Gas Heat Pumps Are Coming: But by a Different Name

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Gas heat pumps are coming, but by a different name. The manufacturers have elected not to call these products "heat pumps" because advertising by gas distributors has been so effective at associating the term "air-source heat pump" with cold blowing air. Nonetheless, gas-fired air-source heat pumps of the engine-driven and absorption types will be marketed starting in 1994 and in 1997, respectively, according to current plans. This paper identifies the generic participants that have been and will be involved in the gas heat pump deployment effort, and it reviews the underlying forces that caused (or likely will cause) those participants to act as they do. The participants include technology developers; the heating, ventilation, and air-conditioning (HVAC) industry; the utility industry; and state utility regulators. The driving forces include the drifting of unitary HVAC products toward a commodity-like status, the decline of the domestic component of global HVAC markets, the restructuring of the HVAC and gas utility industries, the anticipated restructuring of the electric utility industry, the strengths and weaknesses of gas distributors, and state utility regulation. Also reviewed are technology status, manufacturer commitments, and timetables for introducing products. The road to widespread domestic market acceptance of gas heat pumps will likely be very different from that experienced by electric heat pump manufacturers in the 1950s and 1960s.

Introduction

The subsequent sections review the motivations of technology developers, the HVAC industry, utilities, and utility regulators as they relate to gas heat pumps. A summary of gas heat pump technology status, manufacturer commitments, and timetables for introducing products is provided.

Technology Developers

The unitary HVAC equipment markets in the United States are largely cost-driven commodity markets ("unitary" denotes small-capacity, high-volume, factory-assembled products, whether single packages or split systems). Generally, manufacturers maintain core competencies in vapor compression and furnace product technologies and in the associated process technologies for those products. Most manufacturers outsource electric motors, fans, blowers, controls, and burners; and all but the largest manufacturers out-source compressors. All manufacturers outsource the refrigerants used in vapor compression heat pumps and air conditioners.

Product technologies more exotic than vapor compression units and furnaces generally are left to independent developers relying on financial support from the government, the electric industry, the gas industry, or others. The objective of these independent development efforts usually is to create an intellectual property package that appeals to an existing original equipment manufacturer (OEM) or component supplier. Gas heat pumps fall into the exotic category.

HVAC Industry

As a backdrop to explaining the HVAC industry response to gas heat pumps, it is first necessary to provide some information on the structure of the domestic HVAC industry. The markets for unitary HVAC equipment are competitive and dynamic. The price for a particular product class in a market area is likely to be reduced if sales volume is high. A high volume of sales stimulates price competition. If one or more competitors is seeking to increase or hold a market share, prices will tend to be lower. A regional manufacturer may be the price leader in the markets it serves. OEMs with under-used production capacity and/or excessive inventory may break to a lower price level in selected markets to stimulate product sales temporarily. Equipment costs to end-users are also subject to the markup policies of distributors and contractors. In general, the larger and stronger distributors and contractors are able to command higher prices, and prices are higher in peak installation seasons than in off-seasons. The same product may be priced lower to tract builders and developers than to contractors serving replacement markets in the same city.

OEMs bring to the table product design, manufacturing, and marketing capabilities. Some OEMs have considerable brand name recognition, captive distributors, factory training, nationwide networks, and overseas operations. Other OEMs compete primarily on price via independent distribution or direct sales to master dealers. The domestic markets are mature, and equipment replacement is becoming ever more important compared with new construction. Currently, about 60 percent of residential unit shipments are replacement units (Sulfstede 1993).

In the past, residential unitary equipment markets provided OEMs with some opportunity to distinguish their products by making them more energy efficient. Replacement system buyers normally are directly involved with the purchase of their new systems, and their prior experience with the costs and comfort associated with system efficiency may motivate them to upgrade to higher performance. Some house buyers are also involved in purchasing decisions in the custom segment of the new home market. However, during the first year that new mandated minimum seasonal performance standards for high-volume residential classes of equipment have been in effect, the markets have not supported cost premiums for higher-than-minimum-efficiency equipment to a significant degree. In 1992, the shipment-weighted seasonal energy-efficiency ratios (SEERs) of unitary air conditioners and heat pumps 5 tons and less in size were 10.46 and 10.60, respectively, compared with minimum standards of 10 for split systems and 9.7 for packaged units (ARI 1994a). This market truncation (i.e., collapse of efficiency-based differentiation) occurred in spite of widespread efficiency incentive programs offered by electric utilities (EPRI 1993).

Historically, commercial unitary equipment markets have not supported significant differentiation among products based on efficiency. These markets have tended to be even more price-driven than residential markets, because commercial developers and owners often have tenants to pay the utility bills, and utility costs often are tax-deductible business expenses in any event. All things being equal, OEMs are even less likely to pursue efficiency differentiation strategies in these markets in the future, now that federal legislation has expanded the scope of minimum performance ratings to include commercial unitary products (Energy Policy Act of 1992).

The in-house research and development (R&D) efforts of many OEMs and compressor suppliers continue to focus on evaluating non-ozone-depleting refrigerant alternatives for vapor compression machines, and on developing new equipment designs for the selected refrigerant alternatives. Now that near-term alternatives are available for chiller class equipment (HCFC-123, HCFC-22, and HFC-134a), attention has turned primarily to mid-term alternatives to HCFC-22 use in unitary devices and chillers. Some emphasis also remains on a mid-term alternative for HCFC-123 in low-pressure chiller applications. At least in the case of chillers, initial fears that decreased efficiency and capacity would accompany the transition from ozone-depleting refrigerants have not materialized. However, refrigerant producers, OEMs, compressor suppliers, and the electric utility industry have spent (and will spend) hundreds of millions of dollars to realize largely lateral movements in price versus performance.

After refrigerant alternatives, the largest share of the modest remaining OEM R&D resources is applied in areas most likely to build or maintain the competitive edge of the particular company. In domestic unitary applications, this usually means incremental cost reductions for minimum-efficiency units, because those units produce the highest sales volume. Performance ratings have essentially reduced unitary HVAC products to commodity-like status, with the perceived value of vapor compression equipment reduced to one number, the cooling seasonal performance factor or SEER (a heating seasonal performance factor exists for heat pumps, but the marketing emphasis is on SEER). Other important product performance features such as efficiency at utility peak demand conditions, sensible heat ratio (i.e., the ability to dehumidify air and thereby contribute to comfort and prevent damage due to molds and mildew), and heating capacity do not impact SEER ratings and in some cases are being sacrificed in design tradeoffs.

Without question, unitary vapor compression equipment price versus performance has improved over the last decade (Glamm 1993). By investing hundreds of millions of dollars, manufacturers have achieved incremental compressor efficiency improvements due to more efficient motors, lower parasitic pressure drops, and lower running gear losses. More effective heat transfer surfaces, such as internally finned tube and slit fins, have been implemented. Competition has pushed the industry to implement lower-cost methods of doing business, from the front office to the manufacturing floor. Significant improvements in development and factory cycle times have been achieved.

Glamm is also optimistic that unitary vapor compression improvements can continue (1993). Potential developments cited by Glamm include replacement of condenser unit prop fans and indoor air handler forward-curved blades with vane axial or air foil fans; wider application of variable-speed technology; additional incremental improvements in scroll and screw compressors; zeotropic refrigerant blends with controlled composition shifting;

and two-phase ejectors or scroll/screw expanders to recover lost energy from the refrigerant expansion process. However, much of the identified potential remains speculative.

The picture painted here of the unitary domestic HVAC industry is not flattering. The outsourcing culture—with its associated low barriers to entry-and the recent recession have led to over-capacity, savage price competition, lean margins, and corporate restructuring. Industry efforts to assert leadership over the markets and resist the drift of products to commodity-like status largely failed. Variable speed products (Sulfstede 1993), products that achieve efficiency by integrating the water heating function (Reedy 1992), and ground-source (or geothermal) heat pumps (Cane 1992) have not achieved significant market shares. The vast majority of unitary vapor compression machine shipments are still electromechanically controlled, single-speed, on-off cycling, air-source units. Furnaces come in two varieties, noncondensing and condensing, and every manufacturer has them to sell.

Some people in the industry speculate that cash flows from existing products might be better spent on other businesses than on HVAC product and process improvements because of the limited profit potential and the difficulty in establishing product differentiation and a competitive edge. But a few manufacturers have decided to give product differentiation another try, this time with gas heat pumps.

Why gas heat pumps? The prevalent reasoning is as follows. The real value of efficiency in the market is not SEER. Rather, it is determined from the capital equipment that must be placed in service (by end-users and by utilities) and by the energy prices that end-users actually pay. Natural gas is the lowest-cost regulated energy form available to building owners (4 times less expensive to residential customers than electricity on a national average, delivered-Btu basis in 1990) (EIA 1993). The gas grid is already connected to over 50 million houses (EIA 1992) and to millions more low-rise nonresidential buildings. Most electric utilities are summer peaking, or would be if inefficient electric resistance space and water heating were upgraded. Essentially, all gas distributors are winter peaking. Gas heat pumps can be deployed in large numbers without any gas distributor facility investment and with considerable avoided capital expense by electric utilities. The gas industry has just restructured and is ready to compete, Many HVAC OEMs and component suppliers have just restructured and are ready to compete. The electric industry, with its return on ratebase regulation and central planning, is looking increasingly outdated, and major restructuring is inevitable. After restructuring, the electric utility industry likely will not have a regulatory incentive to retain low load factor peak loads. Gas distributors need efficient summer loads and winter peak day savings to improve load factors. HVAC OEMs that pioneer gas heat pumps will have a differentiated product with which to win domestic market share.

It is possible that considerable policy-level support may be generated for this HVAC industry initiative. The HVAC industry is increasing net export growth. From 1987 to 1992, net exports rose from $323 million to $2,638 million, or about 800 percent (ARI 1994b). Gas heat pumps are a very promising export opportunity. Although unitary vapor compression machines are made locally in all of the world's major markets, only Japan and the U.S. (and companies that collaborate with Japanese and American companies) will have gas heat pump production capacity in the foreseeable future. The developing world may be placing relatively more emphasis on building gas than electric infrastructure because of the lower cost of gas infrastructure and the widespread availability of gas supplies (Ives 1993).

Utility Industry

There are many segments of the utility industry and several alternatives for categorizing them. In the case of gas heat pumps, the utilities involved are those with a stake in electric versus natural gas competition at end-use. Rural electric cooperatives are not considered further because they generally serve areas where gas is not available. The motivations of the other major utility industry segments are discussed in the following paragraphs.

Gas-Only Utilities

The gas industry consists of producers, interstate pipelines, and local distribution companies (LDCs). It is important to understand the distinctions between them. The industry has been working to transform the way it is regulated at the federal level for about 15 years. Because it was primarily the producer and interstate pipeline segments that were federally regulated, they were most involved in the effort. The outcome has been gradual federal deregulation and expanded reliance on market forces to set gas prices at the wellhead and service prices for transportation and storage. Producers and users of gas now negotiate directly over gas contract prices and terms; users (or their agents) are responsible for contracting with pipelines for the transportation/storage services necessary to deliver gas when they need it.

In this new framework, rather than being part of a monolithic "gas industry," LDCs are just another large customer along with large industrial gas users, process gas users, independent power producers, and electric utilities. Depending on their size, financial strength, and existing facilities, LDCs may or may not be in a position to provide gas acquisition, transportation, and storage services to these other large customers. The other customers can opt to bypass the LDC and be connected directly with interstate pipelines if, in their judgement, it is more economical to do so. Other customers can also acquire gas and associated services independently or hire gas marketers to negotiate for them.

The only LDC customers that are captive, in the sense that the LDC is their only practical supplier of gas, are the core residential and commercial customers (in some areas, large commercial customers can also opt to buy gas directly and arrange for its delivery). This portion of an LDC's business retains some characteristics of a natural monopoly, and continued state regulation is likely in order to protect the interests of these customers. However, even for these customers, gas is optional in every end-use as a result of competition with electrotechnologies and unregulated fuels.

Since the revenues received by gas producers and interstate pipelines are the same whether gas is consumed as a commodity (e. g., chemical feedstock, power generator fuel) or in a premium end-use (e.g., gas heat pump), the only segment of the gas industry with a potential economic incentive to promote gas heat pumps is the LDC. Even the LDC incentive can vary depending on climate, market characteristics, and how the LDC is regulated.

Two common attitudes toward gas heat pumps have been detected among gas LDCs and their state regulators, "free-market" and "pragmatic." The differences in these points of view often reflect the philosophical leanings within a state and the associated physical circumstances. For example, some states only consume natural gas, whereas others produce and consume gas. Some states are served primarily by large aggressive LDCs, while others have only small municipal or not-for-profit distributors. Some states are more inclined to emphasize activist regulation to achieve efficiency or social goals, whereas others are pro-competition and in favor of minimizing regulation.

The free-market gas LDCs and regulators believe their job is to deliver gas to end-users at the lowest possible rates (Kretschmer 1994). This group generally believes the trend toward deregulation of their industry at the federal level is beneficial and should be carried through by the states and extended to the electric utility industry as well. In this view, end-users are responsible for utilization efficiency and can control their own consumption. Since programs to promote gas heat pumps would cost money and would have the potential to lower throughput (i.e., the amount of gas flowing through the LDC), these programs could raise rates and make gas less competitive in other end-uses. Therefore, this group generally believes that LDCs choosing to promote gas heat pumps should do so using shareholder dollars and accurate seasonal price signals. Because gas heat pumps are unlikely to rank high among load-building opportunities (e.g., cogeneration, industrial refrigeration), widespread promotion by this group may be unlikely.

The pragmatic gas LDCs and regulators also have free-market leanings but find themselves in an imperfect world that they think requires more activism for success. This group faces either electric utility DSM programs—sponsored by rate payers—that subsidize electric options in end-uses contested by gas, or traditional electric promotional programs that have the same effect. If the paradigm is DSM, the electric utilities can justify higher incentives than LDCs because their avoided costs are higher; if it is promotion, the electric utilities can outspend LDCs because they are bigger and have more to gain (gas heat pumps lower gas throughput compared with furnaces in many areas, even though they provide both heating and cooling).

This group believes that leaving the next generation of gas end-use technologies to fend for themselves is not in the best interests of their core customers. It is likely to pursue the integrated resource planning (IRP) framework to the extent that the transaction costs associated with it remain feasible and electric *and* gas options receive fair consideration within an all-inclusive framework (Fulmer 1992; Walrod 1992; Fulmer 1993). This group thinks it can demonstrate the need for seasonal rates, modification of electric utility DSM programs to support options that are best for mutual customers, or suspension of electric DSM programs where gas options are more beneficial. This group believes that in the long run, deregulation of the electric utility industry will solve the electricity promotion that they perceive as a problem.

Combined Utilities

Combined utilities sell both electricity and natural gas in the retail market. The gas divisions of these companies face many of the same issues as gas-only LDCs. Some combined utilities are regulated and managed so that the gas and electric divisions compete. Others try to capture the potential that exists for conducting IRP and implementing DSM programs in a way that is best for customers. Under traditional rate base regulation, it is still better for shareholders of combined companies when these companies emphasize electricity, so long as electric divisions are vertically integrated (generation, transmission, and distribution). However some municipal utilities act as distributors of both energy forms and have no incentive one way or the other.

The level of enthusiasm that combined utilities express for gas heat pumps depends on how they are regulated and managed. The initial response indicates that some combined utilities will be active and forceful gas heat pump stakeholders.

Electric-Only Utilities

Few electric-only utilities have expressed great enthusiasm for gas heat pumps. There are several ways to improve electric utility load factors, and this approach is not generally favored. Municipal utilities that act as distributors of electricity are generally less aggressive in their opposition than vertically integrated investor-owned utilities. Strong resistance can be expected to any attempts to re-cast electric IRP as all-inclusive IRP that considers electric and gas options. Some regulators may have the will and the mandate to prevent these utilities from subsidizing electric options in end-uses contested by gas, where the gas option would be better for the customer. Others will have neither the will nor the mandate. Forcing electric utilities to offer incentives for gas options against their will is unlikely. Fuel choice issues in the IRP context are discussed in detail elsewhere (Goldman 1993).

State Utility Regulators

The next few years will be interesting times for state utility regulators. LDCs will demand higher rates of return because of their greater risk and responsibilities in the newly restructured competitive gas industry. Some LDCs will also demand the flexibility and resources to support market introduction of technologies like gas heat pumps that improve core customer load factors and the efficiency of gas use. They will argue that one of the few remaining justifications for continued state regulation of LDCs is the protection of core customer interests, and that the best way to protect those interests is to improve core customer load factors with efficient uses of gas.

On the other hand, electric utilities will argue that the most efficient use of gas is to generate electric power in combined-cycle plants. They will receive considerable assistance in these arguments from the producer and pipeline segments of the gas industry, who see the greatest gas load-building potential in these markets. Those electric utilities who have made their peace with the deregulation of their industry will also be supported in these arguments by independent power producers.

State regulators will either have to sort out who is right and to what extent, or allow competition on a level playing field to make the choices. The fact is that gas heat pumps and combined-cycle plants are both efficient uses of gas, and one does not exclude the other.

Gas Heat Pump Technology Status

Technology developers sponsored by the Gas Research Institute have successfully developed a long-lasting, clean-burning, natural-gas-fired internal combustion engine suitable for unitary heat pump applications. An American company, the largest small-engine manufacturer in the world, has licensed the intellectual property and will be offering the engine as a component to OEMs. One of the big-three American HVAC OEMs has developed a heat pump product around the engine. Residential sized split-system heat pumps will be commercially available starting in July 1994, according to current plans. Thereafter, a full product line for residential and light commercial unitary applications will be introduced in stages over a period of several years.

Technology developers sponsored by the U.S. Department of Energy have successfully developed a natural-gas-fired absorption heat pump based on an advanced cycle. An American company, the largest HVAC manufacturer in the world, has licensed the intellectual property and will introduce products based on the technology in 1997, according to current plans.

Both manufacturers have elected not to call these products heat pumps because gas distributor advertising has been so effective at associating the term “air-source heat pump” with cold blowing air in many of the target market areas. Some customers apparently do favor the higher delivered-air temperatures achievable with gas furnaces over those delivered by air-source heat pumps during the heating season. Both types of gas-fired air-source heat pumps are capable of delivered-air temperatures comparable to those of gas furnaces. (For technical descriptions of these gas heat pump products, see Hughes 1993a and Hughes 1993b.) The manufacturers intend to use their promotional resources to build awareness for name(s) other than “gas heat pump” [name(s) not mentioned to avoid commercialism], rather than try to reverse the perception of the term “heat pump.”

Summary Conclusions

Gas heat pump products, regardless of what they are called in promotional materials, may have significant strategic importance for HVAC manufacturers, LDCs, and LDC core customers alike. The manufacturers are establishing new core competencies that ultimately could support major advances in space conditioning equipment price versus performance. Product features and a range of efficiency levels will be introduced gradually to minimize risk and finalize attributes based on customer needs and market response. A fair consideration of the coming gas heat pump initiatives by regulators, the environmental community, efficiency advocates, and other interested parties is in order. Those groups need to look beyond simple comparisons between introductory gas heat pump products and mature conventional products. Gas heat pump price versus performance potential and, increasingly, export potential may also merit consideration.

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