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Distribution Control UC95D

MARKET POTENTIAL FOR RESIDENTIAL GAS HEAT PUMPS

Prepared by

Allied Chemical Corporation
For Union Carbide Corporation,
Nuclear Division

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I. BACKGROUND, SCOPE AND APPROACH

The Allied Chemical Corporation (Allied) is in the process of developing a gas-fired absorption heat pump, which is anticipated to be a residential size unit offering a heating coefficient of performance (COP) of approximately 1.25 and a cooling COP of 0.5. The product is now in the prototype stage with an operating laboratory scale unit and is moving towards field testing. Funding for the development of the Allied gas heat pump is provided, in part, by the Gas Research Institute and the United States Department of Energy with the underlying rationale that the high heating COP of the gas heat pump offers an opportunity for conserving natural gas by introducing higher efficiency heating and cooling products. In order to help guide the research and development effort and to provide some market perspective in the product development process, Allied has asked Arthur D. Little, Inc., to conduct a market assessment.

This report covers that market assessment. Arthur D. Little, Inc., has estimated the sales potential for gas fired heat pumps, commented on various design options under consideration by Allied, pointed out ways to improve gas heat pump marketability and commented on the necessary marketing support for gas heat pumps. This has included a discussion of necessary distribution channels and other market-related support.

Our analysis covers all gas fired heat pumps as a generic grouping and is not focused towards the potential volume achievable by one manufacturer or any one technology, although the estimated cost and performance numbers are specific to the Allied absorption heat pump.* The approach included interviews with various members of the heating, ventilating, and air conditioning industry (HVAC), gas utilities, relevant trade associations, manufacturers, distributors, and others closely associated with the industry. These interviews were particularly useful in identifying the steps necessary to insure market acceptance and in identifying market support issues. The study also included a comparative economic analysis of gas fired heat pumps versus other heating and cooling products to estimate the economic attractiveness and market potential of gas fired heat pumps to various potential market segments. We also have relied on our background in the construction and the HVAC industries in order to put the market potential and necessary market support for gas fired heat pumps in an overall construction industry context and in relationship to general trends in the HVAC equipment industry.

* We have not conducted an independent assessment of the probable manufacturing costs for gas heat pumps nor have we attempted to estimate their likely performance.

Our basic approach (Figure I-1) was to start with basic data on housing and heating/cooling systems and using that to define the total annual number of HVAC purchase decisions. These were screened to identify those decisions, homes with gas available and central air conditioning, where gas heat pumps are appropriate substitutes. We then computed comparative payback periods for gas heat pumps and, from these and the number of purchase decisions, we estimated market potential.

Figure I-1

APPROACH

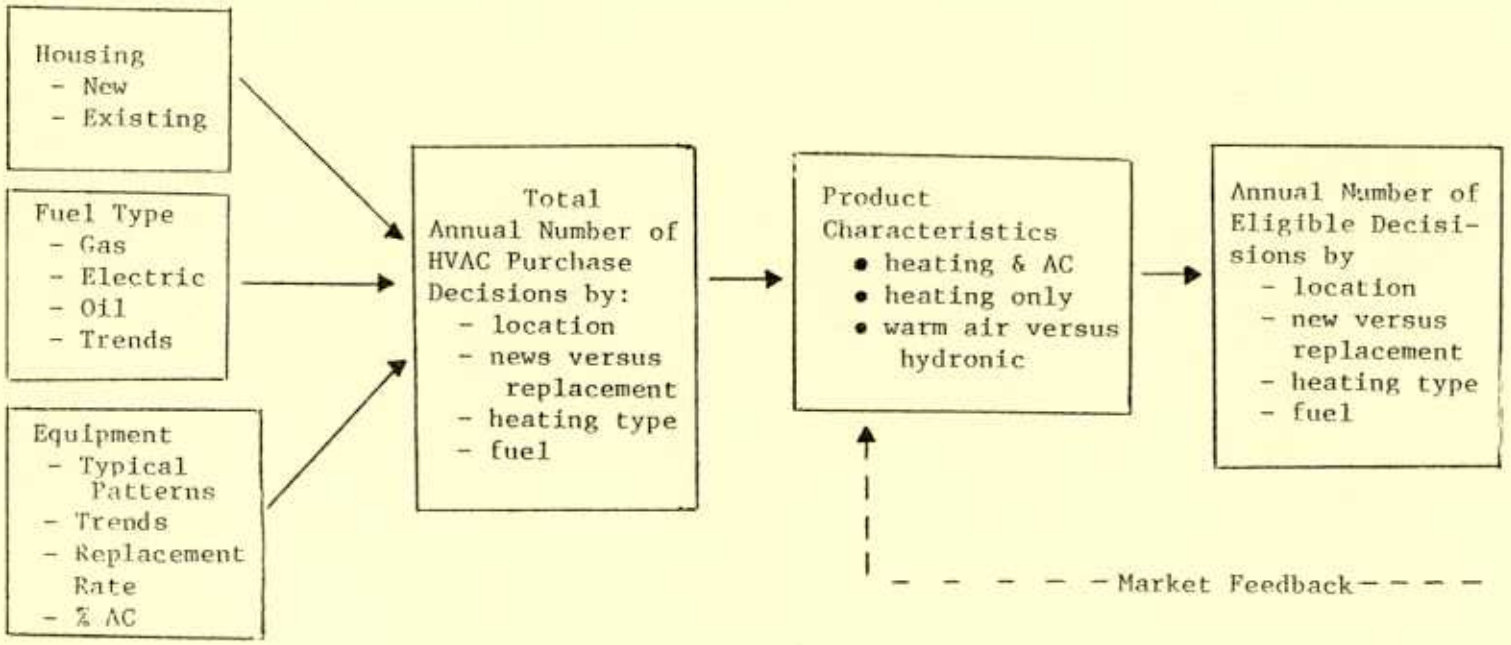
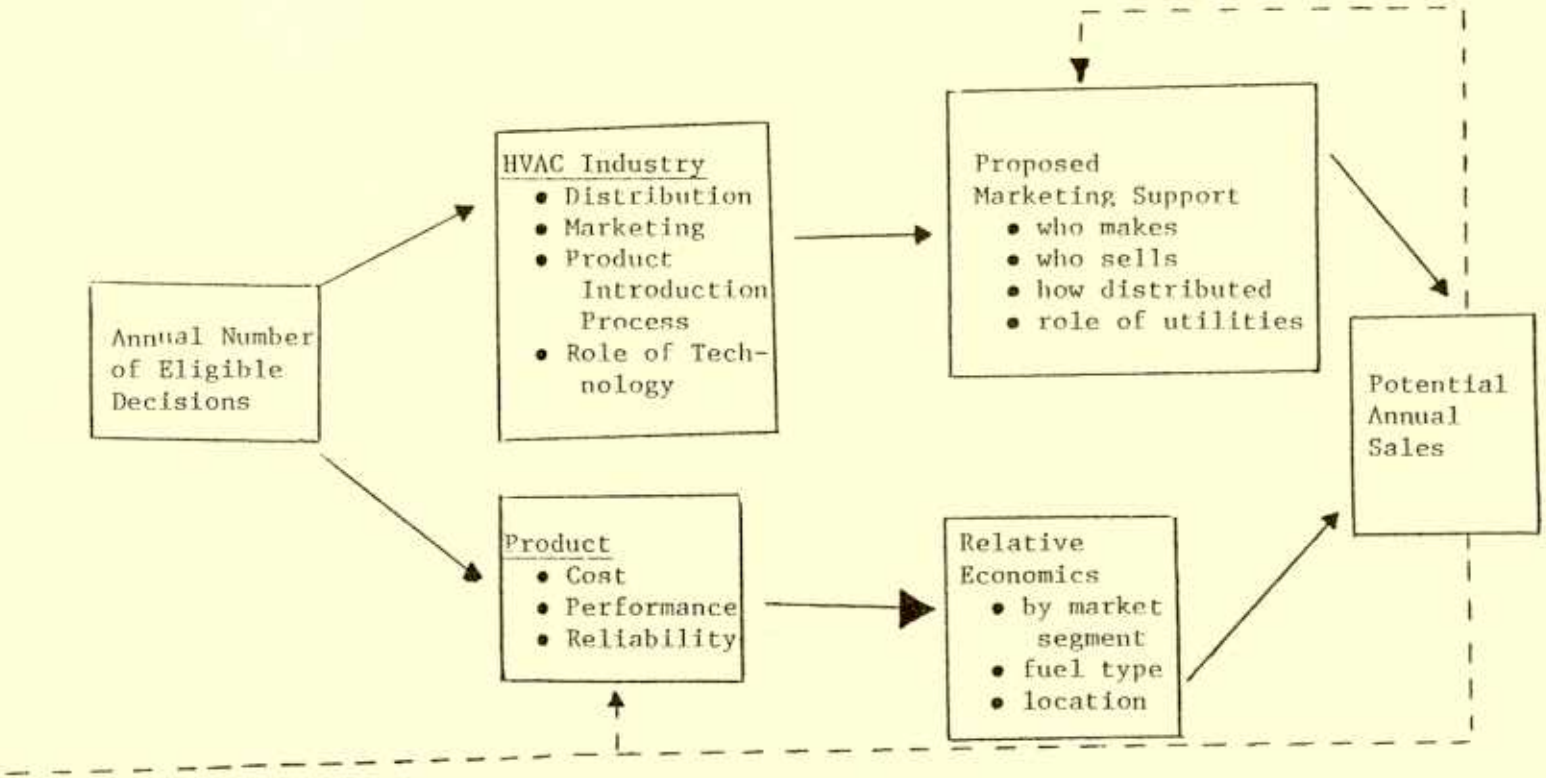


Figure I-1

APPROACH cont.



II. CONCLUSIONS

The market potential for gas fired heat pumps at currently estimated cost and performance levels is relatively modest. The total annual sales at a stable level following market introduction are estimated to be approximately 26,000 units (Table II-1). This represents the sales level that may be realized four to five years following actual product introduction, assuming adequate product and marketing support and reasonably broad distribution. With substantially better distribution, a great deal of marketing effort, including strong promotion by the gas utility industry, and good construction years, annual sales of approximately 85,000 units (optimistic case) could be achieved. Conversely, with poor market support, limited distribution, and lackluster performance, total sales would be roughly 10,000 units (pessimistic case).

The most likely market potential for a lower cost product* is significantly higher, increasing under average market support to 80,000 units annually. Increasing the system's efficiency** has a significantly lower effect on market potential, increasing the market potential under average market support only to 33,000 units from 26,000 units. This implies that research and development efforts should be focused towards lowering manufacturing costs at slight expenses in efficiency, rather than in improving efficiency at the expense of cost.

The greatest economic value to the consumer from this product is its high heating COP. The cooling features are of relatively lesser economic value to the consumer, because of the low cooling COP of the gas fired heat pump compared to the higher, and improving COP's for electric fired, split system air conditioners. The higher electric cooling COP overcomes, in most localities, the difference in cost between gas and electricity. On a raw fuel cost basis, without amortizing capital costs or estimated maintenance costs, in most areas cooling with an electric air conditioner will be less expensive than cooling with a gas heat pump. Consequently, the greatest market potenital for gas heat pumps with low cooling COPs is in high heating load, low cooling load areas. Payback periods for gas heat pumps in high heating load, low cooling load areas are typically less than 6 years versus all systems except gas warm air heat electric air conditioning. Against that system, and in high cooling areas, paybacks are well in excess of six years.

* FOB manufacturing price of $1,100 per unit rather than approximately $1,400

** Increasing the heating/cooling COP to 1.35/.6 from 1.25/.5

Table II-1

POTENTIAL SALES OF GAS HEAT PUMPS

(000 units per year)

Equipment	Marketing Support		
	High	Average	Low
Proposed Unit	85	26	9
Higher Efficiency Unit	92	33	10
Lower Cost Unit	148	80	37
Higher Efficiency and Lower Cost Unit	165	92	58

Source: Arthur D. Little, Inc., estimates.

The relative importance of heating indicates that "a family" of gas heat pump products--rather than a single unit--may be in order. While there will clearly be a demand for heat pumps which offer a cooling function, there will also be a demand for heating-only gas heat pumps, particularly if heating-only heat pumps can be manufactured at significantly lower cost than heating and cooling gas heat pumps. Similarly, gas heat pumps combined with domestic hot water (DHW) heaters may also offer some potential although combined appliances can be difficult to market because of their somewhat greater complexity and narrower market. The opportunities inherent in a product family, particularly if they can increase volume and lower cost, make investigation of these alternative products potentially interesting (Figure II-1).

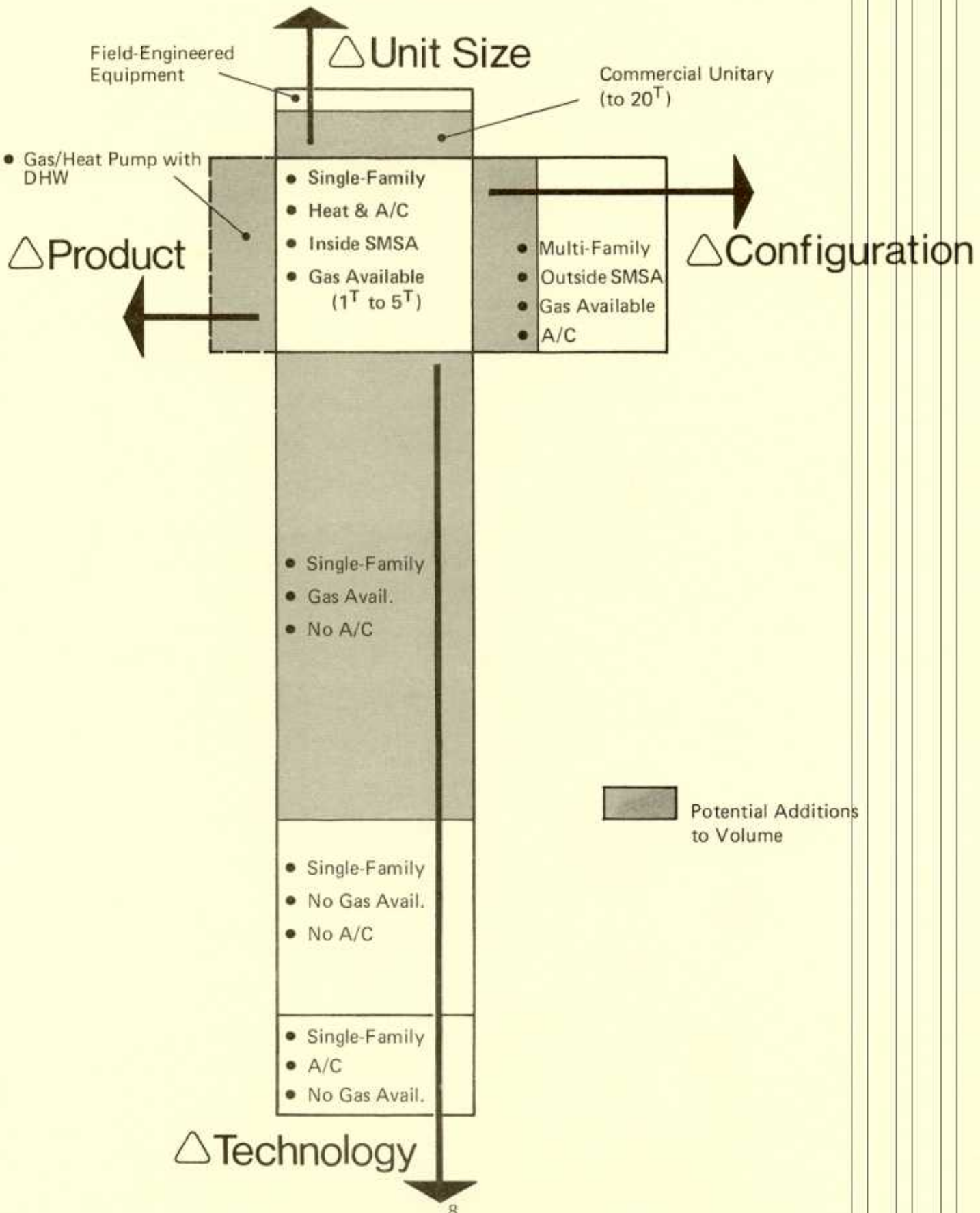
Aggressive market support will be essential for successful introduction of gas fired heat pumps, which can be best provided by existing manufacturers and distributors of HVAC equipment coupled with support from the gas utility industries. An integral part of marketing any HVAC product is gaining wide distribution, which is best accomplished by using the existing HVAC distribution system, the distributors and contractors already covering the entire country. Best access to this system is through a current manufacturer who is already moving large quantities of heating and air conditioning equipment through distribution. Also important will be actual sales support, both to consumers and to contractors/dealers. This will include promotion of the concept of gas heat pumps as well as establishing necessary service and warranty support mechanisms and adequate contractor training programs. The level of effort placed in these areas may well make the difference between sales at the optimistic, or high market support level versus sales at the base line, average, level or at a pessimistic, low support level.

The gas utilities can play a useful role in supporting the introduction of gas fired heat pumps. They are currently playing a crucial role in supporting the sales of gas air conditioners by actively promoting them in many areas and by engaging in sales, distribution, installation and service in certain utility districts. This can be done also for gas fired heat pumps with the utilities taking on the role of the distributor and marketer. However, there is a limit to the volume that can be done using gas utilities as the only distribution channel. Total volume is particularly limited by the trend over the past five to ten years of gas utilities cutting their actual merchandising activities. While there is some trend back towards merchandising by the gas utility industry, there is not enough to actually support gas fired heat pumps above the low market support level. In order for the total market to move beyond the pessimistic low support level and toward the optimistic level, gas fired heat pumps will have to be sold through conventional HVAC distribution channels.

In summary, the gas fired heat pump has a modest market potential. The potential under most likely conditions exceeds current sales of gas fired absorption air conditioners but is relatively small when compared to other unitary heating and air conditioning products.

Figure II-1

APPLICATIONS FOR GAS HEAT PUMPS



III. BACKGROUND ON THE HVAC INDUSTRY

Gas fired heat pumps will compete with other heating and air conditioning (HVAC) products, particularly gas furnaces, electric air conditioners, and electric heat pumps. In order to fully understand the market dynamics affecting gas heat pumps, it is important to understand the general HVAC industry, how it operates, how it accepts new products, what its general trends are, and what the typical basis of competition are for various products. This will provide a general context in assessing the potential for gas fired heat pumps and for identifying the appropriate and necessary market support.

A. INDUSTRY STATUS AND GROWTH TRENDS

The United States HVAC industry includes shipments of equipment valued at approximately 3-4 billion dollars. This covers three broad categories: residential unitary equipment, light commercial unitary equipment, and field engineered (i.e., heavy commercial) equipment (Table III-1).

The target market for the Allied gas heat pump is the residential unitary market. Some other gas heat pumps will be oriented towards other market segments, but for the purposes of this analysis the focus will be on the residential market. Products used in the residential market are principally:

- Gas furnaces.
- Electric heat pumps.
- Electric furnaces.
- Electric baseboard units for heating.
- Electric air conditioners.

The total sales of electric unitary air conditioners, including units for light commercial construction, total between 2.5 and 3 million units annually. Shipments of gas furnaces average approximately 1.5 million units per year. Shipments of electric heat pumps have grown significantly since 1974 and are now in the vicinity of 550,000 units (Table III-2)

Gas air conditioners, the principal alternative to electricity as a cooling source, average 15,000 to 20,000 units, or less than 1 percent of the annual shipment of electric air conditioners. They are sold by only one manufacturer, Arkla.

Table III-1

ANNUAL HVAC EQUIPMENT SHIPMENTS
(1977-1979)

	Billion Dollars
Residential	
Cooling (including electric heat pumps)	1.0 - 1.4
Heating	0.4 - 0.6
Total	1.4 - 2.0
Commercial Unitary	
Cooling and Heating	0.5 - 0.7
Field Engineered	1.0 - 1.3
Total	2.9 - 4.0

Source: U.S. Department of Commerce and Arthur D. Little, Inc. estimates.

Table III-2

SHIPMENTS OF SELECTED HVAC EQUIPMENT

	1979 (Thousand Units)
Air Conditioners	2,681
Heat Pumps	548
Gas Furnaces	1,863
Other Furnaces	441
Gas Air Conditioners	15

Source: U.S. Department of Commerce and Arthur D. Little, Inc., estimates.

There are two principal reasons for sale of residential heating and cooling equipment: use in new construction, and use as replacements for existing but failed units. New construction accounts for between 50 and 60 percent of the shipments of most furnaces and air conditioners. In the case of boilers, where shipments average 200,000 to 300,000 units annually. new construction averages somewhat less, on the range to 30 to 40 percent of total shipments. Consequently, the level of construction activity has a significant effect on the overall annual shipments of most heating or cooling products.

The outlook for new residential construction is only fair for the early 1980's, with total housing starts averaging 1.6 million units per year, roughly equal to the average during the 1970's (Table III-3). Recessions will still have significant impacts on the housing industry and will cause the HVAC industry to be quite cyclical. This characteristic of the industry must be taken into account when production planning and marketing strategies are developed. Overall demand for new construction HVAC equipment will not grow significantly in the 1980's, but will show changes in fuel shares and substantial year-to-year volume changes.

Sales of HVAC equipment to the replacement market will also grow only slowly, less than real GNP growth. Greater growth will occur in electric heat pumps, were a nacent replacement market is beginning to emerge, and much of this will represent cannabilization of the conventional unitary air conditioner replacement market. Replacement sales will be steady and will not experience the year-to-year swings common in new construction. The overall market for HVAC equipment, thus will not show substantial growth and sales of a new technology must come at the expense of existing products.

The most significant change in the HVAC industry over the near term will be the change between heating fuel types in new construction. In the mid-1970's there was a significant shift in fuel patterns in new construction with decline in use of natural gas, due in large part to local gas moratoria. The percentage of new construction with gas as a heating fuel declined from its historic 60 percent level in 1971 to 40 percent in 1979 (Table III-4). At the same time, there was also a decline in the use of electric furnaces and other forms of electric resistance heating, accompanied by a significant growth in the sales of electric heat pumps. Now that natural gas is available again and since it is typically less expensive on a direct operating cost basis, the penetration of natural gas into new construction will move back towards historic, pre-1973 levels. The likely penetration of natural gas by 1985 will, therefore, approach 50 percent in new construction, with electric heat pumps absorbing roughly 25 percent, electric resistance heating 15 percent, and oil and other fuels accounting for the remaining 10 percent.

Table III-3

BUILDING CONSTRUCTION ACTIVITY

	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1988
Residential (Thousand Units)											
Single Family	896	1,166	1,452	1,433	1,190	900	1,190	1,295	1,120	1,225	1,120
Multi Family	275	382	538	590	560	400	510	555	480	525	480
Low Rise	250	356	495	526	500	360	460	500	435	475	450
High Rise	25	26	43	64	60	40	50	55	45	50	30
Total	1,171	1,548	1,990	2,023	1,750	1,300	1,700	1,850	1,600	1,750	1,600
Mobile Homes	213	246	277	276	275	250	275	290	260	280	
Non-Residential Buildings (Million Square Feet)											
Commercial	535	562	699	886	966	976	956	1,032	1,063	1,052	1,195
Industrial	146	152	175	209	238	240	228	239	241	231	265
Institutional[1]	299	271	259	222	202	188	182	180	180	176	180
Small Miscellaneous[2]	147	148	170	198	211	210	205	218	223	219	250
Total	1,127	1,133	1,303	1,515	1,617	1,614	1,571	1,669	1,707	1,678	1,890

[1] Includes educational, hospital/health, public, and religious buildings.

[2] Assumed to be 15% of the reported total.

Source: United States Department of Commerce, F.W. Dodge, and Arthur D. Little, Inc., estimates.

Table III-4

SINGLE FAMILY HEATING FUEL CHARACTERISTICS, NEW CONSTRUCTION

Heating Fuel	Percent		
	1971	1979	1985
Gas	60	39	50
Electricity	31	51	40
Heat Pump	1	25	25
Resistance	30	26	15
Oil	8	6	6
Other/None	1	4	4
Total	100	100	100

Source: U.S. Department of Commerce, Arthur D. Little, Inc., estimates.

B. MARKET SEGMENTS

Successful marketing of HVAC products requires appreciation of the industry's market segmentation. In the residential sector there are three principal market segments:

- New construction
- Replacement
- Retrofit

These segments are of different sizes, have different growth rates, different bases of competition, and different keys to success (Figure III-1).

1. New Construction

The new construction segment includes sales of equipment for use in newly built homes. This is the best known market and accounts for 1.5 to 2 million units of heating equipment and approximately 1 million units of cooling equipment annually. Trends in equipment shipments depend on new construction volume and fuel choices. Actual equipment choice is typically made by the homebuilder, with advice from the HVAC sub-contractor.

The keys to success in marketing to the new construction segment are, in order:

- Installed cost
- Reliability/maintenance
- Delivery
- Efficiency

Installed cost is far-and-away the most important issue to builders since any decrease in cost represents extra profit to them.

Home builders are extremely first-cost sensitive and typically not sensitive to operating costs or efficiency, except where the homebuilding market effectively vetoes certain equipment because of high operating costs. Home buyers have become resistant to certain types of heating systems, most notably low first cost electric resistance heating which can have operating costs over three times as much as gas systems. When customer resistance developed for these homes, home builders moved away from electric resistance heating equipment, often to the more expensive heat pumps. When operating costs are perceived by consumers to be roughly comparable, first cost becomes the most important factor for home builders in selecting equipment. For example, prices of electric heat pumps and gas furnaces plus electric air conditioners are often quite close for the large volume home builder or developer, and the decision to use one system or another can swing on the $50 cost of the chimney required for the gas furnace.

Figure III-1

CHARACTERISTICS OF VARIOUS MARKET SEGMENTS

	New	Replacement	Retrofit
Buying Influences:			
Housing Starts	√√		
Housing Inventory		√	√
Failure Rate		√√	
Energy Economics	√		√√
Key Decision Maker:			
Builder/Developer	√√		
Contractor	√	√	√
Owner			√√
Key Buying Factor:			
First Cost	√		
Equipment Availability		√	
Economics			√

2. Replacement

The replacement market is the other large segment of the HVAC industry and includes the decision to replace (quite frequently in sudden situations)an existing piece of equipment in an existing home, typically when the existing equipment has failed. Annual sales of both heating and cooling products in this market are roughly equivalent or slightly larger than sales of equipment to the new construction segment.

The installing contractor is the principal decision-maker on the brand and, to a large extent the type, of equipment used in the replacement segment because there are frequently short time constraints on the replacement of equipment, particularly heating equipment. The consumer typically relies very heavily on the judgement and recommendations of his contractor. The contractor, in turn, is concerned with the local availability of replacement equipment to close the sale. The pressure of time cuts down on price shopping, making this market less price sensitive with higher margins than the new construction segment.

The key to success in marketing to the replacement segment is local availability of equipment, which is in turn heavily dependent on strong distribution and local inventories. It is also important for equipment to fit the "footprint" of the previous unit either the outdoor pad for the air conditioner compressor/condenser or the space for the indoor furnace. Price is of some concern in these markets, but less than in the new construction segment.

3. Retrofit

The third segment of the residential unitary equipment market is the retrofit segment. This is related to the replacement segment as both involve replacement of equipment in existing construction. However, this segment covers the voluntary decision to replace functioning equipment with other equipment in order to improve efficiency or to save money. This market is characterized by passive decision makers, there are many potential customers who must be convinced to actively enter the marketplace. This is unlike the other markets where the home builder or consumer must make a purchase.

The annual number of retrofit decisions is not known, but is relatively small. The major market recently has come from the conversion of electric and oil heat to gas heat. Rencently, conversions have been running at on an approximate annual rate of 200,000-300,000 units, many of which are the replacement of oil burners with gas burners. The actual, annual number of retrofit heating systems sold is probably on the order of 250,000.

The retrofit market, unlike the other two markets, is susceptible to marketing efforts such as promotional advertising. Only brand preference can be influenced by advertising in the other two segments, while in the retrofit segment, actual market creation can be induced by promotional advertising marketing policies, local peer influences and, of course, changes in local utility costs. The retrofit market tends to attract many high-efficiency gas products, primarily due to the relatively lower cost of gas including such items as high efficiency or condensing gas furnaces, condensing boilers, and gas heat pumps.

The keys to success in the retrofit market are the efficiency and installed cost of the equipment coupled with marketing and promotional support. This is the only segment where efficiency is of any significant competitive advantage.

C. MARKETING AND DISTRIBUTION SYSTEMS

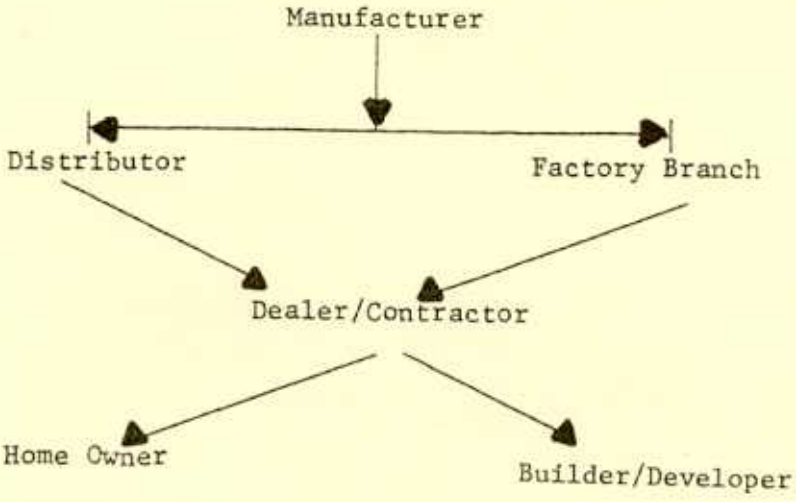
The HVAC industry is not characterized by highly sophisticated or aggressive marketing; marketing is oriented toward gaining wide distribution for products and educating contractors on a product's technical features. Market shares are not particularly fluid between manufacturers, and neither promotional efforts nor consumer advertising have proven to be terribly effective in stimulating demand or changing market shares. Some effect on sales and market share has come from promotion of new products, principally electric heat pumps, but this historically, has not been a major factor in the industry and is not likely to become one.

Obtaining distribution is the principal focus of marketing programs for HVAC products. Equipment oriented towards forced air heating and cooling systems are typically sold by manufacturers to independent distributors, who sell to installing dealer/contractors, who in turn, sell either to home-owners or to home builders (Figure III-2). The market leader in overall unitary equipment is perhaps the best example of this and works almost exclusively through independently-owned distributors. A number of the others also tend to follow this pattern with some exceptions and some captive branches. Two relatively large firms fall outside this pattern with factory branches. These branch offices, however, frequently operate like wholly-owned distributors and are found in many locations.

The function of distributors or captive branches is to hold local inventory and serve as sales agencies. The maintenance of inventory is a particularly important competitive issue in the replacement market. Dealer/contractors purchase equipment from distributors, then sell and install it for home builders and consumers. These contractors are generally firms without a great deal of sales sophistication, principally reacting to customer requests. They do not typically generate and convert leads, and have been particularly ineffective in supporting efforts to create a retrofit market. The retrofit market exists because of demand pulling products through a distribution system rather than because of active sales efforts. Manufacturers do very little marketing aimed at distributors. There tend to be established relationships with little or

Figure III-2

DISTRIBUTION PATTERNS FOR RESIDENTIAL HVAC PRODUCTS



no change, since distributors do not carry competing equipment from different manufacturers. Distributors market to contractors, with credit, applications engineering and product service used as important competitive factors.

Repair and service are significant issues in this system, and the importance of service affects the new product introduction process, since servicemen must be trained through local distributors. This process proved essential in the reintroduction of the electric heat pumps and its growth from 1972 to 1979. In this instance manufacturers ran specific service certification and installation programs. Electric heat pumps were not sold to contractors who did not have certification in order to insure that adequate installation was done and in order to minimize consumer complaints.

Gas and electric utilities occasionally play a substantial role in the marketing and promotion process. Both types of utilities actively solicit home builders to use their fuel through subsidies or other arrangements to install gas pipe or electric lines. This promotion can be active and quite fierce. Utility marketing, however, is not typically oriented toward specific products or brands, rather it is toward influencing fuel choice, except in some instances where utilities have actually marketed appliances. This principally focuses on water heaters, dryers, grills and ranges, but occasionally encompasses gas furnaces and gas air conditioners. Some gas utilities still, in effect, act as distributors for gas air conditioners.

D. TRENDS IN GOVERNMENT REGULATION

Government regulation now has and may continue to have a significant effect on the HVAC industry. The most direct regulation has been the DOE Minimum Appliance Efficiency Standards, which will require cost effective improvements in efficiencies for all residential heating and air conditioning equipment. By 1986 furnaces must have an Annual Fuel Utilization Efficiency (AFUE) of 0.85 versus current efficiencies under 0.7 while air conditioners must have a Seasonal Energy Efficiency Ratio (SEER) of 11.0 versus 7.0 currently. There are now products on the market in both heating and cooling areas which are capable of meeting these new standards, however a significant amount of R&D and product testing work remains to be done by the industry to finally meet the standards. This is taking up much of the research capacity available inside the industry.

Partly as a result of pending regulations and partly due to the movement in energy prices, there have been a series of higher-efficiency products either on the market or in the advanced R&D stage. One manufacturer has already introduced a gas-fired condensing type boiler with an F.O.B. price of roughly $1,000 and with an AFUE in the 0.95 to 0.96 range. Another is currently working on a pulse-type condensing furnace which is estimated to have a F.O.B. plant price of $700-800. Therefore, as a result of standards and new products the average efficiency and, to a lesser extent, the cost of gas heating equipment which will compete against the gas heat pump will increase.

Similarly standards will be forthcoming for residential electric heat pumps, required cooling performance will be close to that of air conditioners and heating performance will increase roughly proportionately.

The DOE Appliance Efficiency Standards have two principal implications for sales of gas heat pumps. First, the increased efficiency of conventional equipment will tend to make gas heat pumps somewhat less competitive because the gas heat pumps heating efficiency advantage will shrink and its cooling efficiency disadvantages will grow. This is particularly true in the case of electric air conditioners where a SEER of 11 corresponds to a COP of approximately 3; nearly five times the expected COP of a gas heat pump. This will tend to make it less expensive to cool with electricity from a fuel cost basis than with a gas heat pump. On the other hand, there will be some increase in the cost of heating and cooling equipment to meet these standards, narrowing the gap between gas heat pumps and other equipment, but that increase in cost will be relatively modest - in the range of $100 to $200 at manufacturers levels.

Second, the standards will direct the attention of the engineering and R&D staffs inside manufacturers away from new product development. Consequently, the existing manufacturers of HVAC equipment might very well be interested in acquiring rights to new technologies and marketing them - something which may be very useful to the developers of gas heat pumps.

IV. OVERVIEW OF THE GAS UTILITY INDUSTRY AND ITS RELATIONSHIP TO GAS HEAT PUMPS

The degree of support given by the gas utility industry to the gas heat pump will have a significant effect on its ultimate penetration as gas utility support can help popularize the concept of gas heat pumps and provide a useful seal of approval signifying that the product is safe and reliable. The absence of such approval could pose a problem, giving the impression that gas heat pumps are not necessarily either safe or reliable and therefore diminishing confidence in the products. Under certain circumstances, the gas utility industry could also help in the direct marketing of gas heat pumps and could directly aid in commercialization.

Over the last decade the gas utility industry has undergone significant trauma. In the 1950's, 1960's and early 1970's gas was the heating fuel of choice for most households outside New England and enjoyed significant market share versus electricity. The gas shortage in the mid-1970's caused many gas companies to deemphasize their marketing arms and caused some state regulatory commissions to restrict attaching new customers. As a result, the skills and ability in marketing declined markedly in the gas industry during the 1970's. At about the same time, many of the gas companies stopped merchandising appliances. Merchandising had often been a marginally profitable activity and was done mostly to encourage the use of gas water heating and gas cooking. Consequently, the gas companies decided that they had better uses for their money and ceased merchandising.

The cycle, however, has begun to swing back in favor of the gas industry again, and gas is again making a resurgence as the principal residential heating fuel. Furthermore, some gas utilities are redeveloping their marketing departments. Gas is reemerging as the heating fuel of choice because it remains the least costly fuel on a delivered BTU basis across virtually all of the country, and is likely to maintain that price advantage at least until price decontrol, which is expected in 1985. Even following decontrol, gas will remain a less expensive fuel on dollars per BTU basis in more northern areas where thermal efficiency of heat pumps is not terribly high.

Interest in gas heat pumps, not suprisingly, varies across the spectrum of gas utilities. Those companies with aggressive marketing departments are looking for ways to sell gas and also ways to sell gas heating products, and these companies are generally very interested in gas heat pumps. Many of these aggressive utilities are in the sunbelt and are interested in the cooling feature of the gas heat pump; they hope to be able to level their loads and improve their return on investment in hook-up costs. Companies in colder areas and companies which have eliminated marketing departments are typically less enthusiastic about gas heat pumps and generally seem more interested in high-efficiency gas furnaces and other more conventional products. From the utilities we interviewed those

who were most interested were in the high-growth areas, interest was also high where electric heating made inroads in the 1970's. The high growth areas tend to have an interest in air conditioning and summer loads, while the companies losing to electricity are looking for new products with which to remarket or push the use of gas and recoup their share from electricity.

Utilities in some slower growing, northern areas were modestly interested in gas heat pumps largely because they have small air conditioning loads, because they have not felt themselves particularly threatened by electric utilities, because they are not growing and because they have relatively small marketing and appliance activities. They wish to continue dominating their space heating markets and their interest in gas heat pumps is dependent somewhat on the competitiveness of the electric heat pumps. Current gas equipment is competitive with current electric heat pumps but this may not continue as gas prices rise and as electric heat pumps become more efficient. Consequently, these utilities want more efficient gas heating equipment rather than gas cooling.

One issue which may constrain utility interest in gas heat pumps, particularly in heavy heating load areas, is available gas supply and pipeline capacity. In particular, summer loads have become less attractive in the North and parts of the Southeast because it has become necessary for some utilities to husband gas for use in the winter. Gas storage and the total allotment available to each utility has put some damper on the desire to add summer loads, which were once off-peak, but are now necessary to build buffer stocks. However, summer gas use is still considered a goal in most of the gas producing areas of the South and Southwest and by some of the other utilities so there remains an interest in gas cooling products in many important areas.

The nature of the marketing support which can be given directly by gas utilities will vary distinctly from utility to utility and is somewhat dependent upon current experiences with gas air conditioning and upon the remaining strength of appliance merchandising activities. Most gas utilities have phased out their merchandising, installation and maintenance programs and the ability or desire of utilities to reestablish these programs is somewhat doubtful. For those utilities that still have merchandising programs, merchandising activities can be very useful in promoting gas heat pumps. Some gas utilities now effectively act as distributors for gas air conditioners; selling them with or through salesmen and providing back up service with utility-trained, utility-supervised or utility-approved service agencies. This support could be extended to gas heat pumps and would be very important at relatively low sales levels such as projected for the gas heat pump or as a substitute for the existing air conditioner distribution system. It will <u>not</u>, however, be possible to sell very large volumes of gas heat pumps with utilities acting as the only distribution and sales organization since utilities coverage is not great enough to serve as the sole distribution network and as the sole marketing organization in most regions of the country.

Those gas utilities which are not interested in or are not in a position to actually merchandise gas heat pumps can also help support the products by engaging in some advertising and promotion and by referring leads to eligible contractors, all of which could go a long way in helping to engender consumer confidence and in generating active sales leads. It is unlikely, however, that rebates, special financing, or special rates will be used to promote gas heat pumps, since there seems to be a trend in the regulation of utilities away from special or promotional rates.

V. MARKET POTENTIAL FOR GAS HEAT PUMPS

A principal task of this project was to estimate the market potential for gas heat pumps. The approach to estimating market potential has two major steps:

- Identify the available markets by determining the number of decisions made annually where there is potential for sale of a gas heat pump.
- Estimate market penetration by determining the likelihood that a purchase decision results in the sale of a gas heat pump.

This analysis is for the market potential for *all* types of residential gas heat pumps and is not restricted to, nor does it attempt to estimate, the potential sales by any one manufacturer or technology. It is also assumed that the products in question are reliable, meet their advertised cost and efficiency targets, can be serviced with reasonable ease, and receive a reasonable level of marketing support and geographic distribution. The actual level of marketing support will have a distinct effect on the market penetration by gas heat pumps. The analysis also represents a "steady state" condition five to eight years after market introduction.

Gas heat pumps, unlike products such as hand-held calculators, will not be introduced into a virgin market where the introduction of the product actually creates the demand, causing the market to grow rapidly as people recognize a new need. On the contrary, gas heat pumps will be sold to the HVAC market which is essentially saturated and where people already have many adequate alternatives. The sale of a gas heat pump will replace the sale of some other heating and cooling equipment rather than create new, previously unrealized demand. Consequently, the best way to begin estimating the market potential for gas heat pumps is to segment the market for other types of heating and cooling equipment and estimate how likely purchasers of those types of equipment would be to change their purchase decision.

To do this we have divided the HVAC industry into eight basic product groupings; those dwellings which either have or otherwise could be expected to have:

- Gas furnaces with central air-conditioning
- Gas furnaces without central air-conditioning
- Gas boilers with central air-conditioning
- Gas boilers without central air-conditioning
- Electric heat pumps
- Other heat with central air-conditioning
- Other heat without central air-conditioning

These product combinations represent the universe of residential HVAC system configurations and are useful in assessing where gas heat pumps

have the greatest potential. The principal segmentation is between those product clusters where gas is, or can be, expected to be present in the house, e.g., gas furnaces and gas boilers, and those clusters where gas is not present. The presence of a gas connection makes the choice of a gas heat pump substantially easier as the choice involves one step, from a competing product to a gas heat pump. In homes without gas connections, there is a two-stage decision involved; first, to have gas installed in the house, and second, to install a gas heat pump. Following product class segmentation, these equipment types can be further segmented by construction types, namely new construction, replacement, and retrofit.

A. AVAILABLE MARKET

1. Total Market

Based on government statistics and estimates by industry trade associations, we have constructed estimates of the number of annual decisions to purchase heating equipment or cooling equipment by equipment type and by construction market segment (Table V-1). This table represents the number of decisions in attached and detached single-family homes (dwellings with fewer than four housing units), inside Standard Metropolitan Statistical Areas (SMSA's). This excludes a relatively small part of the total housing inventory which might be a potential market for gas heat pumps but which is not in SMSA's. These units represent minor potential markets for gas heat pumps because they are in rural areas and often do not have gas connections available. The statistics also exclude multi-family dwellings and light commercial structures, both of which represent markets for electric heat pumps, particularly in the multi-family dwellings, and could conceivably represent some market potential for gas heat pumps. However, these are traditionally segments where first cost is a paramount concern and these markets represent only modest potentials for gas heat pumps or potentials which will be significantly lower than the potential in single-family construction.

A base year of 1977 was chosen as a fairly typical new housing year, and as the latest available inventory statistics at the time of this study. The retrofit inventory columns significantly understate the current installed number of electric heat pumps as major growth for electric heat pumps occurred in 1978 and 1979 and is therefore not reflected in these numbers.

Some explanation of the various product/market segments may be helpful. The new construction segment includes houses started in a given year and represents the actual number and type of equipment purchase decisions made in 1977. This is basically a proxy for how people will decide to choose equipment in the future and therefore is, essentially, a prediction of what the available new construction market for gas heat pumps and the penetration of competing types of heating equipment will be in the future. A gas heat pump would in a sense

TABLE V-1

DISTRIBUTION OF CANDIDATE GAS HEAT PUMP MARKET OPPORTUNITIES*

Market Segment	Gas Furnaces With A/C	Gas Furnaces Without A/C	Gas Hydronic With A/C	Gas Hydronic Without A/C	Electrical Heat Pump	Other Heat With A/C	Other Heat Without A/C	Total
New Construction (Annual)	186	131	2	5	173	43	132	674
Replacement (Annual)	190	575	26	130	40	180	864	2,005
Retrofit (Inventory)	3,193	10,481	477	2,385	601	4,510	17,279	38,926
Estimated Retrofit (Annual)	--	--	--	--	10	40	200	250
Total Annual Opportunities	376	706	28	135	223	263	1,196	2,927

* 1977 data for detached and attached single-family dwellings (excluding multi-family) inside Standard Metropolitan Statistical Areas (SMSA).

Source: Arthur D. Little, Inc., estimates (revised).

replace one of these other pieces of equipment, e.g., someone who ordinarily would have put in a gas furnace would instead put in a gas heat pump.

The replacement category includes the annual number of homeowners who must replace either their heating or their cooling system because of equipment failure. It is developed by taking the inventory of heating and cooling equipment in existing housing and estimating the age of that equipment and the likely number of replacements due to failure per year. This represents roughly a ten-year lifetime for electric pumps, 12 to 15 years for unitary air-conditioners, and 15 to 20 years for gas warm air furnaces and boilers. The resulting estimates of the annual number of replacement shipments of HVAC equipment plus new construction shipments is consistent with the actual level of shipments of heating and cooling equipment.

The annual retrofit market has recently derived from the conversion of heating systems from some other firing fuel to gas and is a reflection, in large measures, of the trend away from oil (seen heavily in New England) in recent years. The 250,000 units of retrofit decisions are a significant growth over the number of such decisions in previous years.

The equipment types are largely self-explanatory, except that many homes without central air-conditioning have some form of cooling through a window unit, explaining the relatively large number of both gas furnaces and other heating systems without central air conditioning. The categories "other heat with central air-conditioning" and "other heat without central air-conditioning" include a wide range of heating systems predominantly electric warm air furnaces and oil-fired warm air furnaces. There are also a smaller number of electric baseboard resistance heating systems and oil-fired boilers.

2. Available Market

Our analysis indicates that there are nearly 3 million potential opportunities (purchase decisions) in single-family houses inside SMSA's where the purchase of a gas heat pump could be considered. It is, however, necessary to screen out of these opportunities those, where for technical reasons, the purchase of a gas heat pump is extremely unlikely, in order to arrive at a true available market. The first screening rule we used was to eliminate houses without central air-conditioning. The penetration of central air-conditioning in both new and existing construction has remained quite constant over the last five years and there is very little evidence that people who do not now have central air-conditioning will choose to install it with an extra cost of $1,500 to $2,000 over heating-only systems. These excluded units could conseivably be a market for a heating-only gas heat pump if such a product's costs were consistent with conventional heating-only systems. They do not represent, however, a potential market under currently-projected prices for gas heat pumps. Secondly, installations without gas

connections or without ready access to gas connections were partially eliminated. We estimate that twenty percent of houses with electric heat pumps are in areas where natural gas is available since most installations of electric heat pumps was at a time when gas lines were not generally being extended. We also estimate that up to 50% of homes with other types of heat, either by electricity or by oil, may be in areas where natural gas is either in the house or readily accessible to the house. Verifying the availability of gas in existing houses is difficult but there is some evidence from the gas industry that approximately 13 million housing units have potential to be converted from other heating systems to natural gas (Table V-2). These include current customers who have gas connections but use other fuels for heating, most of whom are in the Northeast; or potential new gas customers where gas pipes could be run from existing gas mains into the house.

After exclusion of the low-potential applications, we estimate that there are a total of 580,000 single family homes in SMSA's which represent reasonable potential for the choice of gas heat pumps (Table V-3). This is the "available market" for gas heat pumps on an annual basis. If all of these decisions were converted to gas heat pumps, it would represent a significant and attractive market; on the order of the current annual sales of electric heat pumps. It is, however, the raw number of potential purchasers of gas heat pumps without regard to differential operating economics and capital costs. Consideration of these and other more marketing related issues will yield the actual penetration that can be expected by gas heat pumps into this available market.

This available market (Figure V-1) represents the basic market opportunity open to gas heat pumps of the size and configuration of the product currently under development by Allied Chemical. Various types of product changes could expand the available market, although some of these could be theoretically possible but technically impractical.

The simplest expansion of the market would be to include multi-family housing and houses not in SMSA's (Figure V-2). This could require smaller, different size/shape units, but also represents a relatively small additional market. Adding a heating only product would significantly increase the available market, (Figure V-3)but would require costs competitive with conventional furnaces and boilers to be practical. Increasing the size of the system would open up the commercial roof top market (Figure V-4). while adding an integrated hot water, heating, cooling, (Figure V-5) product would also add potential.

B. SYSTEM ECONOMICS

We estimated the market pentration of gas heat pumps through a three-step process. We first estimated the user economics for gas heat pumps by market segment to determine the simple payback from a gas heat pump relative to conventional equipment. We then tested the sensitivity of these payback calculations to potential changes in the cost and/or performance of gas heat pumps to determine the general limitations and sensitivity in the market penetration analysis and also to help guide

TABLE V-2

1978 POTENTIAL FOR CONVERSION TO GAS HEATING

(Thousands of Housing Units)

	Northeast	North Central	South	West	Total U.S.
Current Customers:					
Urban Gas Customers	4,120	1,030	600	340	6,090
Rural Gas Customers	580	190	160	40	970
	4,700	1,220	760	380	7,060
Extensions of Service:					
Urban LPG Customers	20	40	170	30	260
Rural LPG Customers	20	310	490	90	910
Urban Oil Customers	2,240	380	810	250	3,680
Rural Oil Customers	450	390	390	60	1,290
	2,730	1,120	1,860	430	6,140
Grand Total:	7,430	2,340	2,620	810	13,200

Source: Arthur D. Little, Inc., estimates.

Table V-3

AVAILABLE PURCHASE DECISIONS

	New Construction	Replacement	Retrofit	Total
Total Decisions	674	2,005	250	2,929
No Central A/C	268	1,569	200	2,037
No Available Gas	160	122	28	310
Total Available Decisions	245	314	22	581

Source: Arthur D. Little, Inc., estimates.

Figure V-1

APPLICATIONS FOR GAS HEAT PUMPS
BASE MARKET

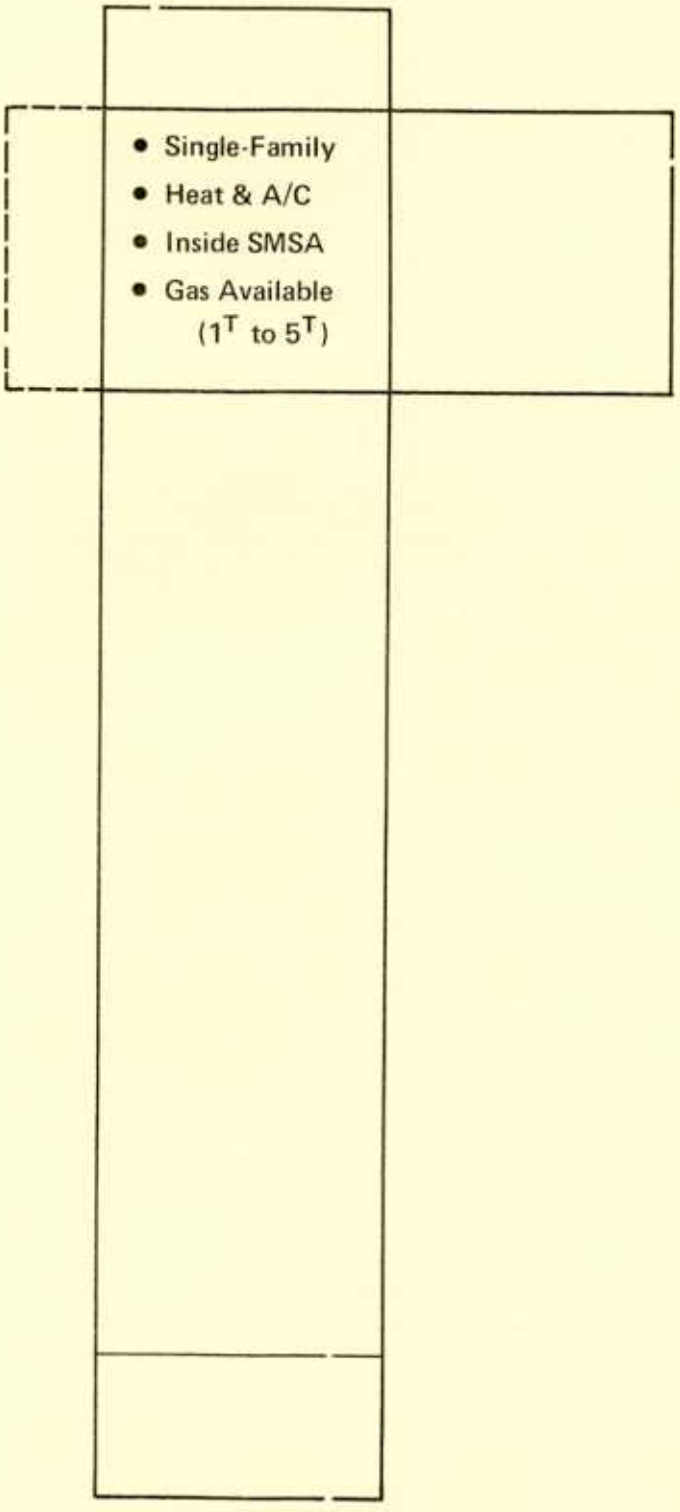
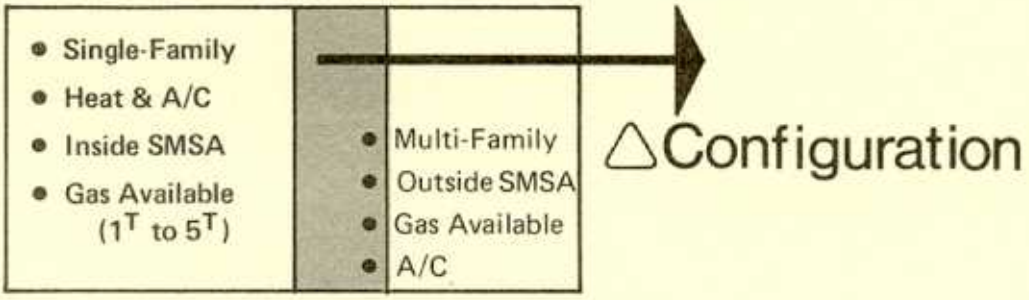


Figure V-2

APPLICATIONS FOR GAS HEAT PUMPS
ADDITIONAL MODELS AND PACKAGES



Potential Additions
to Volume

Figure V-3

APPLICATIONS FOR GAS HEAT PUMPS
HEATING ONLY AND HEATING/COOLING

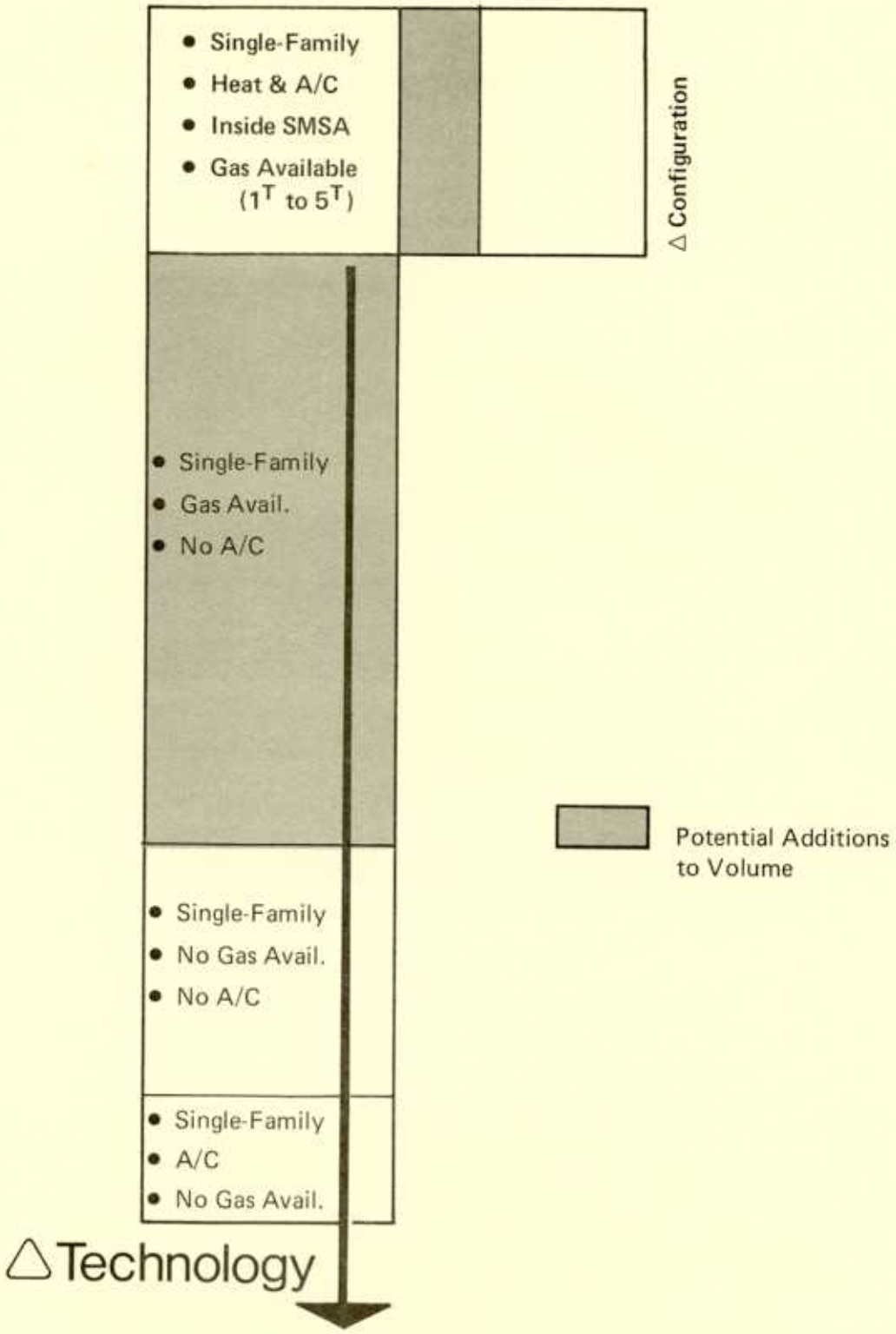


Figure V-4

APPLICATIONS FOR GAS HEAT PUMPS

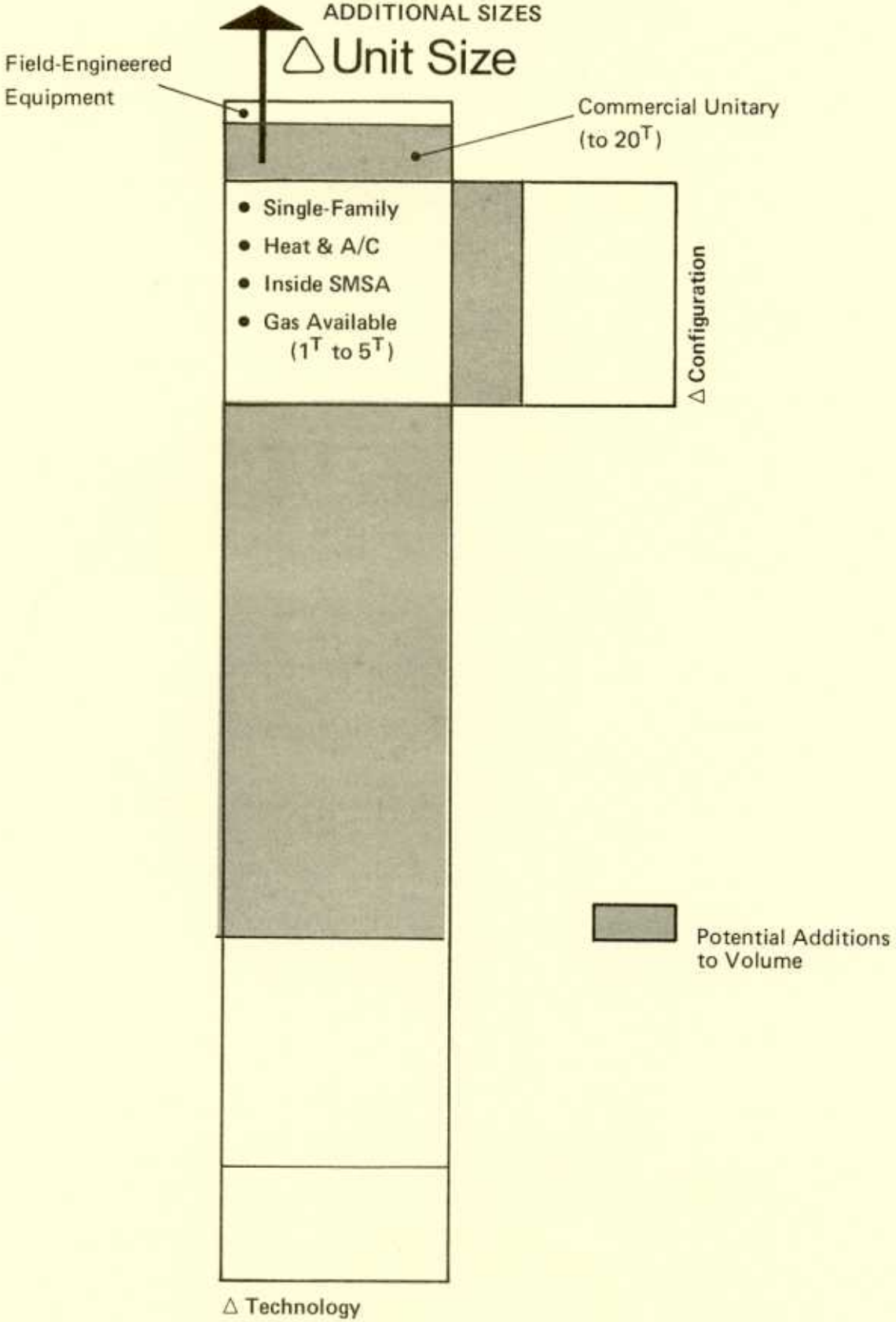
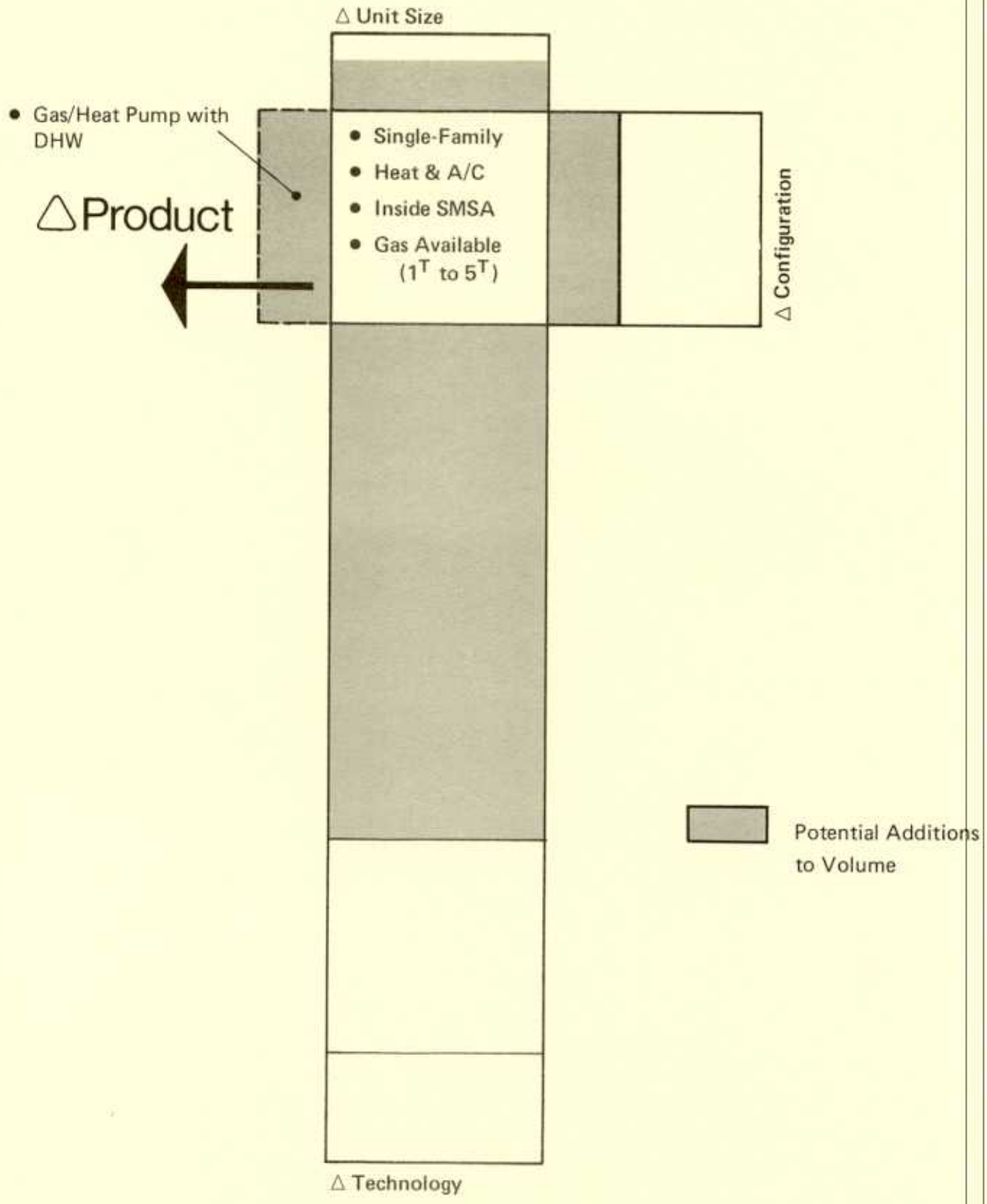


Figure V-5

APPLICATIONS FOR GAS HEAT PUMPS
ADDITIONAL FUNCTIONS



research and development activities. Finally, we estimated the effects of marketing policies on market penetration. Based on this economic and market analysis, we derived probable market penetrations for gas heat pumps. These estimates were based upon our past experience with consumer acceptance of new energy conservation devices and are projected optimistic, most likely, and pessimistic levels which generally correspond to differences that may be achieved through different levels of marketing, promotion and distribution policies.

In the first step, the economics of operating a gas heat pump were compared to other types of heating and cooling systems. For this analysis, we identified the installed cost of conventional HVAC equipment and gas heat pumps by industry segment (new construction replacement and retrofit), and we estimated the operating cost for gas heat pumps and conventional equipment by SMSA. Using these estimates, we calculated the payback period for gas heat pumps compared to other equipment.

The payback periods varied considerably across, SMSA's between equipment types and between market segments. Typically the payback period is shortest in the new construction segment where the incremental cost of a gas heat pump is smallest, and largest in the retrofit segment. In the new construction segment the gas heat pump is compared to the full installation cost of conventional equipment, whereas in the retrofit segment the full cost of the gas heat pump is the incremental cost. Similarly, the paybacks were shortest when compared to electric heat, which is typically the highest operating cost form of heating, and longest when compared to gas heating systems.

The installed cost for heating and air conditioning equipment was derived first by estimating the cost to the consumer of typical heating and air conditioning hardware and then adding the cost of installation. These costs were derived through interviews conducted by Arthur D. Little staff within various levels of the HVAC equipment distribution system and with HVAC contractors (Table V-4).

In general, installation costs are highest for the new construction segment because these costs include the cost of preparing the installation site and wiring and gas piping. Costs are lowest in the replacement segment where a piece of equipment is directly replaced, with the cost principally removing the old equipment and re-connecting the new equipment. Installation costs are typically somewhat higher in the retrofit segment since retrofit equipment is typically slightly different from existing equipment and extra labor will be necessary to ensure proper fits.

The cost of a gas heat pump under mass-production is projected by Allied Chemical to be 20% higher on an equipment basis than an electric heat pump and installation cost will also be somewhat higher, reflecting unfamiliarity with the gas heat pump system and its somewhat greater complexity. It is conceivable, over a time, that the cost of installing gas heat pumps will begin to converge with but remain slightly above the

Table V-4

ASSUMED HVAC EQUIPMENT AND INSTALLATION COSTS

(Constant Dollars)

	Equipment[1]			Labor		
	1980	1985	1990	New Construction	Replacement	Retrofit
Conventional Gas Furnaces	$ 400	$ 520	$ 520	$ 350	$150	N/A[3]
Condensing Gas Furnaces	--	750	750	400	N/A	200
Conventional Gas Boilers	700	800	800	800	300	N/A
Condensing Gas Boilers	--	1,200	1,200	850	N/A	350
Split System Unitary A/C	1,100	1,250	1,450	1,350[2]	150	N/A
Electric Heat Pump	1,750	2,000	2,100	1,350[2]	200	300
Gas Heat Pump	2,200	2,200	2,500	1,600[2]	N/A	450

[1]Delivered to job site, includes a distribution system mark-up.

[2]Includes cost of coil ($150).

[3]Not applicable.

Source: Arthur D. Little, Inc., estimates based on discussions with industry contacts.

cost of installing electric heat pumps. The higher amount will come from the extra cost of running a gas pipe and a chimney compared to electric wiring.

The estimates for the cost of operating a gas fired heat pump relative to other competing heating and cooling equipment were computed through a three step process. First, the COP's for the various heating and cooling products were identified (Table V-5). Then annual loads were calculated based on heating and cooling degree days, and those were multiplied by specific local prices for gas and electricity to produce annual operating costs by system type and SMSA. This yielded annual operating savings for gas heat pumps by each of 270 SMSA's.

Using the incremental inscalled costs and the incremental operating cost savings for gas heat pumps, we computed payback periods for each SMSA. These payback periods varied substantially by SMSA, by HVAC market segment and comparative fuel and equipment type. (Table V-6,7). In general, shortest paybacks come in comparison to "other heat" systems, and in electric heat pumps both using electric rates, because of the substantially higher cost of electricity. The longest paybacks were typically in comparison with gas fired equipment. The best paybacks are also in the areas with the colder climates, where heating costs dominate, because of the gas heat pump's high heating COP. Conversely, payback periods in southern locations with high cooling and low heating loads can be infinite because of the gas heat pump's low cooling COP.

We also analyzed how the payback period would vary under different COP assumptions for gas heat pumps; changing the capital cost of a gas heat pump has significantly greater effect on payback than changing the efficiency. The greatest impact also comes in the new construction segment where changing the cost of a gas heat pump has a significant change on the incremental investment (Appendix A1-4). This change in economics can have a noticeable effect on the potential markets for gas heat pumps as changes in capital cost can make the builder market substantially more penetrable than it would be at currently proposed prices.

C. MARKET PENETRATION

The actual sales of gas fired heat pumps were estimated from the measures of relative system economics and the number of available decisions. There is currently no fully defined methodology for doing this, since we are attempting to model a complicated and not fully understood consumer market determinant choice process. There is general agreement that payback period is important and that market interest begins to drop rapidly for paybacks over four years. There are also indications that, at very short paybacks, reasonable penetrations can be achieved. The construction industry moves very slowly and substantial market penetration by new products are not achieved rapidly even with strongly favorable, economic performance. A reasonably large portion of the market will not purchase gas heat pumps even with favorable system economics. In consequence,

Table V-5

EQUIPMENT PERFORMANCE PARAMETERS

(C.O.P.)

	1980	1985	1990
Heating:			
Conventional Gas Furnace	0.68	0.81	0.81
Condensing Gas Furnace	--	0.94	0.94
Conventional Gas Boiler	0.66	0.79	0.79
Condensing Gas Boiler	--	0.96	0.96
Electric Heat Pump*	1.5 to 2.2	1.5 to 2.2	1.8 to 2.6
Gas Heat Pump	1.20	1.20	1.20
Cooling:			
Split System Unitary A/C	2.50	3.30	3.30
Electric Heat Pump	2.40	2.90	2.90
Gas Heat Pump	0.50	0.50	0.50

* Varies by location.

Source: Arthur D. Little, Inc., estimates based on various trade and government publications.

Table V-6

ANNUAL PURCHASE DECISIONS BY PAYBACK PERIOD

Base Case - New Construction

(000 decisions)

Region	Payback Period (years)	Competing System: Gas Warm Air	Gas Hydronic	Other Heat	Electronic Heat Pump
New England	less than 3	0	0.3	0.1	0
	4 to 6	0	0	0	0.1
	6+	1.0	0	0	0
Middle Atlantic	0 to 3	0	.8	.4	.5
	4 to 6	1.0	0	0	1.5
	6+	14.4	0	0	0
East North Central	0 to 3	0	1.1	3.3	.4
	4 to 6	0	0	0	3.4
	6+	32.3	0	0	0
West North Central	0 to 3	0	.3	1.1	.8
	4 to 6	.5	0	0	.4
	6+	10.9	0	0	.3
South Atlantic	0 to 3	0	0	1.8	0
	4 to 6	0	0	3.0	2.6
	6+	52.6	0	3.0	10.2
East South Central	0 to 3	0	0	.3	0
	4 to 6	0	0	.8	.4
	6+	10.5	0	.5	2.0
West South Central	0 to 3	0	0	.4	.1
	4 to 6	.6	0	1.2	.6
	6+	17.5	0	1.2	.7
Mountain	0 to 3	3.2	0	1.3	2.2
	4 to 6	0	0	.3	.6
	6+	7.3	0	0	.7

Table V-6

ANNUAL PURCHASE DECISIONS BY PAYBACK PERIOD (CONT.)

Region	Payback Period	Competing System: Gas Warm Air	Gas Hydronic	Other Heat	Electronic Heat Pump
Pacific	0 to 3	0	0	.3	0
	4 to 6	3.0	0	2.2	0.3
	6+	31.7	0	.5	3.2
Total	0 to 3	3.2	2.4	9.0	7.8
	4 to 6	5.1	0	7.4	9.1
	6+	178.3	0	5.2	8.3
Grand Total		186.6	2.4	21.6	34.6

Source: Arthur D. Little, Inc., estimates.

Table V-7

ANNUAL PURCHASE DECISIONS BY PAYBACK PERIOD

Base Case - Replacement Market
(000 Decisions)

Region	Payback Period (years)	Competing System: Gas Warm Air	Gas Hydronic	Other Heat	Electric Heat Pump
New England	0 to 3	0	0	.8	0
	4 to 6	0	0	.1	0
	6+	.4	.4	0	0
Middle Atlantic	0 to 3	0	0	4.0	.2
	4 to 6	0	0	1.9	.2
	6+	11.9	6.4	0	0
East North Central	0 to 3	0	0	6.3	1.0
	4 to 6	0	0	1.9	0
	6+	49.4	11.3	0	0
West North Central	0 to 3	0	0	2.3	.3
	4 to 6	0	0	2.6	.1
	6+	31.0	4.6	0	0
South Atlantic	0 to 3	0	0	0	.1
	4 to 6	0	0	10.2	1.0
	6+	27.2	4.1	13.2	1.3
East South Central	0 to 3	0	0	0	.1
	4 to 6	0	0	.4	.1
	6+	9.0	.2	6.3	.8
West South Central	0 to 3	0	0	.6	0
	4 to 6	0	0	4.8	.3
	6+	32.4	.3	15.8	.6
Mountain	0 to 3	0	0	.7	.6
	4 to 6	0	0	1.8	.1
	6+	13.9	.7	.9	0

Table V-7

ANNUAL PURCHASE DECISIONS BY PAYBACK PERIOD (Cont.)

Base Case - Replacement Market

(000 Decisions)

Region	Payback Period	Competing System: Gas Warm Air	Gas Hydronic	Other Heat	Electric Heat Pump
Pacific	0 to 3 years	0	0	0	0
	4 to 6 years		0	3.6	.3
	6+ years	16.4	.6	10.9	.5
Total	0 to 3 years	0	0	15.5	2.8
	4 to 6 years	0	0	26.5	2.2
	6+ years	191.6	28.6	48.2	3.1
Grand Total		191.6	28.6	90.2	8.1

Source: Arthur D. Little, Inc., estimates.

we have estimated penetrations by system economic grouping under differing scenarios which would tend to reflect probable market penetrations, assuming different levels of marketing support and the possibility of somewhat differing economic or external scenarios.

Under the base or average market support scenario the annual sales of gas heat pumps will be in the range of 26,000 units out of the available market of 580,000 annual decisions (Table V-8). This is based on an assumption that approximately one-third of the consumers who would have a payback of less than three years and one-quarter of the consumers with a payback from four to six years and none of the consumers with a payback greater than six years would purchase gas heat pumps (Table V-9).

These levels of penetration are consistent with the general level of sales of gas air conditioners, implying that gas heat pumps, at these proposed price levels, would significantly cannabalize the existing market for gas fired air conditioners and would gain some additional market for applications where the heating potential for the product is recognized. However, at the proposed cost and performance levels, the gas heat pump is not attractive enough to move significantly beyond the current sales of gas fired air conditioners.

We also established general bounds for the probable, maximum and minimum level of sales, reflecting differing marketing circumstances. Strong marketing support, where there is significant incentive to actually sell gas heat pumps throughout the distribution channels, yields a high or optimistic case. Minimal marketing support, where gas utilities are only marginally active in supporting gas heat pumps and other distribution is not obtained, yields sales at a low level.

In summary (Figure V-6) the market potential for gas heat pumps with current designs and under generally applicable market conditions will be on the order of 26,000 units a year. This potential varies somewhat by HVAC market segment and versus other equipment types. We believe the potential is greatest in applications where heating loads are highest because of the higher performance factors for gas heat pumps than lower where the cooling loads are highest.

D. REQUIREMENTS FOR ALLIED TO COMMERCIALIZE GAS HEAT PUMPS

Meeting various marketing requirements will be necessary in order for any supplier to successfully introduce gas heat pumps and the effectiveness with which the suppliers of gas heat pumps marshall these forces will have a great deal to do with the product's actual sales. Differing marketing policies must be focused at each level of the manufacturing and distribution process to allow success and reasonable sales.

Table V-8

GAS HEAT PUMPS

ESTIMATED ANNUAL UNIT SALES

(Thousands of Units)

Case	Optimistic	Most Likely	Pessimistic
Baseline	85	26	9
Improved Efficiency • Heating 1.35 vs. 1.20 • Cooling 0.60 vs. 0.50	92	33	10
Lower Initial Cost • Equipment Cost: $1700 vs. $2200 • Installation Costs remain equal	148	80	37
Combination • Both improved efficiency and lower initial cost.	165	92	58

Assumes stable market 5 to 7 years after product introduction.

Source: Arthur D. Little, Inc., estimates.

Table V-9

ASSUMED MARKET PENETRATION RATES

(percent purchasing)

Payback	High Marketing	Average Marketing	Low Marketing
<3	1/2	1/3	1/4
4-6	1/3	1/4	0
>6	1/10	0	0

Source: Arthur D. Little, Inc., estimates.

Figure V-6

POTENTIAL MARKET OPPORTUNITIES FOR THE GAS HEAT PUMP

	Gas Furnace with A/C	Gas Furnace without A/C	Gas Hydronic with A/C	Gas Hydronic without A/C	Other Heat with A/C	Electric Heat Pump	Other Heat without A/C
New Construction	*Limited*, first cost penalty is significant.	*None*, but potential market for heating only model.	*Fair*, less cost increment, might require air to water model.	*None*.	*Fair to poor*, most alternatives are either oil or electric furnaces.	*Good*, but only if gas is competitively available.	*None*.
Replacement	*Limited to fair*, dependent upon availability.	*None*, little potential for even heating only model.	*Fair*, best when boiler fails.	*None*.	*Poor*, but requires rapid installation response and connection.	*Fair to good*, but requires gas connection.	*None*.
Retrofit	*Limited*, high efficiency furnaces and unitary A/C more attractive.	*None*, some potential market for upgrading dwelling to central A/C.	*Fair*, will depend on type of heating distribution system.	*None*.	*Fair*, some localized pockets of high interest.	*Limited to fair*, most installations do not have gas available onsite	*None*.

Source: Arthur D. Little, Inc., estimates.

An HVAC equipment supplier or product manufacturer will be essential to the commercialization process for gas heat pumps. Sales and promotion of gas heat pumps can best be performed by someone who is already in the HVAC industry and such a participant will be invaluable in the gas heat pump development and commercialization process. Ideally this party should both manufacture and distribute the gas heat pump, although some arrangements could be developed where a party outside the HVAC industry manufactured it, with distribution handled by an existing HVAC equipment supplier. The HVAC supplier must also be perceived as acceptable to most of the gas utilities in the major marketing areas. Most suppliers of reasonable size and reputation meet this criteria; however, particularly for the Allied gas heat pump with its absorption based technology, certain suppliers who participated in the gas air conditioning business may have somewhat tarnished reputations. It would also be extremely beneficial for Allied at this stage to get additional advice from others inside the HVAC industry about the cost and ease of manufacturing their absorption system.

Obtaining good, broad distribution is critical to effectively participation in the HVAC industry and participation by a successful HVAC manufacturer would help insure adequate distribution for the gas heat pump. In fact, gaining access to an established distribution network is the major barrier to entry for any new product within the HVAC industry, since the best distributors are typically closely alligned with single, existing manufacturers. Gas utilities can serve as a parallel system or as an adjunct distribution system, but only for small volumes, roughly under 50,000 units per year. In larger volumes it would be necessary to use directly or to parallel the existing distribution system.

The actual purchaser for most HVAC equipment is a contractor/dealer and the actual installation of most HVAC equipment, including gas heat pumps, will continue to be performed by these small, independent contractors. This route must be tapped as significant volumes cannot be obtained by depending solely on gas utility programs for installation. It will be critical to interest small contractors in gas heat pumps and get them to help promote the product; however, the technical qualifications and sales ability of most residential HVAC contractors are quite low. Very few residential contractors have experience with gas absorption equipment and distributor-sponsored training programs will be necessary. Special utility-sponsored service programs now exist for gas air conditioners and, in the electric industry, for electric heat pumps. These will be a great help if they are continued for gas heat pumps both in helping to overcome the lack of knowledge currently common among contractors and in improving their technical expertise. Gas utilities have substituted for contractors in servicing gas air conditioners with mixed degrees of success to date. They must, at least initially, be willing to do this for gas heat pumps but any large scale penetration will require bridging into the existing HVAC distribution network.

There are two principal downstream markets sold to by the contractor/dealers; homebuilders and consumers. At least initially, promoting to consumers directly will not be very productive since most consumers have no knowledge about their heating or cooling systems making direct consumer promotion very expensive and largely misdirected. Much better efforts can be spent educating dealers and getting a few good dealers to help promote the gas heat pump to consumers.

A very different situation exists for homebuilders. As a general rule homebuilders are concerned mainly with first costs and will rarely use equipment with higher first costs unless there is a substantial gain in the marketability of the house they are building. This did occur when electric heat pumps were provided as an alternative to electric resistance heating which was not acceptable to consumers in northern markets. Whether this phenomenon will be applicable to the gas heat pump is highly questionable, although gas is generally perceived to be an inexpensive fuel, aiding the potential sales of gas heat pumps.

The gas utility industry, while not directly consumers of gas heat pumps, must be sold on the concept so that they can, in turn, help sell consumers. At present, there is a reasonable level of interest in the gas heat pump which can be capitalized on by a well-accepted manufacturer and should be encouraged. Gas utilities are most interested in the cooling features of the gas heat pump, the features typically with lowest economic return to the consumers, creating a dilemma where increasing the basic marketability of the product by introducing a low cost, heating-only pump may cause decreased interest by gas utilities.

E. RECOMMENDED RESEARCH AND DEVELOPMENT DIRECTIONS

One result of sensitivity analyses and the preliminary economic studies we have conducted is an indication of how changes in the product might improve market potential. These basically break down into two families, new products or "product clusters" which may increase the aggregate marketability for gas heat pumps, and research and development directions which might improve either the cost or the performance of the gas heat pump and thereby improve the marketability of Allied's current product.

Given a choice between increasing the efficiency or decreasing the cost of gas heat pumps, Allied should strive towards decreasing the cost even at some minor sacrifice in efficiency. Basically, in the construction and HVAC industries, high efficiency products with higher first costs have not and are not likely to sell particularly well. Higher sales will generally result from lower first costs. The best product is one at the lowest cost, Figure V-7. This is particularly true in the new construction segment where first cost is substantially more important than efficiency. It appears that lowering the first cost of the gas heat pump by roughly 20% brings it closely in line with electric heat pumps and other heating equipment, beginning to give the gas heat pump a significant opportunity to penetrate the new construction segment. Increasing efficiency has a much smaller effect. Unfortunately, decreasing efficiency and decreasing

Figure V-7

ACCEPTABILITY OF NEW CONSTRUCTION PRODUCTS

1. Better Features, Lower Cost.

2. Same Features, Lower Cost.

3. Better Features, Same Cost.

4. Same Features, Same Cost.

5. Better Features, Higher Cost.

cost may tend to make gas heat pumps less attractive to the gas utility industry and to the federal government, but such changes in the product may increase their total sales. Furtheremore, the energy conserved by gas heat pumps of slightly lower efficiency but greater penetration in aggregate may be greater than the energy conserved from gas heat pumps with slightly higher efficiencies but lower penetration, because many more of them will be in use.

There is some evidence from our market study that a product cluster or family may be of benefit to the gas heat pump. Basically creating a product cluster may increase the total sales for all gas heat pumps and may enable sufficiently large manufacturing volumes to produce economies of scale in manufacturing. If a product cluster were to be looked at, two products would represent the first step; one would be the combined heat pump and hot water heater, particularly if this can give significant hot water heater savings; the second would be a heating only heat pump particularly if it can be produced at cost levels approaching those of conventional heating systems. The heating only heat pump is particularly interesting because the greatest economic savings from gas heat pump operation are in the heating mode and research could usefully be done to ascertain whether gas heat pumps offering heat only can be made at or near the cost of furnaces or boilers.

APPENDIX A

ANNUAL PURCHASE DECISIONS BY PAYBACK PERIOD - APPENDIX A-1

High Efficiency Case - New Construction
(000 Decisions)

Region	Payback Period (years)	Competing System: Gas Warm Air	Gas Hydronic	Other Heat	Electric Heat Pump
New England	0 to 3	0	.3	.1	.1
	4 to 6	.9	0	0	.1
	6+	.3	0	0	0
Middle Atlantic	0 to 3	0	.8	.4	.9
	4 to 6	4.2	0	0	1.0
	6+	11.1	0	0	0
East North Central	0 to 3	0	1.1	3.2	1.4
	4 to 6	.4	0	0	2.9
	6+	31.9	0	0	0
West North Central	0 to 3	0	.4	1.1	1.0
	4 to 6	5.4	0	0	.5
	6+	6.1	0	0	0
South Atlantic	0 to 3	0	0	2.1	0
	4 to 6	.5	0	2.8	2.7
	6+	52.1	0	3.0	10.0
East South Central	0 to 3	0	0	.3	0
	4 to 6	0	0	1.1	.4
	6+	10.5	0	.2	2.1
West South Central	0 to 3	0	0	.7	.1
	4 to 6	1.4	0	.6	3.2

ANNUAL PURCHASE DECISIONS BY PAYBACK PERIOD - APPENDIX A-1 (CONT.)

High Efficiency Case - New Construction

(000 Decisions)

Region	Payback Period	Competing Systems: Gas Warm Air	Gas Hydronic	Other Heat	Electric Heat Pump
Mountain	0 to 3	3.2	0	1.3	2.4
	4 to 6	0	0	.3	.8
	6+	7.3	0	0	.3
Pacific	C to 3	0	0	.3	0
	4 to 6	3.0	0	2.1	.7
	6+	31.8	0	.5	2.7
Total	0 to 3	3.2	2.5	9.7	6.0
	4 to 6	15.8	0	7.8	10.3
	6+	167.7	0	4.2	18.4
Grand Total		186.7	2.5	21.7	34.7

Source: Arthur D. Little, Inc., estimates.

ANNUAL PURCHASE DECISIONS BY PAYBACK PERIOD - APPENDIX A-2

High Efficiency Case - Replacement Market
(000 Decisions)

Region	Payback Period (years)	Competing Decision: Gas Warm Air	Gas Hydronic	Other Heat	Electric Heat Pumps
New England	0 to 3	0	0	.9	0
	4 to 6	0	0	0	0
	6+	.4	.4	0	0
Middle Atlantic	0 to 3	0	0	4.1	.4
	4 to 6	0	0	1.3	0
	6+	11.9	6.4	0	0
East North Central	0 to 3	0	0	6.6	.9
	4 to 6	0	0	1.6	0
	6+	49.4	11.2	0	0
West North Central	0 to 3	0	0	2.3	.3
	4 to 6	0	0	2.6	.1
	6+	31.0	4.6	0	0
South Atlantic	0 to 3	0	0	2.3	7.8
	4 to 6	0	0	9.3	1.4
	6+	27.2	4.1	12.4	.6
East South Central	0 to 3	0	0	0	.1
	4 to 6	0	0	.7	.3
	6+	9.0	.3	5.9	.6
West South Central	0 to 3	0	0	.6	.2
	4 to 6	0	0	5.7	.4
	6+	32.3	.3	16.5	.4
Mountain	0 to 3	0	0	.7	.6
	4 to 6	0	0	1.6	1.1
	6+	13.9	.7	.6	0

ANNUAL PURCHASE DECISIONS BY PAYBACK PERIOD - APPENDIX A-2 CONT.

High Efficiency Case - Replacement Market
(000 Decisions)

Region	Period	Competing Decision: Warm Air	Hydronic	Heat	Heat Pumps
Pacific	0 to 3	0	0	0	0
	4 to 6	0	0	12.0	.3
	6+	16.4	.6	2.5	.5
Total	0 to 3	0	0	17.5	3.5
	4 to 6	0	0	34.5	2.5
	6+	191.6	28.5	38.0	2.1
Grand Total		191.6	28.5	90.0	8.1

Source: Arthur D. Little, Inc., estimates.

ANNUAL PURCHASE DECISIONS BY PAYBACK PERIOD - APPENDIX A-3

Low Cost Case - New Construction

(000 Decisions)

Region	Payback Period (years)	Competing Decisions: Gas Warm Air	Gas Hydronic	Other Heat	Electric Heat Pump
New England	0 to 3	1.1	.3	.2	.2
	4 to 6	0	0	0	0
	6+	0	0	0	0
Middle Atlantic	0 to 3	15.3	.8	.4	2.0
	4 to 6	0	0	0	0
	6+	0	0	0	0
East North Central	0 to 3	32.2	1.1	3.2	4.3
	4 to 6	0	0	0	0
	6+	0	0	0	0
West North Central	0 to 3	9.0	.4	1.6	1.5
	4 to 6	2.4	0	0	0
	6+	0	0	0	0
South Atlantic	0 to 3	10.9	0	5.0	5.2
	4 to 6	12.2	0	.1	2.6
	6+	29.6	0	2.9	4.8
East South Central	0 to 3	1.7	0	1.5	1.1
	4 to 6	2.9	0	0	.4
	6+	5.9	0	.1	1.0
West South Central	0 to 3	4.9	0	2.1	1.2
	4 to 6	1.8	0	.3	1.6
	6+	11.4	0	.3	1.5
Mountain	0 to 3	10.6	0	1.6	3.5
	4 to 6	1	0	0	0
	6+	0	0	0	0

ANNUAL PURCHASE DECISIONS BY PAYBACK PERIOD - APPENDIX A-3 (CONT.)

Low Cost Case - New Construction
(000 Decisions)

Region	Payback Period	Competing Decisions: Gas Warm Air	Gas Hydronic	Other Heat	Electric Heat Pump
Pacific	0 to 3	19.3	0	2.6	2.2
	4 to 6	12.8	0	.1	.5
	6+	2.7	0	.2	.8
Total	0 to 3	105.1	2.5	17.7	21.4
	4 to 6	32.1	0	.5	5.2
	6+	49.6	0	3.5	8.1
Grand Total		186.8	2.5	21.7	34.7

Source: Arthur D. Little, Inc., estimates.

ANNUAL PURCHASE DECISIONS BY PAYBACK PERIOD - APPENDIX A-4

Low Cost Case - Replacement Market
(000 Decisions)

Region	Payback Period (years)	Competing Equipment: Gas Warm Air	Gas Hydronic	Other Heat	Electric Heat Pump
New England	0 to 3	0	0	.9	0
	4 to 6	0	0	0	0
	6+	.4	.4	0	6
Middle Atlantic	0 to 3	0	0	5.4	.5
	4 to 6	0	0	0	0
	6+	11.9	6.4	0	0
East North Central	0 to 3	0	0	8.4	1.0
	4 to 6	0	0	0	0
	6+	49.4	11.3	0	0
West North Central	0 to 3	0	0	3.6	.4
	4 to 6	0	0	1.4	0
	6+	31.0	4.5	0	0
South Atlantic	0 to 3	0	0	4.6	2.3
	4 to 6	0	0	7.7	0
	6+	27.2	4.1	11.7	.5
East South Central	0 to 3	0	0	.3	.4
	4 to 6	0	0	2.3	.3
	6+	9.0	.3	4.1	.2
West South Central	0 to 3	0	0	1.9	.6
	4 to 6	0	0	4.6	.2
	6+	32.4	.3	15.9	.2
Mountain	0 to 3	0	0	2.1	.7
	4 to 6	6.1	0	.1	0
	6+	7.7	.6	.1	0

ANNUAL PURCHASE DECISIONS BY PAYBACK PERIOD - APPENDIX A-4 (CONT.)

Low Cost Case - Replacement Market

(000 Decisions)

Region	Payback Period	Competing Equipment: Gas Warm Air	Gas Hydronic	Other Heat	Electric Heat Pump
Pacific	0 to 3	0	0	0	.4
	4 to 6	0	0	12.9	.1
	6+ years	16.5	.6	1.7	.2
Total	0 to 3	0	0	27.1	6.3
	4 to 6	6.1	0	29.8	.6
	6+	185.4	28.5	33.3	1.2

Source: Arthur D. Little, Inc., estimates.