same in our analysis. Here we first consider retailcos without responsibility for selling electricity and/or gas as well.

Selecting the GHP as a Core Product

Will a GHP program meet the requirements of a retailco new product portfolio? It will depend on the scope of the GHP program envisioned, the alternatives available for product development, and whether the retailco is responsible for selling electricity and/or gas as well as other services.

Generating Revenues and Profits

There are several potential revenue streams available for retailcos in a GHP project.

- *Revenue from GHP sales and service:* If the retailco actually becomes a "dealer", it may gain revenues from the margin on sales. Follow-up service can also be contracted through the retailco for added revenue.

- Revenue from GHP leasing: The retailco can provide equipment on a leased basis. Revenue would be generated based on installed cost plus a fee based on financing requirements.

- *Revenue from performance contracting:* Many energy service companies offer contracts to guarantee savings of new energy technologies. They retrofit lighting, HVAC, motors, and other equipment and create long term contracts with customers based upon performance levels. (see discussion below).

A retailco can decide to develop a GHP program based upon the revenues versus costs they foresee when analyzing the marketplace (compared to other alternative product development opportunities they have).

The GHP as One Arrow in the Quiver

Many utility retailcos (and independent ESCOs) are moving their marketing efforts to become comprehensive energy service companies. They wish to sell "solutions" to customers, paying particular attention to the customer's specific needs. These energy service providers often wish to be highly flexible in the types of technologies they offer. This differs significantly from the days of load management and demand-side management. Under DSM, the primary concern was putting specific technologies into the field at an accelerated pace. Load management programs try to clip peaks and fill valleys of power demand. While regulated wires companies may still need to manage load, most of the benefits and therefore market action will be in the energy services arena.

Instead of creating a stand-alone GHP program, many retailcos are likely to use a wide variety of technologies in developing solutions for their customers. Through careful analysis of comfort and productivity requirements, various cost and value trade-offs are considered. The GHP is likely to be but one option that energy service providers consider. As these retailcos understand more about the GHP's benefits, they are more likely to recommend it to their customers. They are also more apt to use them in performance-based contracting, where long-term energy savings can bring benefits to both the retailco and the customer. In this case, the "product" is not the GHP. The "product" is the total package delivered to the customer.

Setting Up Customer Solutions through Performance Contracting

Energy service companies have been working on comprehensive building changes for many years. They use a wide variety of mechanisms to develop and finance contractual arrangements. ESCOs often use a performance-contracting model with customers. A performance contract has many different characteristics than normal engineering specifications. Performance contracts offer the following advantages to customers:

- Customer receives new equipment without the need for up-front payments
- New equipment can (usually) be paid for from energy savings (retrofit)
- ESCO conducts energy and building audit to select optimal equipment
- ESCO takes on the performance risk; guarantees the level of savings for the customer
- ESCO may provide maintenance for equipment

The ESCO seeks those technologies that limit their risk of non-performance while maximizing the energy savings. GHPs can provide excellent life-cycle energy cost savings while lowering maintenance costs as well. ESCOs are also experienced in reducing energy demand in buildings which can then lower the heating and cooling capacity needs. This may enable a reduction in the size and thus the first cost of new equipment.

Conclusions

Since the majority of activity involving end use equipment will be instigated by the retailcos (utility affiliated and independent ESCOs), this is our primary area of investigation. The team developed detailed financial models for employing GHPs in both performance contracting and energy service pricing (see below) situations. These models and the results of our analyses are described in later sections of this report.

Unregulated Energy Service Company Strategies, *With Commodities*

Many retailcos are either charged with selling electricity and gas (by their parent company) or plan to sell energy as part of their package of solutions. It is likely that the profit margins on straight electricity and gas sales will be quite small. But by packaging energy in unique ways, the value and therefore the price and profits can be increased.

Generating Revenues and Profits

There are several potential revenue streams available for utility retailcos that also sell energy, in addition to the methods mentioned in the prior scenario on retailcos.

- *Revenue* from increased electricity sales: If the retailco is responsible for selling electricity, a GHP program can increase sales, if the GHP is replacing natural gas sales and/or adding summer load. (A GHP may decrease sales if replacing less efficient air conditioning or electric heating). The profits will depend upon the margins available on the electricity sales (price minus marginal generation costs) and must be compared against the market clearing prices that electricity could capture on the open market.

- *Revenue on an energy services basis:* The utility retailco could develop a program in which the customer is sold heating and cooling (comfort) services. The utility retailco would charge based upon the total value to the customer, and a GHP is likely to provide the lowest life-cycle costs. The customer receives a no hassle solution with a highly certain monthly cost. The retailco provides equipment specification, installation and replacement as necessary, maintenance, financing, and the energy itself. This is sometime called an "energy service pricing" contract. This is described in more detail below.

The Next Step: Selling End-Use Services

One step beyond the convenience of performance contracting lies energy service pricing (ESP). The benefits of an ESP program can be significant for both the retailco and the customer. As competition becomes more intense between energy service providers, ESP can be a significant competitive tool to help retailcos offer a variety of value added services along with the energy sales. An ESP program can facilitate creation of strong long-term relationships between the retailco and the customer. Long-term energy service contracts can help utilities (through their affiliated retailco) retain valued customers while providing a wider variety of services. Conversely, ESP will enable other retailcos to take customers away from their local utility.

Many, if not most retailcos are selling or planning to sell natural gas as well as electricity. Indeed, a number of the most active retailcos have evolved from the ranks of natural gas marketers. They do not have a cultural bias toward electricity sales as do those emanating from electric utilities. These companies' marketing decisions will be driven by profitability prospects which will depend upon relative commodity prices, equipment efficiencies and the resulting life cycle economics. GHPs should stand in good stead with regard to life cycle cost issues.
Finally, ESP allows the retailco to identify and pursue market niches that are mutually beneficial for customer savings/productivity and the retailco's bottom line profits.

Potential service options include:

- Commodity energy (electricity, natural gas, fuel oil, etc.)
- Design services, engineering and technical assistance
- End use equipment
- Installation and removal
- System optimization
- Maintenance services
- Power quality enhancements
- Backup generation
- Information about the customer's energy use
- Real time monitoring
- Productivity and/or comfort enhancements

With additional bundled services, retailcos can charge more for added value while still offering a low-cost basic service level.

From the customer's perspective, they have the ability to lower their overall cost of energy service or increase the value of their energy service through some of the mechanisms outlined above. Some of the services can replace those already conducted by the customer. Others will add new services that can make businesses more productive. The ESP program becomes the vehicle for delivering the added value.

In order to understand how ESP would work in practice, it is useful to lay out how the marketplace currently works and how that might change with ESP. It is assumed that the retailco will be the provider of the ESP program.

Current Structure	Structure with ESP
Utility bills for monthly kW/kWh	Retailco bills for monthly energy services
Utility has obligation to deliver reliable electricity to customers in service territory	Retailco has contractual agreement to meet customer end-use requirements for a certain price and duration
Customers make technology purchase decisions	Retailco makes technology purchase decisions with customers
Customers pay up-front for or finance technology purchases	Retailco purchases and provides the use of the technologies for a fee bundled with energy
Customers purchase technologies from vendors	Retailco purchases technologies from vendors, distributors, or manufacturers
Contractors and A/E firms specify technologies to install	Retailco determines or specifies which technologies to install
Customers maintain or hire contractors to maintain equipment	Retailco maintains equipment directly or through contractors
Customers have incentive to maintain equipment and operate it efficiently; however, most do not have the knowledge or inclination	Retailco has high level of incentive to maintain the equipment and operate it efficiently
Customers must sort through variety of information sources to piece together their energy and business decisions	Retailco bundles energy services together and can add other value enhancing services

The table above demonstrates how many of the traditional service arrangements can be altered with ESP. GHPs can be an integral part of making the economics of an energy service pricing program work.

Conclusions

Since our analysis has shown that the retailco arena and energy service pricing concept holds the most promise for continuing the linkage between efficient equipment selection and energy purchases in the new market environment, we devoted the majority of our economic investigation to these environments. The results are in the following sections.

CASE STUDIES

If GHPs are to be of significant value to utilities, we believe that it will be through energy service pricing contracts offered by retailcos. The benefits of GHPs are ideally suited to ESP/ESCO type contractual arrangements; however, few retailcos are thoroughly familiar with the benefits of GHPs. Many of the same barriers that have prevented GHPs from reaching their full potential in the current market environment remain in place for retailcos. A lack of awareness, concerns over the actual efficiencies of GHPs, perceptions of extremely high first costs, unknown records for maintenance costs, etc. have all contributed to limited adoption of GHP technology. These same factors are of concern to retailcos as they contemplate long term customer contracts.

The central focus of this project was the creation of models, using actual GHP operating data and the experience of seasoned professionals, to simulate the financial performance of GHPs in long-term ESP contracts versus the outcome using alternative equipment.

While we have run the models using a variety of data sets, for purposes of communicating the results, we have chosen two case studies, which may be most indicative of target markets in the competitive marketplace. The first case is a moderately sized office building in Toronto, Ontario; we also modeled a similar building under the weather conditions of Orlando, Florida. In the second case, we have attempted to model the performance of an aggregated residential energy services project using the mass conversion of over 4,000 residential units at Ft. Polk, Louisiana as a basis for the performance data.

METHOD FOR CASE STUDIES

Financial analyses were conducted for three case studies: a new office building in Toronto, Canada; the same building design in Orlando, Florida; and a large multi-residence retrofit at Fort Polk, Louisiana are provided. In this section each project is described, details for the financial model are; data sources and assumptions are explained; results of analyses and conclusions on what the project demonstrates about the attractiveness of GHP technology in the energy service industry are also provided.

Broadly, our method of analyses involved estimating equipment and energy costs for both the base case and the GHP buildings. These costs, along with assumptions regarding customer bill savings, are input in to a cash flow analysis financial model which calculates an after-tax cost for the base and GHP case. A sensitivity analysis is then conducted to determine how key variables affect the attractiveness of a GHP investment.

All three financial analyses are based on one energy service financial model, but with some important differences which will be explained for each project. Additionally, the majority of analysis effort was spent on the Toronto office building case study, so that section will serve as a reference for the other case study descriptions.

Case One:Toronto Office Building

Building Description

The Toronto office building provides an excellent opportunity to examine GHP technology as applied in new construction. This two story, 37,000 square foot building, built in 1989, was originally designed with a traditional HVAC system. Before construction began, the owner was approached by a commercial mechanical/electrical design firm which convinced the owner to install a GHP system (provided that the first cost would not exceed the already designed base system cost by more than 10%). The building is designed to accommodate 120 people and has a cooling load of 70 tons and a peak heating requirement of 300,000 Btu/hour. The HVAC system design is provided in Table 1.

Table 1
Initial and GHP HVAC System Design

Initial HVAC Design	GHP Design
Rooftop VAV Gas Heating/Electric DX Cooling Gas Reheat terminal Total Installed Cost of \$8.06 per ft^2	Vertical Loop: 220 bore-ft per ton Cost of \$1,550 per ton Gas ventilation air heat exchanger Total Installed Cost of \$8.28 per ft^2

Model Description

The underlying philosophy of energy service pricing is that what the customer really values is the end-use product, in this case comfort, provided at a reasonable cost. In addition, customers value guaranteed, prices. So, ideally, an energy service price would be a fixed price contract with the customer which guarantees the comfort in your building and is less costly than the alternative. The energy service price therefore also includes the cost of designing, constructing, owning and maintaining the system. Therefore, this model estimates the owning and operating cost for both options, (the standard HVAC system and the GHP system), including maintenance, financing, energy usage, taxes and guaranteed customer savings, and calculates a fixed cost energy service payment. Finally, the model also provides an estimate of the internal rate of return to the retailco.

In order to be profitable, energy service pricing typically requires customer contract terms to be several years in length. Therefore this model accounts for expected future cash flows over the contract term and includes a forecast of economic variables. These assumptions include escalation rates for variable cost components such as maintenance and energy, and the rate of inflation.

Model Inputs and Data Sources

The major model components are listed in Table 2.

Table 2
Toronto Office Building Model Inputs

Model Component	Base Case Input	GHP Input
Total Installed System Cost, $/SF	$8.06	$8.28
Annual Maintenance, $/SF	$0.23	$0.11
Finance Costs		
equity-to-debt percent	30%	30%
interest rate	9.0%	9.0%
finance term	10 years	10 years
Escalation Rates, Nominal		
inflation	4.0%	4.0%
gas escalation	3.1%	3.1%
electricity escalation	3.1%	3.1%
maintenance escalation	inflation	inflation
energy service price index	NA	0.0%
Tax Treatment		
state and federal tax rate	40%	40%
depreciation period	39 years	15 years
depreciation schedule	straight-line	accelerated (MACRS)

Energy Cost, $/SF	$1.23	$0.99
Average Energy Rates gas electricity	 $0.49 Therm $0.058 kWh	 $0.49 Therm $0.058 kWh
Customer Savings Guarantee	NA	5.0%

GHP data sources for the largest component affecting the model, installed cost, are from the project itself. Energy costs are from the first year of the building's operation, and may be somewhat conservative according to the HVAC designer[1]. Annual maintenance costs are based on a 1997 study of 25 commercial systems (offices and schools)[2].

Base case HVAC installed costs were from the original building design and maintenance costs were based on the HVAC designer's experience with these types of systems (with corroborating estimates from a survey by the Building Owners and Managers Association). Energy costs for the base case building were estimated using the building simulation program Axcess 10.2e and the applicable commercial gas and electricity rates for Toronto.

Other assumptions:

- Equity-to-debt ratio of 30% based on discussions with local building contractor;
- Interest rate of 9.0% based on prime rate posted in Wall Street Journal + 0.5%
- Inflation set to 4.0% based on the average of the Consumer Price Index from 1981 to 1996;
- Federal and state tax rate of 40% based on current U.S. federal corporate rates of 35-38% for business with annual revenue over $335,000, and average state rates of approximately 5%;
- Gas and electricity escalation rates set to 3.1% from Energy Information Agency 15 year fuels forecast;
- Maintenance cost is assumed to escalate at inflation;
- The energy service price is assumed to be fixed (not indexed);
- Tax depreciation for HVAC equipment is assumed to be a straight-line 39 year schedule for the base case (equipment considered part of the building), and is on

[1]Mancini and Associates, Islington, Ontario.

[2]"Survey and Analysis of Maintenance and Service Costs in Commercial Building Geothermal Systems,"June 1997, Geothermal Heat Pump Consortium, Inc.

an accelerated 15 year schedule for the retailco (due to investment status)[3].

Notes on Conservative Assumptions

The data and assumptions which are used in the model could be considered conservative for the following reasons:

- No energy sales margin— the model assumes no profit margin on energy procurement by the retailco;
- Energy prices rising less than inflation;
- No future value to GHPs flatter load shape— as the market for energy approaches true competition, energy prices (especially electricity) will be more expensive during hours of peak demand (as it already is in areas with real time pricing programs). Therefore, GHP systems will be more valuable because they will not require as much energy during peak hours;
- No value allotted to GHP's longer lifetime— typical commercial rooftop HVAC systems have life expectancies of 15 years, while GHP systems are expected to last 20 to 25 years;
- No credit for reducing new construction cost— buildings design with GHP systems can save $2.00 per square foot, or more, due to the decreased mechanical room space requirements and lower building ceiling heights enabled through reduced ducting[4];
- 30% equity-to-debt requirement— lower ratios will increase the retailco's internal rate of return.

Results of Analyses

Is the GHP system an attractive investment for a retailco? The short answer is yes, however there are really three parts to the question:

- How attractive is it under the given assumptions,
- Is the GHP system offered through energy service pricing appreciably Better than

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[3]This is a difficult issue to determine. An informal survey of ESCOs in the Denver area found a variety of opinions on tax treatment.

[4]Note that the building was already designed for a standard system prior to the switch to the GHP system, hence interactive design benefits were not realized.

the standard system given the same pricing structure and,

- Does the answer change given reasonable variations in the assumptions (i.e. how risky is the project) ?

A Good Investment

Figure 1
Customer Base Case Owning and Operating Costs

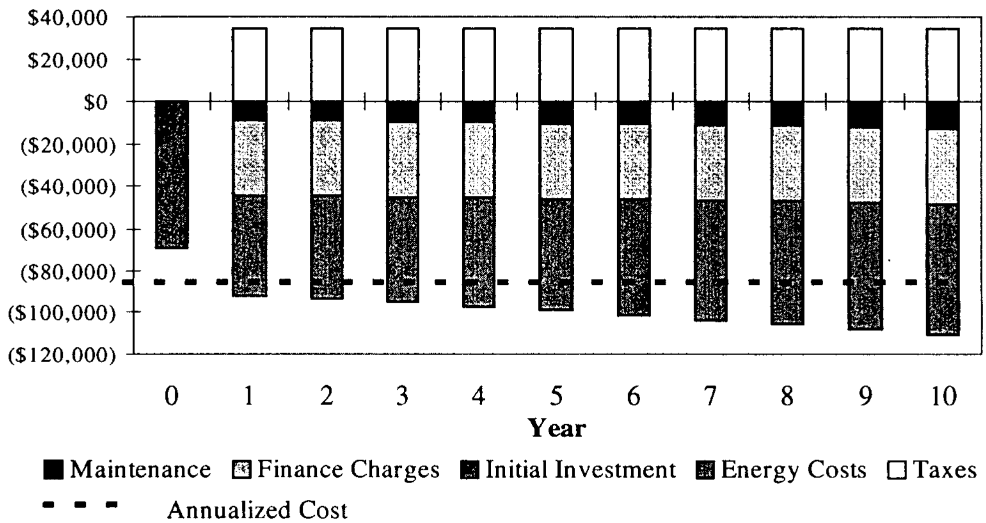


Figure 1 shows the model's cash flow for the customer's base case owning and operating costs over a 10 year finance term. Note that taxes are shown as a positive cash flow. This is due to the interest portion of the finance charge and equipment depreciation, both of which reduce taxable income. The annualized cost of the customer's base case 10 year cash flow is approximately $79,000 per year, or $2.01 per square foot of building area.

The energy service price is then calculated based on reducing the customer's base case cost 5% while still providing an acceptable return on investment to the retailco. Under energy service pricing the customer pays $1.91 per square foot, equivalent to a $3,700 dollar annual reduction in owning and operating costs.

Figure 2 shows the retailco's cash flow components. The internal rate of return for this project is 28% with a net present value of $84,000. The retailco's annualized cost of providing service is $1.63 per square foot.

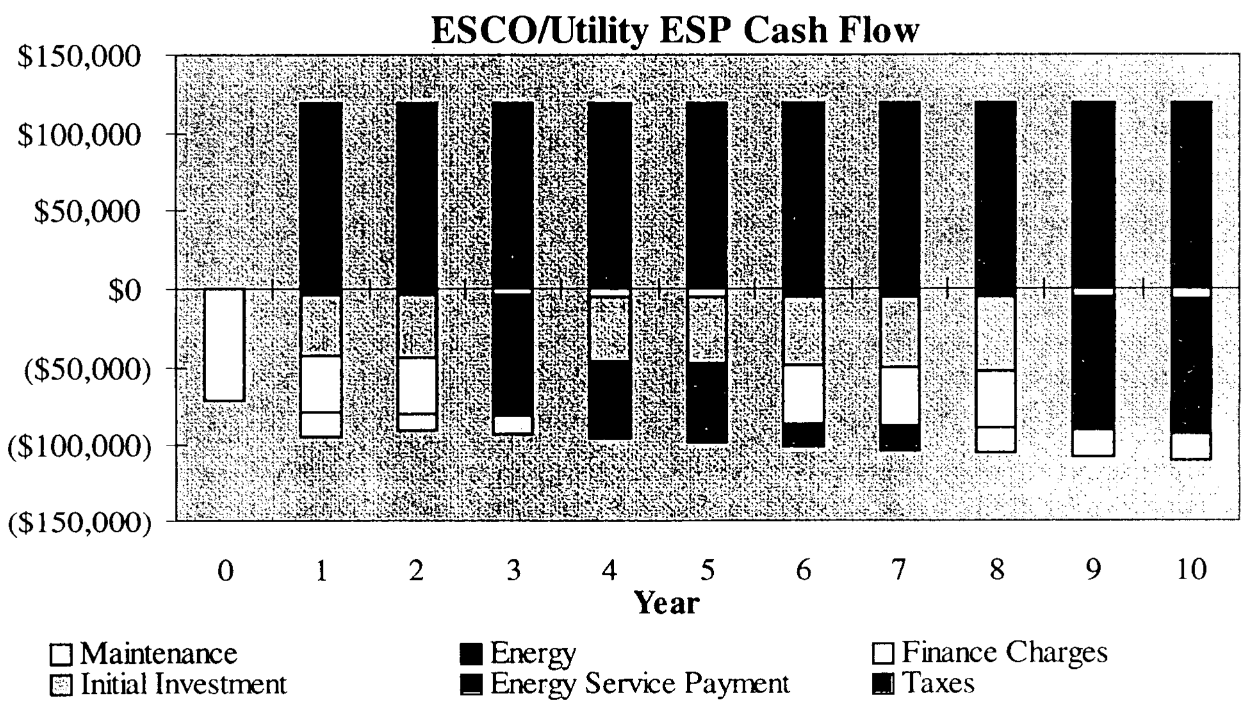
If a reasonable estimate of salvage value is added in to cash flow, the retailco's IRR increases to

30%. Salvage value was estimated by taking the present worth of the energy savings for years 10 through 20 and reducing it by 50% (this worked out to about $40,000, or 13% of the first cost)[5].

Why Should the Retailco Offer the GHP Rather than the Standard Technology?

The simple answer is because it is a much better investment! The conventional VAV system in the base case, if offered to the customer under an energy service pricing contract, would earn an IRR of just 9%.

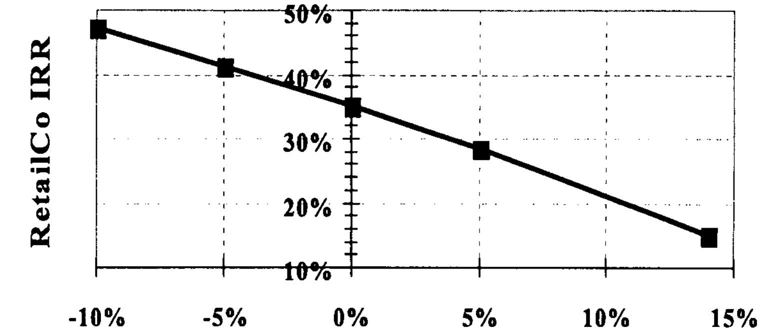
Figure 2.



[5]At least one east coast GHP contractor claims to recover 40% of first cost at the end of their 10 year contracts. Higher salvage values may be justified based on the long life expectancy of these systems (20 years, or more).

How Sensitive (Risky) is the Energy Service Contract?

Figure 3.
Profitability and Customer Savings



Sensitivity analyses were run on the financial model to determine which variables had the greatest impact on the retailco's IRR and, to gauge the riskiness of the energy service contract as a whole. Only one input was allowed to change for each run. Seven model inputs were varied: energy service payment, installed cost, maintenance cost, equipment efficiency, electricity cost escalation, contract term, and finance interest rate. The retailco's minimum rate of return for this analysis was assumed to be an IRR of 15%, below which investments are believed to be unattractive. This criteria was then used to define the "worst case" boundary on the key input variable: the value at which the IRR is equal to 15%. For example, Figure 3 demonstrates the sensitivity of the retailco's IRR to the energy service price it charges the customer. The retailco can offer the customer HVAC owning and operating savings of up to 14% over the base case and still make a 15% IRR. Anything greater will reduce the IRR below the retailco's assumed investment threshold.

Table 4 displays the results of the sensitivity analyses. The results are organized with the base case situation as the first line, the "best" situation is the second line, and the "worst" situation is the third line. Note that the retailco earns an IRR of 28% in the base case situation using the expected values of the key model inputs. So, looking at the installed cost input the retailco earns a 28% IRR on a base case installed cost of $8.28 per square foot; for the best, or high IRR case, the installed cost decreases by 10% and the IRR increases to 37%; in the "worst" case the installed cost rises by 18% pushing the IRR down to a minimally acceptable 15%.

Table 4
Sensitivity Analysis

Key Input Variable	Base Case Value	New Variable Value High IRR Case/ Low IRR Case	Retailco IRR
Installed Cost	$8.28/SF	 Decrease by -10% Increase by +18%	28% 37% 15%
Maintenance	$0.11/SF	 $0.05/SF $0.23/SF	28% 31% 22%
Equipment Efficiency	$0.99/SF	 Increase Eff. 20% Decrease Eff. 50%	28% 33% 15%
Elec. Cost Escalation (nominal values)	3.1%	 0% 8.1%	28% 33% 15%
Contract Term	10 Years	 15 Years 5 Years	28% 32% 23%
Finance Interest Rate	9%	 15% 7%	28% 29% 28%

The sensitivity analysis found that two key inputs had the greatest impact on the retailco's IRR: energy service price and installed cost. The most of important of these is installed cost because the retailco has less control over this input than the energy service price which it has discretionary control. Conversely, the retailco's IRR is relatively nonsensitive to three inputs: maintenance cost, contract length, and finance interest rate. Equipment efficiency and electricity cost escalation also have a minimal affect on IRR, but deserve special mention.

Installed Cost

How much risk does the installed cost represent to the retailco? It is significant, but manageable.

Given anecdotal stories regarding cost overruns for general construction projects, an 18% cost over run would seem to be a distinct possibility. However that risk can be understood to reside primarily in the loop construction cost, the most uncertain cost component of a GHP project. Further, the risk can be significantly minimized by paying attention to good design practices and implementation practices. In fact, GHP systems can actually cost less that the alternative due to lower building space requirements[6]. See Appendices C, E and J for further information on GHP cost, performance and design issues.

Maintenance Cost

The worst case maintenance cost is equivalent to the maintenance cost for the standard equipment, $0.23 per square foot, while the best case maintenance cost was the lowest average cost encountered in GHP literature. See Appendix D for further information.

Equipment Efficiency

The risk to the project's IRR if the equipment doesn't perform as expected is minimal. Because the equipment efficiency was not available the GHP's building energy cost, $ per square foot per year, was used as a proxy. However, HVAC is only 30-40% of the building's energy budget, so it takes large variations in HVAC usage to impact total building energy use. The accuracy of initial system efficiency predictions, especially through building simulations, is within about +/- 10%, well within the risk comfort zone.

Electricity Cost Escalation

The risk represented by rising electricity prices depends on how far off the forecasted escalation is from actual. In this case the forecasted escalation is 3.1% annually over the life of the contract, or in "real" terms (i.e., absent the 4% inflation part of escalation), energy costs are expected to decrease by 0.9% over the next 10 years (Energy Information Agency's 1997 forecast). Once the energy service price has been fixed, if energy prices rise more than expected, the retailco's IRR will decrease. However, given the expectation of decreasing prices it would be an extreme set of circumstances to cause prices to rise the 8.1% per year for 10 years, needed to make the project unattractive.

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[6]Cost savings at schools from reduced mechanical room space requirements and lower ceiling heights (due to much lower ducting needs) have been estimated at $1.50 to $2.75 per square foot when compared to buildings with VAV system. Conversation with Robert Mancini, Mancini& Associates, 8/11/97.

Contract Term

Interestingly, a short 5 year contract in which total installation costs are recovered still provides an attractive return. It is important to note a critical assumption for this analysis: that both the base case customer and the retailco have the same financing term on their loan.

Interest Rate

Interest rate has no affect on the risk of the project. (In fact, higher interest rates slightly favor the GHP project.) This perhaps counterintuitive result is explained by the fact that both the base case customer and the retailco are subject to the same interest rate, which is known prior to the establishment of an energy service price. The energy service price is based on the customer's base case cost, which is greater when interest rates are higher. Therefore, the energy service payment will be greater, and this has a slightly positive affect on the cash flow. Although this is true of new construction when the building owner must install an HVAC system, this is decidedly not the case in retrofit situations.

Conclusions

This case study used real geothermal heat pump operating data and highly reliable base case modeled data to examine the applicability of a GHP system as an energy service offering for a small, newly constructed, office building in Toronto, Canada. The GHP system proved to be an excellent investment, providing an expected internal rate of return of 28% over a 10 year contract while reducing equivalent customer bills by 5%. A five year contract can be offered which provides a 23% IRR to the retailco, still an attractive investment. Additional return on investment can be achieved if the retailco can integrate the HVAC design with the building plan early in the design process.

The primary risk in this business venture is cost over runs for the loop portion of the system. Significant risk can be minimized by incorporating thorough design and project management principles.

Case Two:Orlando Office Building

The Orlando case study is identical in almost all regards to the Toronto case study. The same building was used with identical equipment for the base and GHP cases and all the previous model inputs and assumptions were used except for the following:

- Installed cost was increased for the GHP case to account for greater cooling requirements;

- Different energy escalation rates;
- Orlando utility rates were used, and
- Both the base and GHP building were modeled using Orlando weather data.

Installed Cost

Installed costs for both the base and GHP cases were adjusted to account for changes in location using Means Mechanical Cost Data Cities Index. The HVAC system cost was further adjusted to account for the approximate 10% increase in peak cooling requirements. Table 1 shows the new costs for both systems.

Table 1
Orlando Installed Costs

System	Toronto Costs	Cities Adjustment	Adjustment for Add. Cooling	Orlando Costs
Base	$ 8.06	$ 0.60	$ 0.87	$ 9.53
GHP	$ 8.28	$ 0.62	$ 0.89	$ 9.79

Other Variances from the Toronto Case Study

There are three other points of divergence from the Toronto case study: escalation rates, utility rates, and weather. Energy cost escalation rates are again taken from the Energy Information Agency's Outlook 1997 fuels forecast, but for the South Atlantic region. Computer building simulations were run for both the base and GHP case using an Orlando weather file, and energy bills were also calculated using Orlando utility rates.

Results of Analyses

The Orlando case study results in a 30% internal rate of return for the retailco. The high degree of similarity between the Orlando and Toronto buildings would result in very similar sensitivities, therefore no other analyses were performed.

Conclusions

This case study indicates that given similar cost parameters, GHP technology can be an excellent investment, even in southern climates. Of coarse it would have been preferable to have a "real" southern building, however obtaining accurate case study data proved to be impossible.

Case Three: Residential Retrofit at Fort Polk, Louisiana

As the utility climate continues its move toward competition, there has been much discussion about how utilities can develop new services for commercial and industrial customers. While the Commercial/Industrial segment undoubtedly presents opportunities, residential customers, representing 30% of most utilities revenues, have been virtually ignored. The Fort Polk case study is important because it presents a model for how a retailco might be able to run a profitable large residential program.

Fort Polk presents an excellent case study for at least two reasons:

- The size and scope of the project, and
- The high quality of monitoring and evaluation.

The project is also interesting in that the actual project is structured as a performance contract wherein the equipment is installed and maintained. In this sense it is structured much like a commercial project. However, it also stands as an impressive residential retrofit, which given certain caveats, represents an important retailco opportunity.

Project and Building Description

The Fort Polk project consists of retrofitting 4,003 military housing units in 1,292 buildings with GHP systems employing vertical ground loops. In addition, other efficiency measures were installed including: compact fluorescent lights, low-flow hot water outlets, and attic insulation. The buildings were constructed between 1972 and 1988 and the average living unit is about 1,400 square feet. Finally, prior to retrofitting, 81% of homes had heat pumps and electric water heaters, the remainder were served by air conditioners, gas furnaces and gas water heaters. Table 1 list other project details.

Table 1
Fort Polk GHP Retrofit Details

Total Building Area	5,600,000 ft^2
Project Cost:	$18,900,000
Heat Pumps:	4,003
Average Heat Pump:	1.6 tons
Average cost per unit:	$4,721
Average Loop Length:	278 bore-feet per ton
Loop Cost (estimate[7])	$974 per ton

Reasons for Low Cost

The total cost per square foot for this project is $3.38, which is quite low for a residential project and deserves additional explanation[8]. Certainly the project has the advantage of scale, which the ESCO used to drive costs down. For instance, the cost of the vertical ground loop, traditionally the most difficult cost to control in GHP projects comes in at less than $1,000 per ton, on the low end of the expected cost range. The ESCO also reduced project costs by negotiating directly with the manufacturer to obtain not only price discounts (their order represented about 10% of all commercial units shipped in 1994), but also design modifications which allowed for faster and less expensive field installation.

Model Description

Except for the inputs, the model is identical to the Toronto case study. Also important to note is that the original project was constructed as a performance contract, while this analysis is for energy service pricing. To that end, the shared savings portion of the original ESCO contract with Fort Polk has been replaced by a dollars per square foot annual energy service price, which includes a 5% discount off of their base case cost.

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[7]Estimated using cost of $3.50 per bore-foot.

[8]Other single GHP project residential case studies reported installed costs ranging from $4.01 to $5.45 per gross square foot of home.

Model Inputs and Data Sources

The major model components are listed in Table 2.

Table 2
Fort Polk Residential Model Inputs

Model Component	Base Case Input	GHP Input
Total Installed System Cost, $/SF	$0.00	$3.38
Annual Maintenance, $/SF	$0.24	$0.10
Finance Costs		
equity-to-debt percent	NA	20%
interest rate		7.0%
finance term		15 years
Contract term		20 years
Escalation Rates, Nominal		
inflation	4.0%	4.0%
gas escalation	3.1%	3.1%
electricity escalation	3.1%	3.1%
maintenance escalation	inflation	inflation
energy service price index	NA	0.0%
Tax Treatment		
state and federal tax rate	0%	40%
depreciation period		15 years
depreciation schedule		accelerated (MACRS)
Average Energy Rates		
gas	$0.50 Therm	$0.50 Therm
electricity	$0.06 kWh	$0.06 kWh
Customer Savings Guarantee	NA	5.0%

Data sources for Fort Polk come from a series of papers analyzing energy and maintenance savings for the project[9]. Financing data was provided by the president of the ESCO[10]. Debt financing was provided by an insurance company, while the equity requirement was split 10% from the ESCO, 10% from another investor. It is interesting to note that the financing term was 15 years while the contract term was 20. The analysis assumed the same financing conditions as the performance contract which was assumed to be 9%.

Results of Analyses

Table 3 shows the results of the analysis.

Table 3
Energy Service Pricing at Fort Polk, LA

Investment Components	Fort Polk	Retailco
Initial Investment (Equity)	$0	$3,150,000
Project Net Present Value Cash Flow	$6,300,000	$14,300,000
Initial Investment per GHP	$0	$944
Net Present Value per GHP	$1,573	$3,579
IRR	NA	28%

Over the 20 year contract, the Fort Polk project saves the average customer $116 per year (for an NPV of $1,573) and returns an attractive 28% internal return on investment. Remember, too, that 19% of homes had gas-fired water heaters and furnaces. GHP systems serving these homes saved much less electricity than those serving the all-electric homes, hence suppressing the retailco IRR somewhat.

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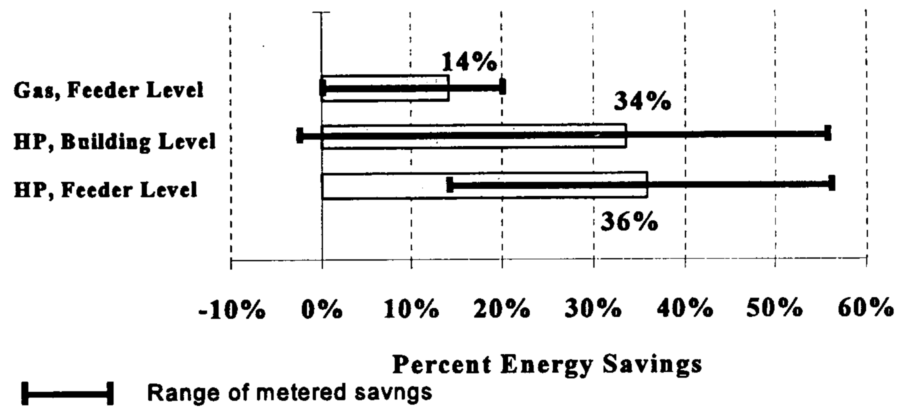
[9]The following papers were authored or co-authored by staff members in the Efficiency and Renewables Research Section of the LA. Oak Ridge National Laboratory: Shonder J., Hughes P., *Electric Energy and Demand Savings From a Geothermal Heat Pump Energy Savings Performance Contract at Ft. Polk;* Shonder J., Hughes P., *Estimated Maintenance Cost Savings From a Geothermal Heat Pump Energy Savings Performance Contract at Ft. Polk.* These papers have consequently been published in 1997 ASHRAE Transactions.

[10]Tom Mitchell, President, Co-Energy Group.

Monitored Energy Savings

Figure 1
Metered GHP Energy Savings at Fort Polk, LA

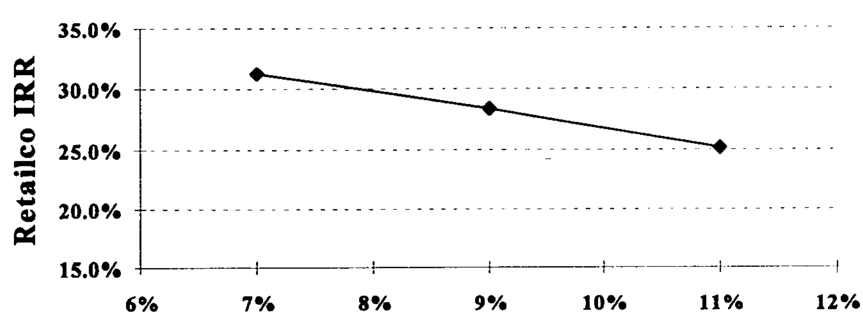


In fact, as detailed in Figure 1, the monitored energy savings at Fort Polk showed a very high variability. Note that for buildings which were originally gas heated, the average annual electricity savings is 14%.

Energy savings were monitored primarily in two ways: at the feeder level and at the building level. Feeder level monitoring involved capturing the impact of all 4003 houses and includes some (small) amount of savings from reduced transformer usage. Meters were also installed at the building level, although the sample size was much smaller (12 buildings).

How Sensitive (Risky) is the Energy Service Contract?

Figure 2
Retailco Rate of Return vs. Interest Rate



A limited sensitivity analysis was conducted for Fort Polk due to the retrofit of the project. However, Figure 2 displays the dependence of the retailco's IRR on interest rates.

Conclusions

This case study used real residential geothermal heat pump operating data to examine the applicability of a GHP system as an energy service offering for a retailco residential program. The Fort Polk model suggests that a program level energy service contract could provide attractive returns provided an adequate number of customers could be aggregated and long term contracts could be signed (or conversely, the customer could agree to buy the equipment at the end of the contract, similar to a balloon payment in mortgage financing).

Appendix A
Financial Model

ENERGY SERVICE PRICING MODEL

Instructions for Using The Energy Service Pricing Model

Note to the User: This model condenses and aggregates many types of data associated with ground source heat pur
It is highly recommended that the user read the Executive Summary for this project titled, "Geothermal Heat Pump P
in Energy Services," prior to using the model.

Organization

Naming conventions: ESP- energy service pricing; ESCO is used to mean Utility or ESCO.

1. All model inputs are entered in sheet "Input Data".
2. Cash flow analyses take place in sheets:
   Basecase, Customer: "Cash Flow Cust, Base"
   ESP Customer: "Cash Flow Cust, ESP"
   ESP ESCO: "Cash Flow ESCO, ESP"
3. Data is organized for chart output in sheet "Sum, Cash Flow", and "Sensitive1"
4. Charts for presentations are in "Charts, for presentations"
5. Sensitivity data has been gathered in "Sensitive1"
6. Ancillary data feeding into the analyses: "Tax Table", "Energy Escalation", "Depreciation".
7. Macro sheets begin with "Mod-".
8. Links:
   Commercial energy price forecast: PRICETBL.XLS
   Building Modeling results: ENRGYTBL.XLS*
   *currently awaiting new $/SF annual energy use values from Mancini & Assoc. (10-28-97). Austin and Los Angeles are suspect.

Caveats

1. This analysis is for a real office building built in Toronto, Canada, in 1989. As such, the data is felt to be accurate. Although this building's energy use was modeled for different cities, it is outside the scope of this analysis to provide specific cost estimates. Therefore, extra caution should be used when interpreting results for cities other than Toront

Using the Model

1. Input data

General- input data is marked with red text; special function cells are marked with blue.

1. The model is set up to analyze an office in Toronto building described at the top of the page. You may alsc run the analysis for different cities by typing the city name in cell F3. The choices are: Washington, Orland Austin, Los Angeles, Seattle, and Minneapolis. (Note that the data for Austin and Los Angeles is suspect, ; subject to revision.)

SYSTEM COST, U.S. Dollars

2. System costs are in $ per Square Foot. Note that these cells contain formulas to convert Canadian dollars If other projects are to be analyzed, the costs can be entered in US dollars, and then set the currency excl at cell F84 to 1.0. This action applies to all sections on the input form.
3. Costs may be broken into components, loop and non-loop costs, or simply input as total installed cost per

OPERATION AND MAINTENANCE COSTS, Canadian Dollars

4. Maintenance costs need not be changed. For US cities change the exchange rate as in point 2.

FINANCING CHARGES, U.S. Dollars

5. Equity and debt are calculated based on the percent equity-to-debt.

6. Enter the financing term in cell W39; the same value is automatically entered for the base case.
7. Cell AA40 is added to the inflation rate to calculate the finance interest rate.
8. Payment start date is not linked to any formulas.
9. Contract term is the length of the contract between ESCO and customer. This is assumed to be the same the financing term. However, the model will accommodate different contract and financing term lengths.

DISCOUNT, TAX, AND ESCALATION RATES

10. Discount is not used.
11. Service index is an escalation factor applied to the energy service payment.

TAXES

12. These numbers are for information purposes only.

CUSTOMER CASH EXPENDITURES, U.S. Dollars

13. Electric and Gas consumption are linked to ENRGYTBL.XLS and are input automatically based on the city entered at the top of the sheet.

ANNUAL ENERGY SERVICE PAYMENT, U.S. Dollars

General- this section calculates the energy service payment the customer is to pay the ESCO. The first number (cell R70 is the before tax cost to the customer, while cell M73 is the after tax cost (the energy service payment is fully t at an approximate tax rate of 40%).

14. The user's only input is specifying the customer's percentage savings off their base case bill.
15. To calculate the cost of service for the ESCO (project financing and energy costs), set the energy service payment t Then go to cell H75 in sheet Cash Flow ESCO ESP. Finally, reestablish the formula in the energy service payment b copying cell Y70 to R70, the energy service payment.

Customer Annualized After Tax HVAC Operating Cost for Contract Term

16. For information purposes only. These cells report back from the cash flow analyses. The base cost is wha customer was paying for their base case annualized energy and HVAC system cost. The ESP payment is guaranteed price using GHP equipment.

Annual Energy Expenditures, U.S. Dollars

17. The annual energy expenditures for the base case and the GHP case. For Toronto, the annual GHP energ are actual, while the base case was derived from computer building simulations based on the originally de HVAC system for the building. Energy expenditures for all other cities were derived via building simulation actual commercial rates applicable to those cities.

Exchange Rate

18. The Canadian to US exchange rate posted in the Wall Street Journal as of Nov 1997.

2. Cash Flow Analyses

Customer base case cash flow- accounts for the cost of the originally specified HVAC system in terms of annu financing, maintenance, and energy. Calculated after tax cash flow by assuming a fully applicable federal+sta rate, and uses a straight-line 39 year depreciation schedule (equipment considered a part of the building).

Customer energy service price case cash flow- wraps all the base case costs into one annual per sq. ft. fee, th by the user specified savings on sheet "Input Data". The energy service price is a cost of doing business and i tax deductible.

ESCO energy service price case cash flow- calculates annual costs of providing service same as in customer maintenance, energy, and financing. Receives energy service payment from customer. Tax treatment differs fr in that ESCO able to use accelerated 15 year depreciation schedule.

3. Sensitivity Analyses1

General- this sheet presents the primary sensitivity analyses. It has two column groups; the right group contai linked to the cash flow sheets and are the same categories as the column group on the left. The layout is stric pasting values into the columns on the left (where they feed into "charts, for presentation" sheet). For example sensitivity category is INSTALLED COST. If we reduce the installed cost by 10%, the new cash flow analysis r are reflected in the right column group. The numbers corresponding to the 10% reduction are then copied to th group as values. (Cell AA27 in the Input Data sheet allows for changing the installed cost easily. For example, value 0.9 would correspond to 10% decrease in installed cost.)

Sensitivity runs were calculated assuming a 10 year financing/contract term.

Installed Cost: the maximum amount installed cost may rise is 18% and still provide the ESCO with a 15% Internal Rat of Return. To find this number use the Goal Seek function found under Tools on the menu. For example, to fin permissible installed cost and an ESCO IRR of 15% set the Goal Seek function as follows:

Set Cell:	Cash Flow ESCO, ESP'!H73
To Value:	0.15
By Changing Cell:	Input Data'!AA27

Maintenance: the maintenance values were set to logical min/max values.

Equipment Efficiency (Increased Energy Costs for GHP due to Equipment Underperformance): use cell Y79 in the Inpı sheet to change GHP energy $/SF usage. For example, entering a value of -0.1 increases the GHP energy us: 10%. Use Goal Seek to find max energy usage percent. Note that the percentage change is for the building as just the GHP system. Typically, HVAC comprises about 40% of an office building's energy usage, hence the G change would have to be greater than the total building energy change (by a factor of 1/0.40=2.5).

3. Sensitivity Analyses2

General- This sheet is used to easily calculate and compare financials for varying finance terms. Use the macı to enter different terms.

Project: Metrus Office Building, Toronto, Canada

Financial Analysis: Energy Service Pricing

City: Toronto
Building: Office

Project Description, Actual:

37,000 ft2 office building built in 1989 with an occupancy of 120. Installed HVAC system is Geothermal Heat Pump with vertical loop; basecase system is rooftop VAV with gas heat and electric cooling. Project was developed by owner/developer. Customer contracts with ESCO/utility to provide comfort.

SERVICES	BASE CASE	GHP SYSTEM	
Site Analysis	No	Yes	
Arrange Financing	No	Yes	
Equipment Specification	No	Yes	
Project Engineering	No	Yes	
Equipment Installation	No	Yes	
Operation & Maintenance	No	Yes	
Monitoring	No	Yes	
Pay Bills	No	Yes	
Procure Energy	No	Yes	
Service Profit Margin			
SYSTEM COST, U.S. Dollars[4]			
Building Area, SF	37,248	37,248	
Non Loop Cost, $/SF	$ 8.06	$ 5.38	
Loop Cost, $/SF	$	$ 2.90	
Installation	$	$ included	
Total Installed Cost per SF	$	$ 8.28	
Project Cost	$ 300,368	$ 308,413	1
OPERATION AND MAINTENANCE COSTS, Canandian Dollars			
Life of Equipment	20 years	20 years	
Maint. Cost /SF [3]	$0.32	$0.15	
Annual Maintenance	$11,919	$5,587	
FINANCING CHARGES, U.S. Dollars			
Loan (from 3rd Party)			
Cash Investment (equity)	$ 69,316	$ 71,172	
Debt	$ 231,052	$ 237,241	
Percent Equity-to-Debt[6]	30%	30%	
Term	10 yr	10 yr	
Interest Rate, Nominal	9.0%	9.0% [1]	5%
Payment Start Date	Jan-97	Jan-97	
Contract Term (default= loan term)	10	10	
DISCOUNT, TAX, AND ESCALATION RATES			
Inflation	4.0%	4.0%	
Discount Rate	15.0%	15.0%	
Combined Federal and State Tax Rate	40.0%	40.0%	
Gas Escalation Rate	3.1%	3.1%	
Electricity Escalation Rate	3.1%	3.1%	
Maintenance Index, CPI	4.0%	4.0%	
Service Index	0.0%	0.0%	

Project: Metrus Office Building, Toronto, Canada

Financial Analysis: Energy Service Pricing

TAXES

Depreciation Method	Straight-line	MACRS-GDS
Depreciation Period, Commercial	39 yr	15 yr

CUSTOMER CASH EXPENDITURES, U.S. Dollars

	Base		GHP		Difference	Savings	
Electric Consumption	802,019	kWh	706,566	kWh		95,453	kWh
Gas Consumption[2]	14,081	Therms	0	Therms		14,081	Therms
Bill Savings							
Electric	$45,860		$36,741		$9,118	$9,118	
Gas [2]	$0		$0		$0	$0	
Maintenance	$8,582		$4,023		$4,559	$4,559	
TOTAL	$54,442		$40,764		$13,677	$13,677	

ANNUAL ENERGY SERVICE PAYMENT, U.S. Dollars — **To ESCO/Utility**

Annual Payment, Before Tax, $/SF	$ 3.18 [5]		##
Specify savings over base	5%		

Customer Annualized After Tax HVAC Operating Cost for Contract Term

Base	$ 2.01 per SF	##
ESP Payment	$(1.91) per SF	

Annual Energy Expenditures, U.S. Dollars

	Base	GHP		
Electricity	$1.23	$0.99	$/SF	0%
Gas [2]	0.00	0.00	$/SF	

Exchange Rate

U.S.= 0.72 x $$Canadian

NOTES:

1 Interest rate equal to prime (currently 8.5%, 8/7/97) + 0.5%

2 Gas savings (due to elimination of boiler from original design) rolled into overall energy savings, shown as electric savings only.

3 Maintenance costs estimated by Mancini based on internal GHP maintenance cost study and experience with standard 2/4 pipe systems.

4 Cost are given in Canadian dollars ($1 Can= $0.72 US) except where noted. However, Mancini believes the costs are about equal in the U.S. because of higher construction and drilling cost, and less competition in many areas, especially the "rust belt".

5 Defaults to setting ESP payment equal to customer $/SF cost for the basecase, but on a pre-tax basis (i.e., no customer savings).

6 Best estimate is that new construction financing will require about 30% equity.

7.

8.

9.

CASH FLOW ANALYSIS WORKSHEET (NOMINAL DOLLARS)

Project: Metrus Office Building, Toronto, Canada

Financial Analysis: Energy Service Pricing

Customer- Base Case

YEAR	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
	0	1	2	3	4	5	6	7	8	9	10
Installed Cost	($300,368)										
Equipment Cost											
Operating and Maintenance CostS											
Life of Equipment	20 years										
Shared Savings Schedule		100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Maintenance Cost	$0	($8,925)	($9,282)	($9,654)	($10,040)	($10,441)	($10,859)	($11,293)	($11,745)	($12,215)	($12,703)
Escalation	4.0%										
Electric Energy	$0	($47,281)	($48,747)	($50,258)	($51,816)	($53,423)	($55,079)	($56,786)	($58,546)	($60,361)	($62,233)
Escalation	3.1%										
Gas Energy	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Escalation	3.1%										
TOTAL		($56,207)	($58,029)	($59,912)	($61,856)	($63,864)	($65,938)	($68,079)	($70,291)	($72,576)	($74,936)
Finance Charges											
Financing Term	10 years										
Interest Rate	9.0%										
Debt	($231,052)										
Equity	($69,316)										
Priniciple Payments		($15,208)	($16,577)	($18,068)	($19,695)	($21,467)	($23,399)	($25,505)	($27,801)	($30,303)	($33,030)
Interest Expense		($20,795)	($19,426)	($17,934)	($16,308)	($14,535)	($12,603)	($10,497)	($8,202)	($5,700)	($2,973)
Lease Payments											
Energy Service Payments											
TOTAL		($36,003)	($36,003)	($36,003)	($36,003)	($36,003)	($36,003)	($36,003)	($36,003)	($36,003)	($36,003)

CASH FLOW ANALYSIS WORKSHEET (NOMINAL DOLLARS)

Project: Metrus Office Building, Toronto, Canada

Financial Analysis: Energy Service Pricing

Customer- Base Case

YEAR	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
	0	1	2	3	4	5	6	7	8	9	10
Receipts											
Equivalent Annual Cost		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Maintenance	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Escalation	4.0%										
Gas Savings	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Escalation		3.1%	3.1%	3.1%	3.1%	3.1%	3.1%	3.1%	3.1%	3.1%	3.1%
Electric Savings	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Escalation		3.1%	3.1%	3.1%	3.1%	3.1%	3.1%	3.1%	3.1%	3.1%	3.1%
TOTAL		$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Net Income Before Taxes	($69,316)	($92,209)	($94,032)	($95,914)	($97,859)	($99,866)	($101,940)	($104,082)	($106,294)	($108,579)	($110,939)
Tax Impacts											
Federal Tax Rate	34%										
State Tax Rate (generic estimate)	6%										
Combined Federal and State Tax Rate	40%	Federal Government									
O&M Cost		($56,207)	($58,029)	($59,912)	($61,856)	($63,864)	($65,938)	($68,079)	($70,291)	($72,576)	($74,936)
Less: Tax Depreciation		($7,702)	($7,702)	($7,702)	($7,702)	($7,702)	($7,702)	($7,702)	($7,702)	($7,702)	($7,702)
Less: Interest Expense		($20,795)	($19,426)	($17,934)	($16,308)	($14,535)	($12,603)	($10,497)	($8,202)	($5,700)	($2,973)
Less: Lease Payments		$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Receipts		$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
TOTAL TAX LIABILITIES (marginal income for tax purposes, or marginal revenue less costs)		($84,703)	($85,157)	($85,548)	($85,866)	($86,101)	($86,243)	($86,279)	($86,195)	($85,978)	($85,610)
TOTAL TAXES (negative numbers indicate increased taxes, or cash out flows)		$33,881	$34,063	$34,219	$34,346	$34,440	$34,497	$34,511	$34,478	$34,391	$34,244
Discount Rate 15.0%											
Net Cash Flow	($69,316)	($58,328)	($59,969)	($61,695)	($63,512)	($65,426)	($67,443)	($69,571)	($71,816)	($74,188)	($76,694)
Cumlative Cash Flow	($69,316)	($127,644)	($187,613)	($249,308)	($312,820)	($378,246)	($445,689)	($515,260)	($587,076)	($661,264)	($737,958)
Present Worth Cash Flow (1997)	($69,316)	($56,085)	($55,445)	($54,847)	($54,291)	($53,775)	($53,301)	($52,868)	($52,475)	($52,123)	($51,812)
Cumlative Present Worth Cash Flow	($69,316)	($125,400)	($180,845)	($235,692)	($289,982)	($343,758)	($397,059)	($449,927)	($502,402)	($554,526)	($606,337)
Net Present Value	($606,337)										
Internal Rate of Return	#DIV/0!										
Annualized Payment	$74,756										
Annualized HVAC Cost per SF	$2.01 per SF										

CASH FLOW ANALYSIS WORKSHEET (NOMINAL DOLLARS)

Project: Metrus Office Building, Toronto, Canada

Financial Analysis: Energy Service Pricing

ESCO- Energy Service Price

YEAR	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
	0	1	2	3	4	5	6	7	8	9
Installed Cost	($308,413)									
Equipment Cost	($308,413)									
Operating and Maintenance Cost										
Life of Equipment	20 years									
Services Cost (engineering, equip. spec, monitoring, ..ect.)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Escalation	0.0%									
Maintenance Cost	$0	($4,184)	($4,351)	($4,525)	($4,706)	($4,894)	($5,090)	($5,294)	($5,505)	($5,726)
Escalation	4.0%									
Electric Energy	$0	($37,880)	($39,055)	($40,265)	($41,514)	($42,801)	($44,127)	($45,495)	($46,906)	($48,360)
Escalation	3.1%									
Gas Energy	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Escalation	3.1%									
TOTAL		($42,064)	($43,406)	($44,790)	($46,220)	($47,695)	($49,217)	($50,789)	($52,411)	($54,085)
Finance Charges										
Financing Term	10 years									
Interest Rate	9.0%									
Debt	($237,241)									
Equity	($71,172)									
Priniciple Payments		($15,615)	($17,021)	($18,552)	($20,222)	($22,042)	($24,026)	($26,188)	($28,545)	($31,114)
Interest Expense		($21,352)	($19,946)	($18,414)	($16,745)	($14,925)	($12,941)	($10,779)	($8,422)	($5,853)
Lease Payments										
Energy Service Payments										
TOTAL		($36,967)	($36,967)	($36,967)	($36,967)	($36,967)	($36,967)	($36,967)	($36,967)	($36,967)

CASH FLOW ANALYSIS WORKSHEET (NOMINAL DOLLARS)

Project: Metrus Office Building, Toronto, Canada

Financial Analysis: Energy Service Pricing

ESCO- Energy Service Price

YEAR	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Receipts	0	1	2	3	4	5	6	7	8	9
Shared Savings Schedule- NA		100%	100%	100%	100%	100%	100%	100%	100%	100%
Energy Service Payment	$0	$118,364	$118,364	$118,364	$118,364	$118,364	$118,364	$118,364	$118,364	$118,364
Escalation	0.0%									
Net Income Before Taxes	($71,172)	$39,333	$37,991	$36,606	$35,177	$33,702	$32,179	$30,608	$28,985	$27,311
Tax Impacts										
Federal Tax Rate	34%									
State Tax Rate (generic estimate)	6%									
Combined Federal and State Tax Rate	40%									
Less: O&M Cost		($42,064)	($43,406)	($44,790)	($46,220)	($47,695)	($49,217)	($50,789)	($52,411)	($54,085)
Less: Tax Depreciation		($15,421)	($29,299)	($26,369)	($23,748)	($21,373)	($19,214)	($18,196)	($18,196)	($18,227)
Less: Interest Expense		($21,352)	($19,946)	($18,414)	($16,745)	($14,925)	($12,941)	($10,779)	($8,422)	($5,853)
Less: Lease Payments		$0	$0	$0	$0	$0	$0	$0	$0	$0
Plus: Receipts		$118,364	$118,364	$118,364	$118,364	$118,364	$118,364	$118,364	$118,364	$118,364
TOTAL TAX LIABILITIES (marginal income for tax purposes, or marginal revenue less costs)		$39,527	$25,712	$28,789	$31,651	$34,371	$36,991	$38,600	$39,334	$40,198
TOTAL TAXES (negative numbers indicate increased taxes, or cash out flows)		($15,811)	($10,285)	($11,516)	($12,660)	($13,748)	($14,796)	($15,440)	($15,734)	($16,079)
Discount Rate 15.0%										
Net Cash Flow	($71,172)	$23,522	$27,706	$25,090	$22,516	$19,953	$17,383	$15,168	$13,252	$11,232
Cumlative Cash Flow	($71,172)	($47,651)	($19,945)	$5,146	$27,662	$47,616	$64,998	$80,166	$93,418	$104,650
Present Worth Cash Flow (1997)	($71,172)	$22,617	$25,616	$22,305	$19,247	$16,400	$13,738	$11,526	$9,683	$7,891
Cumlative Present Worth Cash Flow	($71,172)	($48,555)	($22,940)	($634)	$18,613	$35,013	$48,751	$60,277	$69,960	$77,851

Net Present Value	$83,974	
Internal Rate of Return	28.4%	
Annualized Payment	($10,353)	Note: this number is the cost to the ESCO less any ESP payment from the customer.
Annualized HVAC Cost per SF	-$0.28 per SF	When the ESP payment is included, these number are not applicable.

Appendix B
International Ground Source Heat Pump Association
Annual Meeting

September 1997

Baltimore, Maryland

BACKGROUND

- ➢ How GHP's fare in a competitive market
- ➢ Demise of DSM
- ➢ Emergence of unregulated retail energy services companies
- ➢ Energy service pricing could be the answer - barriers need to be investigated

➢ Emergence of unregulated retail energy services companies: many ESCOs are now advertising this service, for example, Enron, Johnson Controls..

ENERGY SERVICE PRICING

- Sale of "comfort" (heating, cooling, ventilation), light, motive power or other service desired by customer that is the result of combining energy and end use equipment.

- Turnkey service includes:
  - Design
  - Equipment
  - Energy
  - Maintenance
  - Price Guarantee

GEOTHERMAL HEAT PUMP ADOPTION

Premise: Many of the same barriers that have inhibited GHP adoption in the general market will still exist in ESCOs decisions to incorporate into performance contracting or energy service pricing.

- Barriers include:
  - Doubts about a "new" technology and its reliability
  - Doubts about efficiency claims
  - Concerns about long term performance and maintenance costs

Solution: Use real project data to simulate the performance of GHP in a long term performance contract or energy service pricing contract compared to other systems.

APPROACH

- ➢ Gather data including installation cost, energy consumption and maintenance cost on actual GHP installations
- ➢ Build model to simulate the financial performance of a contract compared to more conventional systems
- ➢ Identify areas of risk and run sensitivity analysis

RESULTS OF STUDY

Topics

- Description of building chosen for study
- Data sources
- Financial analysis model description
- Financial analysis of energy service pricing contract
- Sensitivity analysis
- Conclusions and recommendations

Building Description: Toronto Office Building

- 37,000 ft^2, two story, 1989
- 120 person occupancy
- Cooling load: 70 tons
- Heating load: 300,000 Btu/hour

Building Description: Toronto Office Building
Initial HVAC System: Design

➢ Rooftop VAV

➢ HVAC: gas-fired heating, electric DX cooling

➢ Gas-fired reheat terminal units

➢ Installed cost: \$8.06 per ft^2
- Total cost includes ducting and controls
- System was fully designed and specified prior to switch to GHP system

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➢ System was actually designed prior to switch to GHP system- so the base cost is very accurate.. it's not an estimate from Means.

Building Description: Toronto Office Building
GHP System: As Installed

- GHP heat pump with vertical loop
- Gas-fired ventilation air heat exchanger
- Installed cost: $8.28 per ft^2
  - Total cost includes ducting and controls
  - Ground loop cost $1,550 /ton cooling
- Ground Heat Exchanger
  - 15,400 bore-ft
  - Total loop length is 30,800 feet
  - 220 bore-ft per ton
  - Loop cost is $108,000
    - $1,550/ton
    - $7.01/bore-ft

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- The building's owner-developer agreed to go with a GHP system only if it could be installed for $8.25 per SF (slightly higher than the base system cost of $8.06 per SF).
- The installed HVAC cost can actually be lower than the conventional HVAC cost due to the reduced building space needs of GHP systems.
- Reduced mechanical room requirements can result in lower construction costs
  - For schools, worth approximately $1.50 - $2.00 per sq. ft.
  - Lower ducting requirements can reduce ceiling heights
  - For schools, worth approximately $0.75 per sq. ft.

Data Sources: Office Building

Economic Variable	Base	GHP
Installed Cost	Actual Design	Actual
Loop Cost	NA	Actual
Annual Energy Use	Modeled	Actual
Maintenance Cost	Estimated	Estimated

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- Modeled: Hourly simulation using micro-access and original HVAC design. Note that the $/sq.ft. annual energy cost for the base building is less than the U.S. average (see chart next page).
- Maintenance costs based on HVAC system designer's (R. Mancini) experience:
  - Base-experience with two/four-pipe systems (note that their estimated cost is less than ASHRAE's estimated average cost for office buildings).
  - GHP-based on internally conducted survey (and consistent with 1997 study of 25 commercial buildings with GHP systems).

Data Sources: Maintenance Costs

- Conventional equipment maintenance, $0.23 /SF per year
  - BOMA survey of 34 Toronto office buildings estimated $0.24/SF
  - Compares with $0.26 /SF for existing residential HPs at Fort Polk, LA
  - $0.32 /SF for office buildings estimated in 1983 ASHRAE study
- GHP maintenance estimated at $0.11 /SF per year
  - June 1997 study of 25 commercial GHP systems found $0.11 per SF using contractor supplied labor ($0.073/SF using in-house labor)

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- Conventional maintenance costs:
  - Mancini Associates estimate: 30-35 cents Canadian/kWh based on their experience with these systems and internal survey. We used 32 cents/kWh (converts to 23 cents/kWh US).
  - BOMA: 1997 BOMA Experience Exchange Report. BOMA survey covered 1996 building operating expenses and includes over 4000 office buildings throughout North America.
  - ESCO signed contract to provide maintenance for Fort Polk GHP heat pumps for $0.18/SF (actual maintenance must cost less for ESCO to make money). Existing residential HVAC equipment cost about $0.26/SF to maintain (Ft. Polk study by Oak Ridge National Lab)
  - GHP maintenance study: 25 Commercial Systems in Canada and US. Source: Caneta Research Inc, "Survey and Analysis of Maintenance and Service Costs in Commercial Building Geothermal Systems," June 1997, sponsored by the Geothermal Heat Pump Consortium, Inc.

Data Sources: Energy Costs

- ➢ Local energy rates
- ➢ Energy escalation from Energy Information Agency
  - Gas and electricity prices increasing at 3.1% nominal, or -0.9% real.

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➢ Rates: actually a Canadian municipality, New York, which is supplied by Ontario Hydro. Rates are about 8 cents/kWh (don't know the demand charge schedule), and $0.65 per therm (Canadian). [US: 5.8 cents/kWh, $0.49 therm]

Financial Analysis Model: Energy Service Pricing Contract
Toronto Office Building

➢ Customer pays a periodic fixed cost per square foot which includes the following:
- Comfort: cooling, heating, and ventilation services
- System engineering
- Equipment, installation, and commissioning
- Maintenance
- Energy procurement

➢ ESCO/utility assumes risk:
- Project cost overruns
- Equipment nonperformance
- Energy cost
- Maintenance

➢ Customer price provided on a dollars per square foot of building basis

➢ Can include guaranteed savings over standard equipment

➢ Contract does not explicitly address equipment ownership

Financial Analysis Model: Cash Flows
Toronto Office Building

- Model estimates cash flows by analyzing three situations
  - *Base case*- customer finances standard rooftop VAV system, pays for energy and maintenance to run system.
  - *Energy service pricing* - ESCO/utility installs and owns more efficient GHP system and bills customer using a fixed price $/SF contract
  - *Conventional*- VAV system using ESP contract
- Customer after tax base case cash flows are converted into a single annualized HVAC operating cost ($ per square foot)

- ESCO/utility profit is the difference between the fixed energy service price that the customer pays and the actual operating cost (including maintenance) of the HVAC system plus debt service on equipment

Financial Analysis Model: Cash Flow Analysis Assumptions
Toronto Office Building

- Inflation, 4%
- Financing term same as contract term, assumed to be 10 years
- Cost of money, 9%
- 15 year accelerated depreciation - for ESCO/utility ESP
- 39 year straight-line depreciation for conventional ownership
- 30% equity required - for both ESP and conventional financing
- No residual value assumed

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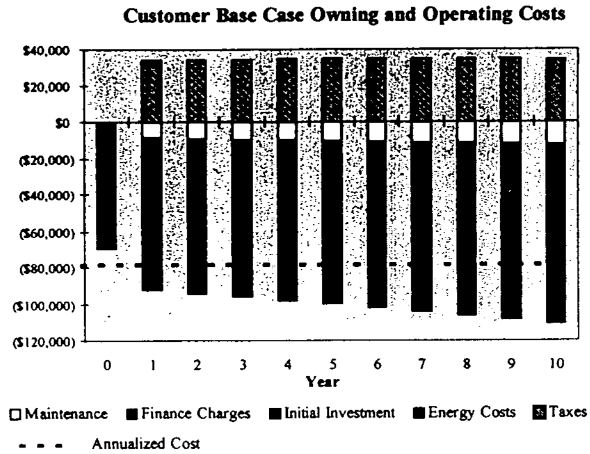
- Economic
  - inflation, 4%-

    Inflation, as measured by the Consumer Price Index (CPI), is about the lowest inflation has averaged over a 5 year period since 1970. The 30 year average is 5.5%.

  CPI, 4%
- Financial
  - The analysis period is set to the life of the contract even though GHP equipment life expected to be 20 years (ASHRAE lists water-to-air heat pumps at 19 years). other GHP consultants report analyzing projects over this time period.
  - 15 year financing- BCI assumption
  - cost of money, 9%- LIBOR (London Interbank Offering Rate) plus 0.5%
  - discount rate, 15%- BCI assumption posed by PGE-ES Chief Financial Officer Dom Falcone. Experienced in project financing.
  - 15 year accelerated depreciation- MACRS. This is a difficult issue to determine. An informal survey of ESCOs by BCI found a variety of opinions. BCI tax consultant, Dan Tobias, suggested MACRS; stayed with most conservative MACRS schedule. Customers assumed to use straight-line 39 year depreciation because the HVAC looks like part of the building for them.

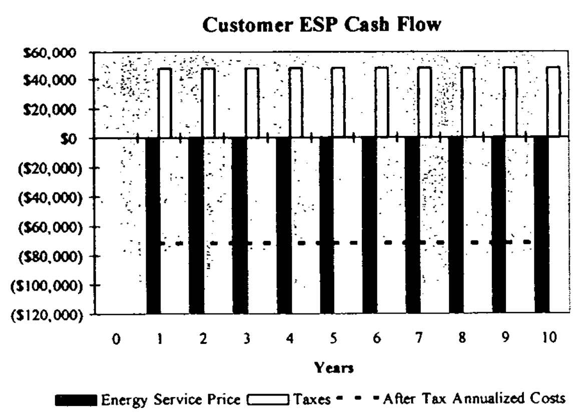
Financial Analysis Model: Base Case Building Cash Flow
Toronto Office Building

- 10 year financing term
- The equivalent owning and operating cost, after tax, is $2.01 per square foot per year



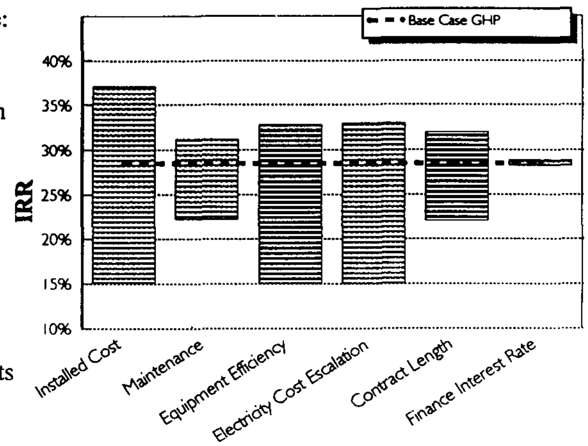
Financial Analysis Model: GHP Energy Service Pricing Cash Flow
Toronto Office Building

- 5% reduction in annual owning and operating cost, equal to $3,700 per year
- fixed, annual, after tax, cost of $1.91/SF for life of contract
- Energy service payment is fully tax deductible



Sensitivity Analyses
Toronto Office Building

- Most sensitive variables are:
  - installed cost (IRR falls below 15% if installed cost increases more than 18%)
  - electricity cost
- Note that:
  - customer receives 5% cost reduction
  - lower IRR limit is 15% below which investments are assumed to be unattractive



Conclusions and Recommendations

- The emerging energy services business will be very large — $500 billion by 2001
- No single company currently has more than 5% market share
- Rapid revenue growth will be possible
- GHPs can provide higher profits than conventional offerings, where competition will be fierce and margins thin
- GHPs can significantly improve the profitability of energy service contracts as well as enhance customer satisfaction

Appendix C
Equipment and Installation Costs

Commercial Cost

A Reality Check

We would like to thank Morris Lovett, Group Vice President of Geothermal Design and Engineering, Inc. and Robert Mancini, President of Mancini and Associates, for their input .

Project Flags: When to Proceed?

- Simplified economic analysis focusing on energy prices
- What is the competing technology?
- What do we know about ground loop installation costs?
- First cost economics
- Anecdotal observations
  - First cost

Commercial Cost, A Reality Check

Simplified Economic Test

- Use life-cycle software
  - Use basic assumptions for building block loads (lighting, heating, cooling, ..)
  - Assume installed costs
  - Use customer's utility rates, or estimate from bill
- Calculate life-cycle costs for GHP and new standard system (and compare to existing system energy use, if applicable)
- Test takes a total 4-10 hours
- Test can be used to sell project to customer
- Some utilities will pay for this test

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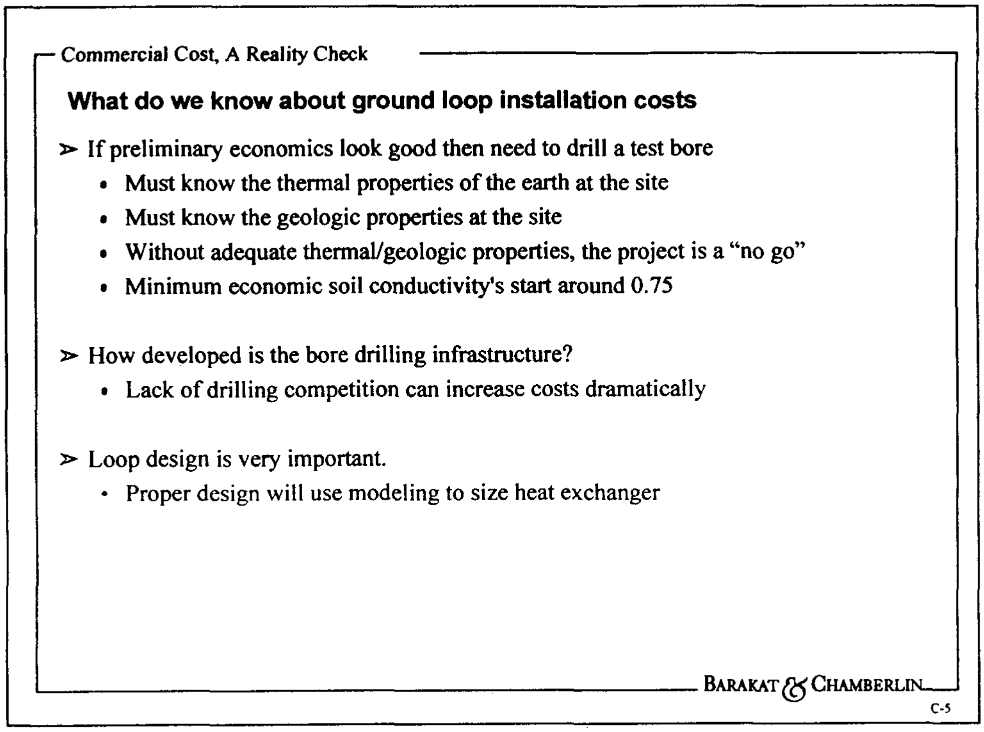
- Basic assumptions: for instance the ASHRAE Pocket Guide
- Simplified economic test from Morris Lovett, GD&E

Two Main Competing Technologies

- 2/4 pipe systems- GHP wins on first cost given reasonable geologic properties
  - 2/4 pipe installed cost, minimum $3,100/ton
  - GHP installed cost, $2,100 - $3,500/ton
- Rooftop Gas/CAC systems
  - Lower first cost
  - GHP more cost effective over the 20 year life-cycle



➢ If preliminary economics look good then need to drill a test bore

- Must know the thermal properties of the earth at the site=> more/less loop=> $$
- Must know the geologic properties at the site => geologic conditions affect boring cost=> $$
- Without adequate thermal/geologic properties, the project is a "no go"
- minimum economic soil conductivity's start around 0.75
  - 0.5 , won't work
  - 0.75 minimally acceptable
  - 1.5 very attractive
  - units btu/ hour-ft-deg F

Commercial Cost, A Reality Check

First Cost Economics

- Standard two-pipe systems, installed:
  - Basic system, air-cooled chiller, boiler, *no* controls, - $3,100/ton
  - Basic system with DDC controls, $4,000 - $4,500/ton

- "High end" commercial GHP systems, installed:
  - High soil conductivity $2,500 /ton
  - Low soil conductivity $3,500 /ton

- GHP system:
  - Inside, $1,650 - $2,000/ton
  - Outside, $1,000 - $1,500/ton

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- Price applies to four pipe systems also
- Price estimates from Morris Lovett, Geothermal Design & Engineering, a subsidiary of Oklahoma Gas & Electric

Commercial Cost, A Reality Check

First Cost Economics

➢ Reduced mechanical room requirements can result in lower construction costs
- For schools, worth approximately $1.50 - $2.00 per sq. ft.

➢ Lower ducting requirements can reduce ceiling heights
- For schools, worth approximately $0.75 per sq. ft.

➢ GHP control is much simpler (similar to residential) and less costly than the standard DDC system

➢ To realize savings GHP designer must work closely with HVAC engineer

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➢ Reduced mechanical room requirements can result in lower construction costs
- Smaller mechanical rooms mean smaller, less costly building

➢ Lower ducting requirements can reduce ceiling heights

➢ GHP control is much simpler (similar to residential) and less costly than the standard DDC system
- GHP systems place residential sized (typically 0.5 -3 ton) water-loop heat pumps in each zone. Each zone is then controlled by a simple residential style thermostat.

➢ To realize savings GHP designer must work closely with architect
- "A major barrier to wider use is the absence of a procedure that integrates the ground loop design methods used by the GCHP industry with traditional HVAC design practices." Kavanaugh, S. P., "A Design Method for Commercial Ground-Coupled Heat Pumps", 1995. ASHRAE Transactions.

Commercial Cost, A Reality Check

Anecdotal Observations: First Cost Economics

- Given positive thermal-geologic properties are present:
  - "GHP will beat two/four-pipe systems every time"
  - "Anywhere I can drill and I have the area (to install the ground-loop), GHP is competitive"
- "Well drillers told me that dedicated bore-holes are less expensive"

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- Morris Lovett, Group Vice President GD&E
- Robert Mancini, President, Mancini and Associates
- Well drillers: Paul Tutt, Austin Independent School District: piping costs were less in this case

Appendix D
Maintenance Costs

Geothermal Heat Pump Performance Issues

Energy Efficiency

- ➢ 40-75% higher than standard air-source heat pumps
- ➢ Efficiency degradation:
  - Standard air-source equipment
    - Good condenser maintenance: 9% permanent efficiency loss
    - No condenser maintenance: 27% permanent efficiency loss
  - GHP no efficiency loss (no condenser)
- ➢ Heat recovery is possible from equipment such as coolers, freezers, and ice-makers further increasing system efficiency
- ➢ In winter, distributed systems save energy by moving heat from building areas requiring cooling to those calling for heat

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<u>Performance</u>

➢ GHP (EERs up to 15.0)

➢ Efficiency degradation : Commercial HVAC efficiency and capacity can drop by more than 25% if condenser's are not cleaned. But even if they are cleaned, permanent efficiency loss averages 10% for standard units. Two types of condensers: Spine Finned Coil and Plate Finned Coil. Plate is standard for commercial apps. Spine loses 10% if not cleaned, with permanent loss of 3%, Plate loses 27% with 9% permanent loss after cleaning. *POINT: GHP's don't have a condenser so efficiency retention is much better.* Also, reduced need for oversize, or safety, factors due capacity retention.Source: California Energy Commission as reported in Climate Master literature.

➢Distributed systems definition: popular HVAC systems for offices, schools, and other buildings using a central HVAC plant consisting of a chiller, boiler, and cooling tower/condenser. Chilled and hot water is then distributed via piping to terminal devices, e.g., fan-coil units, air handling units.. Two basic system designs prevail depending upon the need for simultaneous heating and cooling: two-pipe provides heated or chilled water to the terminal units; four-pipe system provide both simultaneously.

Geothermal Heat Pump Performance Issues

Comfort

➢ Comfort:
- High level of customer satisfaction
- Noise: "I love it. It's so quiet, you never know even know it's on. In our prior home we were always aware of the furnace." *Gail Clizbe, Montana.*
- Summer Comfort
  - 99% of GHP owners rated it eight out of ten, or higher
  - 73% rated it a ten
- Distributed systems allow for greater control

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➢Comfort:

•A 1990 survey by PSI Energy, Indiana, found that GHPs received the highest level of customer satisfaction of any system, including gas furnaces.

•Noise: "I love it. It's so quiet, you never know even know it's on. In our prior home we were always aware of the furnace." *Gail Clizbe, Montana.* [IGSHPA literature]

•99% of GHP owners rated the heat pump's ability to provide summer comfort, as an eight or higher, on a scale of one to ten. 73% rated it a 10. *Source: survey conducted within the Red River Valley Rural Electric Association, OK.*

•Distributed systems allow for greater control: effectively have a heat pump in each area. [IGSHPA literature]

➢Distributed GHP systems allow for greater control, and can heat and cool different parts of the same building. Heat recovery is possible from equipment such as coolers, freezers, and ice-makers further increasing system efficiency. [IGSHPA literature]

➢Ground loop piping guaranteed for up to 50 years.

➢Standard ACs and HPs use 2 to 4 times the refrigerant of a GHP. [IGSHPA literature]

Geothermal Heat Pump Performance Issues

Equipment Life

➢ Heat Pump life 20 years or greater

➢ Group loop piping guaranteed for up to 50 years

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D-3

➢ Heat Pump life 20 years or great (Note: Equipment lines inside and experiences only minor temperature variations. Also, fewer moving parts warranted for 40-50 years.

Geothermal Heat Pump Performance Issues

New Construction/Retrofit

➢ Ideal for commercial retrofit applications:
- Run piping instead of ducting to AHUs in existing walls
- "Forgiving" when designing systems for (uncertain) existing conditions
- Older buildings often have oversized air handlers and radiation allowing heat pumps to operate much more efficiently
- Do not require expensive DDC temperature controls for small applications

➢ Roof top units are avoided with attendant roof penetrations

➢ Usable building space is increased: GHP mechanical rooms are 50-80% smaller than conventional HVAC

➢ Lack of outside equipment improves building aesthetics

➢ GHP's require smaller ductwork in the ceiling saving about 8" per story

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➢Source:Orio, C. D., "Two Successful Commercial Retrofit Projects," Geothermal Heat Pump Systems Conference, Sept 1996. Note that the two projects involved distributed system designs.

➢Less expensive, aesthetic flexibility

•High specific heat of water provide a heat sink/source buffer between building and heat pumps. Basically, the water loop carries enough warmth/coolth to make up for some natural error inherent in retrofit designs.

•Older buildings often have oversized air handlers and radiation allowing heat pumps to operate much more efficiently

•Easy to control because each area has its own unit and thermostat [BCI: small 50-100 tons, equivalent to a typical low rise office building. 18,000 to 36,000 sf.]

➢GHP's require smaller ductwork in the ceiling saving about 8" per story. [IGSHPA literature]

Geothermal Heat Pump Performance Issues

Disadvantages

- ➢ Typically higher first cost than less efficient alternative, although there are exceptions
- ➢ Groundwater heat pumps depend on the availability of well water which may be restricted or regulated
- ➢ Ground-coupled heat pump efficiency is closely linked with soil conditions which vary widely, even within localities.
- ➢ Vertical loop bore-hole cost can be highly variable, ranging from $450 to $3,750 per ton

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D-5

➢Galt House East and Waterfront Office buildings are one exception in that the first cost for GHP is less than the alternative.

➢Groundwater heat pumps depend on the availability of well water which may be restricted or regulated. Disposal wells have the potential to contaminate the aquifer.

➢The point is that cost effectiveness changes according to soil conditions, and that these have to be investigated for each project.

➢Ground-coupled bore-hole costs vary according to two variables [Source: Rafferty, K., "A Capital Cost Comparison of Commercial Ground-Source Heat Pump Systems," GHC Bulletin, Feb 1995]

➢*Required length of bore* (related to ground temperature and soil conditions), and local cost of drilling.

- •*Drilling*: Depending on the location, recent costs per bore-foot have varied from $3 to $15, which could translate into a $600- $3000 per ton* final cost for the ground loop. "Currently (1994), larger commercial jobs are being installed for as little as $4-5 per bore-foot", all costs included.
- •Rocky soils increase drilling costs.
- •In areas where the technology is not as well developed or widely applied, costs can be as high as $10-15 per bore-foot.

*Assumes a 200 ft/ton bore length, typical lengths range 100-300 ft.

Appendix E
Geothermal Heat Pump Performance Issues

Geothermal Heat Pump Maintenance Advantage

Maintenance Savings Examples

- ➢ Louisiana state agency 30 ton retrofit saved $5,000 annually, or about $0.33/sf, by eliminating the need for the pneumatic control system perspective on annual building energy budgets per square foot
- ➢ Goodnight Junior High (near Austin, TX) had no service calls during the first four years of its GCHP operation
- ➢ OK State Capital building decreased maintenance staff 75%

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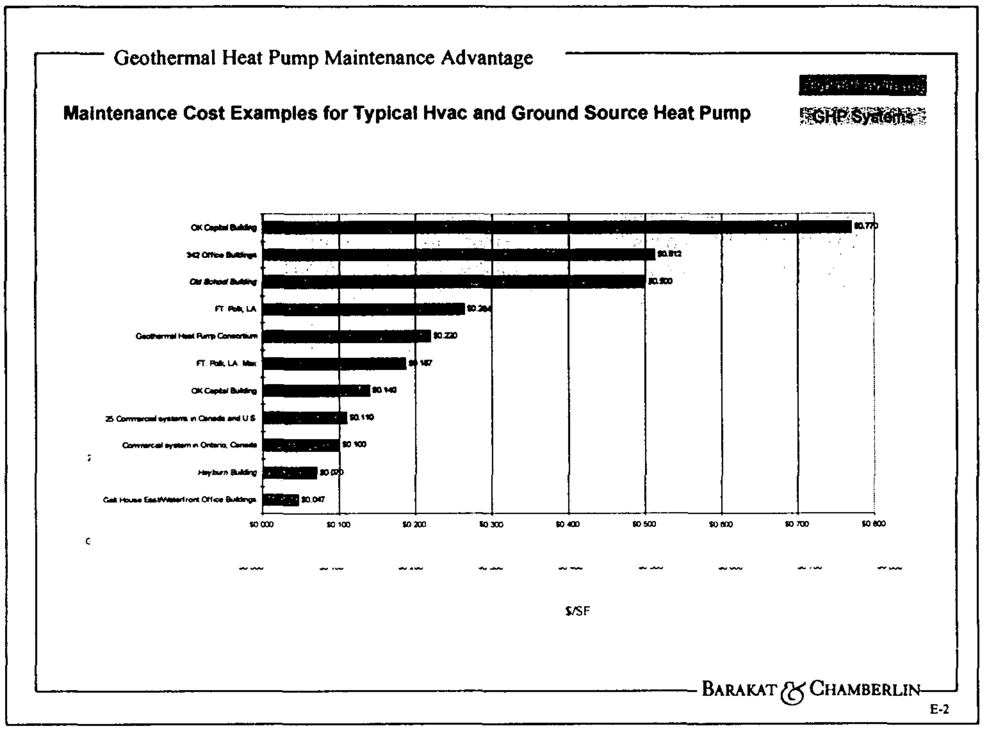
Maintenance Savings Examples

➢ Louisiana state agency 30 ton retrofit saved $5,000 annually, or about $0.33/sf, by eliminating the need for the pneumatic control system **[Braud, H.J., "Ground-coupled heat pump applications and case studies", Geo-Heat Center Bulletin, April 1992]**



Maintenance Cost Estimates

- Oklahoma State Capital Building, was $0.77/sf, now $0.14 $/sf [project info:installed 600 ton distributed heat pump system using vertical ground coupled loop heat exchange. Heat pump size ranges from 1/2 to 30 ton units, 42- units total.]
- OK Capital Building: building HVAC in bad state of repair.
- Old school building, Junction City, Oregon, with 50 year old boiler supplies heat only (no cooling system).
- 50 year old school system (previous to retrofit it had no cooling system) [Warren, M.,"Groundwater Heat Pump Project-Junction City High School, Oregon", Geo-Heat Center Bulletin, March 1994]
- Ft. Polk, LA, New GHPs : maintenance ESCO Contract [:4003 residential pumps]
- Ft. Polk, LA, existing heat pumps [calculated by Oak Ridge analysts]
- Fort Polk: 4003 residences, maintenance contracted out, cost estimated by Oakridge. Actual maintenance cost should be much less.
- Commercial system in Ontario, Canada [Mancini, et al. (1995)]
- 25 Commercial Systems in Canada and US: mean range is $0.072/SF using in-house labor to $0.11 using contract labor. Source: Caneta Research Inc., "Survey and Analysis of Maintenance and Service Costs in Commercial Building Geothermal Systems," June 1997, sponsored by the Geothermal Heat Pump Consortium, Inc.
- ASHRAE Applications Handbook: survey of 342 office buildings costs are for existing buildings and have been escalated from 1983 dollars to 1997 dollars using the CPI. 1983 mean cost for all buildings $0.32/sf. Note that the average age of all systems was 21.4 years, compared to an average of 5 years for the Caneta study (25 Commercial Systems in Canada and U.S.).
- Heyburn Building/Galt House: data reported by Marion Pinckley, Pinckley Engineering
- Heyburn Building- Louisville, KY: 17 story, 250,000sf office building, 1000 tons water-source GHP cooling, 150 heat pumps installed 12 years ago
- Galt House East/Waterfront Office Buildings-Louisville, KY

Geothermal Heat Pump Maintenance Advantage

Reasons for Low Maintenance

- ➢ No outdoor coil requiring cleaning
- ➢ No condenser fan or fan motor requiring regular replacement
- ➢ No exposure to hail damage
- ➢ No defrost cycle (the primary cause of service calls for ASHPs)
- ➢ No boiler operator (and no boiler)
- ➢ No chemical water treatment (boiler)

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E-3

•No outdoor coil requiring clearing **(Climate Master Literature)**

•No condensor fan or fan motor requiring regular replacement **(Climate Master Literature)**

•No exposure to hail damage **(Climate Master Literature)**

•No defrost cycle **(the primary cause of service calls for ASHPs)**
[Braud, H.J., "Ground-coupled heat pump applications and case studies", Geo-Heat Center Bulletin, April 1992]

Appendix F
Customer's Financing Options: Energy Service Pricing

Overview

- Customer purchases comfort
- Contract includes all expenses necessary to deliver comfort
- Can provide positive cash flow without loss of service quality (lower ongoing operating costs
- Eliminates
  - Customer up-front costs
  - Search costs
  - Economic analysis
  - Maintenance staffing

Services

- Project Financing
- Project Engineering
- Installation
- Operation and Maintenance
- Monitoring
- Energy Procurement
- Utility Bill Payment
- Performance Guarantee

HVAC Performance Specifications

- Comfort
  - Temperature range
  - Humidity range
  - Air flow rate
  - Outside air makeup
  - Hours of operation

The Contract

Technology change-outs	Analyze which energy-using technologies are cost-effective and which should be replaced
Pricing	Predict how the energy savings will translate into dollar savings
Pricing terms	Determine duration of contract and flow of money
Operation and maintenance	Specify level of responsibility for operation and maintenance of each technology
Performance specification	Specify energy services that will be provided
Performance monitoring	Address performance measurement and disputes
Ownership	Equipment may initially be owned by the customer or the utility

Loan

- Initial investment required
- Adequate loan terms may be difficult to obtain
- Positive cash flow uncertain
- Incur initial costs:
  - Search costs
  - Economic analysis
- Potential for great net return for project
- Keep tax/depreciation benefits

Customer's Financing Options: Energy Service Pricing

Performance Contract

- Customer finances project through energy savings
- Fee includes all expenses necessary to implement project
- ESCO guarantees positive cash flow without loss of service quality
- Eliminates
  - Customer up-front costs
  - Search costs
  - Economic analysis
- Can lower on-going operating costs

Performance Contract

- Project financing based upon energy savings
- ESCO guarantees savings will cover debt load, plus a little extra
- Third party financing, or customer may finance
- Typically, projects will be financed over 10 years or less
- Maintenance may, or may not, be included

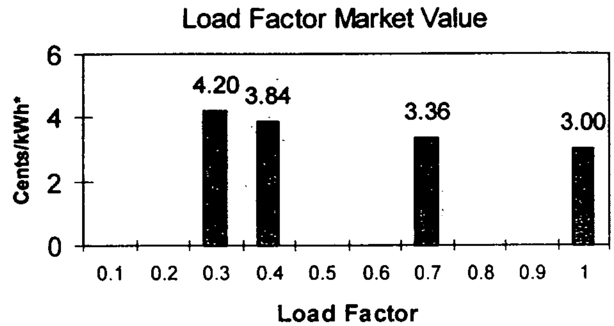
Services

- Project Financing
- Project Engineering
- Installation
- Operation and Maintenance
- Monitoring
- Performance Guarantee

Appendix G
Load Factor Economic Analysis

Load Factors

Under Aggregation, Better Load Factors Receive Lower Prices on the Open Market



Note: Based on recent California Water agencies solicitation, higher load factor power blocks can achieve lower unit prices in the open market.

Load Factors

Geothermal Heat Pumps Improve Load Factor

- Electric load factor for residential heating/cooling improves from 10% to 35%
- Under competition, a group of aggregated GHP homes might receive a $0.025/kWh price break

Load Factors

Geothermal Heat Pump's Increase System Load Factor, Decrease Average Costs (Monopoly System)

- A 5% increase in load factor can increase profits, possibly up 2%[1] or more
- A small municipal utility (5000 customers) may see $300,000-400,000[1] in savings over 5 years with the 5% load factor improvement
- May need 10-15% penetration[2] of GHPs in homes to cause the 5% load factor improvement

[1] Depends on rate structure, costs of demand, energy and climate

[2] Depends on climate and equipment efficiencies

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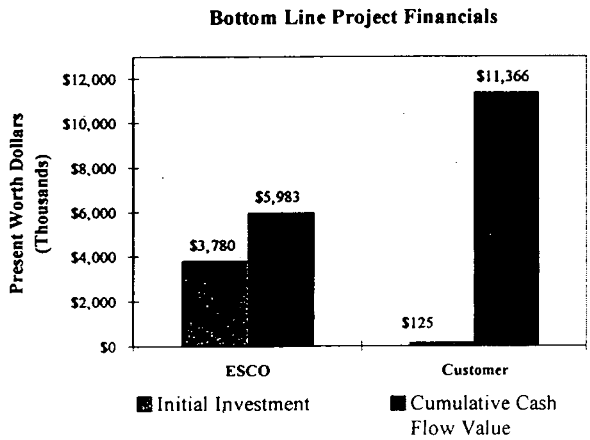
Appendix H
Residential Case Study, Fort Polk, LA

Residential Case Study - Fort Polk, LA

Project Summary - Performance Contract Financing

- ➢ 4,003 Ground Coupled Heat Pumps Installed
- ➢ Fort Polk Internal Rate of Return- 553%
- ➢ ESCO Internal Rate of Return- 20.2%



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Residential Case Study - Fort Polk, LA

Fort Polk Housing, Before Retrofit

➢ 4,003 family living units in 1,292 buildings

➢ Average age of units is 15 years

➢ Average size of unit is 1,393 square feet

➢ Housing stock HVAC distribution:
- 81% Air Source Heat Pumps and electric water heating
- 19% central air conditioning, gas-fired furnaces, and gas water heaters

➢ HVAC maintenance is $369 annually per unit, or $1.5 million per year

➢ Annual Energy Bill: $5.4 Million

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H-2

➢4,003 family living units in 1,292 buildings built between 1972 and 1988.

➢House range is 1,073 - 2,746 ft^2.

➢Maintenance provided by contractors.

➢*Existing HVAC systems* maintained by contractors with less than satisfactory performance record; in other words, residents weren't happy about service.

Fort Polk Housing, After Retrofit

➢ All 4,003 homes are heated and cooled by Geothermal Heat Pump Systems

➢ Other measures installed include:

- 75% of GHPs include desuperheaters for domestic hot water
- Electric water heaters replace gas units
- Compact fluorescent lighting throughout
- Low-flow hot water outlets

➢ HVAC maintenance now the responsibility of ESCO

➢ Annual Energy Bill: $3.3 Million (35% savings)

Residential Case Study - Fort Polk, LA

Project Cost

➢ Project cost of $18.9 million

➢ Average installed unit cost is $4,720

- Heat pump - $3,117
- Ground loop - $1,604

➢ Average installed unit is 1.6 tons

➢ Engineering costs borne by the ESCO

- Modeling of 64 building types
- Three test ground loops installed to determine soil conditions

➢ Monitoring:

- Meters read monthly at 145 units
- 19 electrical feeders

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II-4

➢Project cost of $18.9 million,

➢Average installed unit/ton cost

- •Average unit, $2,950 per ton
- •Heat pump only, $1,893 per ton
- •Loop, $974 per ton

➢Total GHP capacity is 6,593 tons

➢Engineering:

- •Model: represents population of housing on base
- •Existing housing plans available from Army- important because it allowed for easy modeling.
- •Test ground loops:
  - •Determine soil properties which are then plugged into model and used in sizing the ground loops.
  - •Better ground loop models now
  - •Loop oversized by about 20% ($1.3 M)
- •ESCO M&V
  - • Read existing kWh meters at 145 units, pre/post retrofit for 1 year
  - •Nineteen electrical feeder meters for base read monthly

Residential Case Study - Fort Polk, LA

Savings from Retrofits

- ➢ 33.6 million kWh per year, or about $2 million
- ➢ 260,000 therms per year, or about $130,000
- ➢ Maintenance savings for Fort Polk of about $430,000 per year

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➢33.6 million kWh per year, or about $2 million

➢260,000 therms per year, or about $130,000

➢Maintenance savings for Fort Polk of about $430,000 per year

•*Fort Polk perspective*: shared savings payment to ESCO based upon base's estimated maintenance cost of $1.3 million (more accurate number is about $1.5 million- estimated by Oakridge). First year shared savings payment is 80% of $1.3 M, saving Fort Polk $1.5-1.04, or almost $0.5M the first year.

•*ESCO perspective:* ESCO receives 80% of $1.3M, and realizes savings because their cost to maintain equipment is much less than that of the old equipment. Barakat & Chamberlin has estimated the cost at about $0.10 per sf. of housing floor area, or a total of $560,000. Costs are likely less than this the first year because the equipment is new, but they should rise over time. We are probably conservative with this assumption.

Residential Case Study - Fort Polk, LA

ESCO Contract

➢ Services Provided
- Project engineering and management
- Project financing
- Equipment installation and maintenance
- Sample monitoring

➢ Contract Term: 20 years

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➢*Fee Basis*: shared savings for energy savings, fixed fee for maintenance.

•Shared savings schedule: varies over 20 year contract, ranging from 80% first year, rising to 90% in year 3, then steadily declining to 65% at year 20.

•80% of first year energy savings to ESCO, estimated at $1.7 million per year

•Barakat & Chamberlin estimate potential maintenance savings at $560,000 per year- based on $0.10 per sq. ft. maintenance costs (min estimate provided by the Int. Geo. Heat Pump Consortium).

•Maintenance payment indexed to CPI

➢*Financing:* 80% debt to equity; insurance company provider of debt, 15 year term;

➢*Initial investment:* $3.78 million, split 50/50 with 3rd party investor; That is, the ESCO puts up half the required equity, with the remainder provided by the 3rd party.

Residential Case Study - Fort Polk, LA

ESCO Contract

➢ Financing
- 80% debt to equity
- 15 year term
- Initial investment: $3.78 million, split 50/50 with third party investor

➢ Fee Basis: Shared savings schedule for energy and maintenance savings
- 80% of first year energy savings to ESCO, estimated at $1.7 million per year
- First year maintenance share is $1.05 million
- Energy savings calculated for the base as "actual less baseline"

➢Financing
- 80% debt to equity, Insurance company provider of debt
- 15 year term
- Initial investment: $3.78 million, split 50/50 with third party investor

The enclosed diskette contain the test files comprising the presentation and report deliverables, and the Excel models used to analyze the GHP projects. The files are compressed using PKZIP. The following is a list of the files and what they contain:

COMCOST.ZIP	COMCOST.PPT:	"Commercial Cost: A Reality Check"
FACT4.ZIP	FACT4.PPT:	presentation of GHP maintenance advantages
FINANCE.ZIP	ESP PPT:	description of financing options
FTPOLK.ZIP	HTPUMP3.PPT:	presentation and analysis of Fort Polk Project
GHPMODEL.ZIP	TOFFESP1.XLS:	spreadsheet financial model analyses ghp projects; set up for Toronto office building. Directions for model use included on first sheet
IGSPA.ZIP	IGSPA2:	first half of IGSHPA presentation; IGSPAB&W.PPT; second half
INTRO.ZIP	APPENDIX.PPT:	report cover pages for appendix; INTRO.WPD: Geothermal Heat Pump Applications in Energy Services report
LOADFACT.ZIP	LOAD_F.PPT:	presentation on value of GHP load factor improvement
PERFORM.ZIP	PERFORM.PPT:	presentation on various performance issues surrounding GHP