

# GLOBAL PERSPECTIVES ON GSHP TECHNOLOGY, MARKETS AND APPLICATIONS: A BRIGHT FUTURE FOR A FLEXIBLE TECHNOLOGY

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**Abstract:** The future of the world ground source heat pump industry will depend on a number of key factors including technology improvements, market competitiveness as well as market penetration in new applications. Technology integration, a too often overlooked element, may also play a potentially vital role in the speed at which the technology will grow in different applications. GSHP technology is a mature technology and has been mature for decades. Yet, in most countries, the technology cycles through ups and downs since its widespread adoption by the markets in the late 1970s early 1980s. This paper takes a global perspective on the GSHP, and attempts to identify some key components of a long term vision for industry stakeholders in IEA member country national markets.

**Key Words:** market challenges, technology challenges, technology competitiveness, technology integration

## 1 INTRODUCTION

Providing a global perspective for the GSHP industry is a challenge but also a dangerous exercise. A challenge first because I believe there is no single approach that will fit every single GSHP national market. The number of parameters (economic, regulatory and political) are not only numerous but also way too variable from one country to the other. In such context there is definitely no one-size-fits-all solution to GSHP market development. Out of this smorgasbord of potential outcomes, I will nevertheless attempt to identify some common trends.

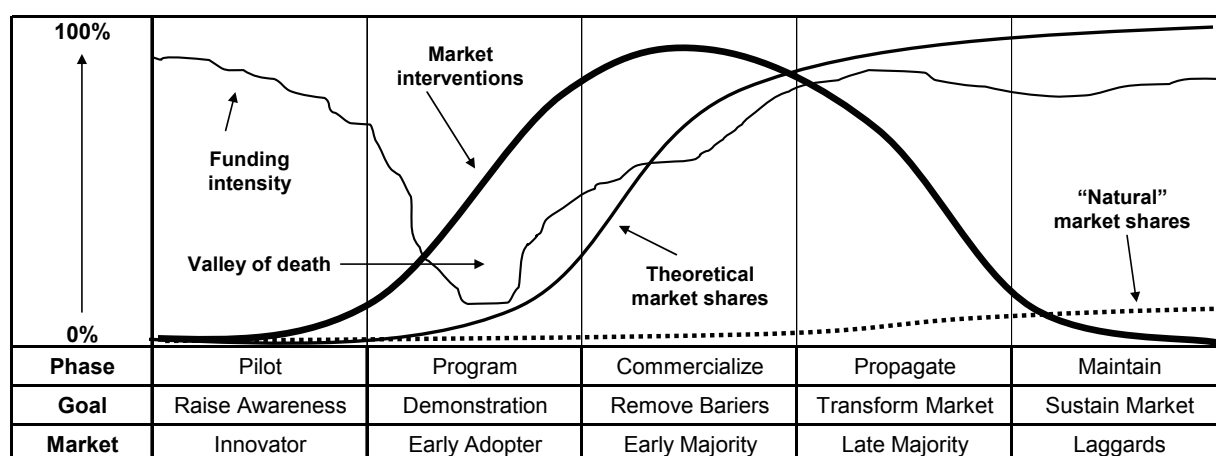
In this paper, I also face some dangers. Experienced market analysts know that any attempt to provide a solid perspective for a single GSHP industry in a single national market is already a difficult task. For example, we need to contrast residential and commercial applications which are driven by very different market realities. Doing the same exercise from the global perspective and for many countries is almost an impossible task.

The recent Canadian experience in executing market transformation was a tough but rewarding one. I am a firm believer that the future of GSHP technology globally depends on adaptive market transformation processes. Through the Canadian experience, there were lessons learned but more importantly and more strategically, there were many longer term market drivers identified in terms of technology, markets and applications. I will discuss some of them in this paper.

## 2 THE “NATURAL” MARKET SHARE FOR GSHP

Many economists would say that the worst enemy of every technology is a shaky understanding of the markets where the technology is intended to provide a service or utility to potential consumers. There are thousands of inventions and technology improvements that have never made it to the market place, strictly for market reasons. Very often, the

commercialization of new and sometimes even older technologies, is stuck in the “valley of death,” the zone where technologies lack the appropriate financing to clear the first market penetration hurdles and adequately reach early adopters. This is illustrated in Figure 1 below.



**Figure 1: A Technology Adoption Lifecycle**

In the technology adoption lifecycle model presented in Figure 1, there is an initial underlying assumption that as market intervention increases, a technology’s market share will increase accordingly. Past the commercialization and propagation phases, market intervention declines and market share continues to increase due to the industry’s momentum and a renewed funding intensity by the private sector. This is the classic theoretical model developed more than 50 years ago at Iowa State College (Bohlen et.al., 1957). In theory, the technology’s market share can reach up to 100 %. This is the case of color televisions as compared to black and white sets. But for many technologies, the reality is harsher. I posit that some will never pass a few percentage points of market penetration while achieving their full “natural” market share. If we are intellectually honest about this proposition, the question we need to ask here is whether the world GSHP industry, *ceteris paribus*, is getting close to or has reached its “natural” market share.

If this were true for GSHP technology, it means that we are more advanced in the technology adoption cycle than we normally think. This would imply in turn that we have passed the stages of heavy market intervention and the program phase, ie, passed the financial incentive phase. From another angle, since market share appears to be reaching a plateau, this means that current financial assistance packages are essentially transferring financial resources to free riders, while the industry should be focussing on market infrastructure and market transformation rather than market adoption phases. Some evidence exists for this argument, and I will discuss this further in section three.

### 3 CHARACTERISING GSHP PROGRAMS

Most GSHP programs were not designed with market transformation in mind but for other purposes. In the United States, the recent tax credit was introduced as a stimulus initiative but also in response to longer term national energy security arguments. In Canada, the recent ecoENERGY program was a green house gas reduction program. Utilities such as Hydro-Québec, Manitoba Hydro, BC Hydro designed programs through their energy efficiency initiatives, each of which is subject to public utility board review.

Program establishment can be based on pure economic and financial analysis, which may ignore social, political or even bureaucratic goals and priorities. The total resource cost

(TRC) test which includes a series of subtests for the consumers, the utilities, the government and the society at large is often used to back such program. Observing different programs which formerly supported the industry, we have found that the technology doesn't meet the TRC test in an increasing number of jurisdictions. This means that given the current development stage of the industry, given current relative energy prices and all others things equal, the current market penetration rate at least in the residential sector reflects a natural equilibrium of the technology in the market place. This should raise some serious concerns in the mind of GSHP industry stakeholders all over the world.

Government programs come and go, usually out of sync with market transformation process and supply chain coordination. Depending on their nature, programs also come and go in sync with an individual country's political or environmental agendas. This would help explain why we frequently live through boom and burst situations (Orsini 2010).

For example, stimulus programs after a recession are meant to create jobs and are usually universal. They do not discriminate between one technology or another because this is generally not their purpose. At the end of the day, if the consumer can have a subsidy for his heating system, whether it is a GSHP, a natural gas or oil furnace, chances are that relative prices will not have changed much from their initial pre-subsidy equilibrium. People will not primarily buy more GSHP systems because they are cheaper, nor will they buy an efficient natural gas furnace because they get a rebate. They will buy them when they need them, and secondarily compare relative prices.

In many countries, the industry already has gone through different cycles of the same phases. It is almost like the industry is stuck in a continuum of program-commercialize-propagate phases, and we are unable to reach and go beyond market transformation. As time goes by, the industry is dragged back to initial stages of the technology adoption lifecycle model and programs are required in an attempt to re-start the growth process. This is one of the key concerns for the long term development of our industry.

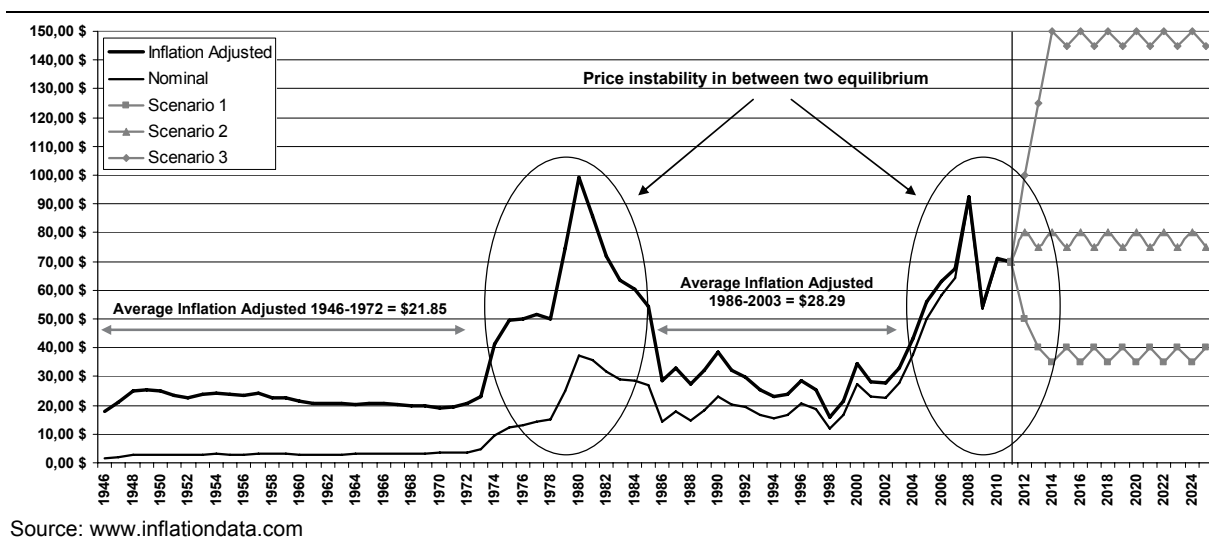


Figure 3: Historical Crude Oil Prices

Some people in our industry live with the unrealistic fantasy of higher energy prices which would make GSHP technology more competitive or more appealing to customers. When we look at post-War oil prices for example, we note that despite the two episodes of high instability (1974-1986 and 2004-2011), average inflation-adjusted prices have remained "relatively" reasonable. Why would the current situation be different than the past?

In real terms, oil prices from 1986 to 2004 – almost 20 years – were lower in every single year than the prices observed in every single year between 1973 and 1985. We don't pretend to have a crystal ball to predict the direction which energy prices will take in the future. One option is that they go back to their long term trend – net of sporadic crises – stabilizing around \$30 or \$40 (in 2011 dollars). Another scenario could be a stabilisation at the current level of about \$75 or \$80. And there is of course the possible outcome of long term price equilibrium around \$150 to reflect high demand in emerging economies. The fact of the matter is that energy prices could be anywhere in between and shouldn't change the dynamics for GSHP as long as relative energy prices remain more or less stable (Kantrowitz and Tanguay 2011).

But the future of an industry – especially a small industry - cannot rest on such unstable assumptions. More importantly, it cannot rest on foundations that are not directly related to its own technical characteristics. We need to look at our own paradigms, forget external influences for a moment, and see how we can better advance the bright side of the GSHP industry on its own merits.

#### **4 THE ESSENTIAL ROLE OF MARKET TRANSFORMATION**

As association managers, my colleagues and I have to work around conflicting priorities from all industry stakeholders. This means the necessity to look beyond existing models and behind existing concerns. Contrary to individual market players who are, by definition, more focused on preserving or expanding their own position within a market, we take a longer term look at the industry and identify what is needed to move the entire market forward. We are often forced by these principles to deliver what stakeholders need collectively, not necessarily what they want individually. At times, this can be a real challenge and a challenge that is not well understood within the industry.

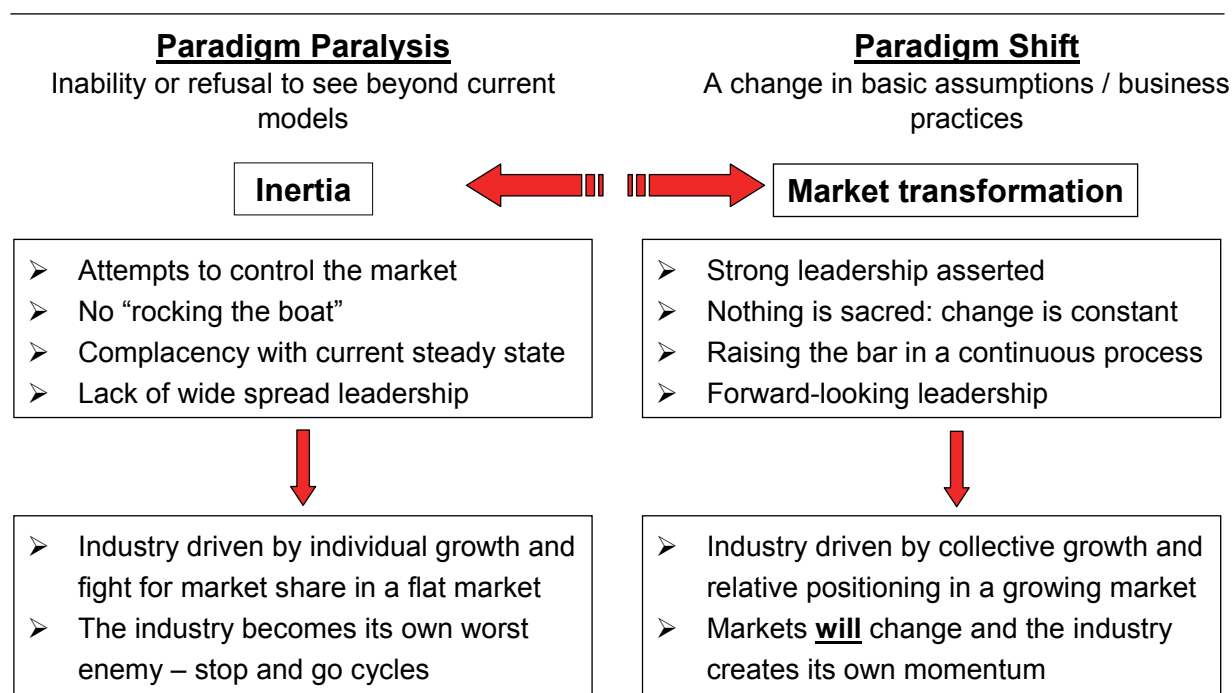
An industry can't move forward if only a subset of it controls the destiny of the group. As shown in Figure 3, these market agents will serve their own short term interest but in the longer term, because the interest of the group are dislocated, their own interest will suffer and the industry as a whole will either fall or remain flat. If the hypotheses in the previous section stand, there are some forces of inertia that are keeping the industry in steady state. This would explain why the technology's market share is anaemic. I believe the answer to this problem at least partly lies in market transformation.

Market transformation is a moving target. We can try to compete with every other technology that has the capability to provide heating and cooling. This is a dangerous game and we are not sure this is a winning strategy. For example, price reduction alone is not a guarantee of increased market acceptance. So, in the market transformation process, addressing high first cost may not be the efficient or appropriate answer to wider market penetration.

The introduction of ultra efficient air to air heat pump in the residential market should be used as a reminder that the end user is first and foremost an economic agent whose behaviour turns around the maximisation of his utility function. Should the price of these ultra efficient units be set at the right level, the higher unit COP of GSHP may well not be sufficient to influence consumer behaviour. The end-user will settle for the best set of parameters (economic and technical) to obtain what he is looking for: heating and cooling.

Indeed, customers do not have the same perceptions about products than the people who create or supply them. Many manufacturers will naturally tend to sell products on the basis of price, special features and technical specifications. The problem is that most customers

oftentimes consider factors such as product support and company reputation to be more important. (Schirtzinger 2011)



**Figure 3: Market Transformation Challenge**

A sound market transformation program is also based on extensive information and knowledge of the industry we are trying to transform. In the GSHP industry, this means to go beyond strict scientific knowledge of heat transfer theory, compressor function, refrigerant phase change, and so on. As we have said before, it means a broad knowledge of the markets. In both cases however, the key to success is the quality of data and of the analysis which turns that data into information.

In less than five minutes, we at CGC can now sit down with any installer in Canada and show them how to reduce the price of a residential GSHP system by more than 40 % without cutting on component quality or on overall annual performance. On the other hand, we can also sit down with a residential customer and in less than five minutes convince him or her that they will never recover their investment in a GSHP system. Why can we do that? Because we have access to a wealth of quality information and we spend a lot of time looking at the industry from the perspective of a neutral market analyst.

Market transformation involves breaking away from past models and this may be painful. This is not an easy task as forces of inertia are extremely strong and, coincidentally, they are often deployed by those who pulled a technology out of the valley of death to make the first significant inroads in the market place. This non-interest or inability to see beyond existing models can be explained by availability cascades. As eloquently described by Kuran and Sunstein (2007), availability cascades are “self-reinforcing process of collective belief formation by which an expressed perception triggers a chain reaction that gives the perception increasing plausibility through its rising availability in public discourse.”

People will tend to forge their beliefs because of other peoples’ own beliefs. “Because it is costly to gather pertinent information, individuals ordinarily seek to free ride on knowledge that is publicly available through sources ranging from gossip and rumours to scientific

reports.” Under the right conditions, this reliance on second or fifth-hand reports, generates availability cascades that spread and worsen misperceptions. But there is more. Kuran and Sunstein (2007) add that “the driving mechanism involves a combination of informational and reputational motives: Individuals endorse the perception partly by learning from the apparent beliefs of others and partly by distorting their public responses in the interest of maintaining social acceptance.” In the organisational behaviour literature this is often referred to as ‘the smart talk trap’. Kuran and Sunstein further argue that what people know depends on their predisposition to believe certain claims more readily than others. This is called the framing effect. Cognitive shortcuts, or heuristics, can produce substantial distortions whenever certain alternatives are easier to imagine than others.

Imbedded in availability heuristics – a pervasive mental shortcut whereby the perceived likelihood of any given event is tied to the ease with which its occurrence can be brought to mind – are the likelihood of error. As long as members of the relevant group are heterogeneous, the transformation of the distribution of beliefs can take the form of a cascade. “An informational cascade occurs when people with incomplete personal information on a particular matter base their own beliefs on the apparent beliefs of others.”

In Canada for example, availability cascades about direct expansion technology resulted eventually in a socially harmful regulatory responses, as DX was excluded from the Canadian Standard C448. People forged their opinion about DX on either false or biased premises repeated by colleagues, whose competence they themselves never investigated or judged. This technology was initially excluded from government and utility financial assistance program simply because it was not part of the national design and installation standard. Yet, the technology works and has been working quite well for decades in North American, with thousands of successful, safe installations. More recently, researchers in many countries have been conducting research on new refrigerants in the context of DX technology. Despite all this, some industry stakeholders are still arguing that DX systems don’t work.

Most individuals base their decisions on the information they have. Today, it is harder and harder to hide facts in favour of one’s own private interest. “Although informational cascades may cause false beliefs to spread and strengthen”, they are nonetheless consistent with individual rationality.” For example, it is rational to believe that oil prices will go up and stay high, permanently, because they have gone up suddenly, dramatically, and recently.

Imperfect information, or the lack of appropriate knowledge, will likely lead to the emergence of availability errors. As a consequence, “public discourse on any given risk may produce scientifically unnecessary, ineffective, even counterproductive policies.” In the Canadian GSHP industry, this situation was discussed and described at length in Tanguay and Kantrowitz (2011).

In the GSHP industry, different countries will most likely have different industry equilibrium. This is why it is useless to try to impose one’s model to another country. For example, every country represented at the IEA Heat Pump conference would be better off creating their own industry support infrastructure rather than adopt foreign models without adaptation. The necessary market transformation phase has to be anchored on every nation’s market situation.

You simply cannot develop a sound vision for your own national GSHP industry if you are looking at it from someone else eyes. Market transformation requires a lot of effort and energy. It requires research, analysis, regulatory adaptation, leadership. This cannot be borrowed from another country. Inspirational directions can be shared and even encouraged. But a carbon copy of one another is not desirable and will likely lead to market transformation failures.

## 5 TECHNOLOGY SILOS AND TECHNOLOGY INTEGRATION

Why was there a boom in wind energy and solar photovoltaic while GSHP lagged behind? We do not believe this has anything to do with the specific financial assistance programs which were applied over the world for each of these technologies. The answer lies rather in the product that these technologies deliver. Wind and solar photovoltaic produce electricity. They are grid technologies and supply electricity which is needed because of higher demand for electricity.

For many people, GSHP systems are seen as an energy supply technology, not as conservation or a building technology. We believe the effort spent comparing GSHP with other forms of renewable energy such as solar photovoltaic, wind, hydro, ocean energy and biomass is a mistake. All these energy sources produce electricity. GSHP uses electricity. This is a fundamental difference.

GSHP, although rightly identified within the renewable energy family, is also mainly a “building” technology or an energy efficiency technology. Their emergence and growth depends on a different set of factors and driven by completely different economic agents and stakeholders than ‘grid’ technologies.

Further, building technologies and electricity supply technologies are not treated in the same manner by government and utilities, whether we agree or not and whether we like it or not. Twenty years ago, demand side management (DSM) programs used to be supported by governments for economic reasons or for socio political reasons. Today, at least in the North American context, DSM programs are, for the most part, filtered and scrutinized by public utilities boards. Programs must pass the TRC Test.

In residential GSHP, the focus is often on the heat pump and our marketing strategies are based on higher heat pump unit COP rather than the much more important system seasonal COP (SCOP). A residential contractor can switch supplier overnight without impact on his business. What they are selling to the customer is a “service experience”. The heat pump is just part of the hardware. And in fact, it may represent as little as 20% of the overall system cost, sometimes less. This is clearly not the main driver for this industry. The availability of truly skilled and competent workers is much more of an issue, particularly in the commercial sector.

In commercial applications, we don’t see the same focus on the heat pump. In certain cases, the focus is on loop design. In some other cases, it is the overall building design that will matter. More and more, the customers and designers will consider the full integration of different technologies within the same building for similar or complementary energy services.

In Canada, four years ago, a number of industry associations gathered together to create a promotional concept where integrated energy systems would be the center piece of new communities development. Odd partners such as the Canadian GeoExchange Coalition, the, the Canadian Gas Association, the Canadian Association of Petroleum Products Producer, NGOs, federal, provincial and municipal governments, gathered around a concept called QUEST -Quality Urban Energy Systems of Tomorrow.

The general idea behind QUEST is to stop thinking about energy supply and energy demand in silos but rather look at the overall energy supply context to deliver the energy services required within the community. In short, rather than try to optimize the individual energy supply and demand situations for individual customers, the premise of QUEST suggests that optimization of the entire energy system will optimize the use of energy. In such an approach,

GSHP plays a key role by moving energy around the community, and makes the use of complementary systems such as energy storage, heat recovery from sewage work or natural gas absorption GSHP, possible.

In reality, there is no single market for GSHP. Every community development, every community retrofit becomes a phenomenal business opportunity. We are used to defining the industry around a single customer and optimizing a GSHP system for this single customer. In the QUEST approach, the role of GSHP is defined at the community level and GSHP systems are optimized at the community level within the overarching energy system optimization framework.

When thinking outside of the traditional supply and demand parameters, we see a bright future for GSHP. This future will require a deeper look at hybrid systems or opportunities like natural gas absorption heat pumps. Technology integration also brings us to rethink how our products are manufactured and marketed. For example, it might be a good idea (technically and economically) to integrate solar thermal hot water with GSHP. In this case, one would be forced to question whether adding a desuperheater to a GSHP is really a best technological idea. In a hot climate however, desuperheater with solar thermal and geothermal may work to create a very effective absorption chiller where a ground loop is a kind of buffer or diurnal storage medium. We are not necessarily saying desuperheaters should not be installed. What we are saying is the following: if there are more efficient options, then all options may end up better off when integrated in one energy system. In our view, this is the kind of thinking that will raise the profile of the GSHP industry. We are not in the business of helping individual companies sell appliances.

We believe the future of GSHP depends on the industry's ability to co-exist with competing technologies where the goal is to optimize the overall energy systems and to optimize the overall energy use of the end-users. This is already taking place. Assuming the future of GSHP technology lies in technology integration, then it means that the higher the integration, the more complex the energy systems will get. This is quite logical since improved energy system efficiencies likely require more competencies and skills than working on individual systems in small silos.

This also implies that our economies will need more multi-faceted generic skills that not only go beyond the existing training models but transcend and/or combine different trades and different engineering fields. In our view, knowledge acquisition within the existing college and university framework and context is the only way to include all sub technologies in a community project. Appropriate skills and competencies can only be acquired through schools. This is the only logical outcome of a market transformation process.

## **6 CONCLUSION**

After many years of substantial growth, under the current business model and economic environment, the residential GHSP may have reached or is in the process of reaching its natural equilibrium market share. Opportunity abounds in the commercial sector and is likely to favour the innovative professional engineer. To move the industry beyond this plateau, we believe stakeholders in every country need engage in a market transformation process. However, there is no off-the-shelf solution for doing so - this can only be achieved through research, analysis, regulatory adaptation and effective national-level leadership.

For commercial applications, we think the future of GSHP technology is intimately linked to their integration with other building technologies. GSHP have a key role to play in community energy systems combined with other sources of energy. Together, various technologies will



work together to optimize the overall energy system while providing efficient services to end users.

Finally, technology integration suggests that tomorrow's workers will need to develop multi-faceted generic skill. These skills will necessarily be best acquired in formal education environments in trade schools and in engineering programs.

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