FINAL REPORT

A HIGH SEASONAL PERFORMANCE FACTOR GAS HEAT PUMP FOR THE NORTH CENTRAL UNITED STATES

APPENDIX VOLUME II

7½ TON MARKET POTENTIAL STUDY

Prepared By: W.E. Hill and Company
Prepared For: Consolidated Natural Gas Service Company Inc.
And The U.S. Department of Energy
Prepared Under: DOE Prime Contract EY-76-C-02-2883

January, 1980

Consolidated Natural Gas Service Company Inc.

MTI 79TR68

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Appendix Volume II

7½-TON MARKET POTENTIAL STUDY

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Prepared Under: DOE Prime Contract EY-76-C-02-2883

January, 1980

Appendices to Final Report

Demonstration of a High SPF Gas Heat Pump
for the North Central United States

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*Contained herein.

CONSOLIDATED NATURAL GAS SERVICE COMPANY

7-1/2 TON MARKET POTENTIAL STUDY

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FOREWORD

A comprehensive evaluation of the market potential for the non-residential heating and cooling market was conducted by William E. Hill and Company under contract to Consolidated. The market potential was segmented by equipment class (unitary and built-up) and by unit size. The evaluation of market potential evaluated a number of important market influences, including: market structure, distribution chain, and customer attitudes.

The market potential estimation effort was carried out in two phases:

- The first phase centered on the 7-1/2 ton concept. The starting point for this phase was a specific product concept (rooftop unitary heat pump) and a specific market area (North Central United States). Thus, the focus of the first phase was the projection of market potential for unitary heat pumps in the 7-1/2 to 50 ton range for the North Central states.
- The second phase centered on the LSM concept. The starting point for this phase was a technological concept. The focus of the second phase was to specify a product that maximized the market potential.

The results of these market studies were used to evaluate the commercial business potential of the two heat pump concepts.

The material presented in this volume covers the first phase of the study. The work was initiated in August 1976 and the report in the body of this volume was submitted to CNG by W.E. Hill in March 1977.

A key output of these market potential studies was a quantitive statement of the commercial HVAC market's sensitivity to price premiums and life cycle costing. Energy-conserving HVAC equipment will generally be more expensive; therefore, it must usually be justified on the basis of life cycle costs. The acceptance of life cycle costing in purchase decision-making was an important criterion in assessing the market potential.

THE MARKET FOR THE GAS-FIRED HEAT PUMP AND THE OPPORTUNITY FOR THE HSPF UNIT

Executive Summary

The objective of this study is to help Consolidated Natural Gas (CNG) evaluate the commercial attractiveness of the HSPF (high seasonal performance) heat pump that is currently being developed by the CNG Research Department with funding assistance from the Energy Research and Development Administration. The market potential for the HSPF unit was projected to 1981, and key technical and market development issues were identified and evaluated. The term air conditioning as used in this report follows the Air Conditioning and Refrigeration Institute's (ARI) unitary classification which includes cool-only devices and combination heating/cooling equipment, such as year-around units (YAC) and heat pumps.

1. Continued development of the HSPF heat pump is recommended on the basis of a projected 1981 market potential of 65-90 thousand air conditioning tons in the North Central Region. This projection assumes that natural gas will be readily available for new nonresidential space conditioning applications in the 1980's, or -- in the case of limited gas availability -- that gas will be made available for certain energy-efficient devices, such as the HSPF unit. The following factors support this projection and recommendation:

   a. Acceptance of unitary equipment will continue, and such equipment will comprise nearly 60 percent of the total nonresidential air conditioning market in 1981. Within the unitary category, combination heating/cooling units will grow

to more than 50 percent of total unitary tonnage.

b. The available market for combination heating/cooling units in the 7-1/2 to 50 ton nominal size range is projected to be more than 300 thousand tons in 1981.

c. The physical growth of nonresidential air conditioning is expected to be 5-7 percent per year from 1981 through the 1980's, including new and replacement applications.

d. Interest in energy-efficient equipment will increase, and will be maintained at higher than current levels through the 1980's.

e. Increased use of life-cycle costing and other more-sophisticated equipment selection analyses will improve the competitive position of premium-priced energy-efficient equipment.

2. A number of key issues relating to market characteristics and requirements will have a major impact on the marketability of the HSPF unit.

a. Confusion and skepticism concerning future natural gas availability are widespread within the trade and important customer groups. Many users, installers, designers, and distributors of space conditioning equipment have experienced supply limitations which have affected equipment choices and produced psychological barriers to the selection of gas equipment in the nonresidential market.

b. Resistance to equipment premiums greater than 30 percent and payback periods greater than three years is evident in the current nonresidential unitary market. Rising energy costs and the use of more-sophisticated equipment evaluation procedures will increase the importance of operating costs, but the market will continue to be sensitive to first-costs and require reasonable payback periods for any first-cost premium.

c. Equipment reliability and the availability of parts and quality service are extremely important requirements in the nonresidential market. In many of these applications, particularly the commercial market, air conditioning is considered to be essential to the operation of the building. Equipment must be reliable, and service and parts must be readily available.

d. The air conditioning trade (manufacturers, distributors, designers and installers) heavily influence the selection of equipment in the nonresidential market. Customers may provide the basic system requirements and selection criteria and constraints, but the trade (particularly system designers) evaluate and recommend specific equipment to meet the customer's needs.

e. Other energy-efficient equipment, such as advanced electric heat pumps, high efficiency furnaces, solar and heat reclamation systems and other gas heat pumps may be competing for the same market potential as the HSPF unit in the 1980's.

f. Government programs and policies at national, state, and local levels, which are being developed to deal with the rapidly changing energy situation, will materially affect the characteristics of the market and the potential for energy-efficient equipment.

3. The following recommendations highlight key action steps relating to the overall HSPF development program:

a. Changes in comparative energy costs should be monitored, and the HSPF unit's cost of ownership should be periodically re-evaluated versus alternative equipment.

b. Perceptions of future gas availability will heavily influence the acceptability and marketability of the HSPF unit, and a comprehensive communication program should be developed to alleviate supply/cost concerns among the trade and important customer groups. The nonresidential market has been affected by supply restrictions in many areas, and a realistic factual presentation will be needed to clarify the relationships between sources and costs of energy, and explain the HSPF unit's potential position in national energy conservation objectives.

c. The selection of an equipment marketer(s) is crucial to successful commercialization, and should consider quality reputation, distribution strength, marketing resources, market position in high potential segments and the willingness to support the introduction and growth of the HSPF unit.

d. Technical development should be guided to ensure that equipment premium/payback and reliability/maintenance features

meet market requirements. Market requirements are currently undergoing significant changes, and should be re evaluated when more concrete equipment characteristics are available.

e. Extensive field tests to thoroughly evaluate actual operating performance and costs should be conducted as soon as possible. These tests should be programmed to provide data for technical development, production of a comprehensive business plan and as a sales tool in the initial market introduction.

f. A comprehensive, conservative, presentation of the unit's characteristics and market potential should be developed for trade introduction. Acceptance by the air conditioning trade, including equipment markets, will be a critical factor in the successful introduction of the unit, and care must be taken to present the unit in a commercial context, supported by factual, well-tested information.

g. A range of equipment sizes, at the lower end of the 7-1/2 to 50 ton range should be developed for initial market introduction to provide a commercially acceptable product line. Potential profitability should be evaluated on the basis of the total product line rather than on individual unit sizes.

h. External influences, particularly government energy policies and programs should be closely monitored and evaluated for potential impact on the HSPF program. Continued government support is desirable to ensure that the HSPF unit is consistent with national energy policies, programs and goals.

4. Specific technical development issues must be addressed in terms of market requirements as well as technical/engineering feasibility.

a. Equipment first-costs will have an important impact on total market potential, and should be held to within 30 percent of the first-costs of premium-quality gas/electric year-around units.

b. Operating efficiency must produce a payback of equipment premium within three years, preferably within two years.

c. Manufacturing feasibility for all components and the assembled unit must be assured, including cost and quality control objectives.

d. Field testing should be designed to determine equipment reliability, ease of maintenance, operating efficiencies, and the practicality of all components and unique features.

e. The introductory units should not include complex features, and should be as simple as possible consistent with reliability and performance requirements. Potentially advantageous product extensions should be evaluated early in the development program for subsequent market introduction. Alternate fuel capability, chiller/heater and split configuration, process (non-air) source and solar boost are among the potentially important areas that should be investigated.

BACKGROUND AND RECOMMENDATIONS

The Market For The Gas-Fired Heat Pump And The Opportunity For the HSPF Unit

It has long been recognized that the heat pump can provide space heating with very efficient use of energy, as well as cooling during the hot season of the year. By using "free" ambient thermal energy released in refrigeration cycle (i.e., the conditioned space is warned with the rejected heat from cooling the outside air), the heat pump cycle can deliver more Btus of heat than are actually consumed to power the process. Currently available air-source electric heat pumps have typically operated efficiently in moderate winter climates with, say, 40 degree F and above ambient temperature. They have only enjoyed moderate success in colder climates, where energy expensive, supplemental electric resistance heating must be included to provide sufficient heat during cold weather, i.e., 30 degree F and below.

Conservation of energy resources is recognized by the gas industry, ERDA (Energy Research and Development Administration) and other groups involved in national energy policy as a means of effectively utilizing our energy resources and meeting our future energy needs. Considering the significant percentage of total energy consumed in

space conditioning, the thermal efficiency of the heat pump places it in a particularly important position as a means of energy conservation.

Consolidated Natural Gas has sponsored a gas-fired heat pump development project for several years, which shows considerable promise of offering an efficient packaged unit in the medium-sized range. This unit is designed for cold climatic conditions and could offer good overall seasonal efficiency (thus "HSPF", high seasonal performance factors) for the climate of the North Central[1] United States. Current technical feasibility indicates an equipment nominal size range of 7-1/2 - 50 tons, which would meet the needs of the commercial and light industrial market for heating and cooling applications.

The development has already been taken to a concept feasibility stage, and Consolidated Natural Gas believes that it is necessary to develop a preliminary measurement of the unit's potential in the market place, and obtain market information which would assist in guiding subsequent steps in the development of the HSPF unit. The objectives of this report are to provide sufficient inputs for management's determination of the direction of the further development of the HSPF unit, and to highlight significant strategic questions related to the eventual introduction of the unit to the market. To achieve objectives, the following tasks have been accomplished:

(1) The term North Central United States refers to the Northeastern quadrant excluding New England, as shown on the map page. 22

1. Measurement of the market for nonresidential unitary equipment, including combination heating/cooling units, in the North Central Region. This includes an analysis of historical market size and growth, and an evaluation of significant trends for all types of unitary equipment, unitary market segments, and macro business factors.

2. Characterization of the market for packaged heating/cooling equipment. This characterization includes detailed analyses of market structure, trade/customer relationships, market segments, equipment selection processes, system design and installation influences and market requirements and attitudes with respect to equipment first-costs, operating costs and reliability. The result of this evaluation is an understanding of the dynamics of the market, and a determination of the equipment selection/use factors with key commercial significance for the HSPF unit. Of particular importance is the analysis of customer attitudes regarding equipment first-costs, operating costs, payback periods and the methods used to analyze system costs.

3. Projection of the total 1981 market for the gas-fired HSPF heat pump in the North Central United States. Based upon the measurement and characterization of the market, the projection focuses on the extent to which the HSPF heat pump can satisfy the requirements of the projected available market for combination heating/cooling equipment. Since the energy situation is difficult to project, three different sets of assumptions are considered to provide market projections for a range of gas availability scenarios. A qualitative evaluation of market potential for the unit in five selected markets outside the North Central Region is also provided.

4. Evaluation of perspectives relating to market potential and penetration, key marketing issues and technical aspects of the HSPF development program. A number of important market development and penetration issues which will impact the introduction and successful marketing of the HSPF unit are highlighted. Specific recommendations are made regarding technical development, program coordination, and the key issues that must be addressed.

Study Approach and Conduct

This study was designed to evaluate the prospects for the HSPF heat pump in the North Central Region, and provide a qualitative comparison to five selected markets in other areas (Atlanta, Dallas, Los Angeles, St. Louis and Washington, D.C.). The approach recognized that the combination of a number of factors -- climate, fuel supplies and costs, gas utility activity, and concentrations of various building types -- creates a series of markets within the North Central Region that could differ from one another. Accordingly ten major metropolitian areas were selected for coverage, representative of these variations are accounting for a significant portion of the North Central market.

The term air conditioning as used in this report includes all types of unitary equipment as defined by the Air Conditioning and Refrigeration Institute (ARI). This includes cool-only equipment as well as combination heating/cooling equipment such as year-around units and heat pumps. Conventional furnaces are not included.

Quantitative information on the market was developed on the basis of statistics from ARI, A.G.A., U.S. Department of Commerce F. W. Dodge Construction Forecasts, and other industry sources. At the same time, benchmarks and qualitative information gathered in field research contributed significantly to the development of quantitative

estimates of the market. In all, an estimated 75 field interviews and 105 telephone interviews were conducted.

- Ten major cities in the North Central Region were visited by members of our staff, who conducted in-depth interviews with consulting engineers, owners and builders, utilities, distributors, mechanical and air conditioning contractors and contractor/dealers. This research emphasized an investigation of the major elements in the market structure and quantitative data on the market in question.

- In-depth interviews were also conducted in the five selected cities outside the North Central Region, primarily to develop qualitative market comparisons with the North Central Region and determine what modifications in the basic HSPF design might be needed to meet user-requirements in these markets.

- Telephone interviews were conducted among mechanical contractors, air conditioning contractors and contractor/dealers in 15 cities in the North Central Region and the five selected cities. This provided a broader statistical base for interpreting the market structure and characteristics and segmenting the market.

Summary of Findings and Conclusions

A. Current Status of the Nonresidential Unitary Air Conditioning Market.

1. The total U.S. nonresidential air conditioning in the three to over 50 ton equipment size range peaked in 1973 at 5.8 million tons and was 3.1 million tons in 1975. Total unitary equipment (in which components are sized and packaged at the factory) in this market was about 1.8 million tons in 1975, with 455 to 490 thousand tons in the North Central Region. The unitary share of the total market has increased from about 45 percent in 1965 to 58-60 percent in 1975. This has come at the expense of central build-up systems (in which components are selected for specific applications and assembled in the field).

   a. In North Central Region, 7-1/2-50 ton units represent 62-65 percent of the total nonresidential unitary tonnage. Equipment between three and 7-1/2 tons represents about 1/3 of the market, and units larger than 50 tons represent

5-6 percent of the total tonnage, a portion that has doubled over the last five years as more equipment has been made available, and larger unitary units have more-frequently been used instead of central build-up systems.

b. Units between 7-1/2 and 15 tons still represent the bulk of units and tonnage within the 7-1/2 to 50 ton range; 80 percent of the units and 57 percent of the tonnage in 1975. Over the last five years, larger size units (20 tons and above) have gained a slightly increased share, due to greater availability of equipment in these sizes, and substitution for central build-up systems.

c. Single package units (horizontal, year-around and some heat pumps) have gained an increasing share of the unitary market over the last five years and accounted for about 65 percent of the total nonresidential unitary tonnage in 1975. Single package units (in which all components are located in one chassis) offer ease of installation, lower installation costs and generally lower first-costs than split or vertical systems (in which certain components are located in separate chasses). They have become very popular in the commercial and light industrial market segments, and are generally installed as rooftop equipment (thus saving internal space).

d. Combination heat/cool units (year-around and heat pumps) have gained an increased share and in 1975 accounted for about 74 percent of total single package tonnage, or almost 50 percent (140-145 thousand tons) of the total nonresidential unitary market in the North Central Region. Year-around (YAC) units, typically gas heating and electric cooling, have become well established in the market and are generally considered to be the lowest-cost solution for heating/cooling requirements. Heat pumps are only starting to penetrate the nonresidential market in the North Central Region, and represent only 2-4 percent of combination heat/cool tonnage.

e. Small tonnage gas absorption systems and gas heating units have been severely affected by uncertainties in the availability of natural gas for new construction in many areas of the country. Gas heating has lost share in new residential construction, and in many areas new nonresidential applications have been severely restricted for the last three to four years.

Although gas is generally preferred in the nonresidential market, gas has lost share in the heating side of year-around combination heat/cool equipment, from 88 percent in 1970 to about 65 percent in 1976.

2. The nonresidential unitary market grew steadily until 1973-74, and then declined dramatically between 1973 and 1975 due to the severe construction recession. Average annual growth between 1965 and 1973 was in excess of 12 percent, but between 1973 and 1975 tons installed decreased 43 percent, due to severely reduced construction activity. Combination heat/cool equipment tonnage also declined between 1973 and 1975, but maintained an annual average rate in excess of 12 percent between 1965 and 1975, primarily due to the first cost advantage of year-around packaged units versus separate heating and cooling systems. The growth rate between 1965 and 1973 was in excess of 15 percent per year.

3. Equipment selection in the nonresidential air conditioning market is heavily influenced by the complex interaction between customers, system designers, installers, servicers, distributors and manufacturers.

   a. The time span of building ownership and whether the system purchaser will also be the user, strongly affect the selection of equipment. Speculative customers, currently about 30 percent of total customers, tend to be very sensitive to equipment first-costs and generally purchase only on a first-cost basis. Non-speculative customers, particularly those who will also be system users, are more concerned with system operating costs and features.

   b. System designers strongly influence, or are totally responsible for, equipment selection. In-house and consulting engineers are most often involved in large and/or complex projects, particularly for large national companies and institutional applications. They do almost all of the design of built-up systems and much of the design of larger unitary systems. Mechanical and air conditioning contractors do a high percentage of the design of unitary applications using 7-1/2 - 50 ton units, particularly in the commercial market, and replacements. Contractor/dealers generally do little design, other than sizing units for residential and small commercial applications.

c. Installing contractors also influence equipment selection, and tend to specialize in certain markets or specific applications. Mechanical contractors do most of the large plan and spec work, almost all of the built-up systems and generally install plumbing and process piping in addition to HVAC equipment. Air conditioning contractors do little or no piping work, generally use non-union labor, and tend to concentrate on commercial and industrial negotiated work. Both will install and service several brands of equipment. Contractor/dealers generally handle one brand of equipment and tend to emphasize residential and small commercial applications.

d. The availability and quality of service/maintenance is an important selection factor, and often different contractors are involved in the installation and service of a system. While all installing contractors provide service during warranty, service generally represents a small proportion of mechanical contractors business, but is very important to contractor/dealers. This highlights the fact that the installing contractor and service contractor are often different parties.

4. The growth in unitary year-around equipment, particularly in the commercial store and office markets, has been heavily supported by market sensitivity to equipment first-costs. Single package, heat/cool units are generally considered to be the lowest first cost alternative for satisfying heating and cooling requirements.

   a. Equipment first-costs are a very important consideration to all customers, and 65-70 percent of the market is highly-first-cost sensitive. To be acceptable, a premium-priced unit must provide significant compensating advantages in terms of operating costs, maintenance or other characteristics.

   b. Even in premium/payback or total cost of ownership analyses, the first-cost premium may be an overriding factor. The current market exhibits resistance to first-cost premiums greater than 30 percent, and payback periods in excess of three years.

5. Rising energy and service costs have recently begun to increase the importance of operating costs, and the analysis of total owning and operating costs in the equipment selection process. First-cost premiums are becoming more acceptable, however, if the energy-use efficiencies of the unit result in significantly reduced operating costs.

6. Equipment reliability and the availability of service and parts are extremely important equipment selection considerations. In many applications, particularly in the commercial segment, air conditioning is considered to be a necessity for conducting business. System designers often built redundancy into the system by using several smaller units rather than a single larger unit.

7. Unitary product lines typically include a range of sizes to provide for combinations of different sizes to meet varying load and redundancy requirements. New products are generally introduced in smaller sized units, with larger sizes being added over time.

8. Historically, the air conditioning market has been slow to accept new products and technologies, unless significant advantages are present. Most of the innovations in the last five to ten years have involved controls and peripheral equipment (i.e., variable-air-volume), rather than radically new components or technologies. New products have only achieved rapid acceptance when they satisfied the prevailing market characteristics and requirements. Examples are: the lower first-costs of combination heat/cool units in the 1960's; variable-air-volume and economizer controls in the early-to-mid 1970's, and electric heat pumps in areas where natural gas is not available.

9. The energy-efficiency characteristics of the HSPF heat pump conceptually fit the changing requirements of the market with respect to the increasing emphasis on operating performance and costs.

B. The Future Market for Combination Heat/Cool Equipment, and the Potential for the HSPF Heat Pump.

1. The identified characteristics and trends in the nonresidential unitary equipment market support the continued acceptance of single package heat/cool equipment through the 1980's. Combination heat/cool units will continue to provide a lower first-cost alternative to the installation of separate heating and cooling systems.

2. The tendency or willingness to accept first-cost premiums in return for greater operating efficiencies and lower operating costs is expected to increase, from the current level of 30-35 percent of total customers to about 40 percent by 1981.

3. Increased application of life-cycle costing and other methods of analyzing total system costs is expected to support the selection of energy efficient equipment. More sophisticated analytical approaches (such as life-cycle costing) will be applied to compare alternative systems that feature significantly different cost and operating characteristics.

4. The available North Central market for single package heat/cool units in the 7-1/2 to 50 ton size range is projected to be 300+ thousand tons in 1981. This includes a projected construction segment of 200-220 thousand tons and a replacement segment of 100-120 thousand tons.

5. The potential North Central market for the HSPF heat pump is projected to be 65-90 thousand tons in 1981 (assuming that natural gas is available for nonresidential space heating applications). This projection is based upon the assumptions that the HSPF unit will have a 15-35 percent premium versus top quality gas/electric year-around units, operating efficiencies sufficient to provide premium payback in less than three years and that the percentage of total customers willing to consider a premium/payback situation will increase to 40 percent.

6. The unitary replacement market is rapidly increasing in importance and is projected to be one third of total tonnage in 1981 and almost one half of total tonnage by 1986. As effective saturation of new nonresidential construction is approached, most of the market growth will occur in replacement applications.

Between 1981 and 1986, construction tonnage is expected to grow at an average rate of 3.5 percent per year, while replacement tonnage should grow at a rate of 14-15 percent per year. This higher growth reflects the high initial growth rate of year-around equipment during the late 1960's and early 1970's, equipment which will be reaching replacement age between 1981 and 1986.

7. The market potential for the HSPF unit is expected to increase over time as increasing energy costs cause shifts in key market characteristics. The market potential for the HSPF unit is heavily influenced by the percentage of total customers who are willing to accept a premium/payback situation. Continued increases in energy costs are expected to result in increased concerns for operating costs, and willingness to pay a first-cost premium to achieve annual fuel savings through improved equipment efficiencies.

C. Recommendations

1. Based upon the product data supplied by the Consolidated Natural Gas Research Department, and a preliminary evaluation of the nonresidential small-to-medium size unitary equipment market, continued development of the HSPF heat pump is recommended. Supporting this recommendation are the following:

   a) Acceptance of unitary air conditioning equipment is expected to continue, with general physical growth of 6 to 8 percent per year for the next five years and 5 to 7 percent through the 1980's. Single package units are expected to continue gaining share within the unitary equipment market.

   b) A projected available market (North Central Region) in 1981 of 300 to 340 thousand tons for single package combination heat/cool equipment, and within this, an initial potential market of 65 to 90 thousand tons for the HSPF heat pump (assuming that natural gas is readily available for space conditioning, or is otherwise made available for the HSPF unit).

   c) Continuing increases in energy costs and concern for energy efficiencies should stimulate interest in energy-efficient space heating equipment and willingness to

accept higher equipment first-costs in return for significant operating savings related to energy costs.

d) An increased concern for total owning and operating costs, and increased use of life-cycle costing to compare equipment alternatives should support the sales of premium equipment. By incorporating all system costs into the equipment selection analysis, costs other than first-costs are given proper consideration.

2. HSPF program objectives, particularly those relating to equipment characteristics, must satisfy market and marketing requirements as well as technical or engineering feasibility. An appropriate understanding of the market framework and the dynamics of the market will help reduce the likelihood of outright failure or retarded market penetration. Commercial sized absorption air conditioners, for instance, were premium-priced but failed to satisfy the prevailing market requirements for first-costs (or premium payback), ease of maintenance and reliability characteristics.

a) First- and operating cost objectives, reflecting expected market requirements, should be established for the HSPF unit. Market requirements and the cost objectives should be re-evaluated on a periodic basis.

b) Design decisions relating to reliability and maintenance must reflect the realities of the market place, and limits for the HSPF should be established for reliability characteristics equal to or better than competing equipment. Certain component failure records and service functions may be quantified based on current equipment and maintenance records. The ease of performing maintenance would require more judgmental guidelines, but should nevertheless be given priority consideration.

c) Comprehensive field testing under actual operating conditions should be initiated as soon as possible to provide solid information on operating costs, performance, reliability and maintenance. These factors will ultimately determine the marketability of the unit and are as yet unanswered. Several years of reliable test data will be needed at the time of market introduction.

d) The selection of an equipment marketer(s) is perhaps the most critical decision from a marketing/business point of

view, and information should be gathered to allow for the identification of appropriate candidates, and a detailed evaluation of each marketer(s) trade position and resources.

e) Acceptance of the product by the air conditioning trade is essential, and will require a thorough, comprehensive marketing/communication program. Many significant problems and perceptions must be addressed and overcome. Field test information will play a central role, and consideration should be given to the use of an independent outside party to verify and certify all test data.

f) Market requirements dictate that the HSPF unit must be commercially developed largely by the air conditioning trade; including manufacturers, designers and contractor-installers. It is strongly believed that gas utilities should not be directly involved in the sale, distribution and servicing of the unit but they must be convinced of the unit's attractiveness and market potential, and play an active supportive role in the introduction of the product.

f) Overall coordination and guidance should ensure that the HSPF development program is consistent with governmental policies and programs for energy conservation and effective utilization of the nation's energy resources. Continued governmental support is desirable, perhaps necessary, to ensure the successful commercialization of this unit.

3. Technical development at this stage should consider the following market requirements: reliability, maintainability, equipment first-costs, system operating costs, and component and product line availability.

a) Reliability is an important consideration in most applications, often the most important "non-cost" factor, and should be an important objective in the technical development effort. High reliability can be an important selling point, and since the unit will have a first-cost premium over conventional equipment, high reliability will probably be expected and must be assured.

b) Equipment first-costs and operating costs will be important determinants of total market potential and an important basis for the development of the strategic marketing plan.

4. Manufacturing feasibility, including cost and assembly considerations, must be assured for all the major components. Required quality control objectives must be obtainable.

5. Extensive field testing should be accomplished as soon as possible to evaluate performance and reliability. Due to the initial problems encountered with electric heat pumps and packaged gas absorption systems, and the likely identification of the HSPF unit with these products, extensive field testing is required to assure technical reliability and support market acceptance.

   a) The equipment must prove reliable under field conditions likely to be encountered in actual use. The ease and frequency of maintenance should be well tested, including diagnostic aids which should be developed and provided for field maintenance. Such aids could include training aids, diagnostic equipment, tools, or instruments mounted on the unit itself.

   b) Operating efficiencies must support a payback period of three years or less, depending upon the amount of first-cost premium. Seasonal operating efficiencies and costs should be documented and analyzed in such a manner that data for other applications and areas can be developed for comparisons to alternative units.

   c) Any feature that is not fully tested in the field should not be included on the initial market units. Unique features such as the defrost cycle, hot water heating, etc., must prove to be practical, effective and reliable.

   d) The introductory units should not include complex features, and should be as simple as possible consistent with reliability and performance requirements. Potentially advantageous product extensions should be evaluated early in the development program for subsequent market introduction.

      - The capability to use alternative fuels is highly advisable due to uncertain attitudes regarding fuel supplies and the added potential in New England, for example, due to climatic conditions and the historical position of oil heating. Units could be designed to utilize several types of fuel, or separate versions could be provided for gas, oil, etc.

- Data provided for this study indicates a first-cost premium (versus a top-line gas/electric year-around unit) of between 15 and 35 percent. A more specific first-cost range (which may be revised as development proceeds) is important for increased accuracy in developing market potential and analyzing costs of ownership. If at all possible, consistent with reliability, the first-cost premium should be 30 percent or less. Higher premiums may be acceptable if compensating features and/or benefits are present, but premiums higher than 35 percent were not specifically considered in this study.

- Operating characteristics sufficient to produce a premium payback period of three years or less (preferably two years or less) should be a key development objective. As the first-cost premium of the unit increases, the unit must be more efficient and cost effective to provide a reasonable payback. Extremely high operating savings, sufficient to cover the premium in less than one year, were not specifically researched in this study and probably represent an entirely different evaluation process.

c) To the extent possible, components and parts utilized in the unit should be standard items already in general distribution in the air conditioning trade. Major components will be entirely new and unique, and the resulting additional stocking and distribution requirements for service and maintenance should be minimized and simplified. A component module approach would probably provide a good alternative, but the development of this approach should not only consider components engineering and technical design, but also maintenance parts distribution and a reduced need for field diagnosis and repair.

d) Technical development should provide a competitive initial product line of three to four sizes at the lower end of the 7-1/2 to 50 ton size range. 7-1/2 tons is presently the smallest technically feasible unit and is a desirable, perhaps necessary, size for the development of a suitable product line. In fact, consideration should be given to the technical feasibility of a five-ton unit. While such a unit may not itself be commercially competitive, it may be an important component of an acceptable commercial product line. Potential profitability should be evaluated on a product line basis, rather than on an individual unit basis.

- Chiller/heater, split configuration, process (non-air) source and solar boost are among the potentially important areas that should be investigated.

6. A number of external factors will have significant impact on the decision to introduce the HSPF unit and its ultimate market success, and these factors should be monitored on a periodic basis to provide an update on the market environment and a frame of reference for scheduled reviews of the unit's market potential.

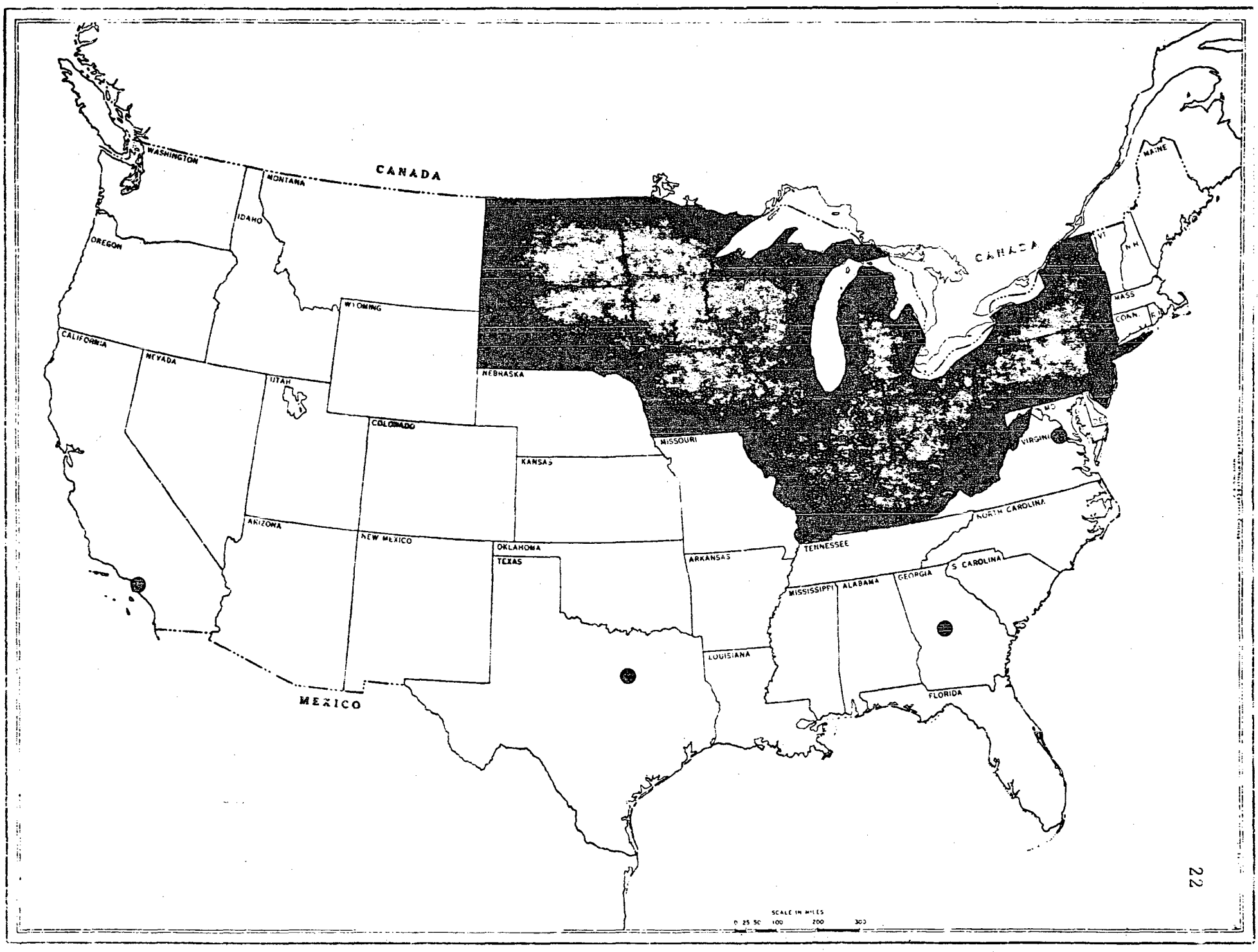
   a) Other types of energy efficient equipment are being developed, and important projects should be monitored for general status and specific information that might relate to the HSPF unit. Various other gas heat pumps, as well as other types of energy-equipment space conditioning devices, including solar systems, are under development and are likely to compete with the HSPF unit in the 1980's.

   b) The gas supply situation is monitored as a matter of course in Consolidated's everyday business, and is perhaps the most critical external factor relative to the potential for the HSPF unit.

   c) Energy costs are likely to be extremely volatile in the next few years and periodic reappraisals of comparative energy costs are desirable to evaluate the HSPF's relative economic benefits. Since the cost of ownership study identified the competitive problem of "all electric" rates, the availability of these rates in the future should be closely monitored.

   d) Design trends are changing rapidly in response to rising energy costs and new energy-related construction standards and periodic evaluations of the effects on market characterists and requirements are desirable. These designs trends will have a significant impact on the air conditioning market structure and characteristics, and the market potential for the HSPF unit.

   e) Methods to effectively monitor governmental energy policies should be implemented as soon as possible. Energy policies at federal, state and local levels must deal with a multitude of complex issues, and will significantly impact the HSPF development program and market introduction.



I. HISTORICAL ANALYSIS OF THE NONRESIDENTIAL MARKETS FOR 7-1/2 TO 50 TON UNITARY AIR CONDITIONING EQUIPMENT

The fastest growing of all intermediate tonnage air conditioning equipment markets has been the single package combination heat/cool unitary market, which consists of year-around units and heat pumps. Together, tonnage installations of these equipment types in the nonresidential market have grown at an average annual rate in excess of 15 percent between 1965 and 1975, compared to about 4.9 percent for total unitary equipment, and 1.8 percent for total air conditioning in this market. Unitary equipment (in which components are sized and packaged at the factory) has increased its share of the total nonresidential market from 44-46 percent in 1965 to 58-60 percent in 1975. This increase in share has occurred at the expense of central built-up systems (in which individual components are selected for specific applications and assembled in the field). The most important market for unitary equipment has been the commercial segment, which includes commercial office buildings, stores, shopping centers and restaurants; representing 44-48 percent of total nonresidential tonnage in 1975. Of primary interest in this report is the market for single package, combination heat/cool unitary equipment which in 1975 represented 420 thousand tons for the total U.S. and 140-145 thousand tons for the North Central Region.

A. Size and Growth of the Market

1. Total market. The market for nonresidential air conditioning in the three to over 50 ton equipment size range peaked in 1973 at 5.8 million installed tons and was 3.1 million tons in the recession year of 1975. Exhibit I-1 shows the size and growth of this market and the proportionate shares of the two basic equipment types, central build-up systems and unitary systems. Between 1965 and 1975 the total market grew at an average annual rate of 1.8 percent, but through the peak year of 1973 growth was an average of 10 percent per year.

2. Total unitary market. Total unitary equipment in this market was about three million tons in the peak year of 1973, and 1.8 million tons in 1975. Average annual growth through the peak year of 1973 was 13 percent. Between 1973 and 1975 installed tons declined 42 percent due to severely reduced construction activity. Unitary tonnage has grown at a considerably higher rate than built-up systems, and the unitary share of the total market increased from 44 - 46 percent in 1965 to 58 - 60 percent in 1975.

3. Unitary market - U. S. and North Central Region. The total nonresidential unitary market for three to over 50 ton equipment in the North Central Region was 455 to 490 thousand tons in 1975. Exhibit I-2. This exhibit clearly shows the tremendous swings in installed tonnage that have occurred over the past five years. Between 1973 and 1975, tons installed declined 43 percent primarily due to the severity of the recent recession. The North Central Region has also been affected by a longer-term shift of economic growth and new construction from the North and East to the South and West. This has resulted in a slight decline in the regions share of the total U. S. market, from 27 - 29 percent in 1970 to 25 - 26 percent in 1975.

4. Unitary market - equipment size segments. Equipment in the 7-1/2 - 50 ton nominal size range represents 62 to 65 percent of the nonresidential market in the North Central Region, a portion that has declined only slightly since 1970. Exhibit I-3.

a. Equipment under 7-1/2 tons nominal size represents approximately one-third of the market. The smaller-sized units are often used as multiples to build redundancy into the total system and to decrease ductwork and field labor costs. In addition to being used as a prime unit, they are also used as "swing-size" units in combination with larger units to provide flexibility in meeting load and zoning requirements.

b. Although units larger than 50 tons represent only 5 - 6 percent of total tonnage, this percentage has doubled over the last five years as more equipment has been made available in the larger sizes, and larger unitary units have been utilized instead of central built-up systems in the 50 to 150 ton size range.

5. North Central unitary market; 7-1/2 to 50 ton sizes. There have been noticeable shifts to larger-sized units within the 7-1/2 to 50 ton size range. Exhibit I-4 compares the percentage of total units and tonnage for three size ranges; 7-1/2 - 15 tons, 20 - 30 tons and 40 - 50 tons for the years 1970, 1973 and 1975. 7-1/2 to 15 ton units represent about 84 percent of the total units and 65 percent of the total tons in 1970, and 80 percent of the units and 57 percent of the tons in 1975. Major reasons for these shifts are the use of larger unitary units instead of central built-up systems and, more importantly, greater availability of units in the larger sizes. 7-1/2 - 15 ton size units still represent the greatest percentage of tonnage, and to an even greater extent, the percentage of units. Details of the distribution of units and tonnage for all nominal sizes in the 7-1/2 to 50 ton range are shown in Exhibit I-5.

B. North Central Market by Major Unitary Equipment Types

1. Five major types of unitary equipment. The 7-1/2 to 50 ton unitary equipment market is classified into five major types. The classifications are based upon both configuration differences (single package and split package) and functional differences (heat/cool and cool only). The five types are shown in the schematic in Exhibit I-6 and briefly described below:

a. Horizontal -- Single package, cooling-only units including compressor, condenser, and fan-coil units on one chassis. Horizontal units comprise an important part of the "rooftop" market and represent a low-cost system in which minimal field labor is required for installation. This equipment has

come to be used in installations where only cooling is required, in low-rise buildings, and where no great degree of control or zoning is necessary. Horizontal units are also often used in combination with heat/cool packaged units in many commercial applications, i. e., discount stores, where the interior area may require cooling but little or no heating. Technically, the term horizontal is a factory definition that implies cool-only (as it leaves the factory), but in practice a high proportion of these units are installed with field-applied strip or duct heaters.

b. Heat pumps -- Heat pumps have been available for a number of years, but have primarily been successful in residental applications in certain (southern and western) geographical areas. The heat pump is a heat/cool device with a cooling cycle comparable to conventional air conditioners and a heating cycle that utilizes refrigeration/compressor technology to extract heat from the outside air for use in space heating. Heat pumps provide equipment efficiencies, at moderate ambient temperatures, two to four times higher than conventional furnaces. Heat pumps have had minimal penetration in non-residential and northern (colder) areas due to higher first-costs, availability of lower-cost natural gas (until the early 1970's), questionable reliability and lack of sufficiently trained commercial maintenance services. Total heat pump sales have grown dramatically over the last three years, and use in nonresidential applications has also increased significantly. Heat pumps are available in both split and single package versions.

c. Year-around (YAC) -- This equipment is identical to horizontal units in configuration and application characteristics except that it provides heating as well as cooling through the apparatus included in the single chassis. For the most part, this heating has been provided by gas-fired heaters with a minimal but growing use of oil or electricity. Because the heating and cooling output ratios are not flexible, applications using year-around equipment are often thought of as being poorly engineered and inefficient. However, the fact that this equipment provides the lowest-cost heating and cooling system has resulted in its wide use in first-cost oriented market segments such as speculative commercial buildings and some industrial buildings. Additionally, as larger sizes and multi-zone and variable-air-volume (VAV) versions have been made available, YAC's have become the most important single equipment type in the non-residential market.

d. Split systems -- Units in which the compressor-condenser section is remote from the expansion coil and/or fan unit. Split systems have historically represented a major portion of the nonresidential unitary market and have been applied in virtually all building types as a high-quality, well-engineered, air conditioning system. Functionally, split systems are cool-only units and where heating is required a separate heating system must also be installed. Although they continue to be applied because of the inherent flexibility of the configuration and recognized quality and performance characteristics, equipment first-costs and relatively high installation costs (particularly where a separate heating system is required) are a disadvantage in many nonresidential market applications.

e. Vertical and remote -- In this equipment the compressor, coil, and fan units are generally mounted on one chassis with the condenser section remote. To a great degree, this equipment was used in early commercial air conditioning applications and a good deal of its current volume is for replacement of similar worn-out equipment. There is considerably less application of this equipment in new structures than was the case five or ten years ago. Vertical systems are cool-only and if heating is required, a separate heating system must be installed. Split systems incorporate the flexibility of these earlier verticals, and in addition offer a more desirable configuration and are generally considered to be superior.

2. Unitary market by equipment type. Year-around systems are the most important single type with about 47 percent of the total tonnage in the 7-1/2 to 50 ton size range. Exhibit I-7. Furthermore, the year-around share has increased at a steady rate for the last five years. Split systems are the second most important type with 27 percent of the total tonnage, a share that has remained constant for the last five years. Horizontal systems represented about 17 percent of the market in 1975, a share that has also remained relatively stable. Vertical systems have steadily lost share, from 12 percent in 1970 to 8 percent in 1975, as other configurations have become more desirable on a cost or quality/performance basis.

3. Unitary market by basic system configuration. Single package units offer significant advantages in many nonresidential applications. Foremost among these are ease of installation, lower installation costs, lower first cost and a configuration that lends itself to maximum utilization of internal space (since single package units are

generally installed on the roof). In 1975, single package units (year-around, horizontal, heat pumps) represented approximately 65 percent of total tonnage in the 7-1/2 to 50 ton size range. Exhibit I-8 shows that the single package share has increased steadily since 1970.

4. Unitary single package market by function. Within the single package category, combination heat/cool systems (year-around and heat pumps) represent a substantial share of total tonnage. Exhibit I-9. Over the last five years, this share has increased from 70 percent to about 74 percent in 1975. Although some of this growth may be a statistical trend due to a higher incidence of factory installed strip heaters in horizontal units (which would historically have had these heaters installed in the field), the major impetus is believed to be the lower cost of a factory assembled single package unit as opposed to the more expensive field installation of separate heating and cooling systems. Although some proportion of horizontal units are installed with field-assembled strip or duct heaters, the segmentation by primary function is desirable due to the difference in relative heating requirements that can be met by each type.

C. North Central Market by Major Markets and Market Segments.

Two additional market segmentations are based upon differences in the type of construction, and application or type of building. In each case, differences exist in significant characteristics such as types of systems used, selection processes used, key specifying influences and equipment selection criteria.

1. North Central Region - major markets. Major markets include new construction, major remodelling, energy retrofit and replacement. Exhibit I-10.

   a. New construction is the largest market, and in 1975 was about half of the total. Major remodelling accounted for another 30 - 35 percent and replacement and energy retrofit 16 to 22 percent.

   b. Energy retrofit represents replacement of inefficient equipment solely for the purpose of increasing energy efficiencies and decreasing operating costs. While this is potentially an important

growth market, current activity is modest and at the present time it represents a small portion of the total market.

c. Replacement is a significant growth segment of the market and to some extent a stabilizing influence relative to the swings in new construction. The replacement percentage for 1975 is probably inflated relative to the total market due to the significant decline in new construction in 1975. In a more "normal" construction environment, replacement would probably represent 10 - 15 percent of the total market.

2. North Central Region - market segments. Exhibit I-10 also shows the relative share of six market segments based upon application/building types. The commercial segment (including commercial offices, stores, shopping centers, etc.) is by far the largest segment with about 46 percent of the total tonnage. The education and science market segment represented about 18 - 20 percent of the total tonnage in 1975 due primarily to two factors; high tonnage required per given area, and a lower immediate correlation to general economic conditions than most of the other segments. The industrial segment was most heavily affected by economic conditions, and represented only eight to ten percent of the total tonnage in 1975.

D. Prime Market Screening Approach.

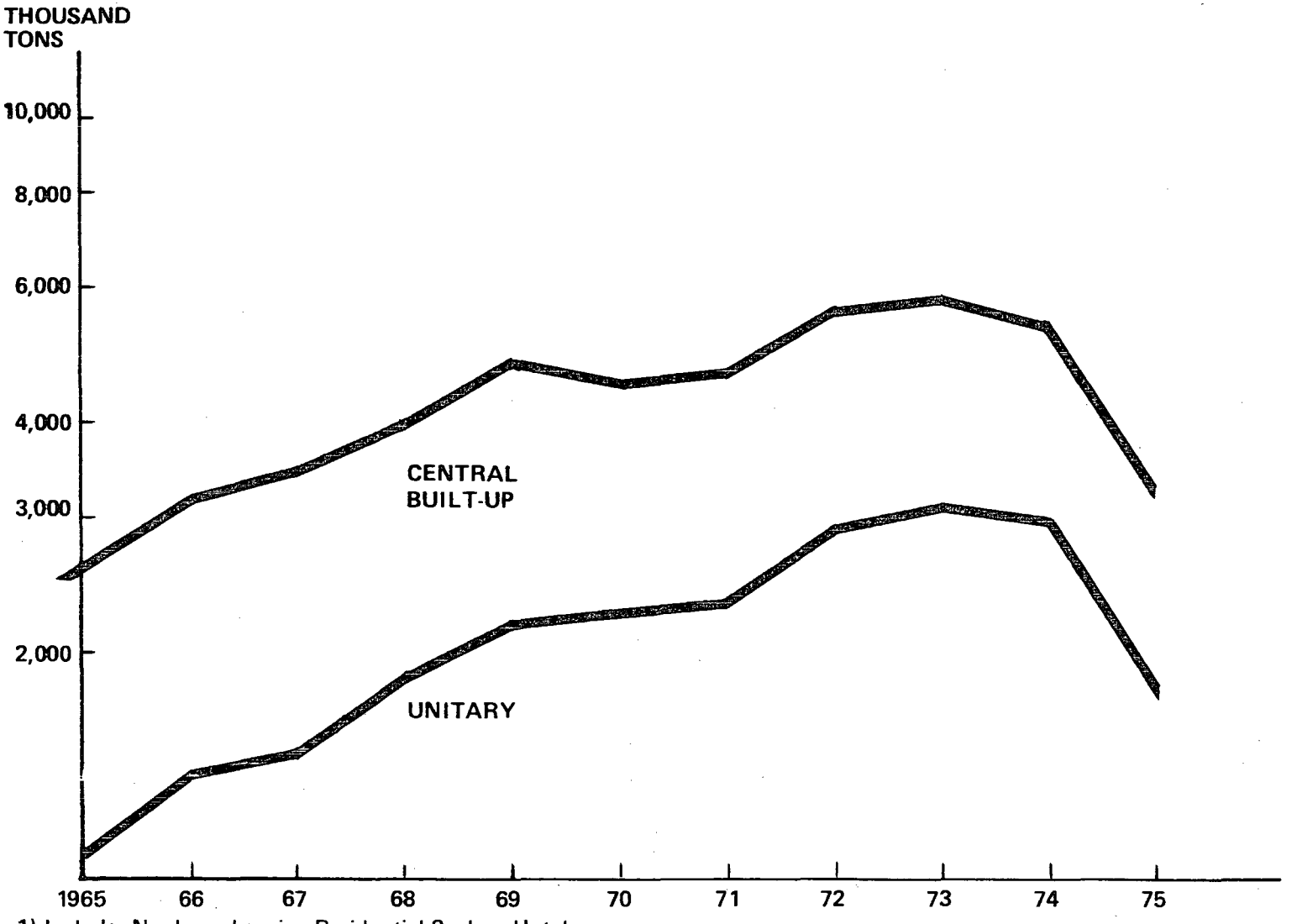
The prime market of interest is 7-1/2 to 50 ton, single package, combination heating/cooling equipment in the North Central Region. Exhibit I-11 shows the screening steps taken to estimate the 1975 prime market of 140 - 145 thousand tons. Of total nonresidential air conditioning tonnage, central built-up systems are screened out, leaving only the unitary equipment portion. Next, the portion of the unitary market that falls within the North Central Region is carried forward, and within this, the tonnage represented by units in the 7-1/2 to 50 ton size range. Within the 7-1/2 to 50 ton size range, only the tonnage accounted for by single package, combination heat/cool units

is retained to define the prime market. Exhibit I-12 utilizes the same analytical process to develop a comparable market for the total U. S. that can be related to the prime market within the North Central Region.

Exhibit I-1

TOTAL NONRESIDENTIAL AIR CONDITIONING TONNAGE [2] BY BASIC TYPE

1965-1975

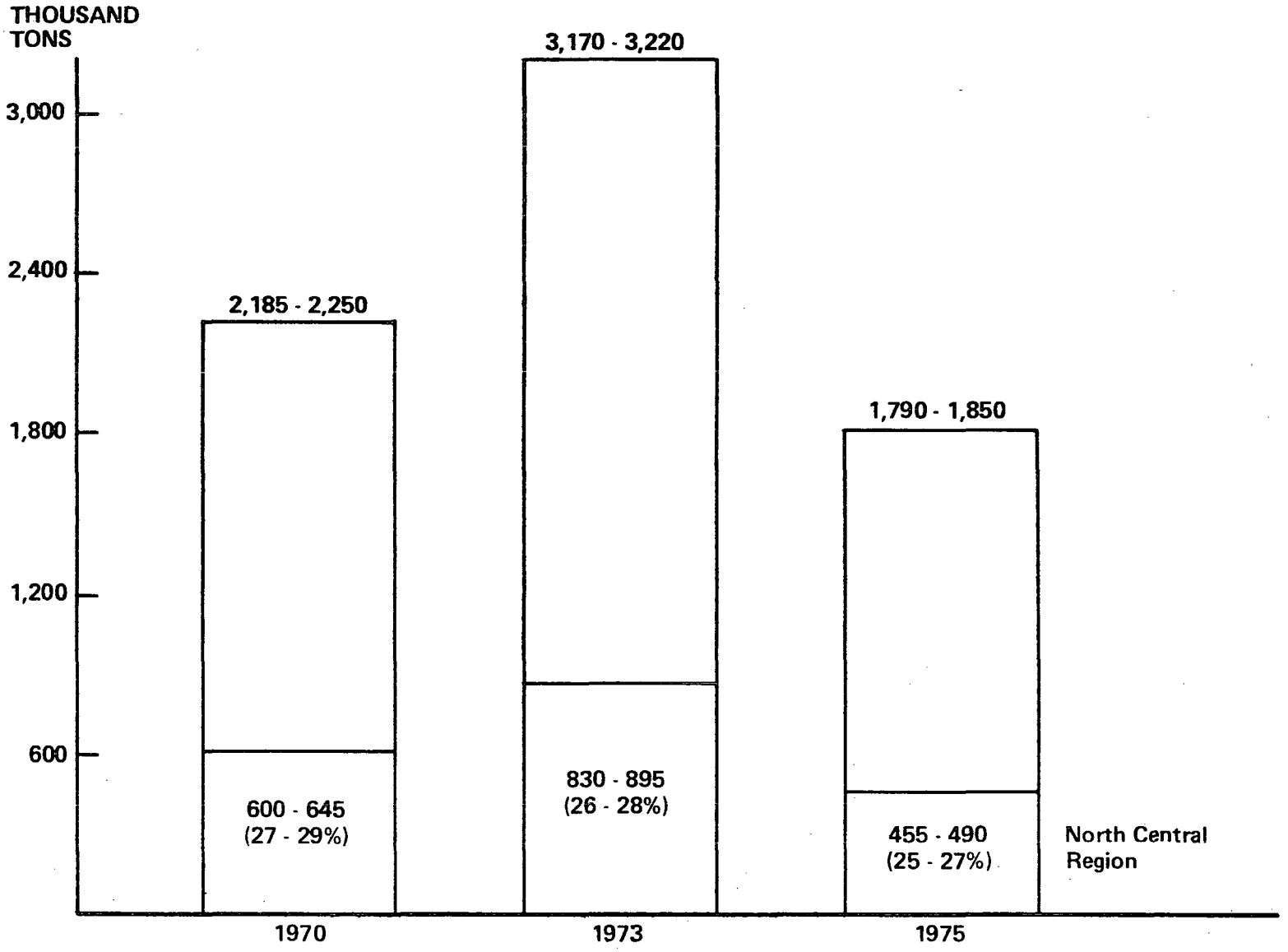


1) Includes Nonhousekeeping Residential Such as Hotels
2) In 3 to Over 50 Ton Sizes

Source: William E. Hill & Company, Inc. Estimates based on Heating, Piping and Air Conditioning Magazine Surveys and Air Conditioning and Refrigeration Institute (ARI) Data

Exhibit I-2

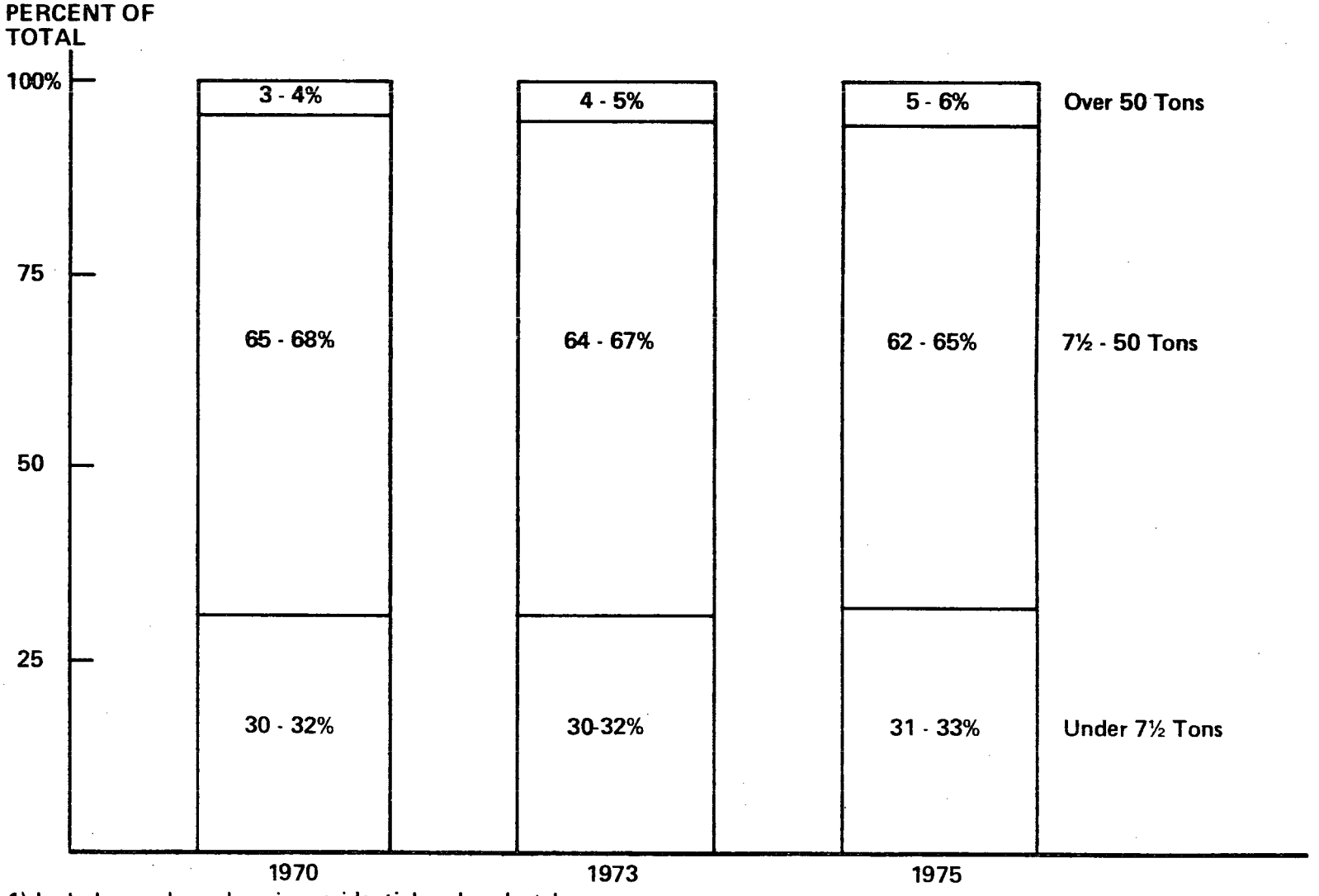
UNITARY AIR CONDITIONING NONRESIDENTIAL [1] TONNAGE [2] TOTAL U.S. AND NORTH CENTRAL REGION 1970, 1973, 1975



1) Includes nonhousekeeping residential such as hotels
2) In 3 to over 50 ton sizes
Source: William E. Hill & Company, Inc. estimates based upon ARI data

Exhibit I-3

UNITARY AIR CONDITIONING NONRESIDENTIAL [1]
TONNAGE DISTRIBUTION BY NOMINAL SIZE RANGES [2]
North Central Region
1970, 1973, 1975



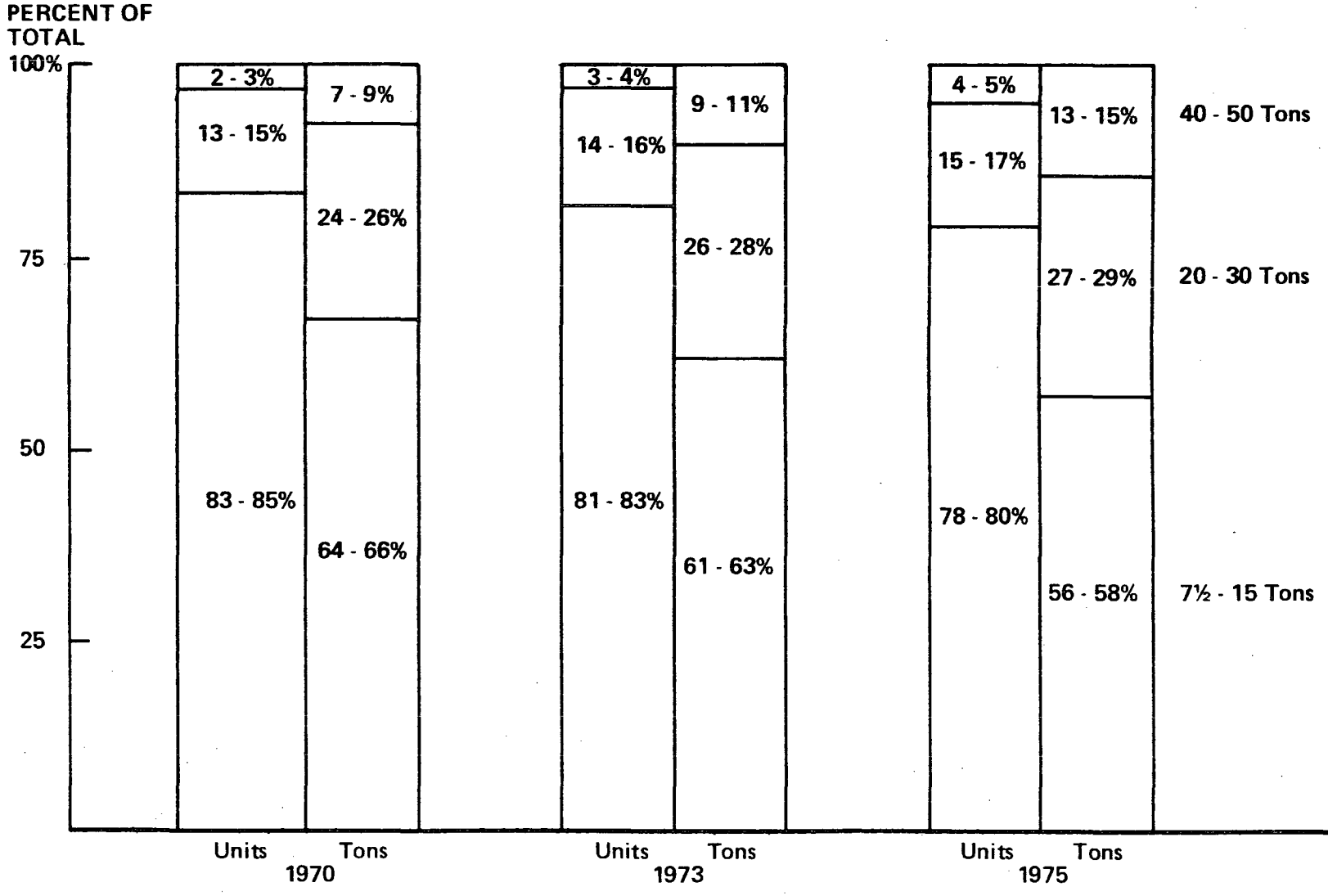
1) Includes nonhousekeeping residential such as hotels
2) In 3 to over 50 ton sizes
Source: William E. Hill & Company, Inc. estimates

Exhibit I-4

UNITARY AIR CONDITIONING UNITS AND TONNAGE BY SELECTED NOMINAL SIZE RANGES 1)

North Central Region

1970, 1973, 1975



1) In 7½ to 50 ton sizes

Source: William E. Hill & Company, Inc. estimates

Exhibit I-5

ESTIMATED DISTRIBUTION OF UNITS AND TONNAGE BY NOMINAL EQUIPMENT SIZE

North Central Region - 1975

Nominal Size (Tons)	Units		Tons	
	#(000)	Percent	#(000)	Percent
7-1/2	7.9- 8.3	37-38 %	59.0- 62.0	20-21 %
10	5.3- 5.6	25-26	53.1- 56.0	18-19
15	3.3- 3.5	15-16	50.1- 53.1	17-18
Subtotal	16.5-17.4	78-80	162.2-171.1	56-58
20	1.5- 1.6	7-8	29.5- 32.4	10-11
25	1.2- 1.3	5-6	29.5- 32.4	10-11
30	0.7- 0.8	3-4	20.6- 23.6	7-8
Subtotal	3.4- 3.7	15-17	79.6- 88.4	27-29
40	0.6- 0.7	2-3	23.6- 26.6	8-9
50	0.3- 0.4	1-2	14.8- 17.7	5-6
Subtotal	0.9- 1.1	4-5	38.4- 44.3	13-15
Total	20.8-22.2	100	290 -300	100

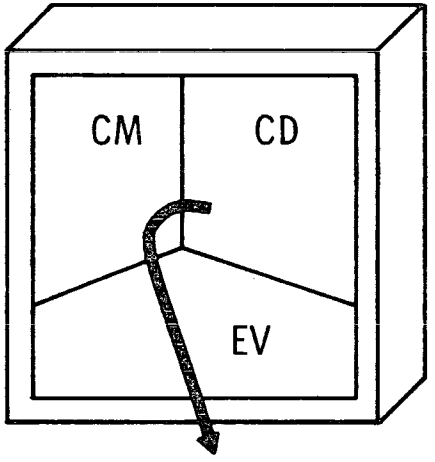
1. 7-1/2 to 50 ton units.
2. Percentage of total within the 7-1/2 - 50 ton range

Source: William E. Hill & Co., Inc.

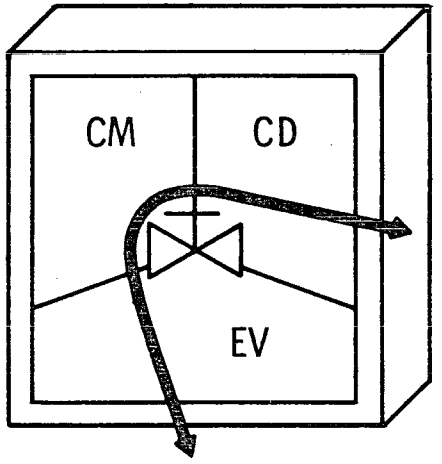
Exhibit I-6

UNITARY EQUIPMENT SCHEMATICS
WITH PRE-DESIGNED AND PRE-SIZED COMPONENTS

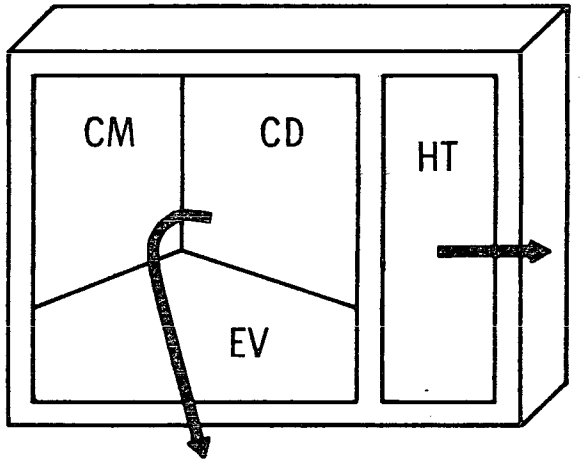
HORIZONTAL
Cools Only



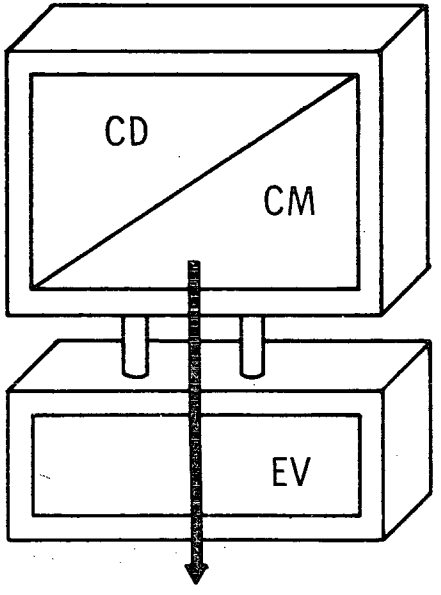
HEAT PUMP
Heats and Cools

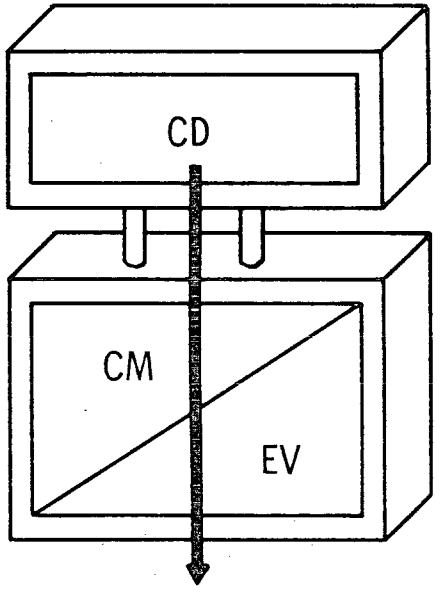


YAC or Combination
Heats and Cools



SPLIT
Cools Only





VERTICAL or
Remote
Cools Only

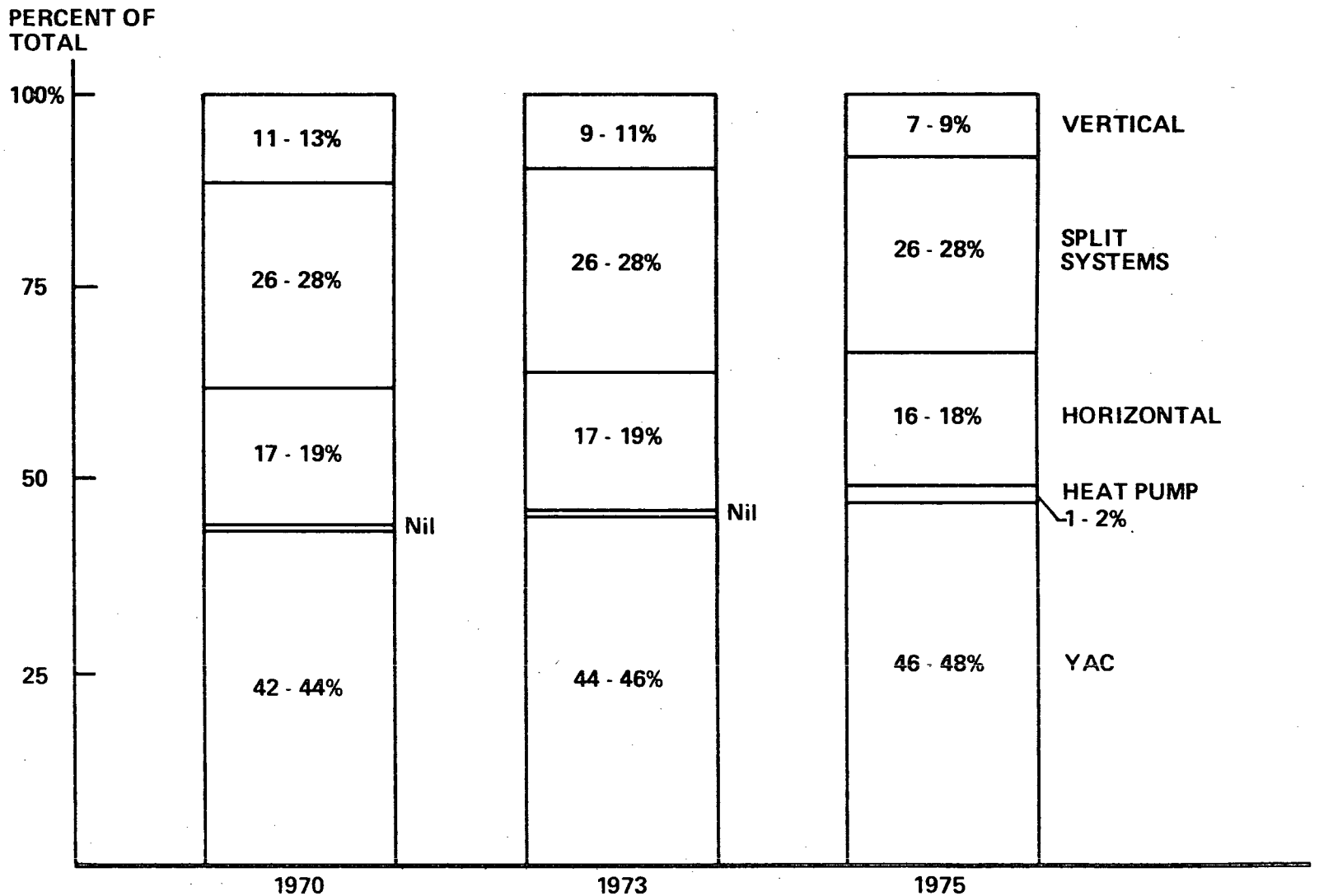
- ☐ CD Condenser
- ☐ CM Compressor
- ☐ EV Evaporator
- ☐ HT Heater
- ➡ Cycle Effect

Exhibit I-7

UNITARY AIR CONDITIONING TONNAGE DISTRIBUTION IN THE 7½ - 50 TON SIZE RANGE BY TYPE

North Central Region

1970, 1973, 1975



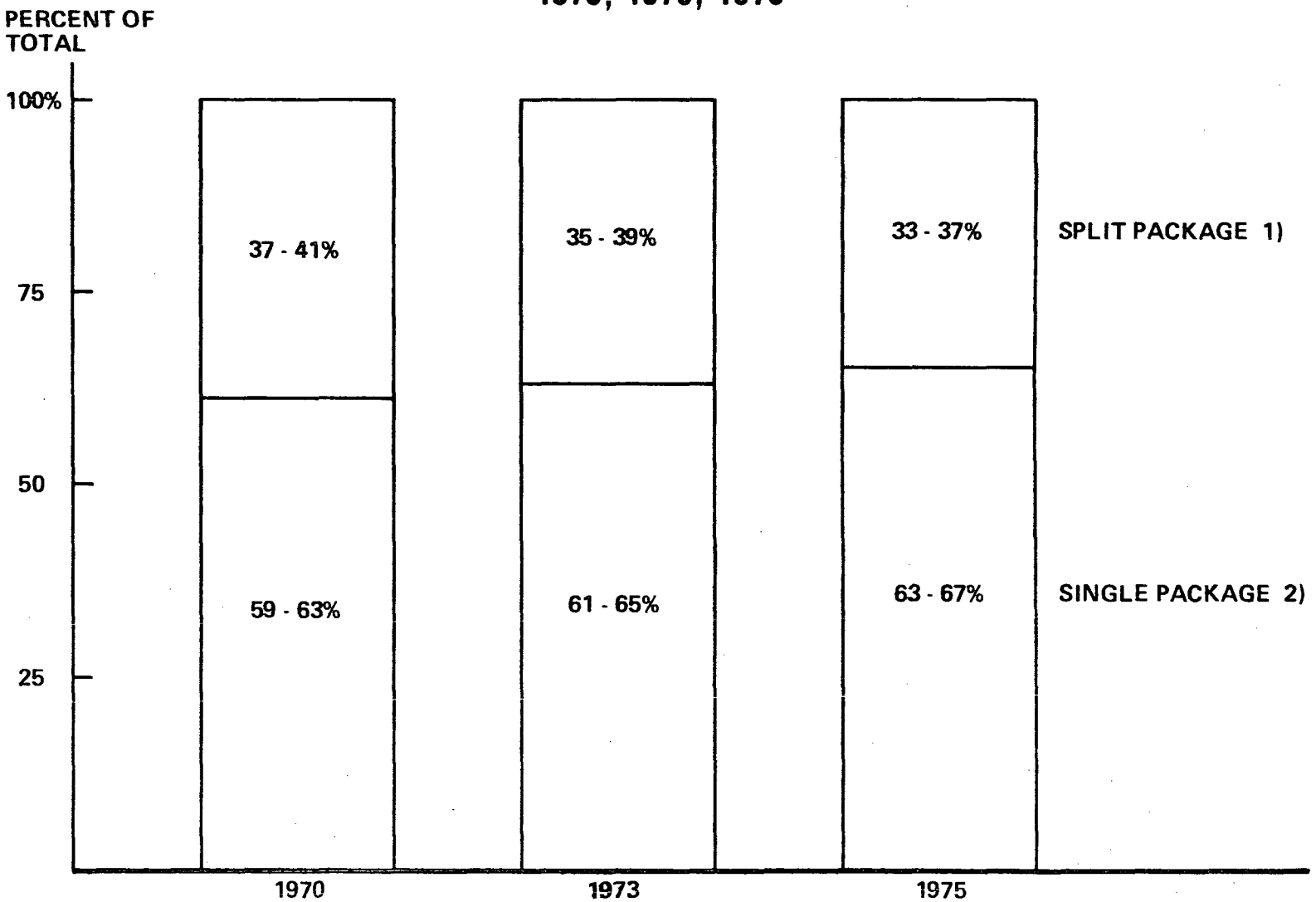
Source: William E. Hill & Company, Inc. estimates

Exhibit I-8

UNITARY AIR CONDITIONING TONNAGE DISTRIBUTION IN THE 7½ - 50 TON SIZE RANGE BY CONFIGURATION

North Central Region

1970, 1973, 1975



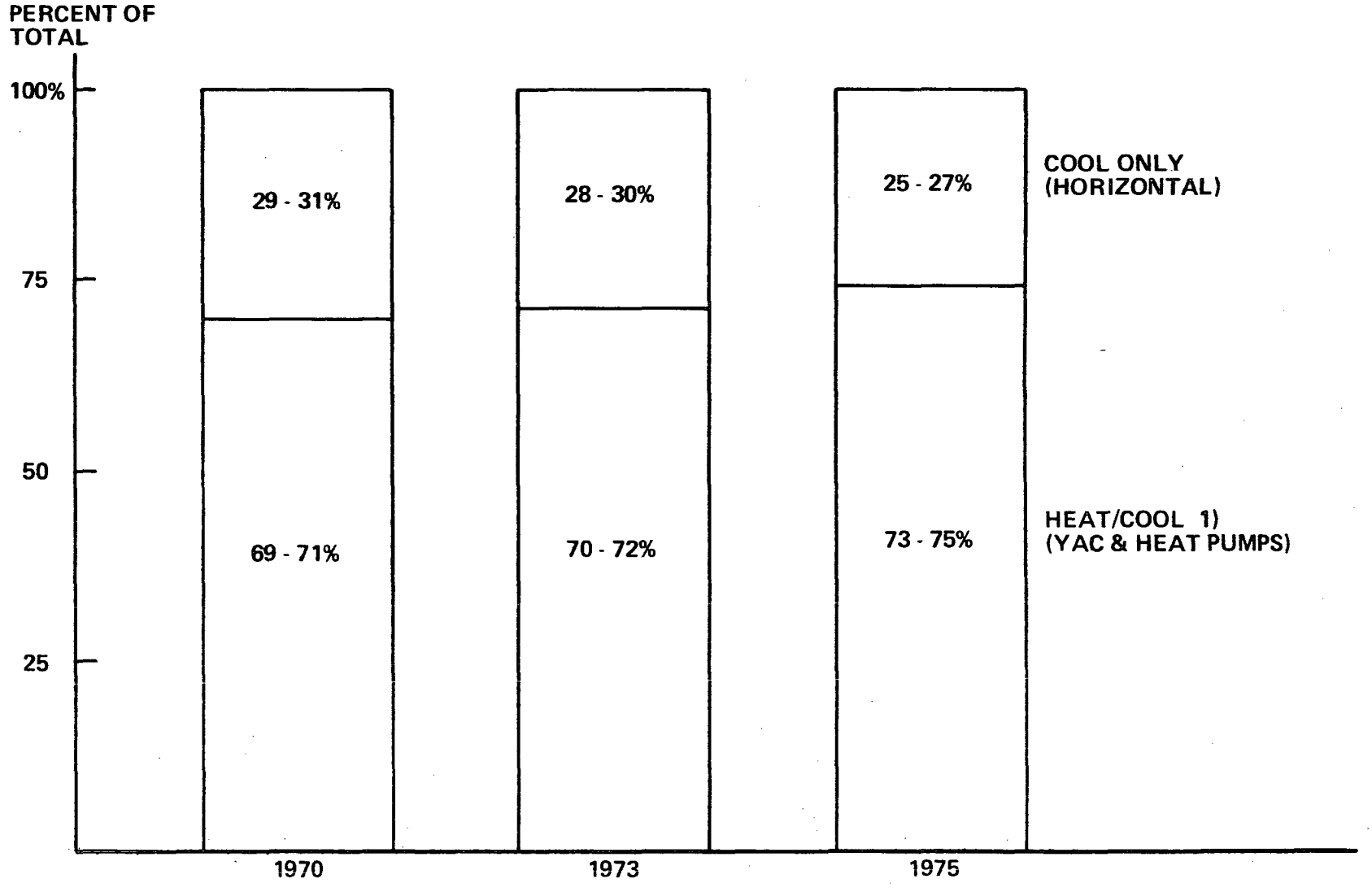
1) Includes split systems and vertical systems
2) Includes YAC, horizontal and heat pumps
Source: William E. Hill & Company, Inc. estimates

Exhibit I-9

SINGLE PACKAGE UNITARY AIR CONDITIONING TONNAGE DISTRIBUTION IN THE 7½ - 50 TON SIZE RANGE BY FUNCTION

North Central Region

1970, 1973, 1975



1) As shipped from factory, does not include field installed supplemental heating

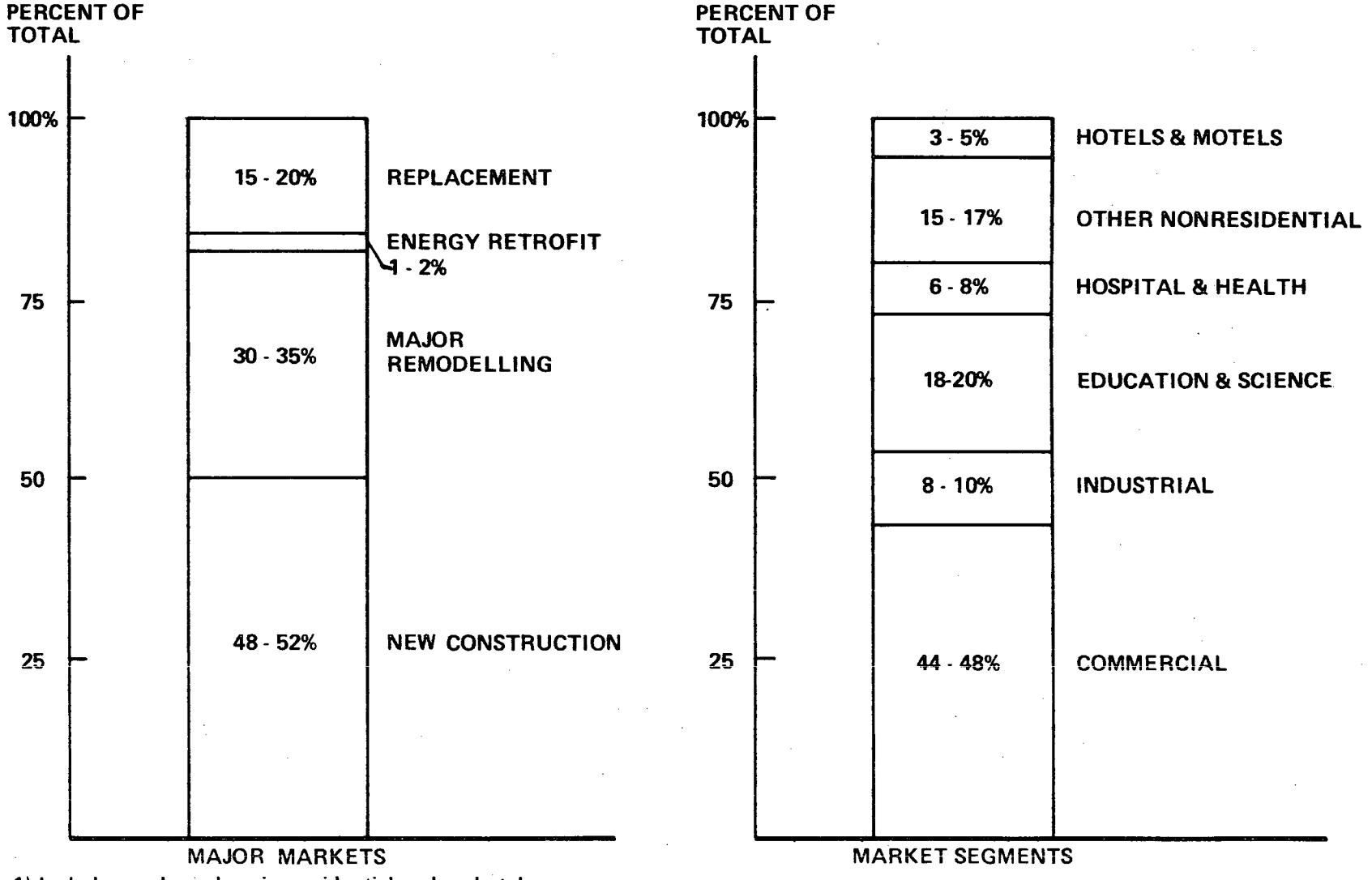
Source: William E. Hill & Company, Inc. estimates

Exhibit I-10

UNITARY AIR CONDITIONING NONRESIDENTIAL [1] TONNAGE [2] BY MAJOR MARKETS AND MARKET SEGMENTS

North Central Region

1975 estimate

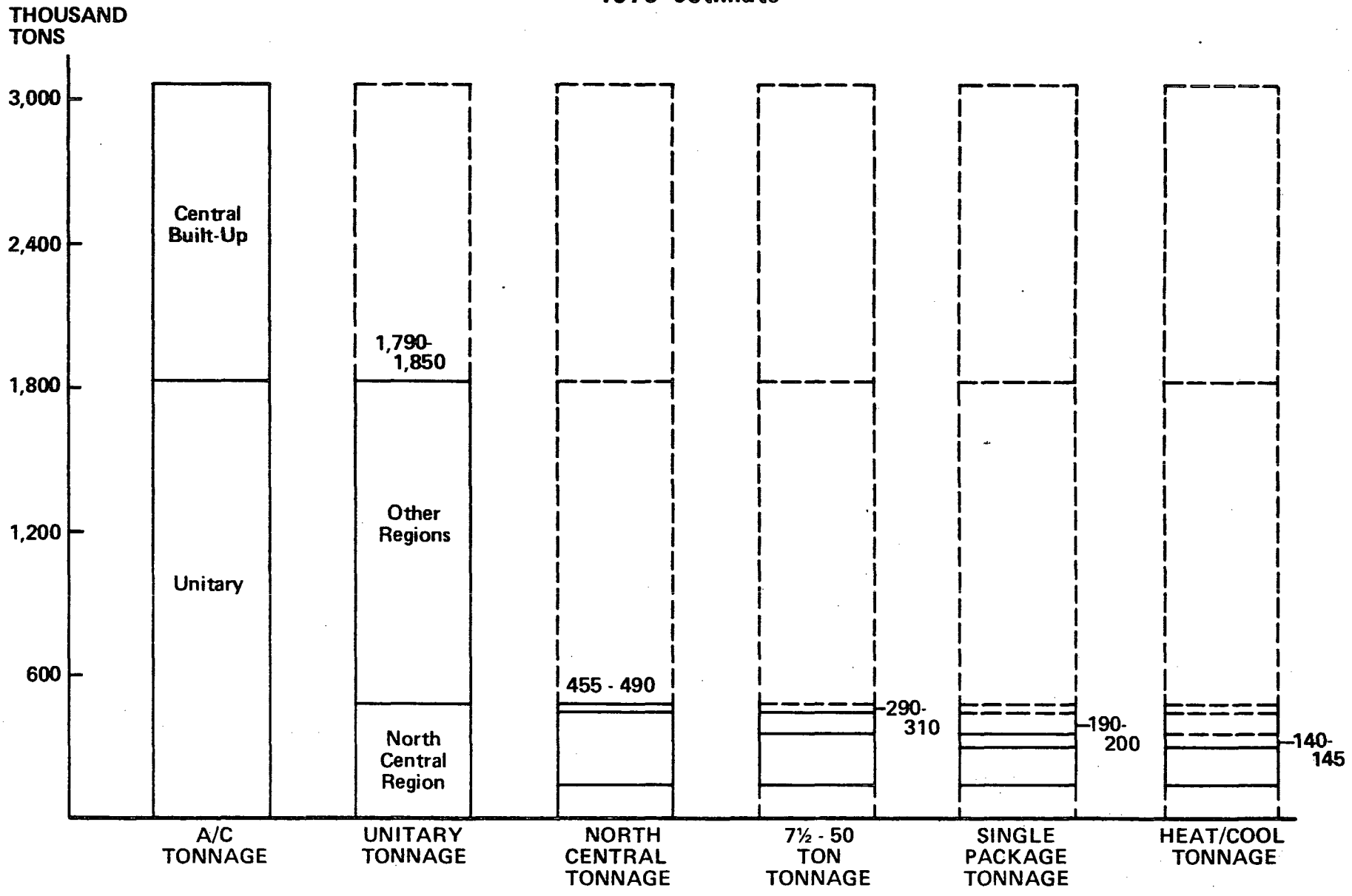


1) Includes nonhousekeeping residential such as hotels
2) In 3 to over 50 ton sizes
Source: William E. Hill & Company, Inc. estimates

Exhibit I-11

PRIME MARKET FOR COMMERCIAL - SIZE SINGLE PACKAGE COMBINATION HEATING/COOLING UNITARY EQUIPMENT

North Central Region
1975 estimate



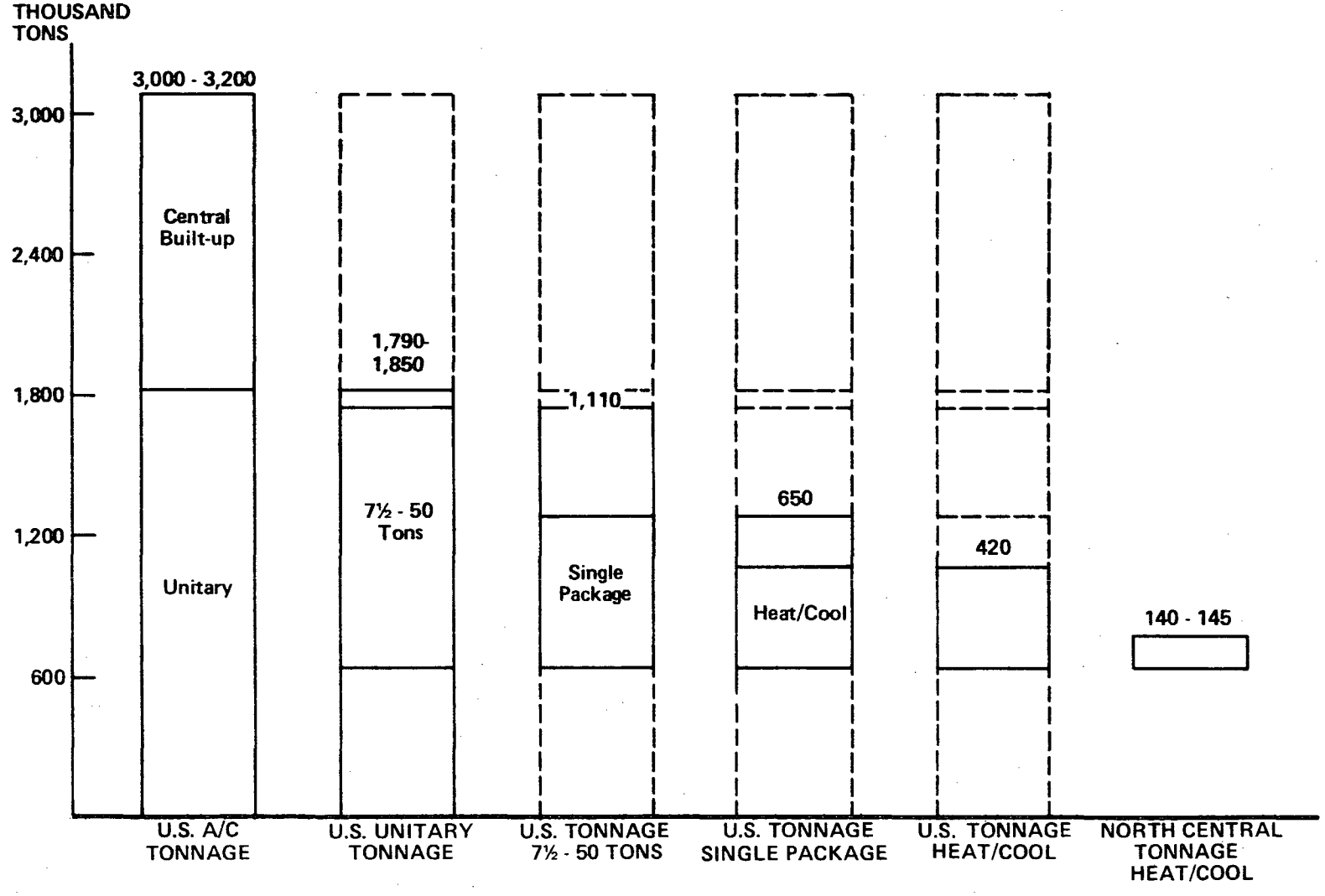
Source: William E. Hill & Company, Inc. estimates

Exhibit I-12

PRIME MARKET FOR COMMERCIAL-SIZE, SINGLE PACKAGE COMBINATION HEATING/COOLING UNITARY EQUIPMENT

United States and North Central Region

1975 Estimate



Source: William E. Hill & Company, Inc. Estimates Based Upon ARI Data

II. KEY MARKET CHARACTERISTICS IN THE NONRESIDENTIAL UNITARY AIR CONDITIONING BUSINESS

A good understanding of the market structure and key market characteristics is an essential step in evaluating the market potential for a new product. The interaction of manufacturers, products, distribution and customers in the nonresidential air conditioning business is very complex, and there are a great many important qualitative factors operating at all levels of the market.

A. The Basic Structure of the Air Conditioning Industry.

The air conditioning industry is a complex spectrum of products, manufacturers, distribution channels, design influences, installation contractors, service contractors, and markets. Exhibit II-1.

1. Product categories. Products in the total air conditioning market range from window room units, through various sizes and types of unitary packaged units to built-up system components that can be assembled in a variety of configurations to produce systems of several thousand tons of cooling capacity. Unitary units range from one ton residential units to 150+ ton units for large commercial applications. Of primary interest in this report, however, are the small-to-medium sized commercial units, comprising the bulk of nonresidential unitary tonnage. While a five ton unit for commercial applications may be identical to a similar sized unit for residential applications, design influences and equipment evaluation/selection processes are quite different between the residential market and each commercial market segment.

2. Manufacturers. Major producers such as Carrier, Trane, York, Lennox and GE may compete across a broad range of equipment sizes and markets, but seldom with comparable strength in all

product areas. Thus each manufacturer tends to specialize or emphasize particular product or market segments such as Trane in large-tonnage systems, Carrier and Lennox in commercial unitary equipment, General Electric in residential and small-tonnage unitary equipment and Whirlpool in room units, to name only a few. Carrier, as the largest competitor in the industry, probably produces the broadest product line and competes to some extent in all segments of the market. Smaller and second line manufacturers compete in specialized or regional markets, often on a price basis.

3. Marketing and distribution. Common types of distributor organizations are the factory branch -- owned/operated by the manufacturer; independent distributors -- who handle one or several brands of non-competing equipment and perform local selling and inventory services; manufacturers agents -- who provide selling but usually don't inventory equipment; and, mass merchandisers such as Sears who primarily handle smaller residential units similar to other major appliances. Many manufacturers also utilize national accounts sales efforts to reach multi-regional customers who select equipment through a centralized purchasing function.

4. Design influences. The importance of specific design or equipment selection influences varies by market and product type and will be analyzed in greater detail later in this section. Basically, the selection decision may be influenced by architects, in-house or consulting engineers, contractors who also provide design services and, in the case of room units, retail salesmen.

5. Installation and service. Air conditioning equipment is installed by a spectrum of contractors (mechanical, air conditioning, and dealers) who tend to specialize in certain types or sizes of equipment, or specific market segments.

6. Markets. Major air conditioning end use markets are: residential, commercial, industrial and institutional. Each major end-use market has unique application requirements and equipment evaluation/selection characteristics.

B. Nonresidential Air Conditioning Market.

Exhibit II-2 is a simplified structure of the nonresidential unitary market showing each level of the business with important qualitative

characteristics that can greatly influence the selection and marketability of unitary equipment. Components of this structure are the types of builders, equipment users, contract methods, system designers and equipment installers and servicers.

1. Builders/users. Two basic types of builders may be identified according to the length of time they own the newly constructed building, and how that time span affects air conditioning equipment selection. Speculative builder/developers typically view their ownership as very short-term. Generally they assume the risks inherent in developing usable building space and expect to sell or lease the property for management within one to two years. Non-speculative builders usually intend to use the building space for a longer period of time for self-occupancy, or for property management.

   a. The importance of equipment first-costs varies considerably between speculative and non-speculative customers. Exhibit II-3. Speculative customers who typically are not the ultimate equipment users, have little reason to consider factors other than first-cost and tend to be highly price sensitive. Non-speculative customers, particularly owner/users, are also first-cost conscious but other factors such as equipment life, operating and maintenance costs and reliability have a stronger influence.

   b. Speculative customers are not evenly distributed among the various market segments, and as Exhibit II-3 shows, are considerably more involved in the commercial office and retail segments, representing 30 - 45 percent of total customers in these markets. Other segments such as industrial, education, and hospital and health are primarily comprised of non-speculative, owner/users.

2. Basic contract methods. Three basic contract methods are utilized for the design and installation of air conditioning systems. Exhibit II-4 analyzes these basic types according to key equipment selection factors and the major markets and market segments where they are used.

   a. Plan and spec. The plan and spec method implies that the system is designed by an in-house or consulting engineer

and the installer selected by competitive bidding. The key features are that (1) design and installation are performed by separate parties, and (2) the competitive bidding process. Equipment is selected by the buyer and the designing engineer. Major plan and spec markets include: institutional (almost all), industrial (most), larger and more complicated commercial applications, new construction, and major remodelling (about half). The major perceived advantage is a quality-designed system at a competitive price. Almost all built-up systems are designed on a plan and spec basis.

b. Negotiated. In the negotiated method, the buyer deals directly with a HVAC contractor, who offers a package price for the design and installation of an air conditioning system. The key feature of this method is that the same party both designs and installs the system. The equipment selection decision is made by the buyer and contractor. Major markets include: small-to-medium commercial, industrial (some, primarily offices), major remodelling (about half) and replacements (almost all). Major perceived advantages include speed of execution, "value received for dollars spend", and essentially "free" design services.

c. Turn-key. The turn-key approach, in which the buyer deals with a general contractor who handles all specifics and subcontracting, has become increasingly important. The key feature is that the general contractor agrees to deliver a particular building at a specified price, and handles all subcontracting -- which may include both plan and spec and negotiated subcontracts. Equipment is selected by the general contractor and designer (consulting engineer or HVAC contractor), with the buyer generally having little or no influence. Major markets segments include: commercial (particularly speculative), some industrial, and apartments. Major perceived advantages are the delivery of a building at a specified price--which can be based upon the buyer's investment criteria, and the fact that the buyer doesn't have to devote time and effort to numerous construction details outside his main business.

3. Contract method by major markets. An analysis of basic contract method by major markets, Exhibit II-5 , shows that air conditioning installation in new construction is approximately evenly divided between plan and spec and negotiated contracts. In major remodelling projects, 60 - 70 percent are negotiated and in the replacement

market 80 - 90 percent are negotiated. Plan and spec is most likely to be used for replacement in the case of energy retrofit or where significant problems have been encountered in the present system. Replacement often involves the immediate need for a new unit, i. e., the old one has broken down, and the time required for the plan and spec process is not available. Having the customer's service contract is often an important factor in getting replacement installation business. Redesign is usually unnecessary as the worn unit is generally replaced with a similar type of equipment.

4. System designers. System designers also represent a spectrum that includes consulting engineers involved in large, complex projects to air conditioning dealers who use very standard design approaches for standard applications. Exhibits II-6, 7 and 8 show the key characteristics of the major types of designers and highlight the important comparisons.

   a. In-house and consulting engineers. Design engineers are involved in the new construction of large and/or complex projects, often where the HVAC systems are only part of the overall building or process design. They do almost all of the design work for central built-up systems, much of the design of large (100+ tons) unitary systems, and generally deal with installations of 20 tons or more.

   b. Mechanical and larger air conditioning contractors. Contractors design new air conditioning installations, but are more likely to be involved in major remodelling and replacement markets. They generally are more heavily involved in designing small-to-medium sized and/or relatively simple installations for straightforward or standard applications. While some contractors may design small-to-medium size built-up systems, most of their design work utilizes unitary equipment. Installation size can vary considerably, but the bulk falls within the five to 100 total ton range. Contractors are often involved, however, in larger installlations where a number of unitary units are used for a simple application, such as a shopping center with 400 total tons that uses 40 ten-ton units.

   c. Contractor/dealers. Dealers generally handle one brand of equipment, and tend to specialize in residential and small commercial applications. Typically, any engineering knowledge present is solely invested in the owner/manager, and "designs" are usually limited to sizing smaller tonnage unitary units.

d. Design comparison. Exhibit II-7 compares the percentage of design work done by consulting engineers and contractors for equipment/installation sizes within the 7-1/2 to 50 ton size range.

(i) The equipment/installation sizes include situations where the equipment of that size represents the total installation tonnage, or is combined with other units for a larger total tonnage installation. Contractors do 80 to 85 percent of the design work for the smaller sizes, and 25 - 30 percent at the higher end of the range. Contractors do about 50 percent of the design work in the 25 to 30 ton size range.

(ii) Exhibit II-7 depicts the percentage design distribution for various equipment sizes, but does not show the design comparison on a tonnage basis, due to the uneven distribution of tonnage by equipment size. Exhibit II-8 shows this analysis and highlights the fact that since contractors are more heavily involved in the smaller sizes, which represent greater total tonnage, they are responsible for the design of the majority of tonnage within the 7-1/2 to 50 ton size range.

5. Equipment installers. Installation contractors range from mechanical contractors who generally install large built-up and unitary systems to contractor dealers who are primarily involved in residential installations.

a. Mechanical contractors. Mechanical contractors typically bid and install most of the plan and spec work, as well as some of the negotiated work in a given market. They tend to install larger, more-complex jobs involving union labor, and also install plumbing and process piping in addition to heating, ventilating and air conditioning. Mechanicals generally install all brands of equipment and sometimes subcontract sheet metal and/or electrical work to other contractors.

b. Air conditioning contractors. Air conditioning contractors do little or no piping work and generally use non-union labor. They may do some residential installations, but generally do not install built-up systems and tend to concentrate on commercial and industrial negotiated work. While they may have a historical relationship with certain manufacturers and tend to favor certain brands of equipment, they will generally install and service several major brands.

c. Contractor/dealers. Contractor/dealers have historically represented the fundamental strength of an equipment supplier's distribution network, and usually install only one brand of equipment. They primarily emphasize the residential market and smaller commercial applications, and to some extent the term "dealer" is inappropriate for the mainstream commercial market, where it is generally felt that contractors must be able to install more than one brand of equipment.

6. Comparison of equipment installers. Exhibits II-9 and II-10 compare four key business parameters: business mix, installation size, contract method and major market segments, for the spectrum of contractors described above. The very large mechanical contractors have been excluded from this analysis due to their concentration on large, built-up systems and little activity in the unitary market.

   a. Business mix. The business mix comparison clearly shows the emphasis placed on installations by mechanical contractors, 75 to 90 percent of their total business versus the contractor/dealer's emphasis on service business, 50 to 60 percent of their total. Air conditioning contractors fall between the two extremes. This analysis highlights the fact that the initial installer and the service contractor may not be the same party.

   b. Installation size. 25 to 40 percent of mechanical contractor installations are greater than 50 tons, while 50 to 90 percent of contractor/dealer installations are less than 7-1/2 tons. Air conditioning contractors generally do 65 to 70 percent of their business in the 7-1/2 to 50 ton range and, along with small to medium-size mechanical contractors, are the most important installers in the intermediate size unitary market.

   c. Major market segments. As would be expected from their emphasis on large jobs and plan and spec work, mechanical contractors do a high proportion of their business in market segments where large projects and plan and spec contracts are most prevalent: institutional, industrial and large commercial. Contractor/dealers, on the other hand, do almost no institutional work and only small scale industrial work (primarily plant offices). Air conditioning contractors and smaller mechanicals do a modest amount of institutional work, generally smaller projects, and concentrate on the commercial and light industrial markets.

C. Project Characteristics of the Market.

Before concluding the market characteristics section, it is necessary to briefly consider equipment evaluation/selection criteria and the basic nature of the project development process. Some of the components of this process have been mentioned previously and only a brief outline will be presented.

1. Equipment evaluation/selection criteria. Exhibit II-11 highlights the most important evaluation criteria divided generally into economic and non-economic categories.

   a. Economic factors. The critical economic factors are equipment and installation first costs, and operating costs: which include preventive and repair maintenance, and fuel costs. Other costs, including various types of "opportunity costs" may or may not be important, depending upon the type of application.

   b. Non-economic factors. Non-economic factors: such as energy source, system performance/features, maintenance, and attitudes/perceptions (on the part of the buyer or designer), may have profound effects on the equipment selection decision. In many commercial applications for example, space conditioning is viewed as essential to the functioning of the buildings activities, and maintenance and reliability are primary considerations.

2. Basic project sequence. Exhibit II-12 describes the basic process involved in a typical air conditioning project. The customer determines the basic building specifications, criteria and constraints (often financial), for example, a certain size and type of restaurant to be built within a given budget restraint. He then selects designers for all (or portions) of the project, and may play a role in the equipment selection decision.

3. Basic design sequence. The designer generally considers key factors in a logical sequence as depicted in Exhibit II-13. The order of these considerations is not intended to represent the order of importance, but rather the typical thought process and sequence of events. It should be noted that the buyer's specifications and

constraints, and the complexity of the application in question heavily influences the relative importance of each stage, and the thoroughness of the analysis. The dotted line indicates those sequence steps that may be included in a reiterative process.

a. System requirements. The first step in the design sequence involves the determination of building loads and system requirements, and is the basis for all further stages of the analysis.

b. Energy alternatives and equipment categories. An initial analysis of energy alternatives is performed to determine what type of basic equipment categories can be considered. If gas service is not available for instance, obviously gas equipment will not be considered. Key considerations are typically; the availability of energy sources, comparative price, and perceptions as to future conditions. The evaluation of broad equipment categories generally includes considerations such as built-up versus unitary systems, combination heat/cool units versus separate systems, one or a few larger units versus a higher number of smaller units. Specific brands of equipment may or may not be considered at this point.

c. Reliability and availability of service. The customer's criteria would generally include guidance as to the emphasis on these factors, i. e., a commercial or retail outlet would probably place high priority on the availability of service. Various brands (and their respective record of performance) within the equipment category would be evaluated.

d. Cost analysis. At this point the type and brands of equipment selected in the previous screening process are evaluated in terms of first costs and operating costs. The relative importance of each of these cost categories is determined by the customer's criteria and the designer's evaluation of the system and application. In many cases, first-costs are the overriding cost criterion, but in other instances primary emphasis is placed on operating costs.

e. Reiterative process. Depending upon the nature of the project, the customer's desires and the designers inclination, this can be a reiterative process in which a number of alternatives may be evaluated. The degree of sophistication in this type of evaluation varies greatly, but generally systems are compared

on a simple payback basis which compares the differences in first-costs with the differences in operating costs, ignoring the time value of money and other factors such as taxes, depreciation, etc. Sophisticated designers may use discounted cash flow analysis (of all owning and operating costs), at the customers request.

Exhibit II-1

SIMPLIFIED STRUCTURE OF THE AIR CONDITIONING INDUSTRY

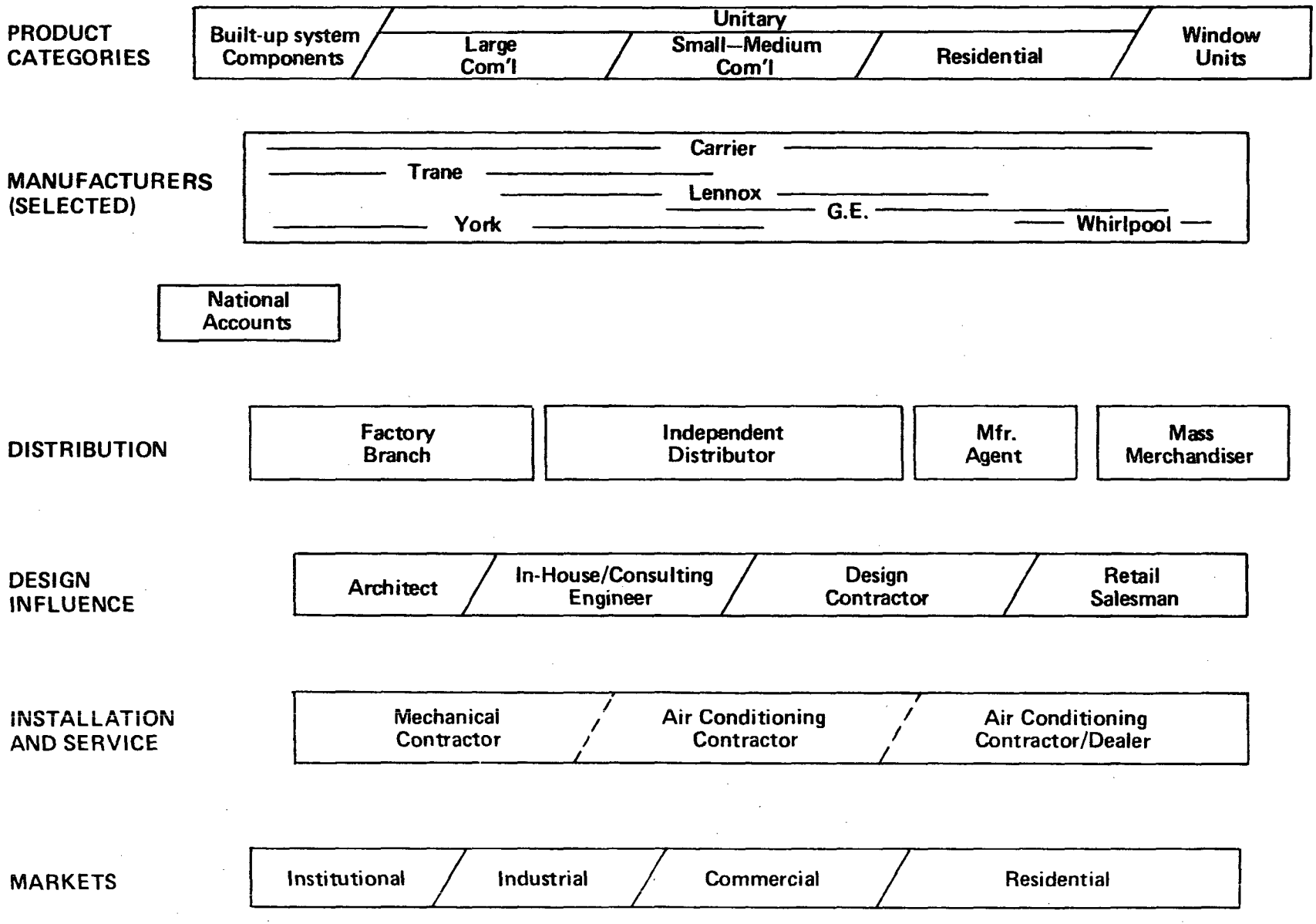


Exhibit II-2

SIMPLIFIED STRUCTURE OF THE COMMERCIAL UNITARY AIR CONDITIONING MARKET

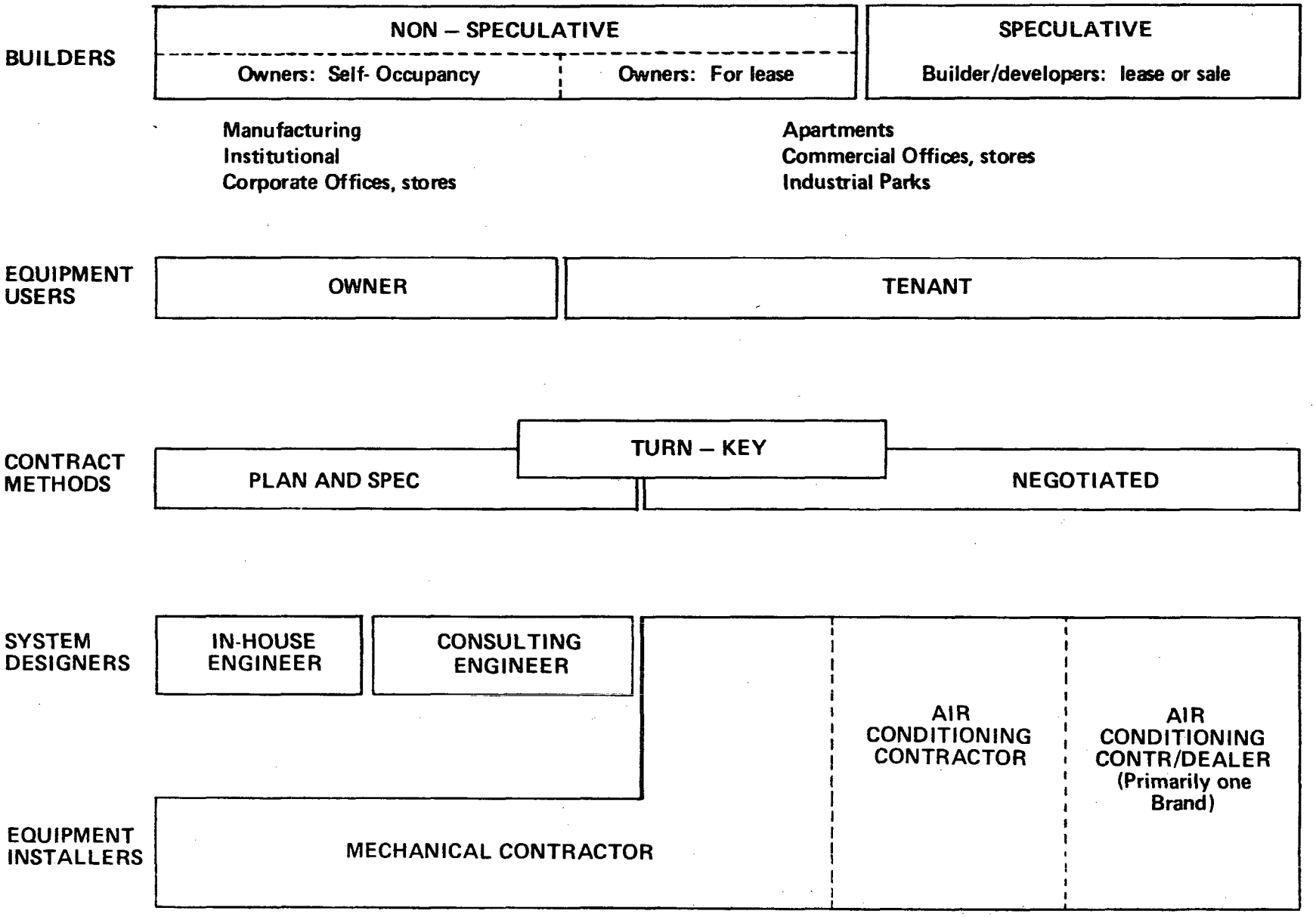
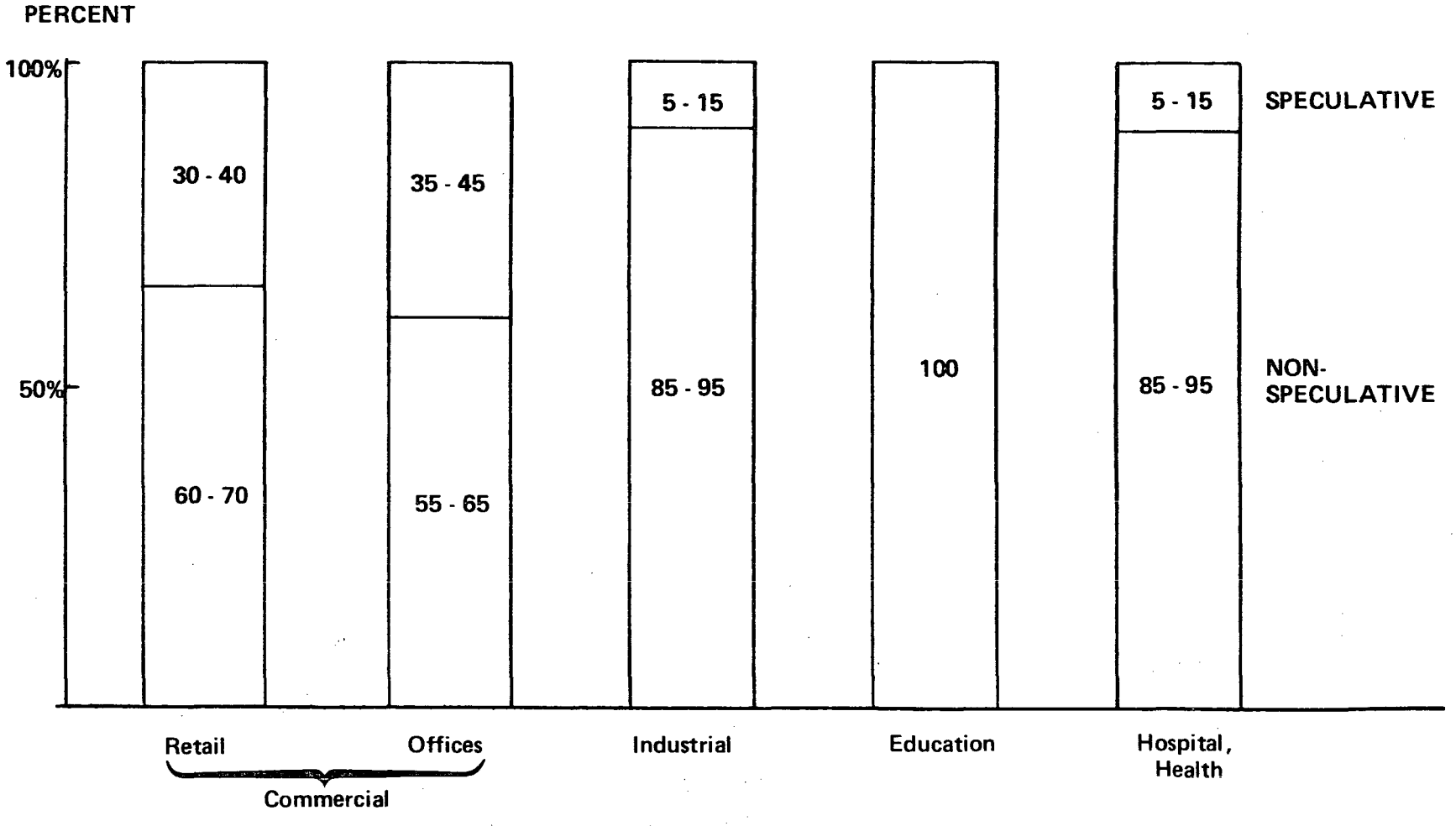


Exhibit II-3

BASIC BUILDER TYPES ANALYZED BY SELECTED MARKET SEGMENTS

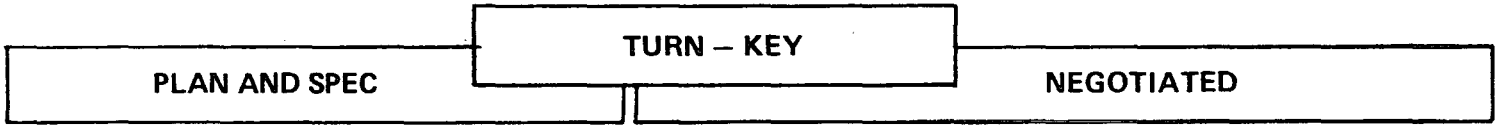
NON-SPECULATIVE		SPECULATIVE
Owners: Self-occupancy	Owners: For Lease	Builder/developers: lease or sale



Source: William E. Hill & Company, Inc. Estimates.

Exhibit II-4

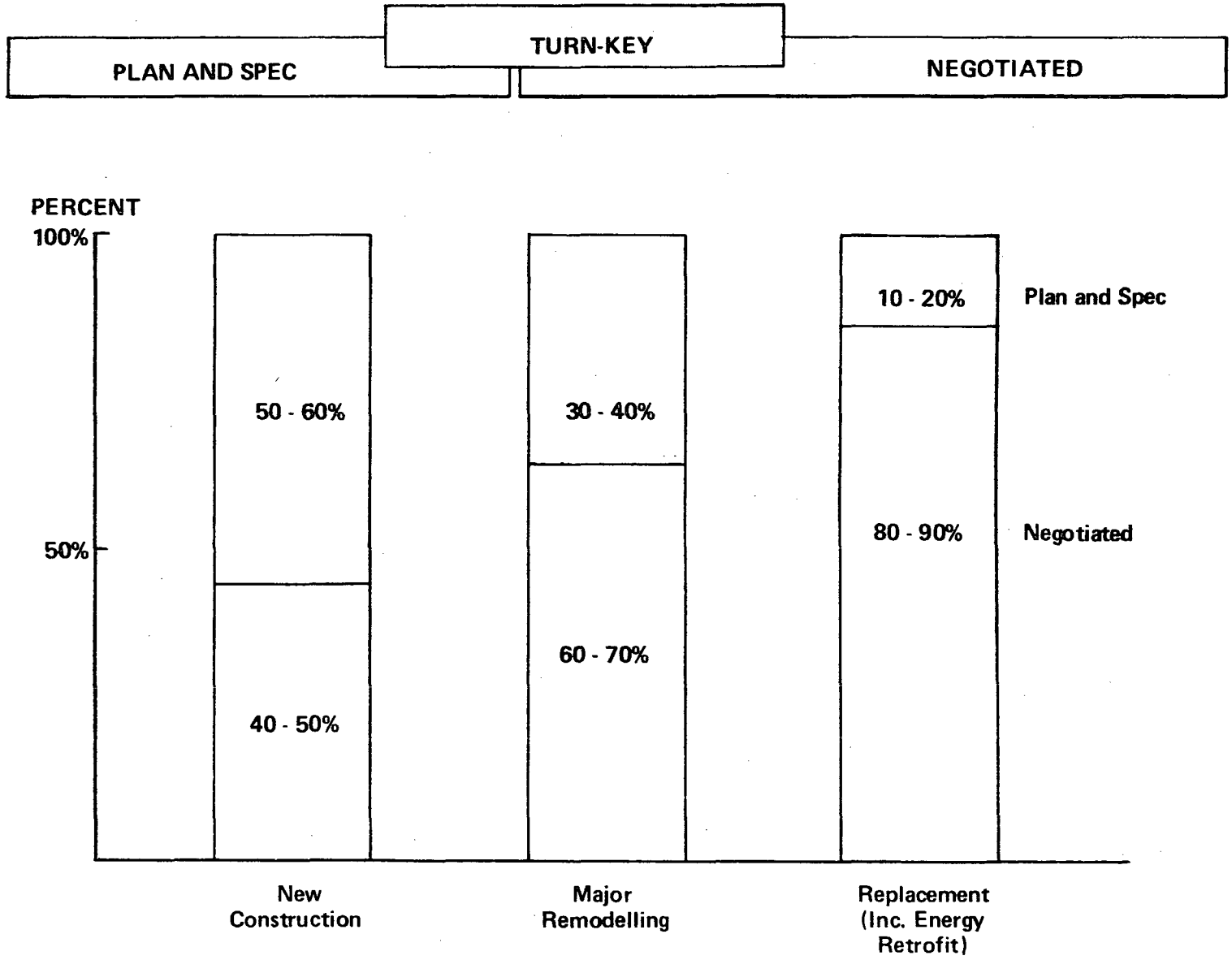
CONTRACT METHODS ANALYZED BY KEY FEATURES, EQUIPMENT SELECTION AND MARKETS



	PLAN AND SPEC	TURN – KEY	NEGOTIATED
KEY FEATURES	• Separate parties for design and installation	• General contractor delivers buildings at agreed-upon price	• Same party designs and installs (generally)
	• Competitive bidding	• Negotiated price (total)	• Negotiated price
EQUIPMENT SELECTION	• Buyer and CE	• General contractor and designer (CE or HVAC contractor)	• Buyer and HVAC contractor
MAJOR MARKETS AND SEGMENTS	• Institutional (almost all)	• Commercial (particularly speculative)	• Commercial
	• Industrial (most)	• Industrial (some)	• Industrial (some)
	• Commercial -- larger, more complicated jobs	• Apartments	• Remodelling (about half)
	• New construction	• New construction	• Replacements (almost all)
	• Remodelling (about half)		

Exhibit II-5

CONTRACT METHOD ANALYZED BY MAJOR MARKETS



Source: William E. Hill & Company Inc. estimates.

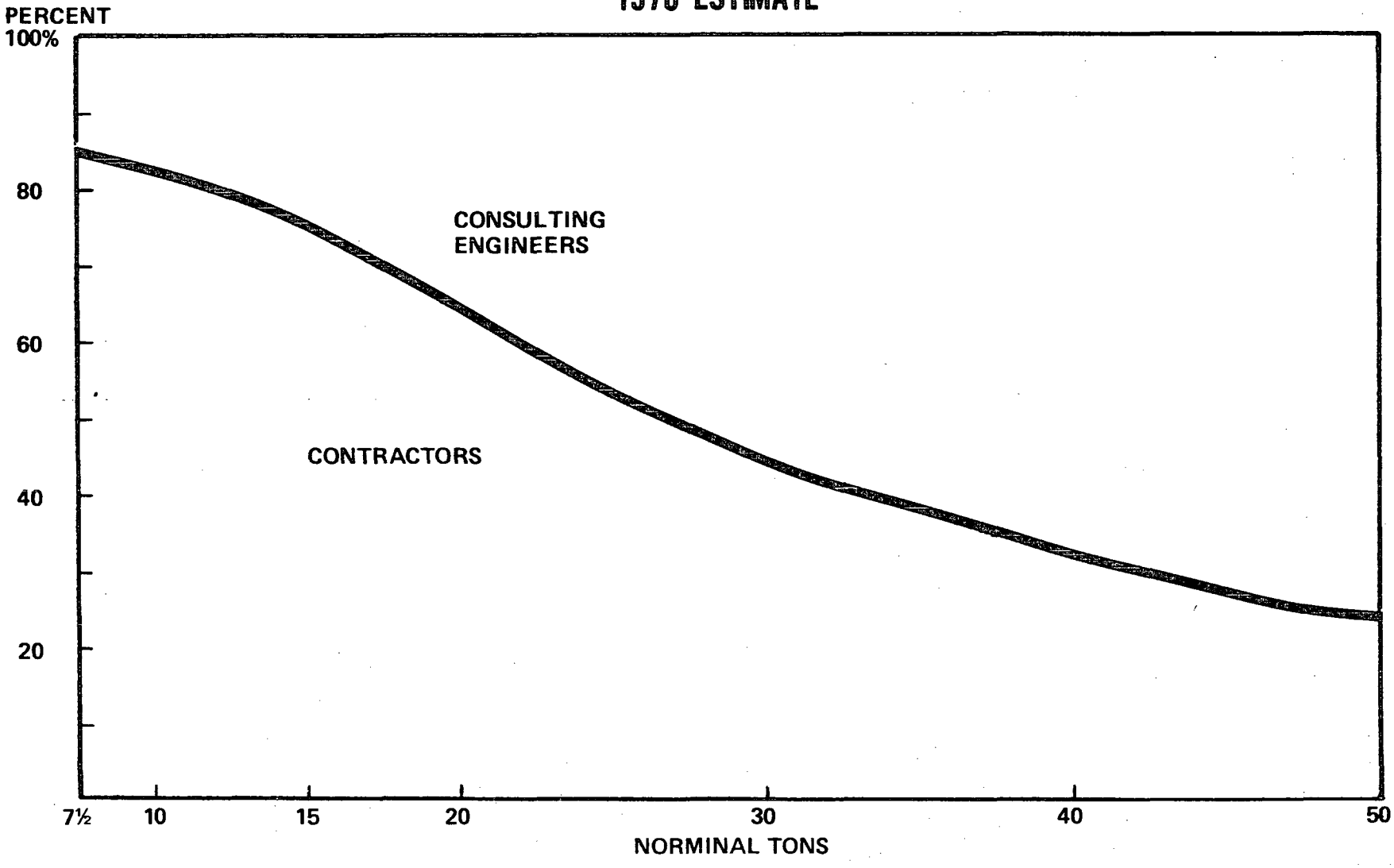
Exhibit II-6

SYSTEM DESIGNERS ANALYZED BY MAJOR MARKETS AND SEGMENTS EQUIPMENT TYPE AND INSTALLATION SIZE

	IN – HOUSE ENGINEER	CONSULTING ENGINEER	MECHANICAL CONTRACTORS	AIR CONDITIONING CONTRACTORS	AIR CONDITIONING CONTRACTORS/ DEALERS
MAJOR MARKETS	• New construction • Major remodelling		• New construction • Major/minor remodelling • Replacement		• Remodelling • Replacement
MARKET SEGMENTS	• Institutional • Industrial • Commercial		• Industrial • Commercial		• Commercial • Residential
EQUIPMENT TYPE	• Central built-up (large; complex) • Unitary (medium-large)		• Unitary (medium) • Central built-up (small-medium; simple)		• Unitary (small-medium)
INSTALLATION SIZE	• 20 tons and larger		• 5 to 100 tons		• 2 to 30 tons

Exhibit II-7

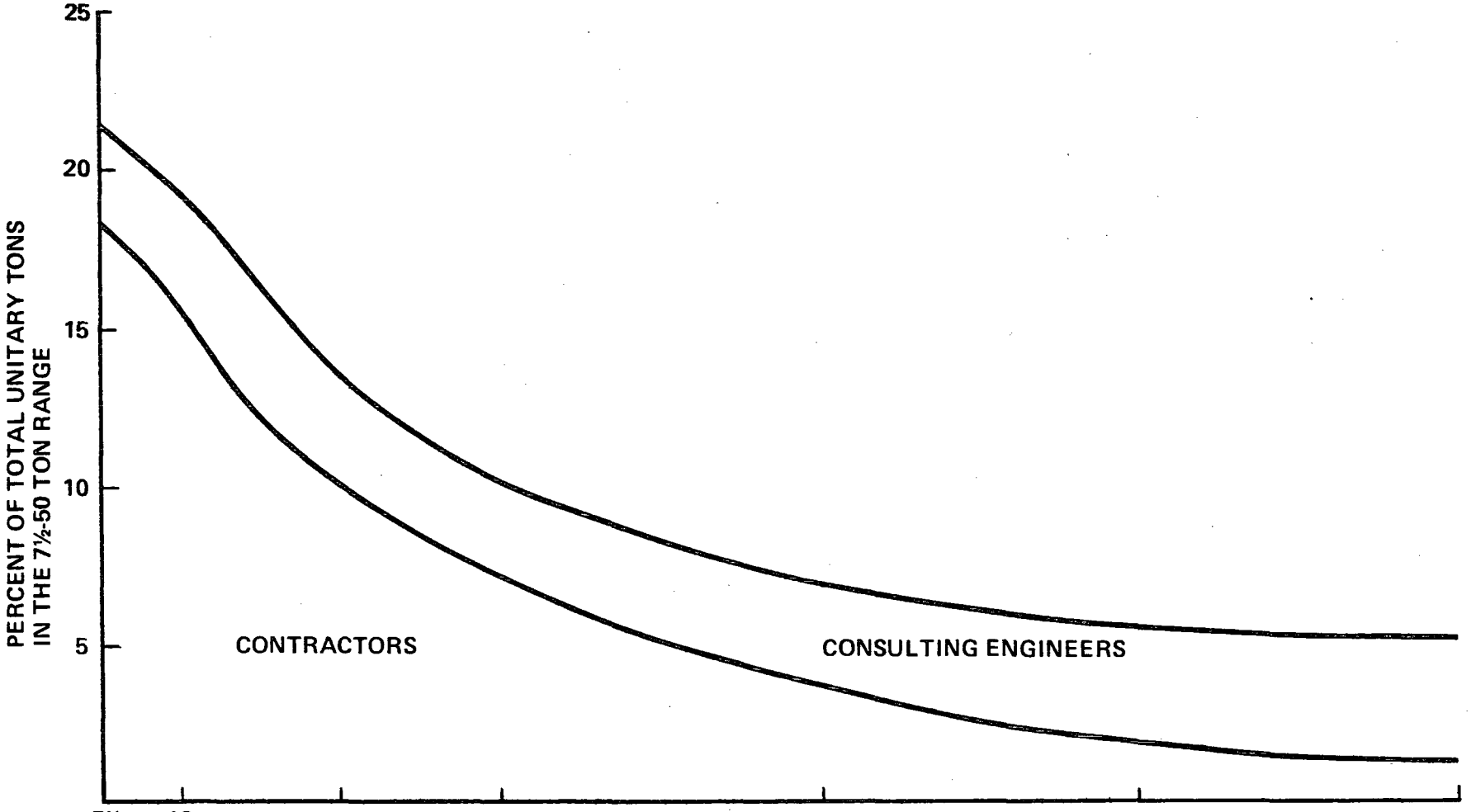
PERCENTAGE DISTRIBUTION OF UNITARY APPLICATION DESIGN BY EQUIPMENT/INSTALLATION SIZE AND SYSTEM DESIGNER 1976 ESTIMATE



Source: William E. Hill & Company, Inc. Estimates.

Exhibit II-8

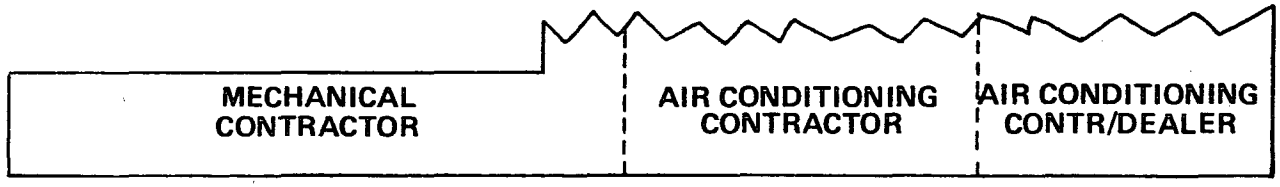
ANALYSIS OF UNITARY APPLICATION DESIGN IN THE 7½-50 SIZE RANGE BY SYSTEM DESIGNER

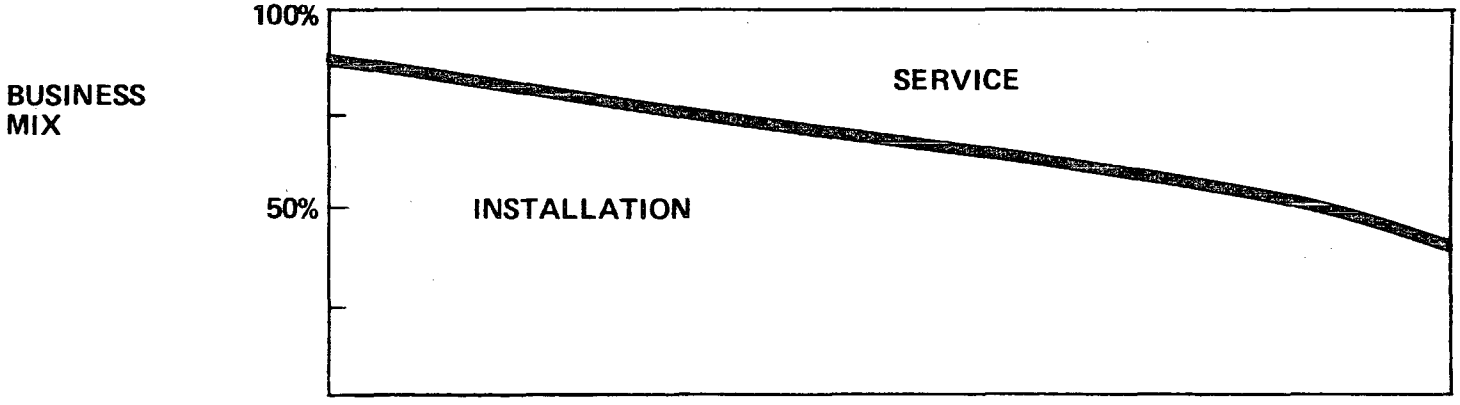


Source: William E. Hill & Company, Inc. Estimates

Exhibit II-9

EQUIPMENT INSTALLERS ANALYZED BY BUSINESS MIX AND INSTALLATION SIZE





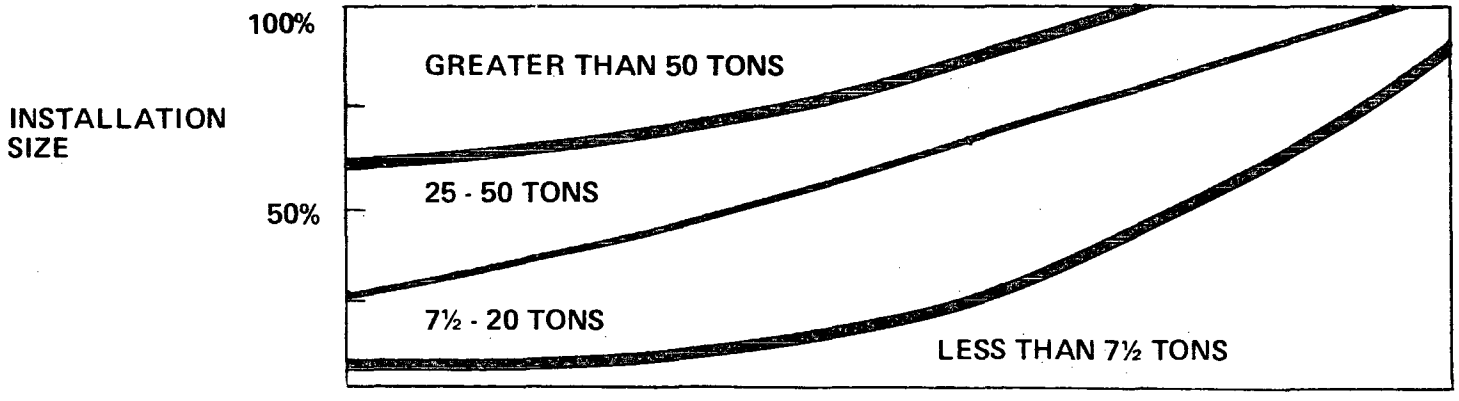
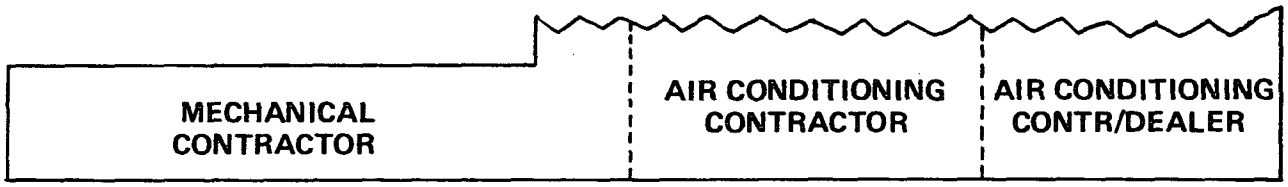
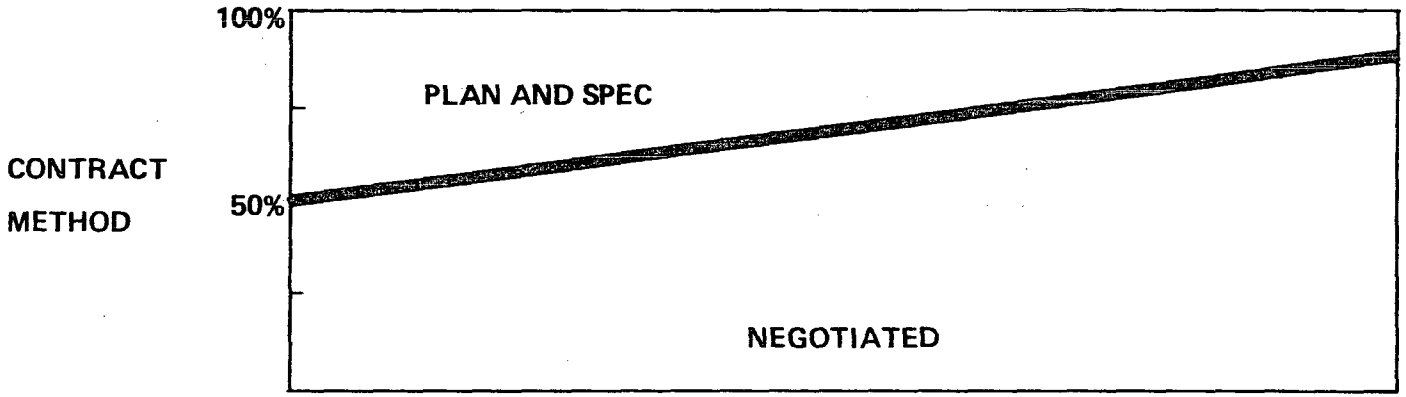


Exhibit II-10

EQUIPMENT INSTALLERS ANALYZED BY BUSINESS MIX AND INSTALLATION SIZE





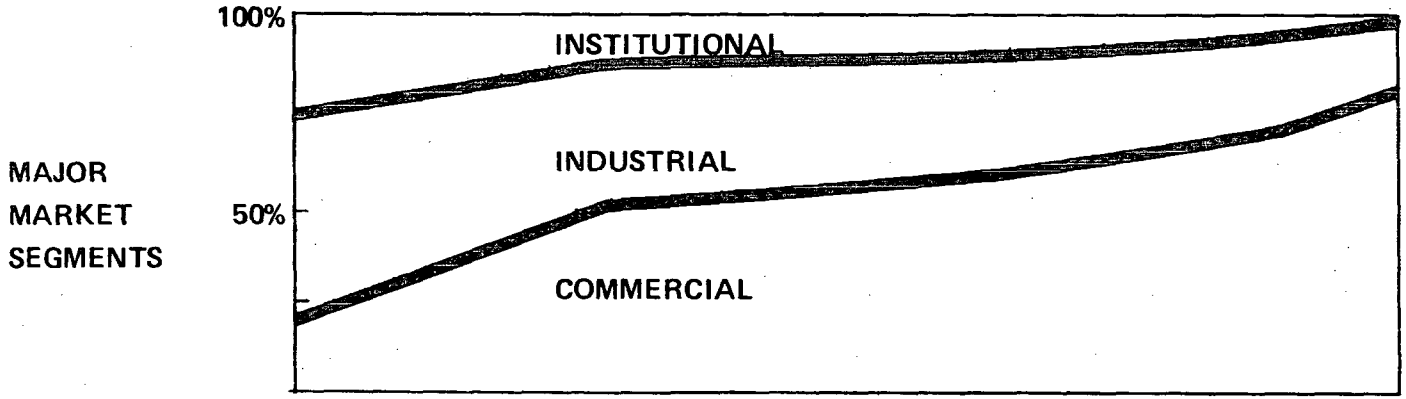


Exhibit II-11

KEY EQUIPMENT SELECTION FACTORS

Economic

First Cost
- Equipment
- Total installation

Operating Costs
- Annual maintenance
- Repair maintenance
- Energy (efficiency; fuel costs)

Other Costs (Indirect)
- Floor or interior space -- equipment configuration, i. e., rooftop
- Loads and distribution -- sizes and complexity of equipment; i. e., ducting vs. multiples, etc.
- Interest costs/investment criteria -- funds available, reqjired returns, etc.
- Time -- inception to occupation/ operation

Non-Economic

Energy Source
- Availability
- Restrictions
- System types/configurations

System Performance/Features
- Reliability
- Ease of operation
- Operational features
- Equipment life

Maintenance
- East of maintenance
- Service availability
- Availability of parts and replacement units

Attitudes
- System design, i. e., CE or contractor
- Equipment manufacturer
- Stability -- number of suppliers, i. e., equipment, parts service, etc.
- Prior experience with equipment, manufacturer, energy source, etc.

Exhibit II-12

BASIC PROJECT SEQUENCE

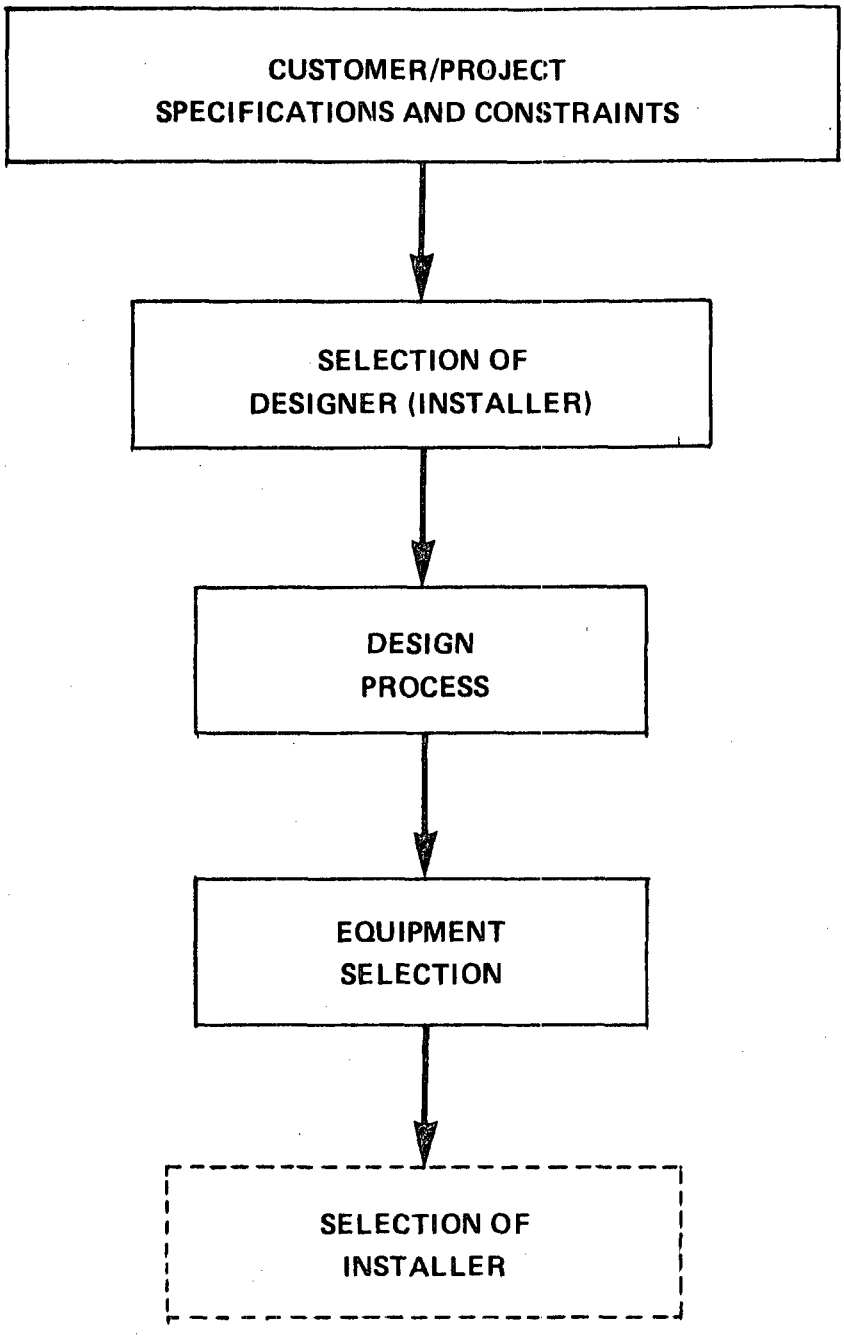
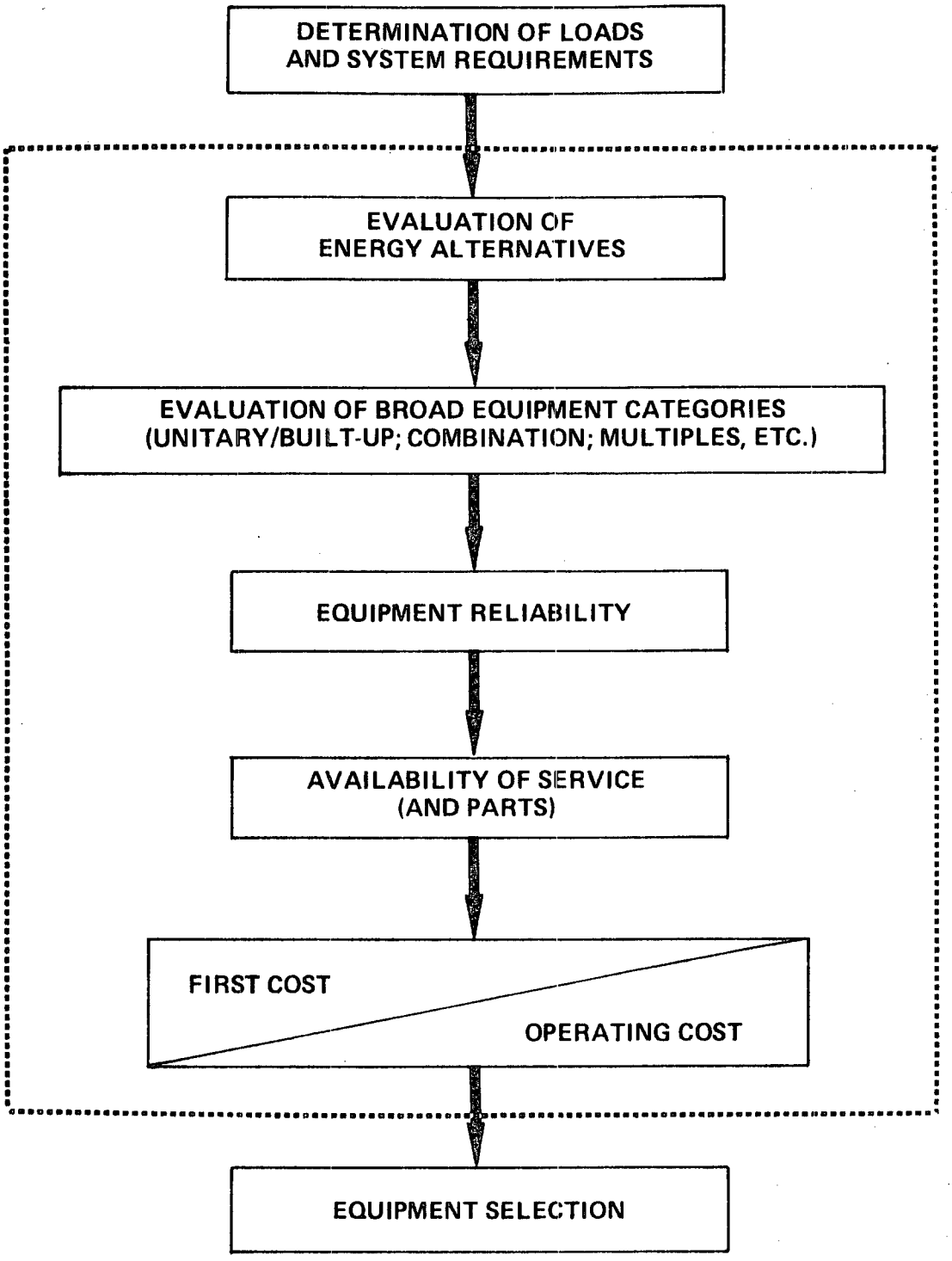


Exhibit II-13

BASIC DESIGN SEQUENCE
FACTORS CONSIDERED



III. SIGNIFICANT TRENDS AFFECTING THE NONRESIDENTIAL UNITARY AIR CONDITIONING BUSINESS

Many of the basic factors that affect the unitary air conditioning business and the nonresidential air conditioning market are undergoing pronounced changes. Economic and business conditions, the energy supply/price situation, unitary equipment trends and changes in the design and evaluation processes for air conditioning equipment will heavily influence the market potential for the HSPF heat pump.

A. Business/Economic.

While a number of macro business and economic factors impact the air conditioning market, the most important are those which relate to new construction, particularly the commercial and industrial building segments. Exhibit III-1 shows annual nonresidential floor space addition in the United States and the North Central Region for selected years between 1965 and 1975. Also shown is the total (nonresidential) air conditioning tonnage for those years.

1. Construction. After many years of general growth, dramatic changes have occurred in the new construction and air conditioning businesses. High energy costs are beginning to impact building design and construction, and eliminating energy waste and providing efficient energy utilization will be significant factors in the future construction market. New construction has become less speculative, and should remain so for the next five years.

2. Air conditioning penetration. Throughout the 1960's and early 1970's air conditioning grew at a rate several times higher than the general

economy and new construction, due to its increasing penetration of new construction. By 1975, however, a relatively high level of saturation has been achieved in nonresidential markets, and future growth will be more closely tied to new construction until the replacement market becomes a more significant factor in the early 1980's.

3. Regional construction. The North Central Region's share of the U. S. construction market has declined from 40 percent in 1965 to 34 percent in 1975. This decline is related to regional shifts in population and economic activity which are expected to continue at a slower pace over the next five years.

4. Industry consolidations. The recent dislocations have severely impacted the air conditioning business, and preliminary shake-outs and consolidations have occurred among manufacturers, consulting engineers and contractors. Although the unitary air conditioning business is expected to grow at an average annual rate of 6 - 8 percent over the next five years, continued consolidations and shake-outs are likely.

5. Trade diversification. In response to these conditions, larger contractors have expanded services offered such as design, maintenance, energy retrofit, etc., and have also expanded by acquisition of other related businesses or contracting firms in other geographical areas. Smaller contractors have relied more heavily on service business and have also tried to develop related businesses in their local area. Many consulting engineering firms are diversifying services, and/or merging with construction companies.

6. Cost sensitivity. Over the last ten years, less-costly air conditioning systems have gained an increasing share of the market, i. e., unitary equipment versus built-up, primarily on the basis of first-cost. This trend is likely to continue, but more of the emphasis will be on operating costs or total owning and operating costs (which include both first and operating costs).

B. Gas Equipment.

Gas equipment has historically had an important share of total heating business, but a modest share of the intermediate and small tonnage nonresidential cooling market. Gas has also been

important in the heating side of packaged, year-around unitary equipment. Since the early 1970's, however, the market has been affected by an uncertain gas supply situation brought about by a number of factors that have resulted in an under-valuation of natural gas as compared to other fuels, and a burgeoning demand for it. Since the early 1970's, many gas distribution utilities have been required by their regulatory commissions to restrict gas availability for new construction in certain customer segments.

1. Furnace shipments by energy source. Exhibit III-2 shows two comparisons of new furnace shipments for selected years by energy source. For each year, column A represents shipments of conventional furnaces, while column B represents conventional furnaces plus electric heat pumps (which perform heating as well as air conditioning functions). The gas equipment share decreased from 74 to 78 percent in 1967 to 64 - 70 percent in 1975, and has apparently stabilized at this level for the last two to three years.

2. Penetration of new residential construction. Furnace shipments include units for both new and replacement applications and, since gas equipment has enjoyed a high share of the market for many years, may mask a more significant recent trend. Exhibit II-3 shows the distribution of fuel source for single family construction for 1970, and 1973 through 1975. While other factors may also be involved, this exhibit dramatically indicates the decline in gas share in new residential construction, from 70 percent in 1970 to 38 percent in 1975. Some of this adverse trend can be attributed to an increased proportion of recent new construction in areas lacking access to natural gas distribution systems.

3. Year-around units by energy source. More relevant to this report is the decrease in the gas share of the commercial-size, packaged heat/cool market. The general decline in gas heating share is shown in Exhibit II-4, from 88 percent in 1970 to an estimated 65 percent in 1975.

4. Gas availability perceptions. The potential ramifications of these trends are numerous, but the most significant relate to perceptions concerning the future availability of natural gas. At this time,

psychological barriers to the use of gas equipment have developed in many areas (due to uncertain availability), in spite of the fact that most users and designers would prefer to use gas for heating. Field research strongly indicates that the declining trend in gas equipment is not due to a dislike for gas equipment, but rather to the inability to get gas for many types of new construction. These psychological factors must be recognized and dealt with by any one considering the future marketing of gas equipment.

C. Unitary Equipment.

Perhaps the major trend in unitary equipment has been the increasing share of single package equipment. Reinforcing this trend has been the continued introduction of larger sizes of single package units.

1. Distribution of tonnage by equipment type. Exhibit III-5 shows the percentage share of total tonnage for selected size ranges, by equipment type in 1970. Split systems were more important below 7-1/2 tons and above 30 tons, and verticals represented a reasonable share of the larger-tonnage market.

2. Single package units. With increasing availability of larger-tonnage single package units, single package systems have gained a progressively increased share of the larger tonnage market, as shown in Exhibit III-6. The less-expensive, single package units have been substituted for built-up systems, splits and verticals. Although heat pumps are relatively new to the commercial market in many areas, they have also been affected by this trend. Exhibit III-7 shows that single package heat pumps have increased from 42 percent of the total tonnage, for units of 7-1/2 or larger size, in 1970 to 56 percent in 1975.

D. Electric heat pumps.

Heat pump growth in the nonresidential market has been apparent in warmer climates and areas where natural gas has been unavailable for new construction.

1. Growth factors. The recent high growth of commercial heat pumps has primarily been due to substitution for resistance heating as a sole source of heat, where electricity is the only available energy

source, rather than strictly the result of superior performance characteristics.

2. Appropriate growth trends. Consideration of these factors seems to indicate that future inroads available to a gas heat pump are more likely to follow the single package unitary trends, rather than the electric heat pump trends.

E. Equipment Design Trends.

A number of significant equipment design trends are likely to have considerable impact on the future air conditioning market.

1. Unitary application designers. There has been a general shift to more negotiated work, supported by both contractors and equipment manufacturers. As a consequence, mechanical and air conditioning contractors are performing more of the unitary equipment design and selection functions in commercial markets. This is at the expense of consulting engineers.

2. Energy concerns. Historically, building design and construction practices have typically paid little attention to energy efficiencies, a situation that has resulted in tremendous energy waste. The estimated percentage of total building energy that is currently being wasted, ranges from 25 to 35 percent. In light of this, new standards are being developed by various trade associations and levels of government, and standards such as ASHRAE 90 - 75 and similar measures are being instituted in many states.

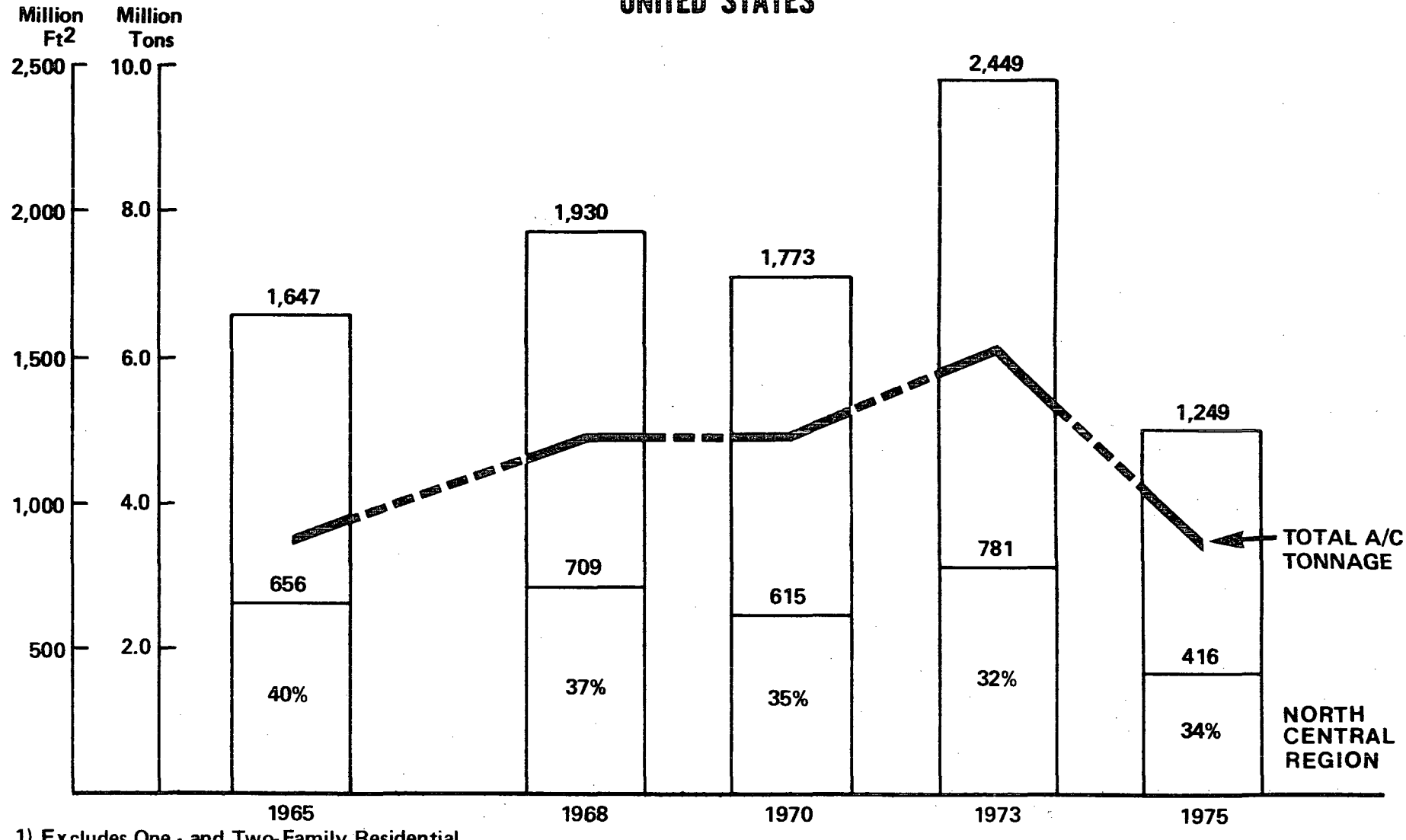
3. Energy conservation. In addition to new building standards, peripheral equipment, controls and supplies are being up-graded to produce more energy efficient HVAC systems. Essentially the major conditioning components or devices remain unchanged, while the cost/quality of the total system increases. Given the current emphasis on building design and construction standards, and an increased awareness of the simple adjustments that can lead to higher system efficiencies, it is very likely that by the 1980's the most extravagant wastage will have been removed, and further savings will require significantly improved performance characteristics.

4. Heat reclamation. Numerous technologies to effectively utilize solar energy (exclusively or in combination with conventional systems), and to reclaim excess or wasted heat for space conditioning and other purposes are being vigorously investigated. The appli-

cability of these technologies should be considered in the development of any new space conditioning device.

Exhibit III-1

ANNUAL ADDITION OF NEW FLOOR SPACE, 1) AND AIR CONDITIONING TONNAGE 2) UNITED STATES

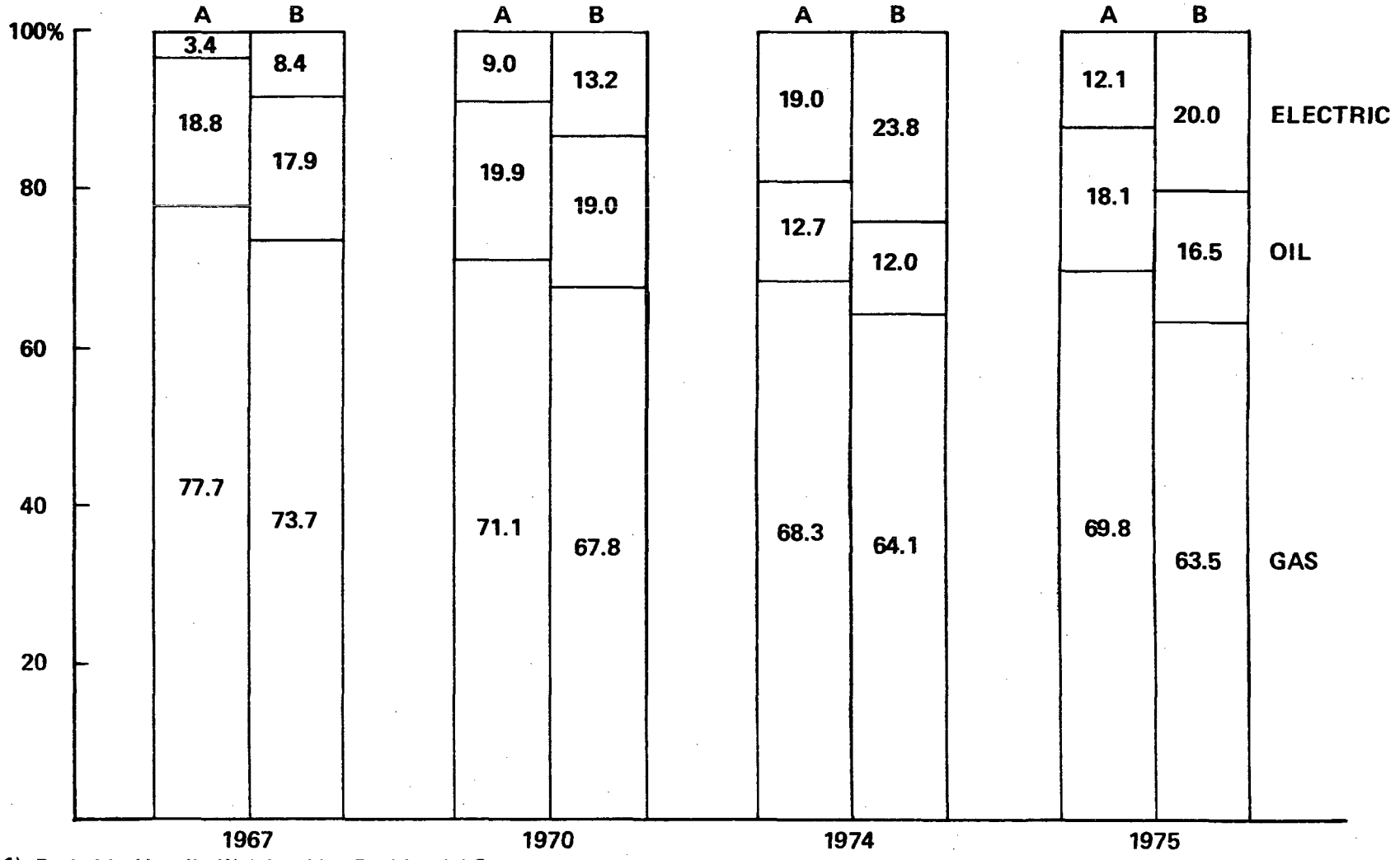


1) Excludes One - and Two-Family Residential
2) In 3 to Over 50 Ton Sizes (Unitary and Built-Up)

Sources: F.W. Dodge Co. and William E. Hill & Company, Inc. Estimates

Exhibit III-2

PERCENTAGE DISTRIBUTION OF FURNACE AND FURNACE PLUS ELECTRIC HEAT PUMP SHIPMENTS (1) BY ENERGY SOURCE

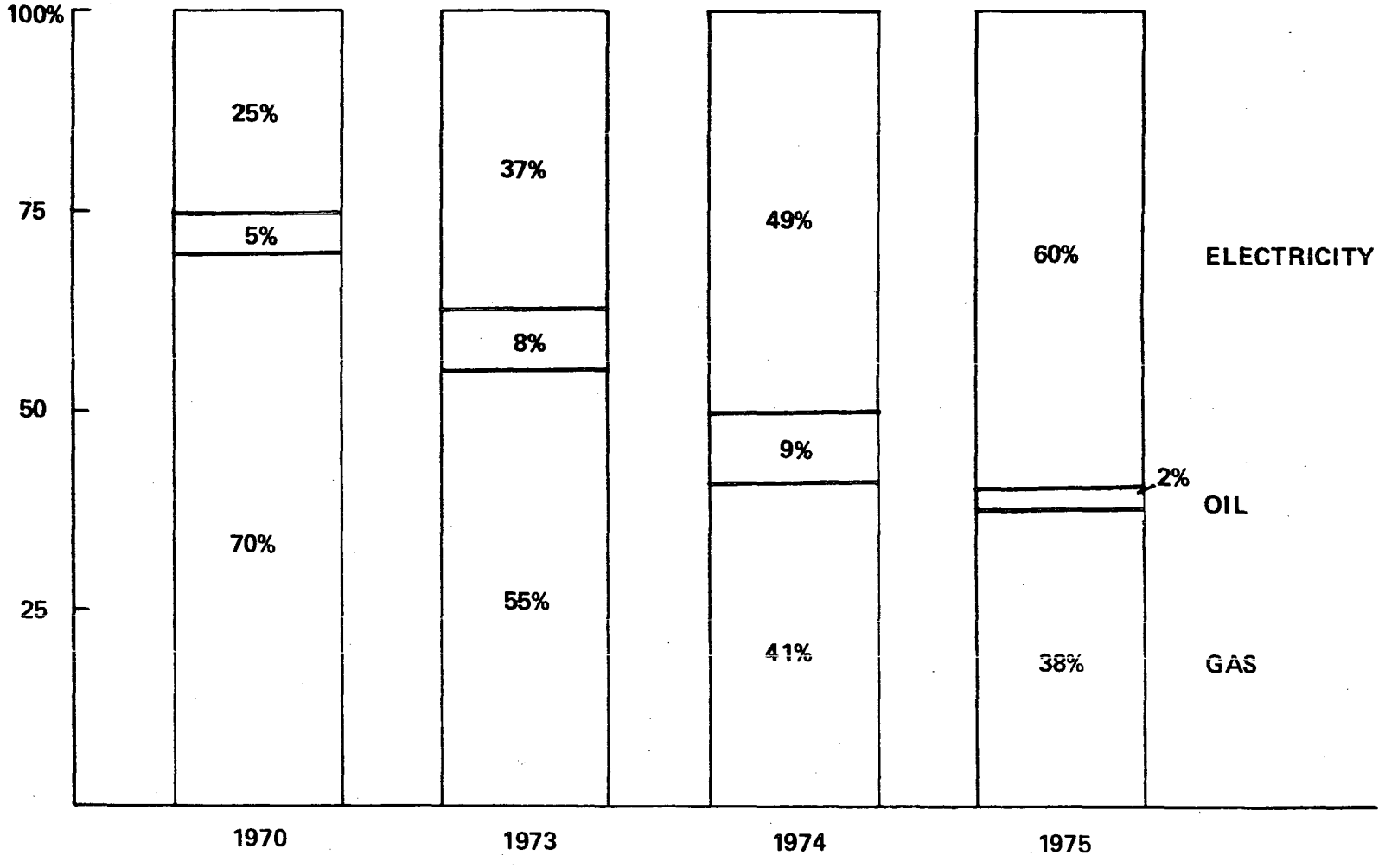


1) Probably Heavily Weighted by Residential Sizes
A) Gas, Oil and Electric Furnaces
B) Gas, Oil and Electric Furnaces Plus Electric Heat Pumps

Source: Air Conditioning, Heating and Refrigeration News

Exhibit III-3

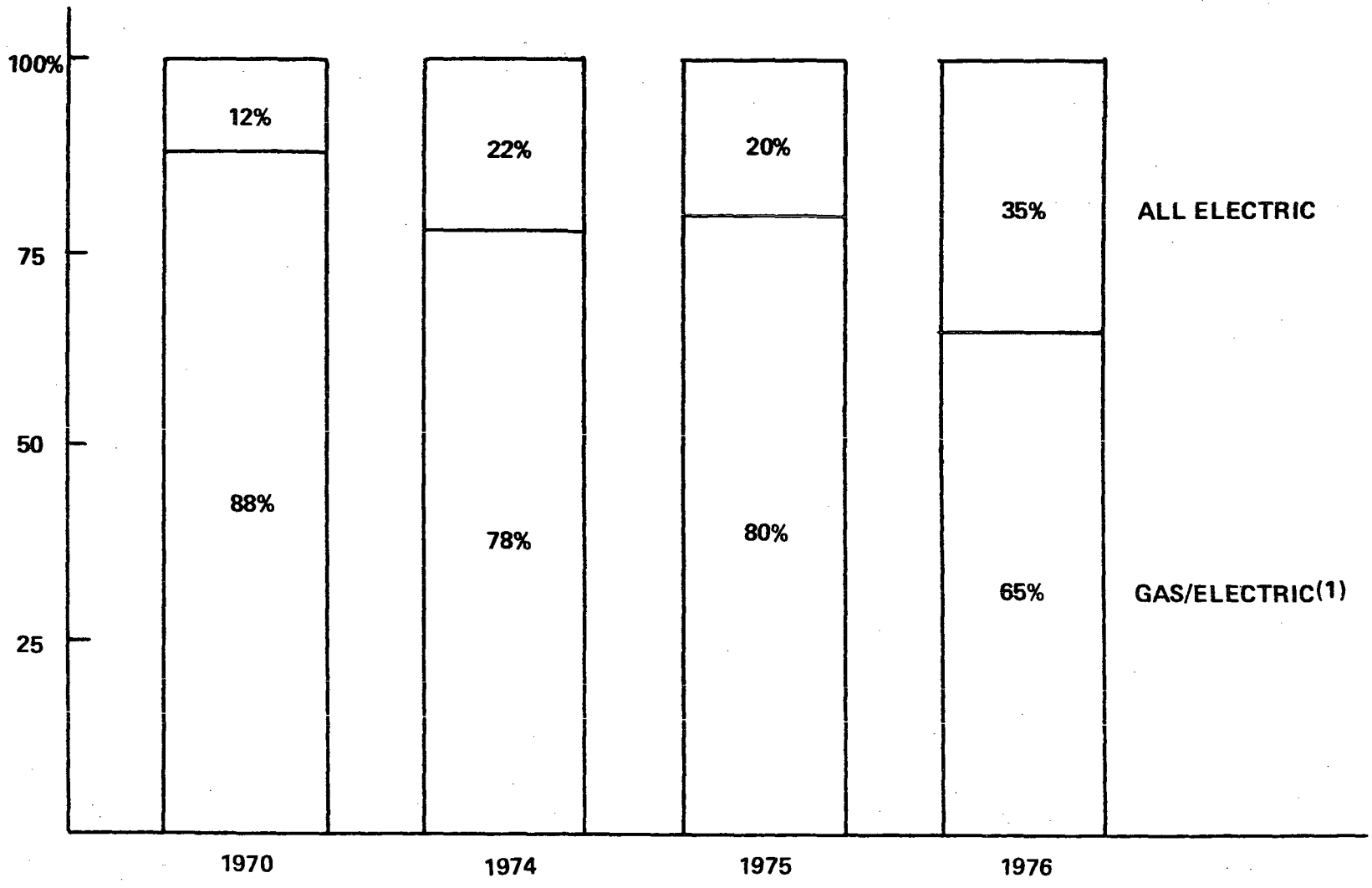
PERCENTAGE DISTRIBUTION OF FUEL SOURCE FOR NEW SINGLE FAMILY RESIDENTIAL CONSTRUCTION



Source: Air Conditioning, Heating and Refrigeration News.

Exhibit III-4

PERCENT DISTRIBUTION OF YACS IN 7½ - 50 TON SIZES BY ENERGY SOURCE 1970 - 1976

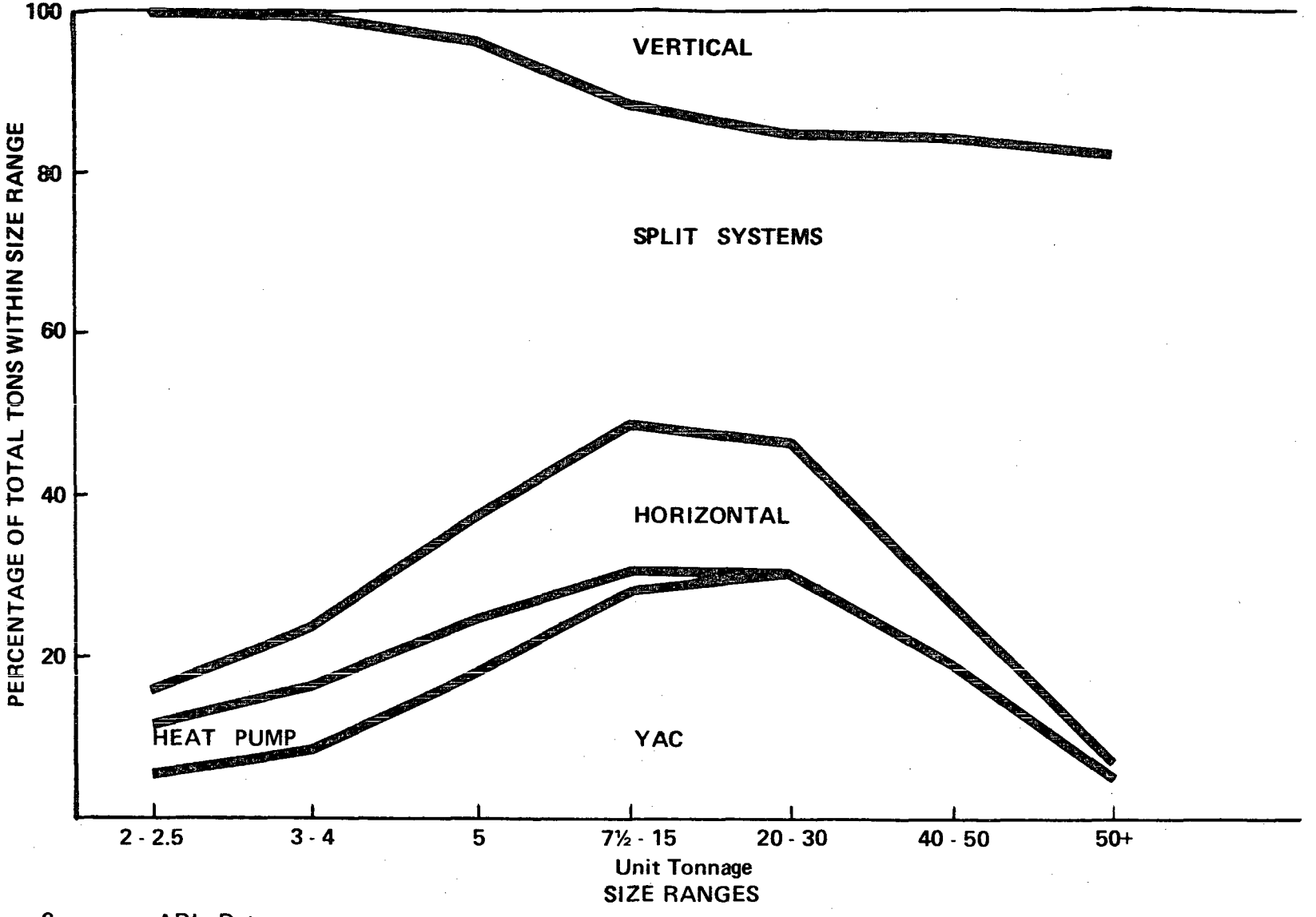


(1) Includes some oil-fired.

Source: ARI data and William E. Hill & Company, Inc. estimates.

Exhibit III-5

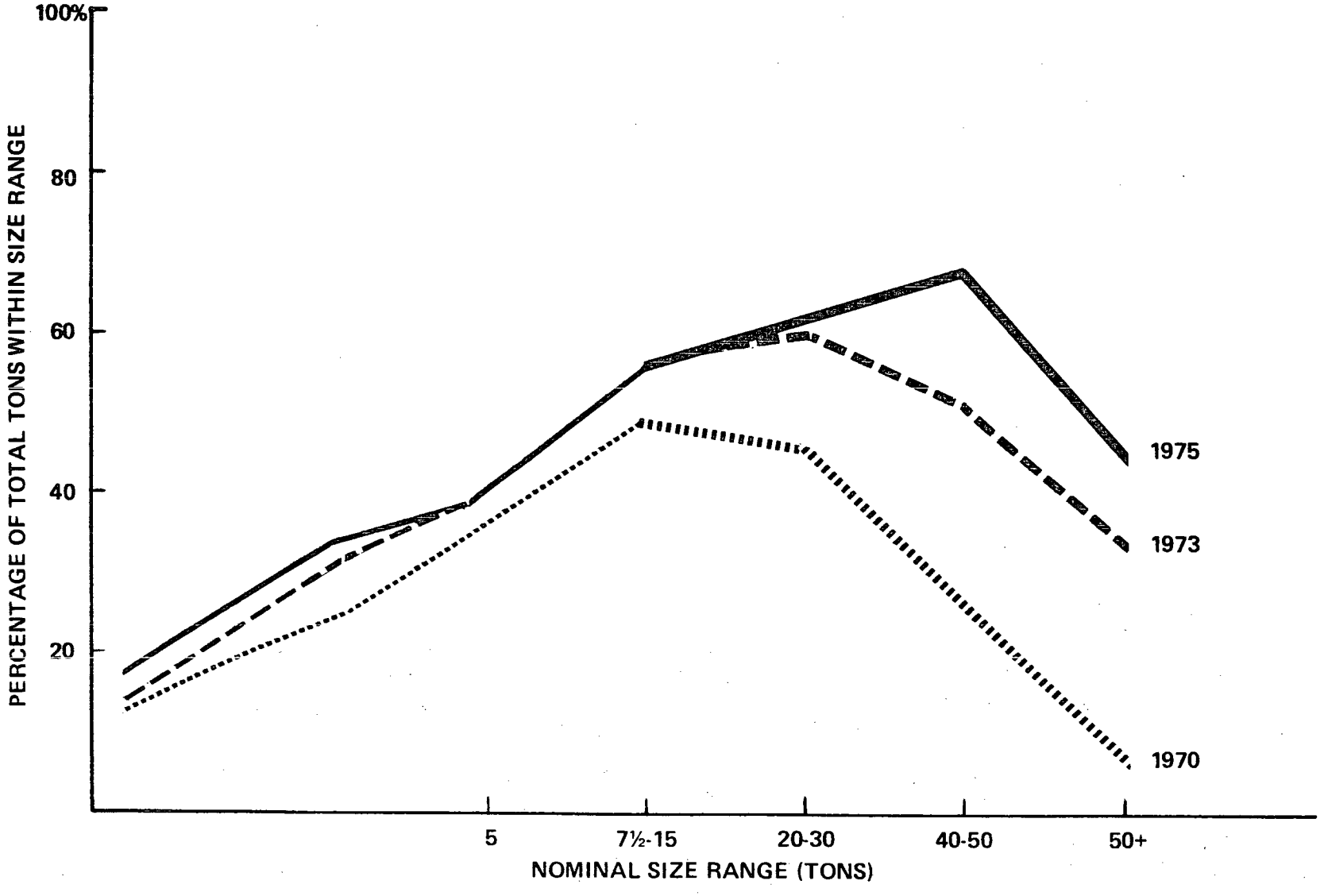
DISTRIBUTION OF UNITARY TONNAGE (2+TONS) BY UNIT SIZE RANGES AND TYPE OF EQUIPMENT 1970



Source: ARI Data

Exhibit III-6

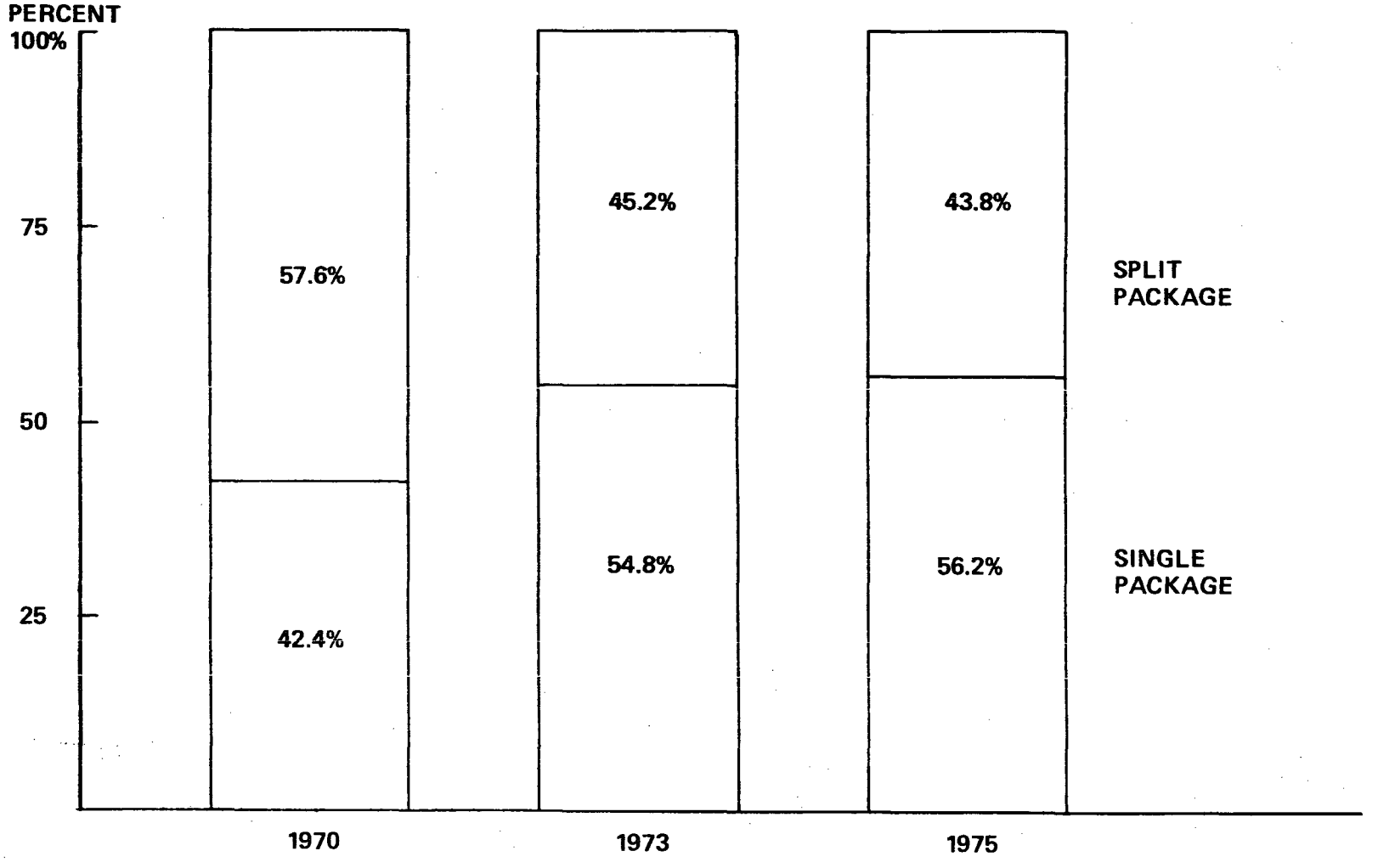
TREND IN PERCENT DISTRIBUTION OF SINGLE PACKAGE UNITARY EQUIPMENT BY NOMINAL SIZE RANGE 1970-1975



Source: ARI Data

Exhibit III-7

DISTRIBUTION OF HEAT PUMP UNIT SHIPMENTS BY CONFIGURATION 1970,1973,1975



(1) Units over 7½ nominal tons.

Source: ARI data.

IV. THE HSPF HEAT PUMP

Gas-fired heat pumps are presumed to have a number of distinct advantages over the electrical heat pump. Most important, gas-fired heat pumps have the advantages of the greater prime-energy efficiency offered by natural gas and a lower net operating cost to the user. The gas industry, i. e., individual gas distribution utilities, the A. G. A., and equipment manufacturers, and the Energy Research and Development Administration have sponsored a great deal of technical development of various types of gas-fired heat pumps. Consolidated Natural Gas has sponsored a gas-fired heat pump development project for several years which shows considerable promise of offering an efficient, packaged unit in the medium-sized equipment range. This unit is designed for colder climatic conditions and could offer good overall seasonal efficiency (thus "HSPF", high seasonal performance factors) for the climate of North Central United States.

A. The HSPF Unit.

The HSPF unit is a fuel-fired, steam driven heat pump that utilizes a steam turbine/compressor and conventional heat exchange components. Exhibit IV-1 presents a simplified schematic of the unit. Other significant components include a heat regenerator, a three-phase, high-frequency generator, which uses the spinning charac-

teristics of the turbine to generate the normal electricity requirements of the unit, and an efficient defrost cycle which eliminates the serious defrost problem common to electric heat pumps. The electric generating system is an important component, as it allows modulation in system operation according to varying load requirements, providing excellent partial load performance.

B. Product Concept Statement

1. Objective. The primary objective is the development of a reliable, gas-fired heating/cooling device that would combine the inherent efficiencies of the heat pump with the clean-burning qualities, lower cost, and high heating values of gas.

2. Supporting market factors. A number of significant market factors and trends appear to support the development of such a unit.

   a. Space conditioning (particularly heating) has been and continues to be a major energy use.

   b. All forms of energy are increasing in cost, some of them dramatically, and increasing emphasis is being placed on improving the efficiency of space conditioning devices on a performance and/or a cost performance basis.

   c. Although heat pump technology offers significant efficiency advantages, it has not been widely applied in colder climates, such as the North Central United States, where the majority of the country's heating requirements are located.

3. Physical and performance characteristics. The HSPF heat pump is envisioned as a single package, heat/cool device initially positioned in the 7-1/2 - 50 ton nominal size range. Emphasis is being placed on the development of a highly reliable unit that will require minimum field maintenance, provide self-generation of required electricity for fans, pumps, etc., and allow for modulation and superior partial load performance.

   a. Heating cycle. The unit is being designed to provide a significantly higher coefficient of performance (at least twice

as high on a seasonal basis) than advanced gas furnaces currently under development. The unit will also have good low ambient temperature performance, and an efficient defrost cycle.

b. Cooling cycle. The HSPF unit's potential coefficient of performance (COP) on the cooling cycle is approximately twice that of current packaged gas air conditioners, .9 versus .5. While the HSPF unit's seasonal cooling COP will be lower than conventional electric units, it should provide better cost/performance due to the lower price of natural gas.

4. Cost characteristics. Basic cost information was provided by the HSPF Project Manager. While these cost assumptions are preliminary, and are likely to be modified and solidified as technical development progresses, they are the best available at this time and served as the basis for field research and market analysis. Equipment first cost is currently expected to be 15 to 35 percent higher than a premium-quality gas/electric year-around unit. The premium payback will certainly be within three years and likely much shorter. The cost of ownership analysis, being conducted by Consolidated Natural Gas, indicates possible payback periods of one year or less, but due to the lack of actual in-use field data for an operating unit, a payback period of two years is used in this report.

C. Key Factors of Commercial Significance.

Certain characteristics and features of the HSPF unit have key significance to the commercial evaluation and success of the unit.

1. New technology. The technology of the HSPF unit is quite different from conventional equipment currently available in the market, and very sophisticated compared to intermediate-size units that installing and service contractors are familiar with. Acceptance of such radically new technology is a critical factor, and reliability and ease of maintenance are often the most important non-economic factors in equipment selection.

2. Equipment first-costs. Historically, first-costs have been a primary determinant of equipment selection in many markets, and even in those cases where owning and operating costs or life-cycle costing are used, first-costs have an important influence on the results of the analysis.

3. Operating costs. Operating costs are particularly important to certain market segments, but are generally becoming more widely utilized in equipment selection decisions. The operating cost savings of a premium-priced product must be sufficient to provide for premium payback in a reasonable amount of time -- generally two to three years.

4. Size and configuration. Unit sizes and configuration, as well as the mix of sizes in the product line are important factors impacting commercial success. A range of sizes is usually desirable to provide flexibility in combining uits of various sizes to meet variable application requirements.

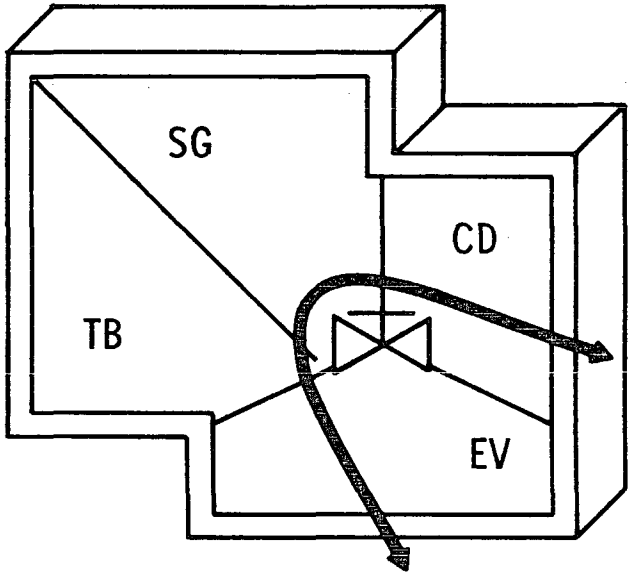
5. Relative performance. The relative heating and cooling performance of a piece of equipment affects its potential versus alternative units, as well as the geographical/climatic areas for which it is best suited.

6. Fuel source. Due to the considerable variation in the availability and costs of different energy sources, fuel source is a critical factor and the ability to utilize several types of fuel is an important consideration.

Exhibit IV-1

SIMPLIFIED HSPF SCHEMATIC

Fuel-fired,
Steam Driven
Turbine/Compressor
Conceptually
Functions As A
Compressor



Conventional Heat
Exchange Components

- ☐ CD Condenser
- ☐ SG Steam Generator
- ☐ TB Turbine/Compressor
- ☐ EV Evaporator
- ➡ Cycle Effect

V. THE PROJECTED MARKET POTENTIAL FOR THE HSPF HEAT PUMP IN THE NORTH CENTRAL REGION

Projecting the market potential for the HSPF gas heat pump is a complicated task requiring a thorough evaluation of the market and product characteristics described in the previous sections. This section includes a description of the projection method; the projection of the available market for single package, combination heat/cool units; the projected market potential for the HSPF unit; and an evaluation of this market potential under three gas availability scenarios.

A. Projection Methodology.

The method utilized to project the market potential for the HSPF heat pump in 1981 involves a projection of the available market for single package heat/cool units, and an evaluation of the potential for the HSPF unit within this available market.

1. Construction segment. The available year-around equipment market in construction depends upon: (1) the level of construction; (2) the amount of total air conditioned floor space and the tonnage of air conditioning required; and (3) the proportion of total tonnage represented by single package, combination heat/cool units. This analytical approach proceeds in progressively more-specific stages in terms of market/equipment characteristics, and is diagrammed in Exhibit V-1.

   a. Construction/market segments. Exhibit V-2 lists the construction market segments used in the market projection. Expected additions of floor space in 1981 for the total U. S. and the North Central Region were developed from F. W. Dodge

five-year construction forecasts. Summarized construction statistics for the total U. S., the Midwest region and the Northeast region are provided in Appendix A.

b. Air conditioned space and tonnage. The amount of air conditioned space for each segment is developed from estimated levels of air conditioning penetration. Average data for square feet per ton of air conditioning (developed from technical manuals and field research) are applied to the amount of conditioned space for each segment to project total tons of air conditioning required.

c. Projected construction tonnage. Equipment use factors for each segment are applied sequentially to total tonnage to project the use of: (1) unitary equipment, (2) 7-1/2 - 50 ton units, (3) single package units and (4) combination heat/cool units. This results in the projected available market (in tons) for 7-1/2 - 50 ton, single package, heat/cool units in construction applications.

2. Replacement segment. The replacement market in 1981 is projected in a separate analysis of historical sales and replacement schedules for year-around units.

3. HSPF heat pump market potential. The projected market potential for the HSPF heat pump is developed through an evaluation of the characteristics of the market for single package, heat/cool equipment; and the cost/performance characteristics of the HSPF unit.

B. Construction Tonnage Projection.

1. Key parameters. The key parameters for each construction segment were determined on the basis of historical analysis, considerations of market structure and characteristics and field research. The projected changes in the values of these parameters for the total market from 1975 to 1981 are shown in Exhibit V-3.

a. North Central construction. The North Central Region's share of total U. S. construction varies considerably by segment, but the overall share is expected to remain essentially constant.

b. Air conditioning penetration. Air conditioning penetration of new construction is projected to increase slightly, from 65 percent of total floor space to about 68 percent in 1981.

c. Average square feet per ton. Building design and construction trends related to improved energy efficiency will affect the amount of air conditioning needed for a given amount of floor space. As the extent and effects of these recent trends are difficult to project at this time, the conservative figures from currently available design guides are used in the projection. This increases the overall average per ton of air conditioning from 285 to 300 square feet.

d. Unitary air conditioning. The unitary equipment market share is expected to remain essentially the same over the next five years, at 55 - 57 percent. While unitary equipment will still provide ease of installation and first-cost benefits, growing concerns about energy costs should alleviate to some extent the trend away from central built-up systems (which tend to be more energy efficient).

e. 7-1/2 to 50 ton units. No major change is projected for the proportion of unitary tonnage represented by 7-1/2 to 50 ton units.

f. Single package units. The trend to single package units within the 7-1/2 to 50 ton size range is expected to continue, reaching 68 to 70 percent by 1981.

g. Combination heat/cool units. Combination heat/cool units within the single package, 7-1/2 to 50 ton size range are projected to increase in market share to 77 - 79 percent.

2. Available market projection. The projection of the available market in 1981 for single package, heat/cool units within the 7-1/2 to 50 ton range is shown in Exhibit V-4, by market segment.

a. Nonhousekeeping residential (primarily hotels/motels). Available market of 5 - 6 thousand tons. Dormatories generally use built-up systems. High-rise hotels/motels primarily use built-up systems, as do many low-rise buildings (which also use window units and small unitary through-the-wall units). Mid-tonnage unitary equipment is often used for attached restaurants, lounges, meeting rooms and lobby/office areas, representing perhaps 20 - 25 percent of total floor space.

b. Hospital and health. Available market of 10 to 12 thousand tons. Historically this market has been operating cost/quality conscious, and central built-up systems were better

suited to the types of buildings (high-rise), and the often stringent space conditioning requirements. The growth of smaller clinics, nursing homes and professional buildings provides increased potential for higher-quality unitary equipment.

c. Education and science. Available market of 20 - 24 thousand tons. A need for new elementary and secondary schools is projected for the early 1980's to replace older schools, while only modest construction is expected for colleges and universities. Classroom areas require a relatively high amount of air conditioning per unit area due to the high internal load conditions, and low-rise buildings are well suited for unitary equipment. Elementary and secondary school markets tend to be more first-cost conscious than colleges and universities, which often use built-up systems or central steam plants.

d. Miscellaneous nonresidential. Available market of 24 to 26 thousand tons. This category includes public, religious, amusement, social and recreational buildings that very greatly with respect to application and equipment-use characteristics.

e. Industrial. Available market of 40 - 45 thousand tons. Plant offices and single story plants are well suited for unitary equipment. The increasing emphasis on "spot conditioning" (rather than conditioning the total plant space) is probably a positive factor for the use of unitary equipment. While 50 percent or more of new plants are expected to be air conditioned, research indicates that on average only about 30 - 35 percent of the floor space is involved.

f. Commercial -- offices. Available market of 25 - 30 thousand tons. High-rise office buildings use built-up equipment, while low-rise offices are an important market for unitary equipment. A significant portion of this market has been speculative and highly first-cost sensitive. Heat reclamation systems, sometimes using heat pumps, are being actively investigated to utilize excess interior heat for heating external areas.

g. Commercial -- stores and other. Available market of 70 - 75 thousand tons. This segment, which includes stand-alone stores, shopping centers, restaurants, commercial warehouses and garages, is the largest and most important market for unitary equipment. Restaurants, particularly fast food types,

represent an excellent market for heat/cool combination units due to average size (20 - 30 ton requirement), use requirements (door openings) and construction practices (stand-alone, need an individual system). Overall store construction continues to be strongly weighted to shopping centers. Commercial warehouses and garages represent a significant portion of total commercial floor space, but continue to have a low air conditioning penetration.

3. Market segment comparison. Exhibit V-5 shows the comparison of available markets by segments for 1975 and 1981. The highest growth potentials are in the industrial and commercial segments, which were most affected by the recent construction recession.

C. Replacement Tonnage Projection.

The replacement market for combination heat/cool unitary equipment is growing in importance, and by 1981 will represent a significant portion of the total market. The procedure utilized to project the replacement market involves the analysis of historical sales and the application of an average replacement schedule to allocate replacement tonnage in future years.

1. Replacement schedule. A replacement schedule (average age at replacement) for combination heat/cool units (in 7-1/2 to 50 ton sizes) was developed from field research and telephone interviews. Exhibit V-6. Average age at replacement was first estimated for ranges of years and then distributed over each range to arrive at an overall average of 10 to 11 years. Generally, up to five years components rather than the whole unit is replaced, between six and ten years the total unit is replaced 50 percent of the time, while after ten years the whole unit is usually replaced. This general sequence applies on an overall basis, but is highly dependent upon equipment quality and size. Components are more likely to be replaced on larger units, while smaller equipment is typically replaced on a unit basis.

2. Replacement projection. The replacement projection for 1981 is shown in Exhibit V-7. The projected raw total of 122 - 137 thousand tons is adjusted for net demolitions and replacement of units

during major remodelling (which is included in the construction projection) to yield an adjusted total of 100 to 120 thousand tons.

D. Key Considerations in Evaluating the Market Potential for the HSPF Heat Pump.

The considerations listed in Exhibit V-8 represent interaction between market structural characteristics and product characteristics, and are key factors affecting the market potential for the HSPF heat pump. The most important factors relate to the cost evaluation framework and cost sensitivities.

1. Cost evaluation framework. The growth of unitary equipment, particularly versus built-up systems, has been heavily supported by market sensitivity to first-costs.

   a. Speculative customers. Speculative customers currently represent 25 - 35 percent of total customers and are extremely first-cost sensitive. Exhibit V-9. First-cost is the sole or primary criterion 80 to 85 percent of the time and operating costs are only an important, not necessarily prime, criterion 20 - 25 percent of the time.

   b. Non-speculative customers. While operating costs are a more important consideration for non-speculative or owner/operator customers (40 - 45 percent), first-costs are the sole or primary consideration in 60 - 65 percent of the equipment selection decisions.

   c. First-cost concern. Exhibit V-9 depicts the extreme importance of first-cost in the current unitary market. First-cost orientation was more pronounced in the past, but recent energy cost increases and other factors are beginning to increase the importance of operating costs. The weighted average of first-cost-oriented unitary customers in 1976 is 68 percent, and even for the remaining 32 percent, first-costs are an important consideration.

2. Cost sensitivities. Air conditioning systems are evaluated on two basic types of costs -- first-costs and operating costs -- and a product bearing a first-cost premium must present compensating

advantages (usually operating costs) to be acceptable in the market. This premium evaluation process is extremely complex, particularly when qualitative factors, such as new technologies, are involved.

a. Premium/payback. One of the most common methods of premium evaluation is the analysis of the length of time required for operating savings to equal (or payback) the first-cost premium. The analysis is a comparison between equipment (or perhaps other investment) alternatives, and consists of three basic elements: first-cost differential, equipment operating efficiencies/characteristics, and operating cost differential. All three elements, and the resulting payback period, must be considered in combination, rather than as separate factors. Equipment alternatives are not evaluated solely on payback period, or premium.

b. Payback example. Exhibit V-10 shows a simple payback analysis for four hypothetical units. All three alternatives have a payback period of two years, but due to different operating efficiencies and premiums, represent quite different investment decisions. This simple example highlights three often encountered "real world" situations.

(i) Unit A offers sizable operating savings and return on investment, but requires a significantly higher capital outlay. In many cases, particularly in the commercial market, large premiums are not feasible due to insufficient availability of capital.

(ii) Unit B has a moderate premium and moderate annual savings and may represent a feasible, attractive investment alternative. However, the customer could have other investment alternatives with higher returns.

(iii) Unit C has a relatively small premium and small annual savings. In this case, the premium investment may be no problem, but the annual savings may be insignificant in comparison to other business costs and opportunities.

3. Premium/payback analysis. The premium/payback curves shown in Exhibit V-11 were developed from extensive field and telephone interviews, and reflect the judgment of approximately 100 contractors with respect to the acceptability of various premium/payback

period combinations to their customers. The customer group in question includes those who would accept a premium-payback situation, i. e., those who do not purchase on a first-cost only basis. Acceptability indicates the willingness to consider the product, not necessarily the willingness to purchase it.

a. Three-year payback. If the payback period is three years, a 10 percent premium is acceptable to about 80 percent of the relevant customer group, while a premium of 40 percent is acceptable to less than 20 percent. Acceptability declines rapidly beyond a 20 percent premium and reaches 25 percent at a premium of 30 percent.

b. Two-year payback. A payback period of two years results in higher acceptability at all first-cost premiums, ranging from 95 percent at a 10 percent premium to 30 percent at a premium of 40 percent. At a first-cost premium of 30 percent, acceptability is slightly less than 50 percent.

4. Premium/payback and market potential. One of the important features shown in Exhibit V-11 is the slope of the curves, which provides an indication of cost sensitivity. These cost sensitivities can be related to the customer base (the percentage of total customers willing to consider a premium/payback situation) to produce an analysis of market potentials at various first-cost premiums and percentages of premium/payback customers. This is shown in Exhibit V-12 for the two year payback situation.

a. First-cost premiums and market potential. The effects of changes in the percentage of premium/payback customers and first-cost premiums can easily be analyzed in this exhibit. If the current customer level is 32 percent, and the first-cost premium is reduced from 30 percent to 15 percent, the market potential increases from about 16 percent to 27 percent of the available market.

b. Premium/payback customers and market potential. Exhibit V-13 represents the same data plotted to show premium/payback customer curves over a range of first-cost premiums. This exhibit clearly indicates the changes in market potential that can result from shifts in the percentage of first-cost customers at a given first-cost premium. If the first-cost premium is 20 percent and the percentage of premium/payback customers increases from 30 percent to 40 percent, market potential increases from 22 percent to 30 percent of the available market.

c. Structural shifts and market potential. Exhibits V-12 and V-13 show the changes in market potential that can result from shifts in the structural characteristics of the market. This analysis highlights the dynamic nature of market potential, and indicates how product and market characteristics interact to define the potential.

5. Product life cycle and market potential. Exhibit V-14 describes the basic product life cycle concept and provides a framework for defining three key terms: available market, market potential and market penetration.

   a. Available market. The available market represents the realizeable market for a given product category, i. e., unitary heat/cool equipment, generally defined by function or use characteristics. A product category includes various products, each of which represents a portion of the total available market.

   b. Market potential. Each product within a product category, i. e., heat pump, has a market potential or share of the available market based upon market characteristics and its competitive position versus other products in the category.

   c. Market penetration. The market penetration curve represents the product's life cycle or cumulative product sales over time, and the degree to which market potential is achieved in any time period.

6. Marketing elements. Of the four basic marketing elements: product, pricing, promotion and distribution; product and price primarily affect market potential, while promotion and distribution affect market penetration (or sales). Exhibit V-15. This indicates that the product and pricing elements are key and must satisfy market requirements to provide suitable market potential. The effectiveness of the promotion and distribution elements determine market penetration (or sales levels), but only within the framework established by the market potential.

7. Shifts in market potential. Market potential is determined by the interaction of product characteristics and market structural characteristics. Market potential is dynamic rather than static, and can change with shifts in the underlying structural characteristics. Exhibit V-16 depicts the possible shifts in market potential over time, in response to shifts in the underlying product or market characteristics.

a. Market potential $t - t_1$. The market potential for the period t to t_1 is determined by the structural characteristics during this period. If these characteristics remain unchanged, market potential continues at this level and forms an upper limit for market penetration.

b. Market potential $t_1 - t_2$. With positive shifts in the underlying structural characteristics, the market potential for the period t_1 to t_2 increases and market penetration can proceed to a higher level of sales (penetration of available market). This then becomes the upper limit of sales for the period $t_1 - t_2$.

c. Higher market potentials. Additional positive shifts in structural characteristics can continue, i. e., market potential $t_2 - t_3$, until the maximum limit (total available market) is reached. Negative shifts in structural characteristics can also occur, which would reduce market potential.

d. New technologies/products. The possibility of shifts in market potential is an extremely important consideration in the introduction of new technologies/products. The initial market potential for these products often appears to be limited, but if structural shifts are possible (or probable), more suitable potentials may develop to provide adequate sales and return on investment.

E. Projected Market Potential for the HSPF Heat Pumps.

The projected available market for 7-1/2 to 50 ton, single package combination heat/cool units in 1981 includes a replacement segment of 100 - 120 thousand tons and a construction segment of 200 - 220 thousand tons for a total of 300 - 340 thousand tons. Both quantitative and qualitative factors are used to evaluate the HSPF unit's potential within this available market. Exhibit V-17 shows these projections: 20 - 30 thousand tons in the replacement segment and 45 - 60 thousand tons in the construction segment for a total potential of 65 - 90 thousand tons.

1. Construction segment potential. The key quantitative factor is the acceptability of a premium-priced product as described in Exhibit V-12. Key qualitative factors include: concern about the gas supply situation, past experience with gas air conditioning equipment, willingness to accept new technologies, the complexity of the unit, and uncertainties about the reliability and maintenance requirements.

   a. Quantitative factors. The current premium/payback customer percentage is estimated to be between 30 and 35 percent. Increasing concerns about energy and other operating costs are affecting operating cost sensitivities in the market, and should result in a higher percentage of premium/payback customers by 1981. This trend is only beginning to develop, but the percentage of premium/payback customers in 1981 is expected to be at least 40 percent. The estimates for first-cost premium, provided by the HSPF heat pump project manager, are between 15 and 35 percent.

   b. Qualitative factors. While gas equipment is generally preferred for commercial heating applications, most of the qualitative factors appear to have a negative effect on the potential for the HSPF unit.

   c. Projection. The raw market potential, based upon 40 percent premium/payback customers and a first-cost premium of 15 to 35 percent is 15 to 35 percent of the available market. Adjustments for qualitative factors results in a range of 20 - 30 percent of the available market, or 45 to 60 thousand tons.

2. Replacement segment potential. The replacement market tends to be slightly less first-cost sensitive, and customers frequently upgrade equipment, particularly if problems or high operating costs have occurred.

   a. Quantitative factors. The percentage of premium/payback customers in the 1981 replacement market is projected to be 50 percent, with the first-cost premium ranging between 15 and 35 percent.

   b. Qualitative factors. Although there is some tendency to upgrade on replacement, generally the same type of equipment is selected. This is particularly the case for fuel source, and electric/electric year-around units are likely to be replaced by electric/electric units.

c. Projection. Historically, gas/electric units have represented about 80 percent of year-around unit sales so the available gas replacement market is 80 to 96 thousand tons, rather than the total 100 - 120 thousand tons. The raw market potential, based upon 50 percent premium/payback customers and a first-cost premium of 15 to 30 percent, is 18 to 40 percent of the available gas market. Adjustments for qualitative factors and field research result in a range of 25 to 35 percent of the available gas replacement market, or 20 to 30 thousand tons. This represents 18 to 28 percent of the total year-around replacement market.

F. HSPF Heat Pump Market Potential for 1981 -- Three Scenarios.

Perhaps the major non-cost factor affecting the market potential for the HSPF unit is the expected availability of natural gas in the 1980's.

1. Gas availability scenarios. Since an accurate projection of gas availability is extremely difficult under the current uncertain energy situation, market potential is analyzed for three gas availability scenarios, described in Exhibit V-18.

   a. Scenario I. Gas is readily available for new nonresidential construction. The major equipment competition for the HSPF unit is expected to be gas/electric year-around units.

   b. Scenario II. Gas is available for new nonresidential construction, but only if "specified" energy efficient equipment is used. Competition in the replacement market is expected to be the gas/electric year-around units; and in the construction market, electric/electric year-around units and electric heat pumps.

   c. Scenario III. Gas is not available for new construction, but a gas/electric year-around replacement potential exists as established customer allotments continue. The HSPF unit would compete in the replacement market versus gas/electric year-around equipment.

2. Evaluation of market potentials. Exhibit V-19 shows the comparison of HSPF market potentials under the three gas supply scenarios.

   a. Potential -- Scenario I. The projections developed in the previous sections represent the market potential under Scenario I:

20 - 30 thousand tons for replacement, 45 - 60 thousand tons for construction for a total of 65 - 90 thousand tons.

b. Potential -- Scenario II. Initially, it was thought that the potential under Scenario II would be less than that for Scenario I. However, Scenario II represents a complex interaction of positive and negative factors that could result in a market potential that is higher, or lower than Scenario I; or about the same.

(i) Positive factors. Since gas is only available for energy efficient equipment, such as the HSPF unit, competion from gas/electric year-around units is effectively eliminated, and the HSPF unit could be the only gas equipment available for the large protion of the market that prefers gas heating. Such an emphasis on energy efficient equipment should also support a faster, stronger shift to life-cycle costing and concern for operating costs.

(ii) Negative factors. The key negative factor is the psychological impact of a highly controlled gas availability situation. This would undoubtedly affect perceptions concerning future gas availability and the willingness to consider the purchase of any kind of gas equipment. Other important factors would be the willingness of manufacturers, distributors, designers, installers and service contractors to become invoved with, and support, gas equipment under such restrictions.

c. Potential -- Scenario III. In this situation the potential for the HSPF unit is restricted to the replacement of gas/electric year-around units and a limited amount of the construction market (some remodelling and relocation of customer gas allotment). The maximum potential would be 20 - 30+ thousand tons, but the severity of the gas availability situation could result in significantly retarded market penetration. Under this situation, it is unlikely that an effective marketing and distribution system could be established.

3. Market potential -- 1981 - 1986. Exhibit V-20 shows the projection of market potential for the HSPF unit in 1981 under Scenario I, and expectations for 1982 through 1986. An estimate for 1975 is included for comparison.

a. Projection technique. Since reliable projections of construction activity beyond 1981 were not available, the market

potential projected for 1981 was used as a base for expected average annual growth in each segment.

(i) The construction market was increased at the historical average growth rate of 3.5 percent.

(ii) The replacement market was increased at an average annual rate of 15 percent, reflecting the sales growth of year-around units in the 1960's and early 1970's; and the expected increase in energy retrofit applications.

(iii) Product and market characteristics were held constant at the values utilized for the 1981 projection.

3. Growth in market potential. Total market potential for the HSPF heat pump is expected to increase from 65 - 90 thousand tons in 1981, to 94 - 120 thousand tons in 1986. Due to a significantly higher growth rate, the replacement segment is expected to increase as a percent of total, from 32 percent in 1981 to 42 percent by 1986.

G. Qualitative analysis -- Five Selected Cities.

A qualitative analysis of five markets outside the North Central region was conducted for comparison purposes. These five markets were Atlanta, Dallas, Los Angeles, St. Louis and Washington, D. C.

1. Objective. The objective of this analysis was to define the basic requirements for a marketable HSPF unit in these areas. Qualitative factors relating to market structure and characteristics and equipment requirements were evaluated and compared to those in the North Central Region.

2. Findings. The major findings resulting from the qualitative analysis are:

a. The market structure in these cities is generally similar to the North Central Region.

b. The major difference in market characteristics is a higher relative seasonal cooling requirement, leading to a greater emphasis on equipment cooling performance.

c. Other market differences (particularly in the Southern three cities are:

(i) Generally higher air conditioning penetration.

(ii) Longer history of air conditioning use -- particularly residential.

(iii) Existence of a large, will-established replacement market.

3. Conclusions.

a. Modest changes in equipment characteristics would not significantly increase the market potential for the HSPF unit in these cities.

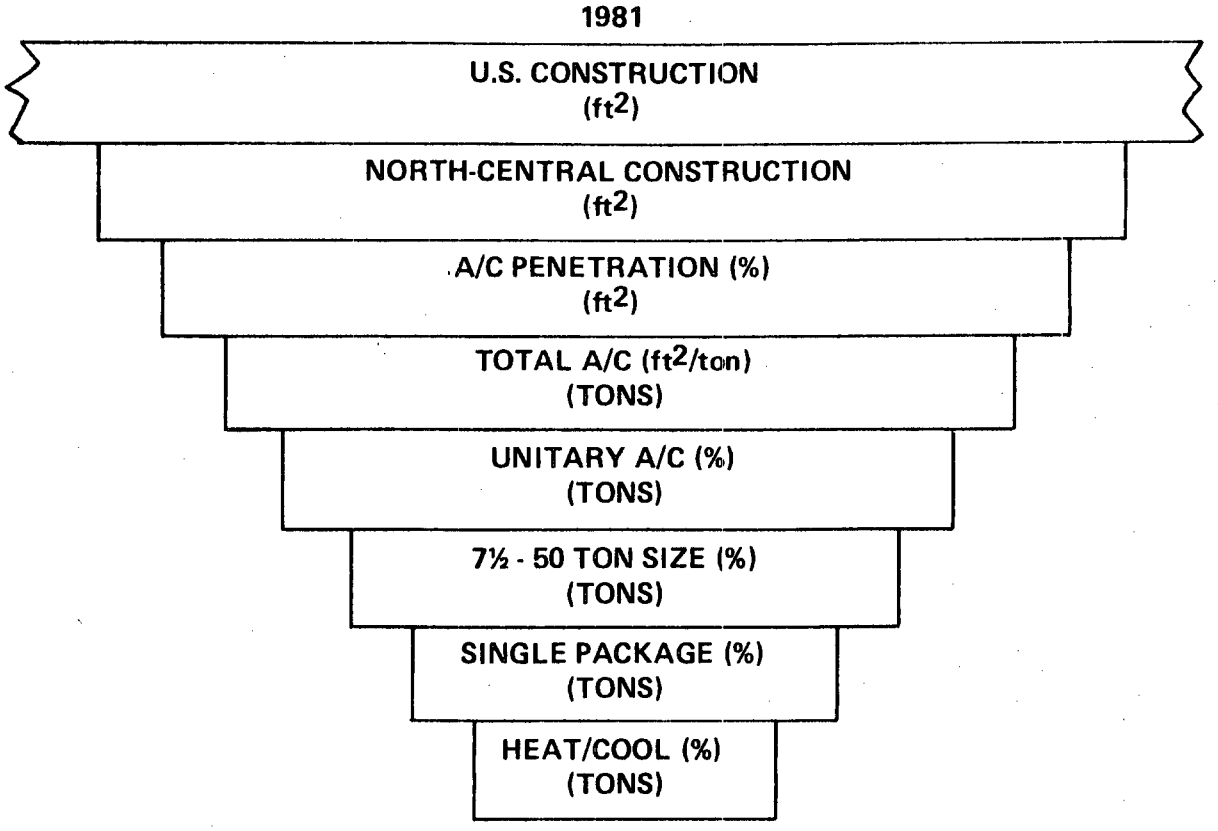
b. Major improvements in cooling performance would increase market potential in Atlanta, Dallas and Los Angeles.

c. Any possible reduction in first-costs related to unneeded heating capacity would improve equipment payback and market potential.

d. Except for possible gas availability conditions, there is not an apparent greater potential for the HSPF heat pump in these cities than in the North Central Region.

Exhibit V-1

ANALYSIS OF THE POTENTIAL MARKET FOR THE HSPF HEAT PUMP



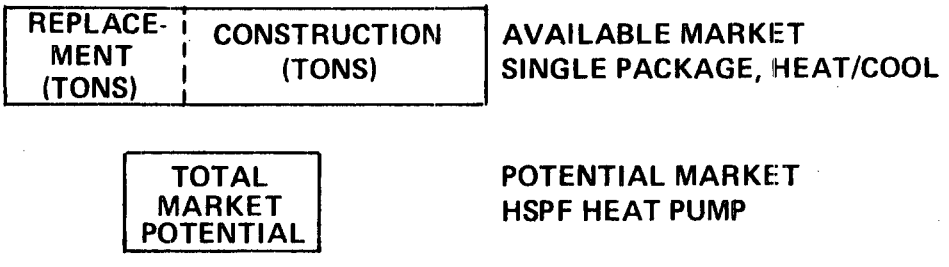


Exhibit V-2

CONSTRUCTION SEGMENTS

COMMERCIAL

- Stores and other commercial buildings
- Offices and banks

INDUSTRIAL

- Manufacturing buildings
- Manufacturer owned labs and warehouses

EDUCATION AND SCIENCE

- Classroom buildings
- Laboratories, libraries, museums

HOSPITAL AND OTHER HEALTH CARE

- Hospitals and clinics
- Nursing homes

HOTELS/MOTELS AND MISCELLANIOUS SHELTER

- Hotels/Motels
- Dormatories

OTHER BUILDINGS

- Public
- Religious
- Amusement, Social and Recreational
- Miscellanious Nonresidential

Exhibit V-3

ASSUMPTIONS - KEY PARAMETERS UNITARY HEAT/COOL MARKET POTENTIAL NORTH CENTRAL REGION

Parameter	1975 (e)	1981 (P)
North Central Region (Avg. % U.S. Constr.) (1)	31.7%	31.9%
A/C Penetration (New) (Avg. NCR %) (2)	65.0%	67.6%
A/C Ft^2/Ton (Avg. NCR) (2)	285	300
Unitary A/C (Avg. % of total, NCR) (2)	55-59%	55-57%
7-1/2 - 50 ton sizes (Avg. % NCR) (2)	62-64%	62-64%
Single Package (Avg. % NCR) (2)	65-67%	68-70%
Heat/Cool (Avg. % NCR) (2)	73-75%	77-79%

(1) William E. Hill & Company estimates based upon F. W. Dodge Data.
(2) William E. Hill & Company estimates.

(e) Estimated
(P) Projected

Exhibit V-4

PROJECTION OF THE AVAILABLE MARKET FOR SINGLE PACKAGE HEAT/COOL UNITARY EQUIPMENT

North Central Region - 1981
(Thousands of Tons)

Market Segment	Projected Construction Floor Space (1)		Air Conditioning Penetration (1)		Total Air Conditioning		Unitary Air Conditioning (2)		7-1/2 - 50 Ton Equipment (2)		Single Package Units (2)		Combination Heat/Cool Units (2)	
	U.S.	N. Central	%	Ft^2	Ft^2/Ton	Tons	%	Tons	%	Tons	%	Tons	%	Tons
Nonhousekeeping Residential	77	23.6	98	23.0	300	77.0	60	46.2	21	9.7	68	6.6	90	5.9
Hotels/Motels	67	20.6	100	20.6	297	69.4	65	45.5	21	9.5	68	6.5	90	5.8
Dorms and Other	10	3.0	80	2.4	310	7.6	10	0.7	25	0.2	50	0.1	90	0.1
Hospital & Health	80	28.8	100	28.8	250	115.2	35	40.3	65	26.2	50	13.1	90	11.8
Education & Science	132	44.9	82	36.8	260	141.5	60	84.9	60	50.9	60	30.5	73	22.3
Classrooms	113.5	38.6	80	31.1	255	121.8	63	77.0	60	46.2	62	28.6	74	21.2
Labs, Libraries, etc.	18.5	6.3	90	5.7	290	19.7	40	7.9	60	4.7	40	1.9	60	1.1
Misc. Nonresidential	233	74.6	65	48.5	330	147.0	50	73.5	62	45.6	65	29.6	82	24.3
Religious	33	10.2	30	3.1	286	10.8	50	5.4	50	2.7	50	1.4	80	1.1
Public Buildings	55	17.8	80	14.2	320	44.4	50	22.2	60	13.3	65	8.6	80	6.9
Amusement, etc.	145	46.6	67	31.2	340	91.8	50	45.9	64	29.6	66	19.6	83	16.3
Industrial	320	120.0	40	48.0	285	168.3	62	104.4	70	73.1	76	55.6	76	42.5
Plants	226.6	85.0	40	34.2	275	124.4	60	74.4	80	53.5	77	41.2	77	31.7
Plant Offices, Labs.	16.0	6.0	95	5.7	300	19.0	75	14.3	60	8.6	75	6.5	75	4.9
Labs (Separate)	7.7	2.9	100	2.9	290	10.0	60	6.0	70	4.2	50	2.1	60	1.3
Warehouses	69.8	26.1	20	5.2	350	14.9	65	9.7	70	6.8	85	5.8	80	4.6
Commercial	650	184.5	74.1	136.8	320	425.9	61	261.1	66	173.3	75	130.8	77	100.4
Offices	200	65.2	100	65.2	317	205.6	38	77.4	65	50.3	68	34.2	80	27.4
High Rise	48	17.6	100	17.6	310	56.8	0	-	-	-	-	-	-	-
Low Rise	152	47.6	100	47.6	320	148.8	52	77.4	65	50.3	68	34.2	80	27.4
Stores and Others	450	119.3	60	71.6	325	220.3	83	183.7	67	123.0	79	96.6	76	73.0
Retail Buildings	235.8	62.5	100	62.5	324	193.1	85	164.1	68	111.6	78	87.0	75	65.3
Warehouses	155.7	41.3	20	8.3	350	23.7	75	17.8	63	11.2	85	9.5	80	7.6
Garages and Others	58.5	15.5	8	1.2	340	3.5	50	1.8	10	0.2	75	0.1	90	0.1
Total	1,492	476.4	68	321.9	300	1074.9	57	610.4	62	378.8	70	266.2	78	207.2

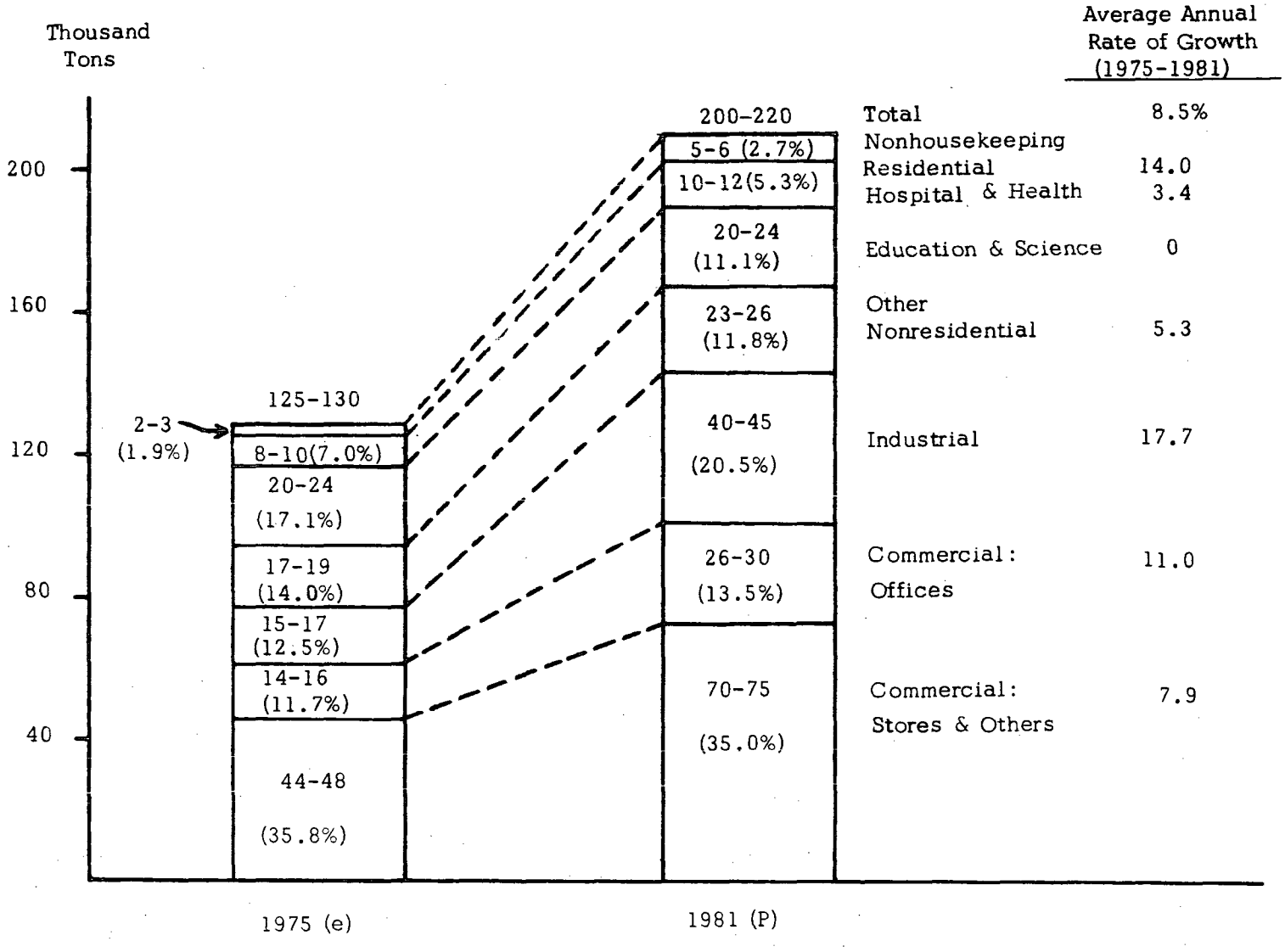
1. Millions of square feet. 2. Thousands of tons.

Source: William E. Hill & Company, Inc. estimates.

Exhibit V-5

AVAILABLE CONSTRUCTION MARKET - SINGLE PACKAGE, HEAT/COOL UNITARY EQUIPMENT [1] [2]

North Central Region
(Estimated 1975, Projected 1981)



	Average Annual Rate of Growth (1975-1981)
Total	8.5%
Nonhousekeeping Residential	14.0
Hospital & Health	3.4
Education & Science	0
Other Nonresidential	5.3
Industrial	17.7
Commercial: Offices	11.0
Commercial: Stores & Others	7.9

1) In 7-1/2 to 50 ton sizes
2) Including new construction and major remodelling

Source: William E. Hill & Co., Inc. estimates.

Exhibit V-6

Estimated Replacement Schedule

Year-Around Unitary Equipment

Age in Years	Percent of Units Replaced (1)	Percent of Units Replaced (2)
1 - 5	2%	2%
6	24%	6%
7		6
8		6
9		6
10	34%	11%
11		12
12		11
13	40%	10%
14		10
15		10
16		10

(1) Estimated percentage of units replaced by age-ranges.

(2) Estimated percentage of units replaced by age-ranges, distributed over the years in the range.

Exhibit V-7

Projected Replacement Tonnage

Year-Around Unitary Equipment

North Central Region – 1981

(thousands of tons)

Year	Estimated Tons Installed North Central Region	Replacement Factor	Replacement Tons - 1981
1965	30 - 40	10 %	3 - 4
1966	40 - 50	10	4 - 5
1967	60 - 70	10	6 - 7
1968	85 - 95	10	8 - 10
1969	135 - 145	11	14 - 16
1970	165 - 175	12	19 - 21
1971	190 - 200	11 %	20 - 22
1972	210 - 220	6	12 - 13
1973	245 - 255	6	14 - 15
1974	240 - 250	6	14 - 15
1975	140 - 145	6	8 - 9
Raw Total	---	---	122 - 137
Non-Replacement Adjustment (15 - 18 %)(1)			18 - 23
Adjusted Total			99 - 119

(1) Adjustment for net demolitions, and replacements included in the construction segment (i.e., major remodelling).

Exhibit V-8

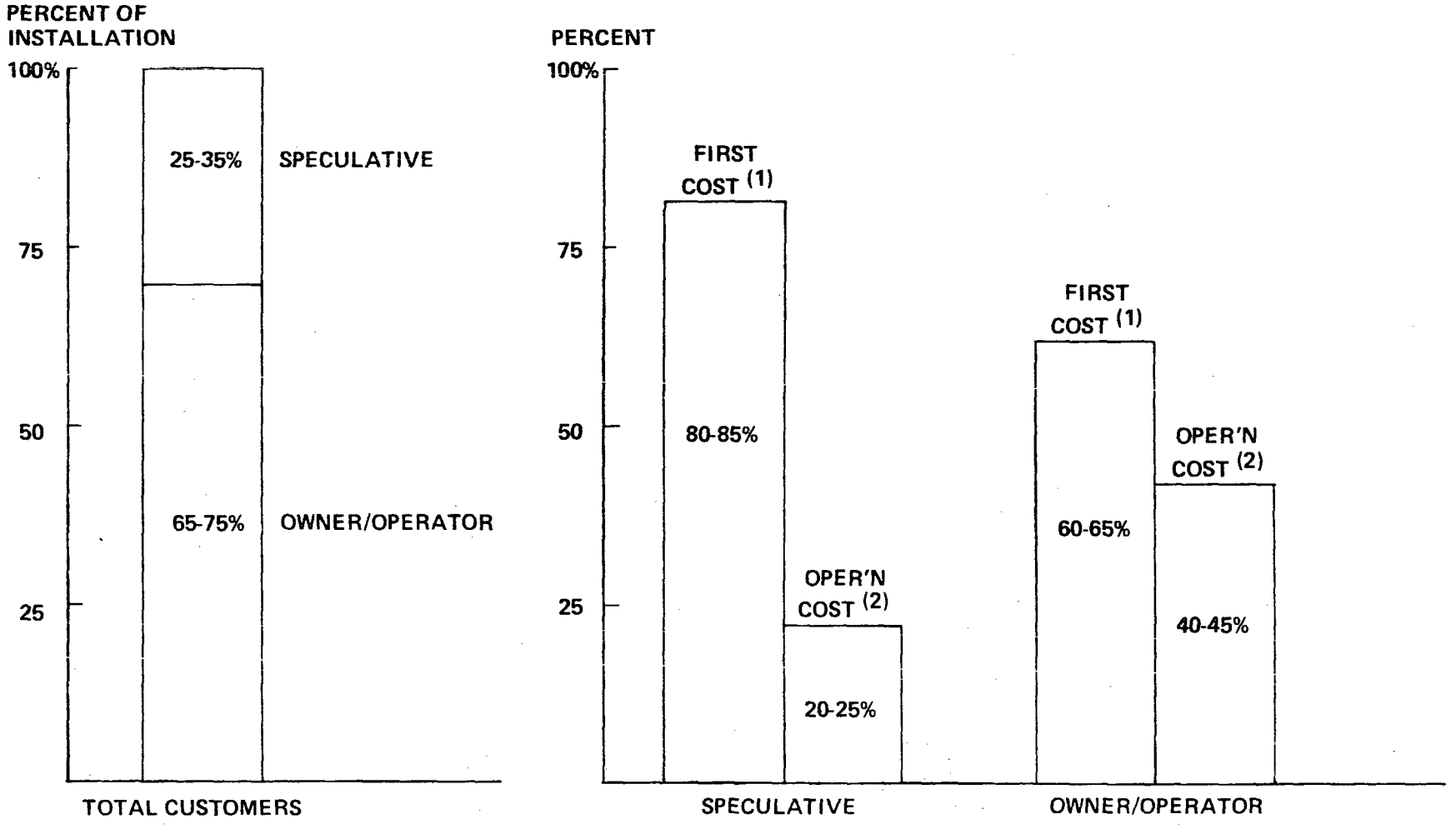
CONSIDERATIONS IN THE EVALUATION OF THE MARKET POTENTIAL FOR THE HSPF HEAT PUMP

- First cost and operating cost customers
- Inclination to accept various premium/payback situations
- Comparative energy costs
- Comparative equipment costs (first and operating) and performance
- Receptively to new products/technologies
- Trade attitudes and considerations

Exhibit V-9

IMPORTANCE OF FIRST AND OPERATING COSTS BY CUSTOMER TYPE - NORTH CENTRAL REGION

1976 Estimates



(1) First cost sole or primary criterion.

(2) Operating cost an important criterion – not necessarily prime.

Source: William E. Hill & Company, Inc. estimates.

Exhibit V-10

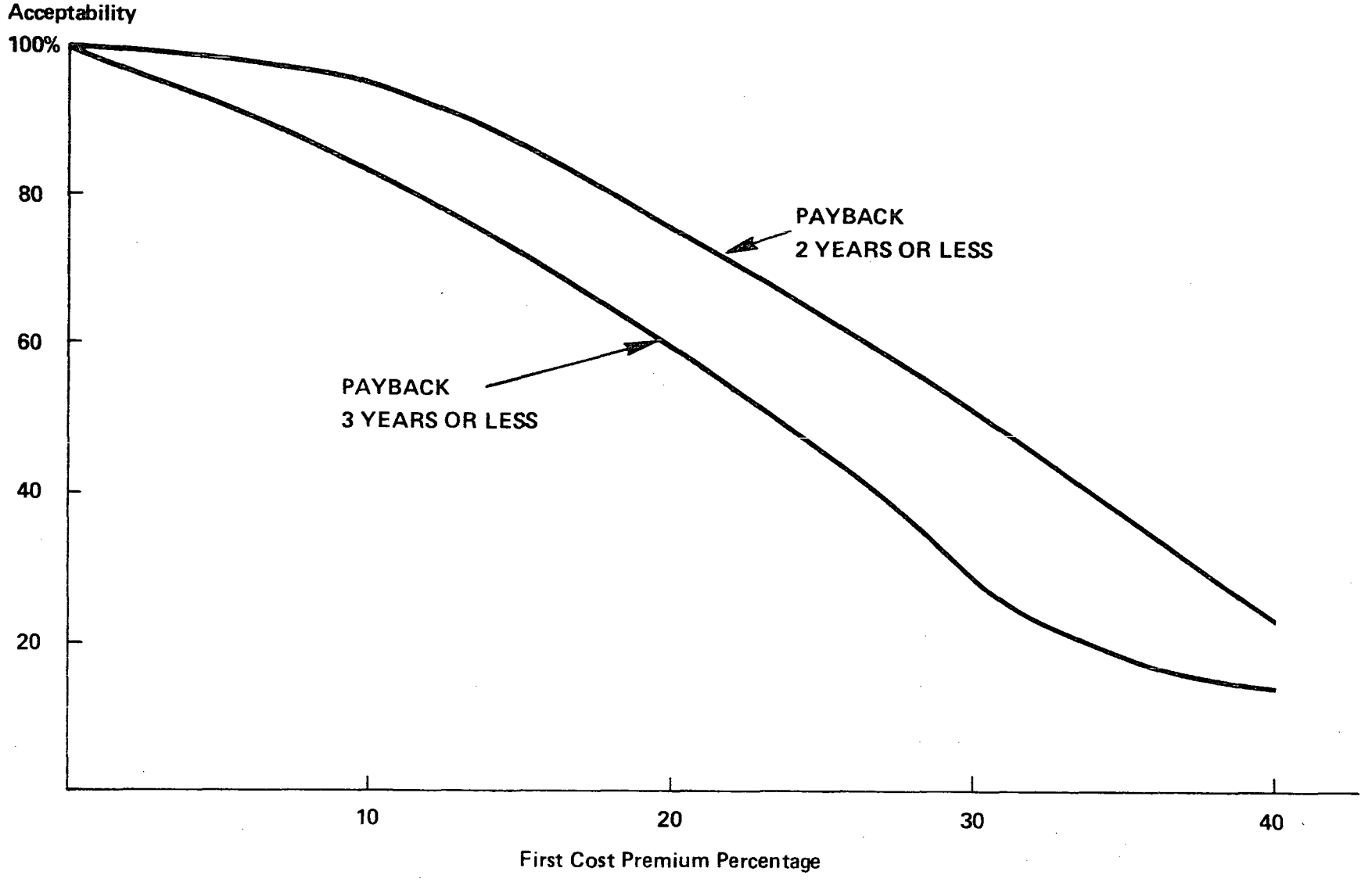
SAMPLE COMPARISON OF PREMIUM/PAYBACK ALTERNATIVES

Unit	First-Cost	First-Cost Premium	Annual Operating Cost	Payback Period[1]
Base Unit	$2,000	---	$2,000	---
Unit A	$4,000	100 %	$1,000	2 years
Unit B	$2,500	25 %	$1,750	2 years
Unit C	$2,200	10 %	$1,900	2 years

(1) Simple payback.

Exhibit V-11

OPERATING COST COST SENSITIVITIES - PREMIUM/PAYBACK ANALYSIS



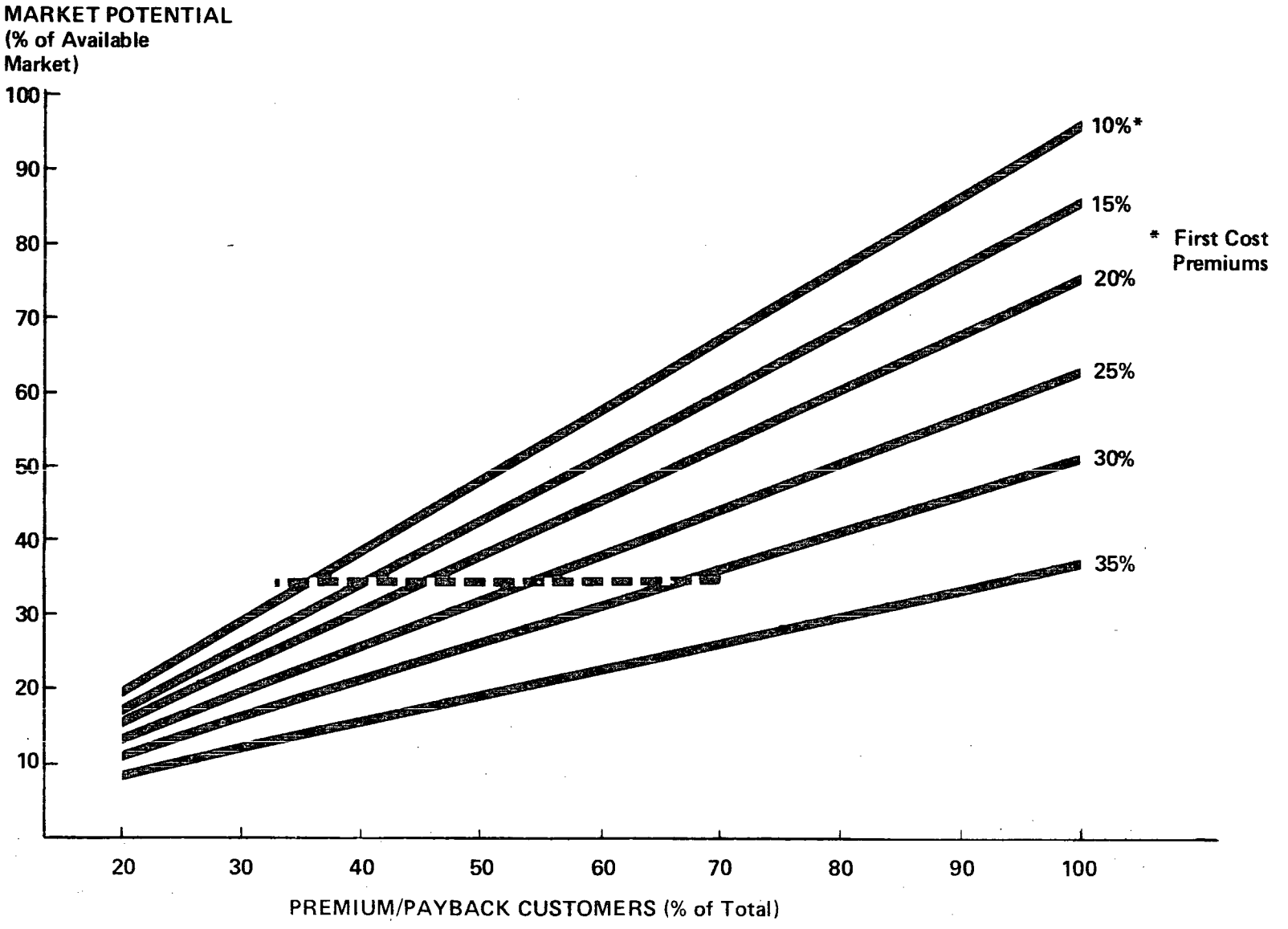
1) Of customers willing to accept a premium/payback approach.

Source: William E. Hill & Company, Inc. estimates.

Exhibit V-12

ANALYSIS OF MARKET POTENTIALS -

PREMIUM/PAYBACK CUSTOMERS AND FIRST COST PREMIUMS [1]

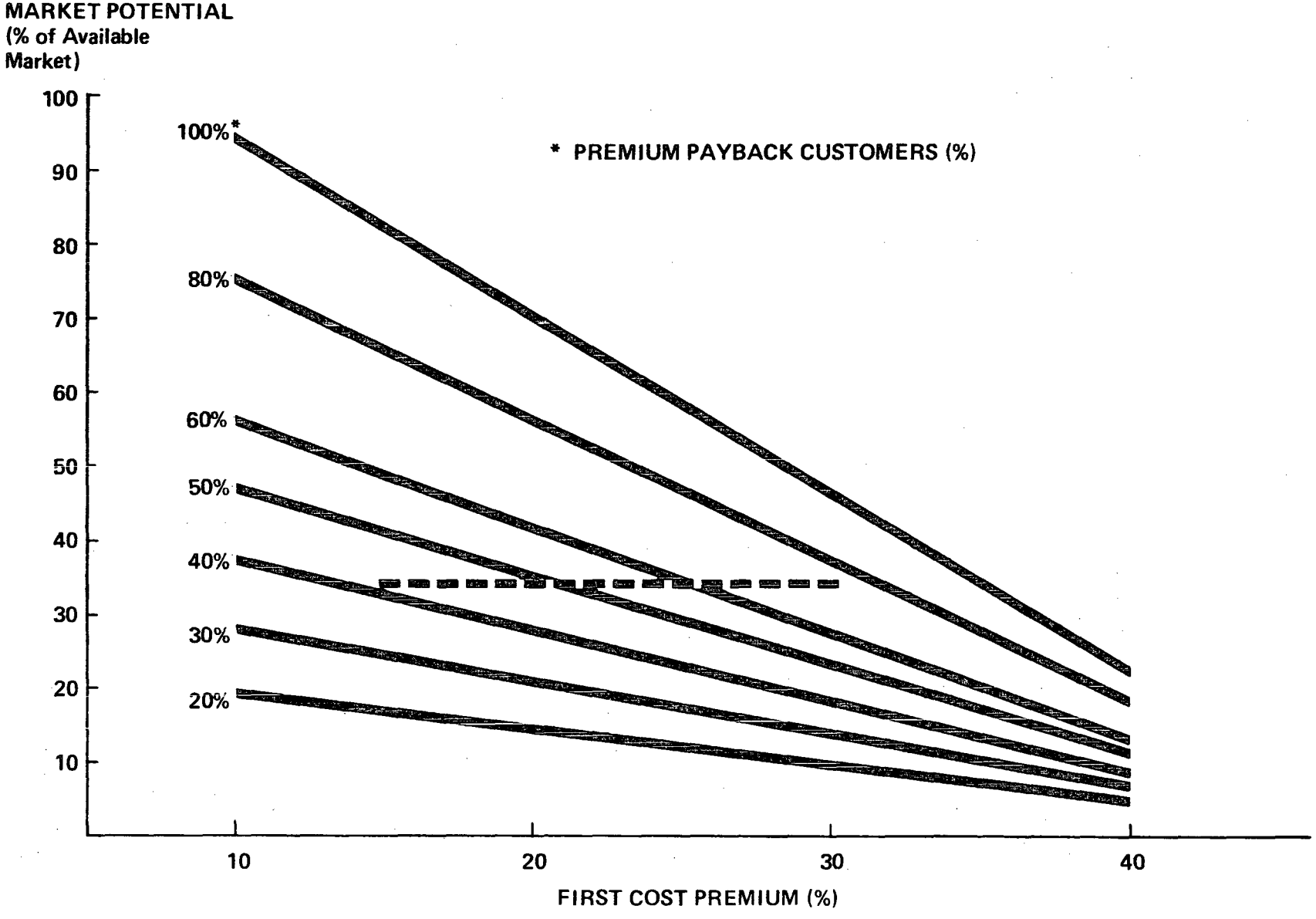


1) Payback 2 years or less.

Source: William E. Hill & Company, Inc. estimates.

Exhibit V-13

ANALYSIS OF MARKET POTENTIAL— FIRST COST PREMIUMS[1] AND PREMIUM/PAYBACK CUSTOMERS



(1) Payback 2 Years or less

Source: William E. Hill & Company, Inc. estimates

Exhibit V-14

BASIC PRODUCT LIFE CYCLE CONCEPT

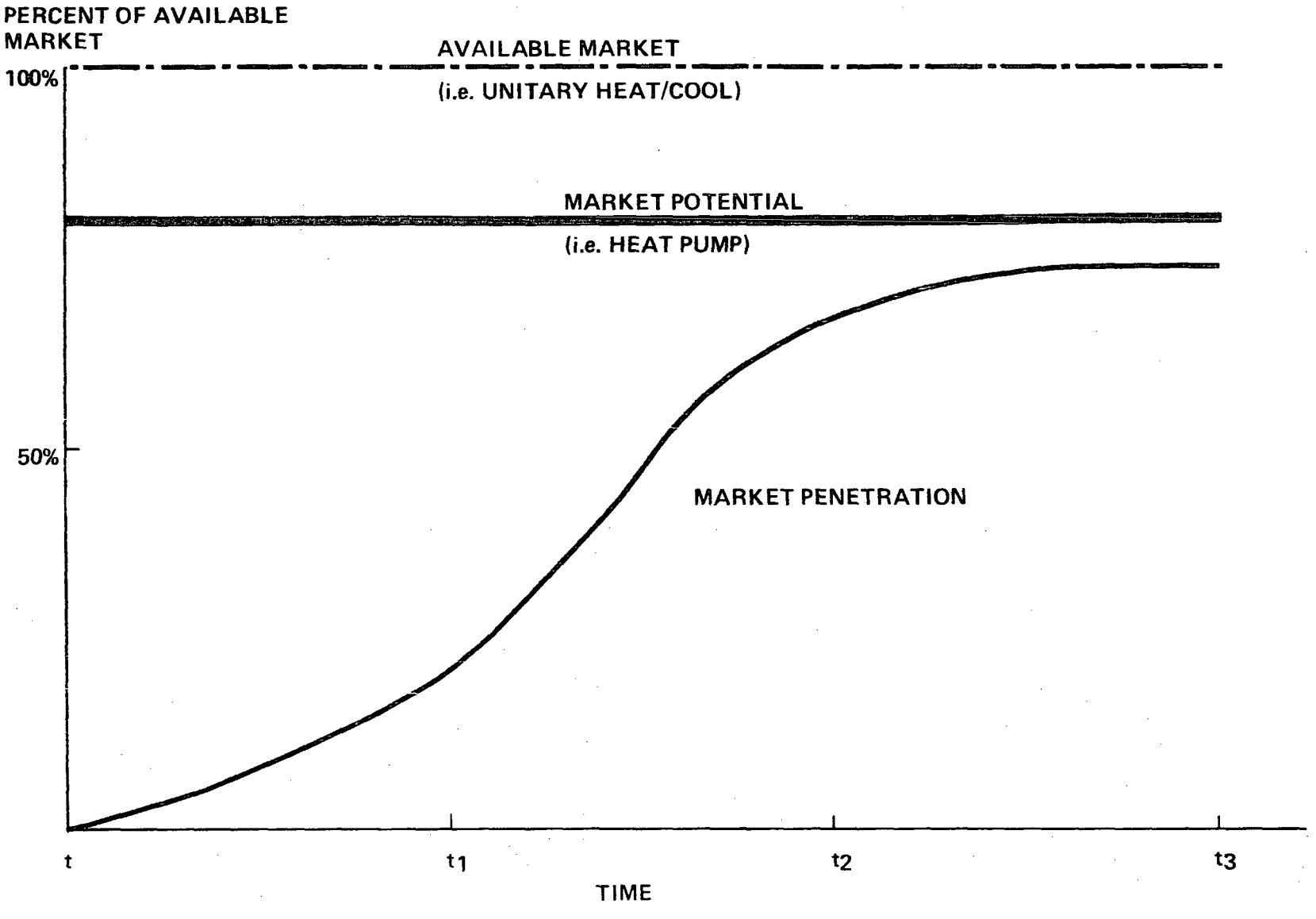


Exhibit V-15

MARKETING ELEMENTS

Primarily Affect Market Potential	Primarily Affect Market Penetration (1)
• Product	• Promotion
- Physical characteristics	- Level
- Performance characteristics	- Effectiveness
• Price	• Distribution
- First cost	- Extent
- Operating cost	- Appropriateness

(1) Sales potential

Exhibit V-16

PRODUCT LIFE CYCLE - MARKET WITH VARIABLE STRUCTURAL CHARACTERISTICS

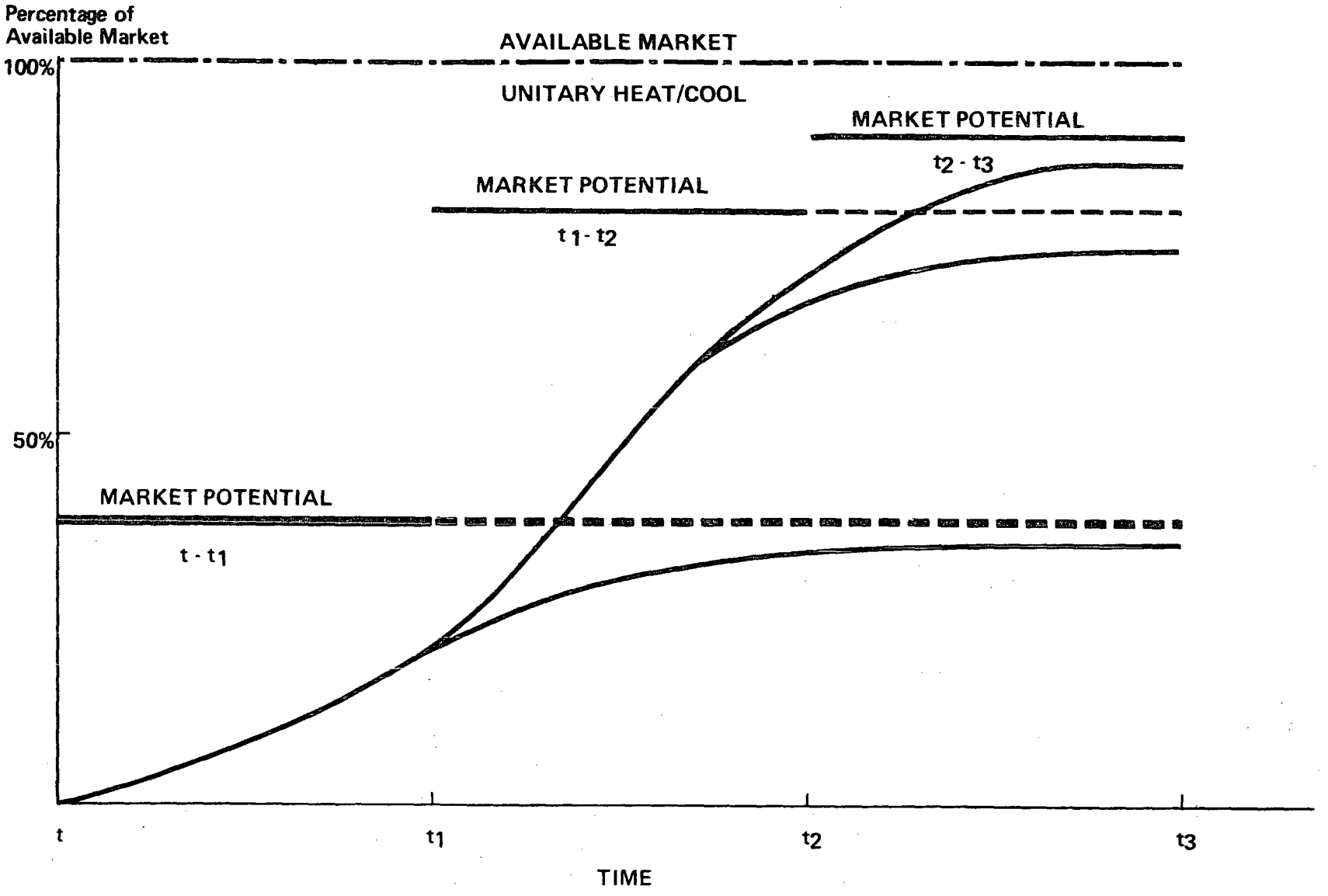


Exhibit V-17

AVAILABLE AND POTENTIAL MARKETS

REPLACEMENT	CONSTRUCTION
100 - 120	200 - 220
300 - 330	

AVAILABLE MARKET[1)]
SINGLE PACKAGE
HEAT/COOL

REP'L	CONSTRUCTION
20 - 30 (18 - 28)	45 - 60 (20 - 30%)
65 - 90	

POTENTIAL MARKET[1)]
HSPF HEAT PUMP[2)]

1) Thousands of tons.
2) Or Comparable Product.

Source: William E. Hill & Company, Inc. estimates.

Exhibit V-18

HSPF HEAT PUMP MARKET POTENTIAL
THREE SCENARIOS - 1981 (1)

	Competing Equipment (2)	
	Rep'l Market	Construction
SCENARIO I.		
Gas readily available for new nonresidential construction	GAS YAC HSPF HP	GAS YAC HSPF HP
SCENARIO II.		
Gas is available for new nonresidential construction, if 'specified' energy efficient equipment is utilized	GAS YAC HSPF HP	ELECTRIC YAC ELECTRIC HP HSPF HP
SCENARIO III.		
Gas is not available for new nonresidential construction - established customer allotments hold	GAS YAC HSPF HP	ELECTRIC YAC ELECTRIC HP

(1) Alternative fuels not considered.
(2) Primary types, single package heat/cool.

Exhibit V-19

COMPARATIVE MARKET POTENTIALS [1]
HSPF HEAT PUMP

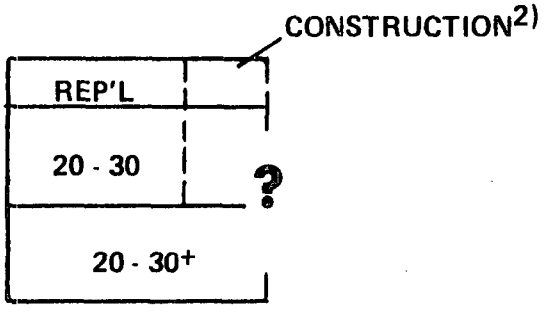
SCENARIO I:

REP'L	CONSTRUCTION
20 - 30	45 - 60
65 - 90	

SCENARIO II:

REP'L	CONSTRUCTION
20 - 30	45 - 60 ?
65 - 90 ?	

SCENARIO III:

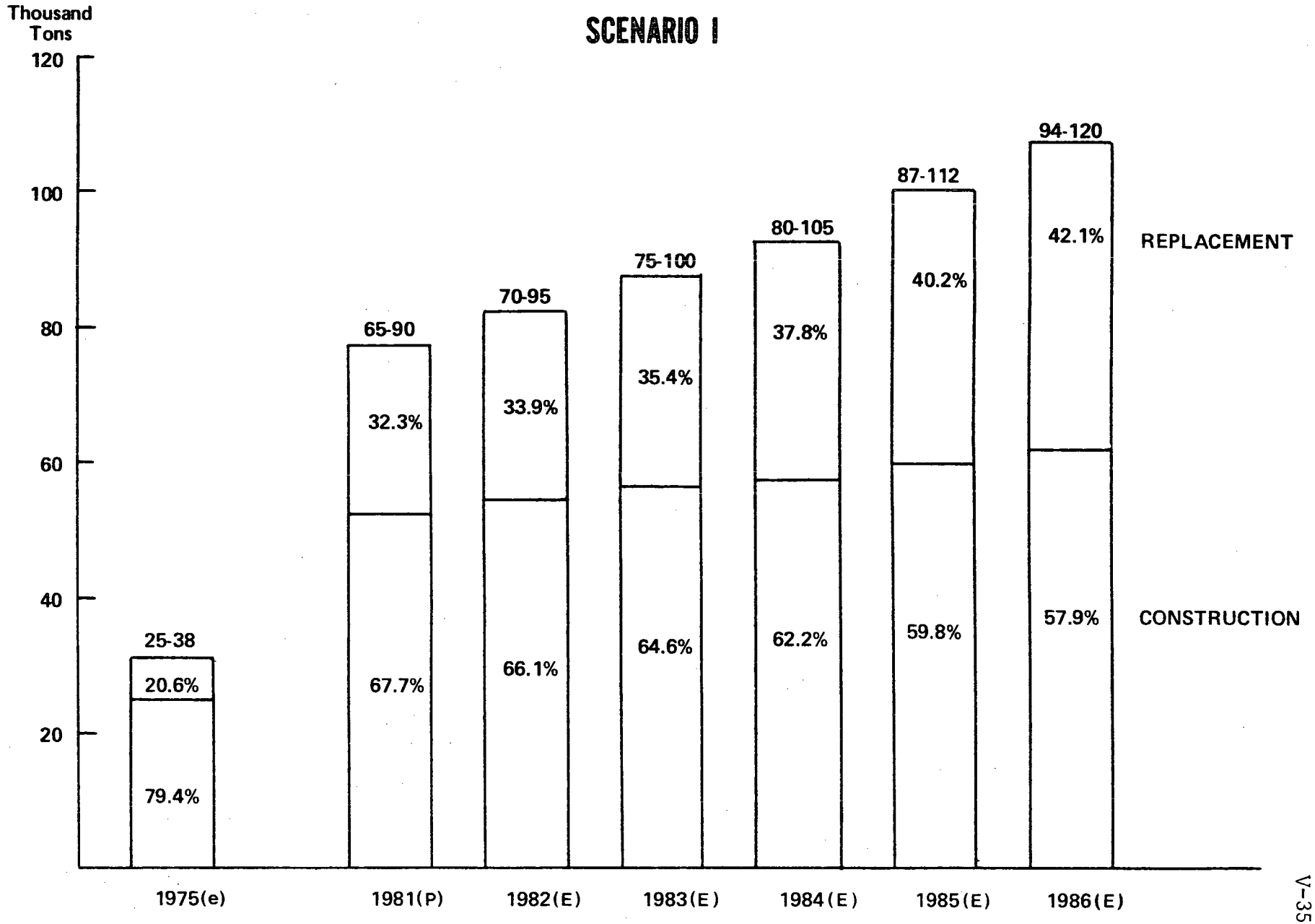


1) Thousands of tons.
2) Some remodelling and relocation of gas allocation.

Source: William E. Hill & Company, Inc. estimates.

Exhibit V-20

HSPF HEAT PUMP MARKET POTENTIAL
PROJECTION AND EXPECTION - NORTH CENTRAL REGION
SCENARIO I



Source: William E. Hill & Company, Inc. estimates.

VI. PERSPECTIVES -- FACTORS THAT WILL AFFECT THE SALES POTENTIAL OF THE HSPF UNIT

The projected market potentials for the HSPF are based upon a number of product characteristic assumptions, and an analysis and interpretation of the likely structure and characteristics of the space conditioning market in the early-to-mid 1980's. The important distinctions between available market, market potential and market penetration (or sales potential) were indicated and described in terms of the primary effects contributed by the basic marketing elements. It is appropriate at this point to highlight some of the factors that will affect the sales potential or market penetration of the HSPF unit.

A. Choice of Equipment Marketer(s).

The choice of equipment marketer(s) may be the single most-critical marketing decision, and one which will influence all phases of the marketing plan and ultimately, the rate and level of market penetration.

1. Choice of a single marketer might restrict maximum market share as total sales would be based upon the effectiveness of that marketer's distribution system, promotional efforts and overall position in the market. On the other hand, if several marketers are selected, each loses the benefits and incentives inherent in the possession of a proprietary new product.

2. A large-company marketer, who currently has a significant share of the market, may resist selling a new unit at the expense of existing, proven equipment. Unless the unit has potential for expanding the market, providing higher profit margins, or taking

business from competitors, a company with a high market share may have little incentive (other than as a defensive measure) to push the product, since most sales would simply represent cannibalization of current products.

3. An established marketer with a quality reputation is desirable, perhaps necessary, to best overcome skepticism among the trade concerning the reliability and maintenance requirements of a complex device based upon such new technology.

4. A large marketer is preferred, perhaps required, to support the training and motivation of a distributor/contractor network that would be required to sell, install and service the new units.

5. As stated in section two, all companies in the business don't compete with comparable effectiveness in all segments of the market. The potential marketer(s) of the HSPF heat pump should be assessed relative to their share of particular high potential equipment and application markets.

B. Competing Equipment in the 1980's.

In addition to currently available equipment, new technologies are being investigated which could impact the space conditioning market and compete with the HSPF unit. Included in these developments are: high efficiency furnaces, other gas heat pumps, solar and heat reclamation systems and advanced electric heat pumps. The specific impact of these developments is impossible to predict at this time, but several general effects are likely:

1. Effects on energy sensitivity. The availability of a number of energy related products is likely to reinforce and promote energy concerns, and more sophisticated analyses of owning/operating factors as a means of comparing technologies with different cost and performance characteristics. This could have the effect of enlarging the total market potential for higher-cost, energy efficient equipment.

2. Effects on individual share. Unless the effects discussed above significantly expand the total market potential, the share for each

individual technology is likely to be much smaller than if competing new technologies were not available.

C. Consideration of Equipment Premiums and Payback Periods.

Although operating costs are becoming more important in the equipment selection decision, first costs continue to be a very significant factor -- regardless of the analytical methods utilized. The premium/payback question is a complicated one, which should be thought of as a trade-off between specific premium/payback period combinations.

1. Equipment premiums. Equipment premiums are only acceptable if compensating advantages are provided. Usually, this involves lower operating costs in terms of energy efficiencies and/or maintenance. Research indicates market resistance to equipment premiums greater than 30 percent, unless the payback period is extremely short, or there are other associated benefits. In some instances, premiums are not acceptable under almost any conditions due to budget or other constraints.

2. Payback periods. To be relevant, the payback period must be shorter than the customer's normal business time frame. Business time frames are quite variable depending upon the characteristics of the business in question and other factors. Many institutional customers and some large industrial and commercial customers are willing to accept payback periods of five years or more, but generally there appears to be resistance to payback periods in excess of three years.

D. Extreme Importance of Reliability/Maintainability.

Reliability is often the most important non-cost equipment selection factor, and ease of maintenance is critical for trade acceptance and support.

1. In many applications, particularly in the key commercial markets, reliability and dependability are viewed as essential characteristics. If the space conditioning system fails, the business may be quickly, and heavily impacted.

2. The introduction of new technologies requires extensive efforts to provide service and installation training. Currently, heat pump manufacturers are requiring the certification of heat pump mechanics despite the close similarity to conventional air conditioning equipment. The HSPF unit involves complex components and systems, with which the trade is generally unfamiliar.

3. An additional parts/service system will be necessary to handle the parts and service requirements unique to the HSPF technology. Trade willingness to participate in training programs and invest financial resources in additional, and probably expensive, parts inventories will have a direct and critical effect on market penetration.

4. Prior experience with the initial technical problems associated with electric heat pumps and packaged gas air conditioners, will affect the attitudes of customers and the trade concerning the HSPF heat pump. Extensive documentation of reliability and maintenance requirements will be necessary.

E. Confusion and Skepticism over Future Gas Supplies.

Many users, designers and installers of space conditioning equipment have experienced gas supply limitations which have affected equipment choices. Customers, designers, installers and service suppliers are comfortable and confident about electric equipment and supplies, and must be assured of future gas availability. This will be an important task, perhaps central to the successful marketing of the HSPF unit.

F. The HSPF Heat Pump Must Gain the Acceptance of the Trade.

To achieve optimal market share, the HSPF unit must gain the acceptance of the air conditioning trade (with manufacturer(s) support), rather than local utilities being directly involved in marketing and servicing. Local utilities will have an important function in promotion

and in supporting local marketing efforts, but the successful penetration of the market will depend upon the efforts of the trade, emanating from their appraisal of the commercial attractiveness of the unit.

G. Government Programs.

Government programs at national, state and local levels can materially affect the structure and characteristics of the market and the market potential for the HSPF unit. Programs; such as incentives or regulations concerning energy use and/or conservation, regulations relating to the analysis of alternative equipment (i. e., energy impact statements), and basic policies dealing with energy supplies and prices, can heavily impact equipment use and equipment selection processes.

Appendix

PROJECTED ANNUAL CONSTRUCTION FLOOR SPACE ADDITIONS

(Millions of Square Feet)

	Miscellaneous Non-Residential			Total Non-Residential		
Year	U.S.	Midwest	Northeast	U.S.	Midwest	Northeast
1965	169	38	40	1,233	335	304
1970	145	30	35	1,223	295	314
1975	182	42	34	998	241	182
1976	185	42	34	1,050	248	204
1977	199	45	37	1,172	289	226
1978	210	47	39	1,324	326	248
1979	217	49	41	1,417	347	277
1980	226	50	41	1,457	349	271
1981	233	52	44	1,492	330	278
Average Annual Rate of Growth						
1965-1975	0.7%	1.0%	(1.6)%	(2.1)%	(3.2)%	(5.0)%
1975-1981	4.2	3.6	4.4	6.9	5.4	7.3

Source: F. W. Dodge 5 year construction forecasts.

Appendix

PROJECTED ANNUAL CONSTRUCTION FLOOR SPACE ADDITIONS

(Millions of Square Feet)

	Non-Housekeeping Residential			Hospital and Health		
Year	U.S.	Midwest	Northeast	U.S.	Midwest	Northeast
1965	92	25	22	60	16	14
1970	66	11	12	75	19	23
1975	33	5	4	65	20	12
1976	40	7	7	75	22	15
1977	47	9	9	76	20	15
1978	62	12	11	77	20	15
1979	67	13	13	78	20	15
1980	72	15	14	79	21	15
1981	77	16	15	80	21	15
Average Annual Rate of Growth						
1965-1975	(9.7)%	(14.9)%	(15.7)%	0.8%	2.3%	(1.5)%
1975-1981	15.2	21.4	24.6	3.5	0.8	3.8

Source: F. W. Dodge 5 year construction forecasts.

Appendix

PROJECTED ANNUAL CONSTRUCTION FLOOR SPACE ADDITIONS

(Millions of Square Feet)

	Industrial			Education and Science		
Year	U.S.	Midwest	Northeast	U.S.	Midwest	Northeast
1965	266	95	62	228	58	66
1970	212	60	53	195	56	62
1975	148	41	31	152	37	31
1976	155	43	31	130	30	29
1977	200	68	38	125	30	28
1978	250	82	39	125	31	28
1979	275	88	52	130	31	28
1980	300	88	54	130	31	28
1981	320	93	58	132	31	28
Average Annual Rate of Growth						
1965-1975	(5.7)%	(8.1)%	(6.7)%	(4.0)%	(4.4)%	(7.3)%
1975-1981	13.7	14.6	11.0	(2.3)	(2.9)	(1.7)

Source: F. W. Dodge 5 year construction forecasts.

Appendix

PROJECTED ANNUAL CONSTRUCTION FLOOR SPACE ADDITIONS

(Millions of Square Feet)

	Commercial Office			Commercial Stores and Others		
Year	U.S.	Midwest	Northeast	U.S.	Midwest	Northeast
1965	109	24	30	309	79	70
1970	171	37	53	359	81	77
1975	109	22	23	309	63	41
1976	110	22	24	355	82	64
1977	125	25	29	400	92	72
1978	150	30	35	450	104	81
1979	180	36	43	470	108	85
1980	190	38	46	460	107	75
1981	200	40	48	450	76	72
Average Annual Rate of Growth						
1965-1975	0%	(0.9)%	(2.6)%	0%	(2.2)%	(5.2)%
1975-1981	10.7	10.5	13.1	6.5	3.2	9.8

Source: F. W. Dodge 5 year construction forecasts.