A FINAL REPORT

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

APPENDIX VOLUME VI

LARGE SIZE MODEL MARKET POTENTIAL

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

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Consolidated Natural Gas Service Company Inc.

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Appendix Volume VI
LARGE SIZE MODEL MARKET POTENTIAL

Prepared BY: William E. Hill & Co.
640 Fifth Avenue
New York, N.Y. 10019

Prepared For: Consolidated Natural Gas Service Company Inc.
Research Department
11001 Cedar Avenue
Cleveland, Ohio 44106

And

The U.S. Department of Energy
Consumer Products Division
Technology & Consumer Products Branch
20 Massachusetts Avenue
Washington, D.C. 20545

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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

LARGE SIZE MODEL 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 in this volume covers the second phase of the study. The work was initiated in October 1977 and the report in the body of this volume was submitted to CNG by W.E. Hill in April 1978.

A key output of these market 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 LARGE-TONNAGE HSPF CONCEPT

Executive Summary

The objective of this study is to help Consolidated Natural Gas (CNG) evaluate the commercial attractiveness of the large-tonnage HSPF (high seasonal performance factors) equipment that is currently being developed by the Research Department of CNG with funding assistance from the Department of Energy (DOE). The market potential for the HSPF concept was projected to 1981, and key technical and market development issues were identified and evaluated. The term "large-tonnage" as used in this report refers to unitary and central built-up (chiller) equipment in the 50 to 400 ton nominal capacity size range.

A. KEY MARKET CHARACTERISTICS

1. A limited number of manufacturers participate in the large-tonnage equipment market. Trane, McQuay, Mammoth (Div. of Lear Siegler), Dunham-Bush and Miller-Picking are the major producers of large-tonnage unitary equipment. Carrier Trane and York are dominant in the built-up equipment market with a combined share of 85 to 90 percent.

    a. Built-up equipment is primarily sold by manufacturer sales representatives, and shipped directly to the job site.

    b. Large-tonnage equipment is primarily sold on plan and spec contracts.

c. Manufacturers are heavily involved in the servicing of built-up systems and to a lesser extent, large-tonnage unitary equipment.

2. Market characteristics, functional requirements and equipment evaluation processes are changing in response to key external and industry trends.

   a. Functional requirements are being impacted by dramatic shifts in the energy situation and changes in building design and construction practices.

   b. Many large-tonnage building applications have minimal heating requirements and/or require simultaneous heating and cooling for different zones.

   c. Greater sophistication is being applied to the analysis of functional requirements, total energy use and equipment/system design and selection.

   d. Although first-costs are still important, rising energy and service costs are increasing the importance of operating costs and system efficiencies.

   e. Total owning and operating costs are becoming more widely used in equipment selection decisions.

3. Equipment reliability and the availability of service and parts are extremely important equipment selection considerations.

4. Historically, the air conditioning market has been slow to accept new products and technologies unless significant advantages are present and they satisfy the prevailing market characteristics and requirements.

B. Projected Markets.

1. The available market for large-tonnage unitary equipment (50 ton and over) and for 50 to 400 ton built-up equipment is projected to be 950 to 990 thousand tons in 1981.

2. The market potential for HSPF equipment is projected to be 400 to 500 thousand tons in 1981.

3. The market potential for the HSPF concept is expected to increase over time as increasing energy costs cause shifts in key market characteristics.

4. Simple system modifications and improved building efficiencies could preempt the energy efficiencies that the HSPF is exptected to accomplish.

5. Although the HSPF unit offers "unit-of-energy-use" efficiencies versus certain other types of equipment, the major energy cost advantage is the comparative price differential between gas and electricity.

6. Market perceptions with regard to the future availability of natural gas is perhaps the most important basic issue affecting the market potential for the HSPF concept.

C. Key Recommendations.

1. Continue development of the large-tonnage HSPF concept, provided gas will be available in the 1980's. This recommendation assumes that the HSPF will have a first-cost premium of 25 to 50 percent and a payback period of two to three years for unitary configurations; and a premium of 10 to 25 percent and a payback period of one to two years for built-up configurations. The following factors support this recommendation:

   a. A projected available market (domestic U.S.) of 950 to 990 thousand tons of large-tonnage air conditioning by 1981.

   b. Basic trends in key external factors and market characteristics are generally positive.

   c. An increased concern for energy-efficient equipment at greater than current levels is expected to be maintained through the 1980's

   d. Increasing concern for total owning and operating costs, and greater use of life-cycle costing to compare equipment alternatives.

2. Technical development should emphasize built-up (chiller) configurations, but development of large-tonnage unitary heat pump versions should be continued on a lower priority basis.

   a. The built-up configuration appears to represent the largest potential market -- 190 to 230 thousand tons in the 50 to 200 ton size range and 160 to 200 thousand tons in the 200 to 400 ton size range.

b. The built-up equipment markets tend to be less first-cost sensitive and more quality/operating cost-oriented than most unitary equipment markets.

c. The production, marketing, applications and servicing of built-up equipment is comparable to the technological sophistication of the HSPF concept.

d. The large-tonnage unitary market appears to be growing, and may provide a reasonably attractive secondary market in the 1980's.

3. To the extent possible, the technical development program should emphasize design/applications flexibility, and strongly consider some type of modular approach in component assembly. A modular approach to component assembly would provide flexibility and ease of applications design, equipment installation and field maintenance.

a. Ease of application and equipment use should improve acceptability in the marketplace, particularly among key trade groups such as designers and installers.

b. This approach might also permit manufacturing cost reductions across the product line, due to the possible commonality of certain component assemblies.

c. To the extent possible, auxiliary components and parts utilized in the unit should be standard items already in general use and distribution in the air conditioning trade.

4. Technical development should consider market requirements such as reliability, maintainability, equipment first-costs, system operating costs; as well as manufacturing feasibility.

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.

b. There apparently is a great deal of manufacturer discounting from list prices in the built-up equipment market, and cost comparisons should be based upon realistic factory costs and/or selling prices.

5. Begin to evaluate alternative licensing strategies and prospective marketers. The selection of licensing strategies and equipment marketer(s) are two of the most important marketing activities, and will require thorough analysis and a good understanding of the competitive dynamics of the marketplace.

   a. Estimate the strategic (market development) and financial ramification of alternative licensing strategies. Many alternatives should be developed for discussion with prospective marketer(s).

   b. Gather and evaluate relevant information on all potential marketers. This should include market/competitive position, product lines and market emphasis, track record in developing and introducing new products and financial performance.

   c. The nature of the large-tonnage equipment market suggests that the marketer(s) should have a strong current position in the market. An established position (and good technical reputation) in the marketplace is desirable, perhaps necessary, due to the uniqueness of the HSPF. Starting from scratch would probably be prohibitively expensive, and unlikely to succeed in the face of strongly entrenched competition.

   d. Most major suppliers of large-tonnage equipment do not produce boilers, so marketing the HSPF (which can heat and cool) could increase their total dollars per installation.

   e. The selected marketer(s) must be willing, and able, to commit adequate efforts to market development and product support. The marketer must be willing to aggresively push the product in the face of possible market resistance and competitive reactions, and guarantee the product's reliability and performance claims.

BACKGROUND, FINDINGS AND CONCLUSIONS

The Market for the Large-Tonnage HSPF Concept

Consolidated Natural Gas Service Company (CNG), together with the Department of Energy (DOE), is developing an energy-efficient, gas-fired heat pump -- the HSPF unit. Although the developmental unit is believed to be technically feasible, estimated equipment costs have not justified commercialization in residential and light commercial applications.

In a previous assignment, a potential market for the HSPF equipment in the 7 1/2 to 50 ton size range, located in the North Central United States, was projected at about 80 thousand tons of air conditioning in 1981. The machine components unique to the HSPF, at the product volumes that would satisfy the projected market demand, have an expected cost -- and resulting equipment first-cost premium -- well above that which would justify further development of the HSPF in the light commercial size range.

The HSPF Project Advisory Board has suggested that the large-tonnage (50 tons and above) air conditioning business is sufficiently different from the mid-tonnage segment to warrant further study

of the appropriateness of commercializing the HSPF technology. The market potential, technical requirements, competitive alignment of manufacturers and the production scale of component manufacture and assembly are among the factors that could support the decision to further develop the HSPF for application in the large-tonnage size range.

Both CNG and DOE strongly believe that the market potential for a large-tonnage HSPF must first be determined before additional equipment development is pursued. The objectives of this report are to project the market potential for large-tonnage HSPF equipment in the early 1980s, to provide sufficient inputs for managing the direction of further HSPF technical development and to highlight significant strategic issues related to the eventual introduction of the unit to the market. To achieve these objectives, the following tasks have been accomplished:

1. Measurement of the Market for Large-tonnage Air Conditioning Equipment in the United States. This includes analysis of historical market sizes and growth rates, and an evaluation of significant trends for unitary equipment (50 tons and over), built-up equipment (50 to 400 tons), market characteristics, and key external factors.

2. Characterization of the Market for Large-tonnage Air Conditioning Equipment. This characterization includes detailed analysis 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 alternative systems.

3. Projection of the 1981 Market Potential for Unitary and Built-up (chiller) Versions of the HSPF Unit. Based upon the measurement and characterization of the market, the projection focuses on the extent to which the HSPF units can satisfy the requirements of the projected market for large-tonnage equipment.

4. Evaluation of Issues Related to Market Potential and Penetration, Marketing Requirements and Technical Aspects of the HSPF Development Program. A number of important marketing and technical development issues which will impact the introduction and successful marketing of the HSPF unit are highlighted. Specific recommendations are made regarding technical development, program development, overall 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 unit in large-tonnage heat pump and built-up (chiller) configurations in the United States market. 1981 was selected as the base projection year.

The term air conditioning as used in this report, includes all types of unitary and central built-up (chiller) equipment as defined by the Air Conditioning and Refrigeration Institute (ARI). The term "large-tonnage" refers to unitary and central built-up equipment in the 50 to 400 ton nominal size range. Conventional furnaces, boilers and other types of heating systems 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.

1. Seven major cities were visited by members of our staff, who conducted in-depth interviews with consulting engineers, owners and builders, utilities, distributors and contractors. This research emphasized the investigation of the major elements in the market structure and qualitative information on the market in question.

2. Telephone interviews were conducted among additional mechanical contractors and consulting engineers involved in large-tonnage equipment applications. This provided a broader statistical base and additional quantitative data not available from other sources.

3. In-depth personal interviews were also conducted with top level management of several equipment manufacturers active in large-tonnage equipment. Numerous manufacturer field sales managers and technical sales reps were also interviewed.

Summary of Findings and Conclusions

A. Current Status of the Nonresidential Air Conditioning Market.

1. The total U. S. nonresidential air conditioning market peaked in 1973 at 5.1 million installed tons, and was 3.9 million tons in 1976. Between 1967 and 1976, the market grew at an average annual rate of 1.3 percent, with unitary equipment expanding at a rate of 3.8 percent while central built-up equipment declined an average 2.5 percent per year.

   a. The total unitary portion of the market represented 2.7 million tons, or 68 percent of the total in 1976. Of this

amount, equipment 50 tons and larger was 138 thousand tons or 5.2 percent of the total commercial unitary tonnage. Single package equipment represented 43 percent of the large-tonnage unitary volume and split package equipment 57 percent.

b. Central built-up (chiller) equipment represented slightly over 1.2 million tons, or about 32 percent of the total. Built-up equipment in the 50 to 400 ton size range represented 600 thousand tons or about half of the total built-up equipment tonnage. Centrifugal chillers were 57 percent of the tonnage for the 50 to 400 ton size range, reciprocating chillers 35 percent and absorption equipment 8 percent.

c. New construction represented 65 - 70 percent of the total tonnage, or 2.5 to 2.7 million tons. Replacement and remodeling totaled 1.0 to 1.4 million tons and energy retrofit about 70 to 80 thousand tons.

d. Commercial and institutional buildings were the largest market segments at 32 to 36 percent and 20 to 24 percent respectively. Commercial buildings include offices, stores, restaurants, etc.; institutional buildings include schools, hospitals, public buildings, etc.

2. A limited number of manufacturers participate in the large-tonnage equipment market. Trane, McQuay, Mammoth (Div. of Lear Siegler), Dunham-Bush and Miller-Picking are the major producers of large-tonnage unitary equipment. Carrier, Trane and York are dominant in the built-up equipment market with a combined share of 85 to 90 percent.

a. Built-up equipment is primarily sold by manufacturer sales reps, and shipped directly to the job site. Major manufacturers maintain an extensive technical field sales organization calling on consulting engineers and mechanical contractors.

b. Large-tonnage equipment is primarily sold on plan and spec contracts. Systems are generally designed by consulting (or in-house) engineers, with the installing contractor selected by competitive bidding. The designer specifies the type of equipment, and the contractor selects the particular brand for his bid.

c. Manufacturers are heavily involved in the servicing of built-up systems, and to a lesser extent, large-tonnage unitary equipment. In contrast to smaller-tonnage markets, where local, independent firms provide most of the service and maintenance functions, built-up equipment manufacturers closely control the service business related to their equipment, and perform much of it through their own service organizations.

3. A number of key external factors affect market characteristics and requirements, equipment selection processes and the size of the air conditioning market. The most important of these external factors are the general economy, construction activity, product saturation and penetration levels, government activities, basic technological developments and the energy situation (availability and costs).

4. Market characteristics, functional requirements and equipment evaluation processes are changing in response to key external and industry trends. These key trends impact the need for, use of, and selection of space conditioning equipment.

   a. Functional requirements are being impacted by dramatic shifts in the energy situation, and changes in building design and construction practices. The energy situation is significantly affecting space conditioning requirements and the methods employed. Energy efficient buildings can provide energy-use savings of 15 to 20 percent in most cases. System efficiencies and flexibility in terms of control and capabilities are becoming increasingly important, and it is likely that less capacity will be required for a given conditioned space -- affecting equipment size and other features.

   b. Many large-tonnage building applications have minimal heating requirements and/or require simultaneous heating and cooling for different zones. The importance of such applications is expected to increase with improvements in energy-efficient building design and construction practices. Thus in many cases, heating is becoming a secondary consideration, which can often be handled by small auxiliary systems -- primarily used for start-up and very cold weather. Use of condenser heat exhaust is one such auxiliary approach which is gaining rapid acceptance.

c. Although first-costs are still important, rising energy and service costs are increasing the importance of operating costs and system efficiencies. To be acceptable, a premium-priced unit must provide significant compensating advantages in terms of operating costs, maintenance or other characteristics. Approximately 50 percent of the large-tonnage market considers operating costs to be extremely important, but resistance exists to very large first-cost premiums or long payback periods.

d. Total owning and operating costs are becoming more widely used in equipment selection decisions. As operating costs increase, greater sophistication is being applied to the analysis of functional requirements, total energy use and equipment selection to insure that all relevant cost and use factors are given proper consideration.

e. Energy retrofit activity is increasing rapidly to replace older, energy inefficient systems. In addition to new, more energy-efficient equipment, a great deal of the retrofit activity has involved peripheral systems such as automated controls and variable air-volume terminals.

5. 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 build redundancy into the system by using several units rather than a single, larger unit.

6. 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 5 to 10 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.

B. The Future Market for Large-tonnage Air Conditioning Equipment and the Potential for the HSPF Concept.

1. The identified market characteristics and trends with regard to equipment-use patterns suggest some changes in the sizes and types of equipment used over the next few years. There

are slight trends toward larger-sized unitary equipment and greater use of reciprocating chillers in the 100 to 200 ton size range. Water source heat pump loops are also receiving increasing attention in applications that require simultaneous heating and cooling for different zones. Increased use of technologies and equipment with good variable-load or partial-load performance is also expected.

2. The tendency and willingness to accept first-cost premiums in return for greater operating efficiencies and lower operating costs is expected to increase over the next few years. Research indicates that approximately half of the large-tonnage market is willing to accept a premium/payback situation, but this percentage declines rather rapidly as the first-cost premium increases from 10 percent to 50 percent or as the payback period increases from 2 to 4 years.

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 market for large-tonnage unitary equipment (50 ton and over) and for 50 to 400 ton built-up equipment is projected to be 950 to 990 thousand tons in 1981. This includes a projected market of 160 to 200 thousand tons for large-tonnage unitary, 410 to 450 thousand tons for 50 to 200 ton built-up equipment and 340 to 380 thousand tons for 200 to 400 ton built-up equipment.

5. The market potential for HSPF equipment is projected to be 400 to 500 thousand tons in 1981. This includes a projected market potential of 40 to 80 thousand tons for unitary configurations (50 tons and over), 190 to 230 thousand tons for 50 to 200 ton built-up configurations and 160 to 200 thousand tons for 200 to 400 ton built-up configurations.

6. The energy retrofit market is currently small, but it is expected to grow significantly during the next few years. Over the past two years, there has been more "talk than action" in the energy retrofit market, but the potential is enormous. This is the only market whose size can to some extent be influenced by trade

efforts. The size of the other markets (construction, remodeling, replacement) are primarily determined by external and/or uncontrollable factors.

7. The market potential for the HSPF concept 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 willing to accept a premium/payback situation. This willingness is expected to increase as energy costs continue to escalate.

8. Simple system modifications and improved building efficiencies, however, could preempt the energy efficiencies that the HSPF is expected to accomplish. The use of automated control systems and energy-efficient building design and construction practices could reduce the amount of energy savings achievable by the HSPF. This could reduce the potential dollar savings below the amount required to recoup the first-cost premium.

9. Although the HSPF unit offers "unit-of-energy-use" efficiencies versus certain other types of equipment, the major energy cost advantage is the comparative price differential between gas and electricity. The ratio of comparative energy prices is expected to narrow slightly in the future. This ratio has important implications to the competitiveness of the HSPF unit, and the required coefficients of performance versus other systems.

10. Market perceptions with regard to the future availability of natural gas are perhaps the most important, basic issues affecting the market potential for the HSPF concept. Tremendous confusion and skepticism about the energy situation (particularly natural gas) exists in the marketplace. The extent of this problem must be recognized and effectively dealt with in the HSPF commercialization program.

RECOMMENDATIONS

Based upon the product data supplied by the Research Department of CNG, and a preliminary evaluation of the large-tonnage air conditioning equipment market, the following recommendations are made.

1. CONTINUE DEVELOPMENT OF THE LARGE-TONNAGE HSPF CONCEPT, PROVIDING NATURAL GAS WILL BE AVAILABLE IN THE 1980s. Supporting this recommendation are the following:

   a. A projected available market (domestic U. S.) in 1981 of 950 to 990 thousand tons for unitary equipment of 50 tons and over and built-up equipment in the 50 to 400 ton size range.

   b. Within this available market, a projected HSPF market potential of 400 to 500 thousand tons for all configurations. This assumes a first-cost premium of 25 to 50 percent and a payback period of 2 to 3 years for unitary configurations; and a premium of 10 to 25 percent and a payback period of 1 to 2 years for built-up configurations.

   c. Basic trends in key external factors and market characteristics are generally positive.

   d. Continued increases in energy costs and concerns 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.

   e. An increased concern for total owning and operating costs, and increased use of life-cycle costing to compare equipment alternatives should facilitate the evaluation of dissimilar technologies.

2. EMPHASIZE BUILT-UP (CHILLER) CONFIGURATIONS, BUT CONTINUE DEVELOPMENT OF THE LARGE-TONNAGE HEAT PUMP VERSIONS ON A LOWER PRIORITY BASIS.

   a. The built-up configuration appears to represent the largest potential market -- 190 to 230 thousand tons in the 50 to 200 ton size range and 160 to 200 thousand tons in the 200 to 400 ton size range.

   b. The built-up equipment markets tend to be less first-cost sensitive and more quality/operating cost oriented than most unitary equipment markets. First-cost sensitivity does exist, however, for a given quality/performance level.

   c. The production, marketing, applications and servicing of built-up equipment is compatible with the technological sophistication of the HSPF concept.

   d. The large-tonnage unitary market appears to be growing, and may provide a reasonably attractive secondary market in the 1980s. Large-tonnage heat pumps are currently only available on a custom-built basis, but more standardized equipment may be developed for certain applications and geographical areas (i. e., light industrial plants in the South).

3. EMPHASIZE DESIGN/APPLICATIONS FLEXIBILITY IN TECHNICAL DEVELOPMENT, AND STRONGLY CONSIDER SOME TYPE OF MODULAR APPROACH IN COMPONENT ASSEMPLY.

   a. To the extent possible, technical development should stress flexibility in design, combination of components and installation. Ease of application and use of the equipment should improve acceptability in the market place, particularly among key trade groups such as designers and installers. The variety of applications for which the HSPF can be adapted will increase its market and sales potential.

   b. A modular approach to component assembly would provide flexibility and ease of applications design, equipment installation and field maintenance. This could permit the selection of various component module combinations and permit customers to add capacity and/or easily revise system capabilities. This approach might also permit manufacturing cost reductions across the product line, due to the possible commonality of certain component assemblies.

c. To the extent possible auxiliary components and parts utilized in the unit should be standard items already in general use and 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.

4. TECHNICAL DEVELOPMENT SHOULD CONSIDER MARKET REQUIREMENTS SUCH AS RELIABILITY, MAINTAINABILITY, EQUIPMENT FIRST-COSTS, SYSTEM OPERATING COSTS; AS WELL AS MANUFACTURING FEASIBILITY.

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. Reasonable equipment, installation and operating cost estimates should be developed as soon as possible.

- There apparently is a great deal of manufacturer discounting from list prices in the built-up equipment market. First-cost comparisons for planning purposes should be based upon the actual factory and/or selling price.

- Equipment premiums should be held to a minimum -- 25 to 50 percent at most. Research clearly indicates that market potential declines rapidly with increases in the first-cost premium.

- Operating efficiencies should support a premium payback period of 3 years or less. Although the acceptable payback appears to be lengthening slightly, market potential declines rapidly for payback period greater than 2 to 3 years.

c. Manufacturing feasibility for components and final assembly must be assured. Required quality control objectives must be obtainable.

d. Field testing should be accomplished as soon as possible to demonstrate reliability and document operating costs. The equipment must prove to be reliable under field conditions

likely to be encountered in actual use. Well-documented operating data will be an important sales tool.

5. DEVELOP AN OVERALL PRODUCT DEVELOPMENT/COMMERCIALIZATION PLAN TO FACILITATE THE MANAGEMENT OF TECHNICAL AND MARKETING ACTIVITIES.

   a. Structure key technical and marketing activities and decision points in terms of sequence and time (i. e., PERT approach). This should be comprehensive, but need not be unnecessarily complex or detailed. From an overall standpoint, only the most important activities need to be included.

   b. Ensure the timely flow of information between technical development and market planning activities to facilitate effective coordination of technical and marketing aspects. These requirements will become more critical as the development program progresses toward commercial introduction.

   c. Highlight strategic issues and decisions. Attention should be focused on the most important items, and details should only be considered when they are absolutely necessary.

   d. Develop a "canned sales presentation" to describe the HSPF product concept and market potentials to prospective marketers, gas utilities and other key groups. This is a critical requirement as these groups will have to be "sold" on the HSPF concept, and convinced to provide the desired support for product introduction and market development.

6. MONITOR KEY EXTERNAL FACTORS AND MARKET CHARACTERISTICS ON A FORMALIZED PERIODIC BASIS. These factors are currently in a dynamic state of change, and can have pronounced effects on the potential for the HSPF unit.

   a. 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.

   b. 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-efficient space conditioning devices (including solar

energy systems) are under development and are likely to compete with the HSPF unit in the 1980s.

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 HSPFs relative economic benefits. Comparative energy-use costs will perhaps be the most important factors in evaluating alternative types of equipment and systems.

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 characteristics and requirements are desirable. These design and construction trends will have a significant impact on the structure and characteristics of the air conditioning market, 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 the federal, state and local levels must deal with a multitude of complex issues, and will significantly impact the HSPF development program and market introduction.

f. Key market characteristics and requirements should be monitored on a periodic basis. The most important items to monitor are functional-use requirements, equipment-use patterns, equipment selection processes and cost sensitivities (first-cost versus operating costs).

7. DEVELOP BASIC BUSINESS AND MARKETING STRATEGIES AND PREPARE A PRELIMINARY BUSINESS PLAN.

a. Analyze potential opportunities in specific market segments. The two market analyses completed to date have addressed broad market categories, appropriate to the current stage of technical development and decisions required. As some point, in-depth evaluations of specific market segments will be required to develop detailed market introduction and business plans.

b. Develop basic business objectives and evaluation criteria. Specific product sales objectives and check points should be developed along with criteria to be used to compare actual

results with sales forecasts. Deviations should be thoroughly analyzed to determine whether or not acceptability of the HSPF unit in the market place is meeting reasonable expectations. It is generally advisable that the objectives not be changed to mask inadequate market acceptance.

c. Develop basic (or alternative) marketing strategies. Strategies are required in the following areas: product (configurations, sizes, features), pricing (including replacement parts, warranties and preventive maintenance), promotion (including technical sales efforts) and distribution and service.

d. The preliminary business plan should stress key objectives, strategic issues and alternative business/marketing strategies.

- Emphasize alternative strategies and contingency plans. At this stage of the development program, a variety of alternative strategies should be evaluated and thinking should not be unduly restricted to a limited number of possible courses of action. Due to the dynamic nature of the current market environment, contingency planning should receive adequate attention.

- Limit quantitative data to key items, which can be easily up-dated. The inclusion of overly-detailed data can divert attention from the truly important issues and require massive efforts for updates and revisions.

- Strategies and projections should be refined and expanded as technical development, field testing and market analysis progresses. Technical and marketing activities should be properly coordinated to ensure mutual support, and the appropriate degree of refinement required at each stage of the development program.

8. BEGIN TO EVALUATE ALTERNATIVE LICENSING STRATEGIES AND PROSPECTIVE MARKETERS. The selection of licensing strategies and equipment marketer(s) are two of the most important marketing activities, which will require thorough analysis and a good understanding of the competitive dynamics of the market place.

a. Estimate the strategic (market development) and financial ramifications of alternative licensing strategies. Many

alternatives should be developed for discussion with prospective marketer(s).

b. Gather and evaluate relevant information on all potential marketers. This information should include, but not be limited to:

- Market/competitive position -- including geographical and market segment strengths.
- Product lines and market emphasis.
- Track record in developing and introducing new products.
- Financial performance.

c. The nature of the large-tonnage equipment markets suggests that the marketer(s) should have a strong current position in the market. An established position (and good technical reputation) in the marketplace is desirable, perhaps necessary, due to the uniqueness of the HSPF. Starting from scratch would probably be prohibitively expensive, and unlikely to succeed in the face of strongly entrenched competition. Most major suppliers of large-tonnage equipment do not produce boilers, however, so that marketing the HSPF could increase their total dollars per installation.

d. The selected marketer(s) must be willing, and able, to commit adequate efforts to market development and product support. The marketer must be willing to aggressively market the product in the face of possible market resistance and competitive reactions, and guarantee the product's reliability and performance claims.

I. HVAC INDUSTRY OVERVIEW

The HVAC industry (including manufacturers, distributors, contractors, engineer/designers, and others) in large, diverse and highly segmented. The purpose of this overview is to highlight some some of the key components of the industry, describe the analytical approach used in this report and provide a background for the analysis of the market potential for the HSPF.

A. General Flow of Analysis.

Exhibit I-1 depicts the general flow of analysis of this report. The analysis of the current market provides an understanding of the key market elements and forms a basis for projections. Analysis of key trends provides the dynamics, which in combination with the understanding of the current market, provides a 'picture' of the expected 1981 market. The HSPF concept is then described and compared to 1981 market characteristics to evaluate the 'degree of fit' and project a market potential for the HSPF. Some preliminary evaluations of the HSPF as a business venture are also provided.

B. Key External Factors Affecting HVAC Markets.

A number of external factors have pronounced affects on the HVAC

industry and its markets, Exhibit I-2. Some of these factors directly impact the operations of companies in the industry, but most operate indirectly by affecting the size, structure and/or characteristics of the end-use markets.

1. The General Economy. The level and growth of the general economy has a major impact on the need for business expansion and defines the general investment environment. Interest rates and the level of corporate profits are key considerations which affect acceptable (or required) levels and return on investment, as well as the basic ability to finance such investments.

2. Construction Activity. The overall level of construction, and activity in specific building segments, affects the total amount, sizes and types of equipment installed. Market segments generally develop specific equipment-use patterns and tend to follow slightly different construction cycles, thus affecting the equipment-type mix in a given year. New construction is still the largest market for most types of space conditioning equipment and has the greatest impact on equipment sales.

3. Product Saturation and Penetration. Product saturation represents cumulative product sales and indicates the degree to which the product has achieved its market potential, and the amount of market potential remaining. Penetration of new construction represents the current level of market acceptance of the product and indicates the direction and rate of growth versus its cumulative market position (saturation). These factors affect equipment growth rates and the relative importance of specific markets and channels of distribution.

4. Government Activity. Government policies concerning energy availability and costs are perhaps the most important governmental impacts at the present time. Government regulations affect construction and equipment standards, tax and other policies affect investment criteria and research funding supports technological developments.

5. Basic Technologies. Both basic research and product development activities impact HVAC markets by upgrading present equipment technologies and developing new approaches. Product

innovation has tended to be modest in the HVAC business, but this is changing rapidly in response to the interaction of other factors (particularly energy).

6. Energy. Changes in the national energy situation over the past few years have strongly impacted the HVAC industry, and future trends with regard to energy costs and availability will be the most important external factors impacting HVAC markets. Energy costs and availability affect functional requirements, the types of equipment used, equipment evaluation and selection processes and (perhaps most importantly) the acceptable levels of equipment quality and efficiency.

C. Major HVAC Markets.

The term major markets as used in this report refer to markets defined by type of construction - new construction, major remodeling, replacement and energy retrofit (replacement to improve energy efficiency and/or reduce energy costs), Exhibit I-3.

1. New Construction. The size of the new construction market is primarily determined by the level of general business activity and the business/construction investment environment. For the purpose of market projections and forecasting, both the direction and level of activity are reasonably predictable.

2. Major Remodeling. Major remodeling involves both periodic renewal and construction activities undertaken in-lieu of new construction at a different site. Neither the direction nor level of major remodeling is as predictable as new construction.

3. Replacement. This market represents the replacement of equipment that is worn out and can no longer fulfill the functional requirements or whose maintenance costs are excessively high. The future replacement market will grow, reflecting the historical growth of space conditioning, but the level in any given year is difficult to predict. This is due to the fact that replacement is dependent upon the complex interaction of expected equipment life, the quality of maintenance, and equipment use levels -- all of which are difficult to project. In addition, large-tonnage

equipment tends to be replaced component by component rather than in total. This is especially true of built-up systems.

4. Energy Retrofit. As used in this report, energy retrofit, refers to replacement soley to increase energy efficiency and/or reduce energy expenses. While this is expected to be a significant, high-growth market in the future, the rapidity of market development and the eventual market level is not predictable at this time.

D. Basic Market Segments.

The total HVAC market is divided into two basic markets -- residential (single family; mobile home) and nonresidential. Since the emphasis of this study is large-tonnage equipment, only the nonresidential markets are considered.

1. Nonresidential Market Segments. The nonresidential market includes all applications except single family residential and mobile homes.

   a) Commercial - includes retail stores, shopping centers, restaurants, banks and offices, commercial warehouses, garages and other miscellaneous commercial buildings.

   b) Industrial - includes plants, manufacturer warehouses and labs and other industrial buildings.

   c) Institutional - includes secondary schools, colleges, hospitals, medical clinics and various types of public buildings.

   d) Apartments - includes low-rise and high-rise apartment buildings.

   e) Hotels/Motels - includes high and low rise hotels, attached restaurants, meeting rooms, etc.

2. Typical Installation Sizes. Exhibit I-4 indicates standard terminology for basic equipment markets and typical total installation sizes.

a) Residential: 1-5 tons
b) Light nonresidential: 3-20 tons
c) Medium nonresidential: 25-100 tons
d) Large nonresidential: 100 + tons

E. Functional HVAC Systems.

HVAC systems are designed to provide heating, cooling, ventilation and other space conditioning functions. Various types of equipment may use different fuels and technologies, but all are either packaged (at factory) or non-packaged, and composed of three basic subsystems, Exhibit I-5.

1. Three Basic Subsystems. All HVAC systems are composed of essentially three basic subsystems - distribution, conditioning and rejection.

   a) Conditioned Medium Distribution. This subsystem represents distribution of the conditioned heat transfer medium (air and/or water) to the space being conditioned. Typical components include ducting, piping, air handlers, pumps, blowers, etc.

   b) Heat Transfer Medium Conditioning. This represents the basic components for the heating and/or cooling of the heat transfer medium (air and/or water). Typical equipment in this category includes unitary equipment, chillers, boilers, furnaces, etc.

   c) Operating By-product Rejection. This represents the rejection of operating by-products (heat and/or combustion gases), generally to the atmosphere. Included in this category are chimneys, air-cooled condenser, water-cooled condenser, cooling towers, etc.

2. Built-up Systems. Central built-up (or applied) systems represent centrally located equipment in which individual components are selected for specific applications and assembled in the field. Exhibit I-6 describes the three basic subsystems for built-up equipment.

a) Distribution. Built-up systems typically use water distribution, or more correctly -- when water distribution is required, built-up equipment is used.

b) Conditioning. Various types of chillers are available, but generally only one or a few centrally located units are used. Generally, "packaged" chillers are available up to 1,500 tons (compressor, evaporator/chiller, condenser, etc., located on a single skit), while above this the components are usually shipped separately.

c) Removal. Built-up equipment typically features air-cooled condensing below 150 tons and water-cooled condensing above 150 tons.

3. Unitary systems. Unitary systems may be central or decentralized units in which the major components are sized and packaged at the factory with minimal field assembly. Exhibit I-7 describes the three basic subsystems for unitary equipment.

a) Distribution. Unitary systems are always DX (direct expansion -- air) distribution. Typical applications require single or limited zoning, and ductwork is often minimized by using multiple rooftop equipment.

b) Conditioning. The conditioning components are self-contained in one (or two interconnected) packages. A single package may provide both heating and cooling or cooling only (with separate heating equipment generally required). Generally, several packages are used and are often located on the roof or outside of the building.

c) Removal. Unitary equipment is almost exclusively air-cooled, and in all cases either the entire package or the condenser is located outside in direct contact with the air.

4. Basic Comparison of System Types. Exhibit I-8 presents a comparison of the major commercial advantages and disadvantages of built-up and unitary equipment. As can be readily seen, the advantages for built-up equipment are primarily applications/performance related, while the disadvantages are cost related. The reverse is true for unitary equipment where the major advantages tend to be cost related, and the disadvantages applications/performance related.

a) Built-up Systems. Built-up systems tend to be higher quality (efficient), more flexible and provide a high degree of control and zoning -- but are considerably more expensive on an installed basis.

b) Unitary Systems. Unitary systems provide lower installed costs, but are generally lower in quality and operating performance and somewhat limited in terms of zoning and control.

F. Large-tonnage Unitary Equipment.

Large tonnage unitary equipment can be broadly segregated into three basic categories, Exhibit I-9. These categories are primarily defined by the degree of design/performance flexibility and relative first-cost.

1. Standardized Units. Standardized large-tonnage equipment is basically an extension of small and mid-tonnage unitary equipment technologies. First-cost is relatively low, but only standard sizes and a limited variety of features are available.

2. Modular Units. The modular unit approach provides increased flexibility by permitting selection of individual components modules that together constitute the total equipment package. Thus a total package may contain five component modules (each of which comes in a number of sizes or has different features) which may be selected in a variety of combinations to provide flexibility.

3. Customized Units. Customized units are built for specific customer applications. Although they have the highest first-cost, they also provide the greatest flexibility. Custom equipment represents a significant portion of the market for unitary equipment of 100 tons and above.

Exhibit I-1

GENERAL FLOW OF ANALYSIS

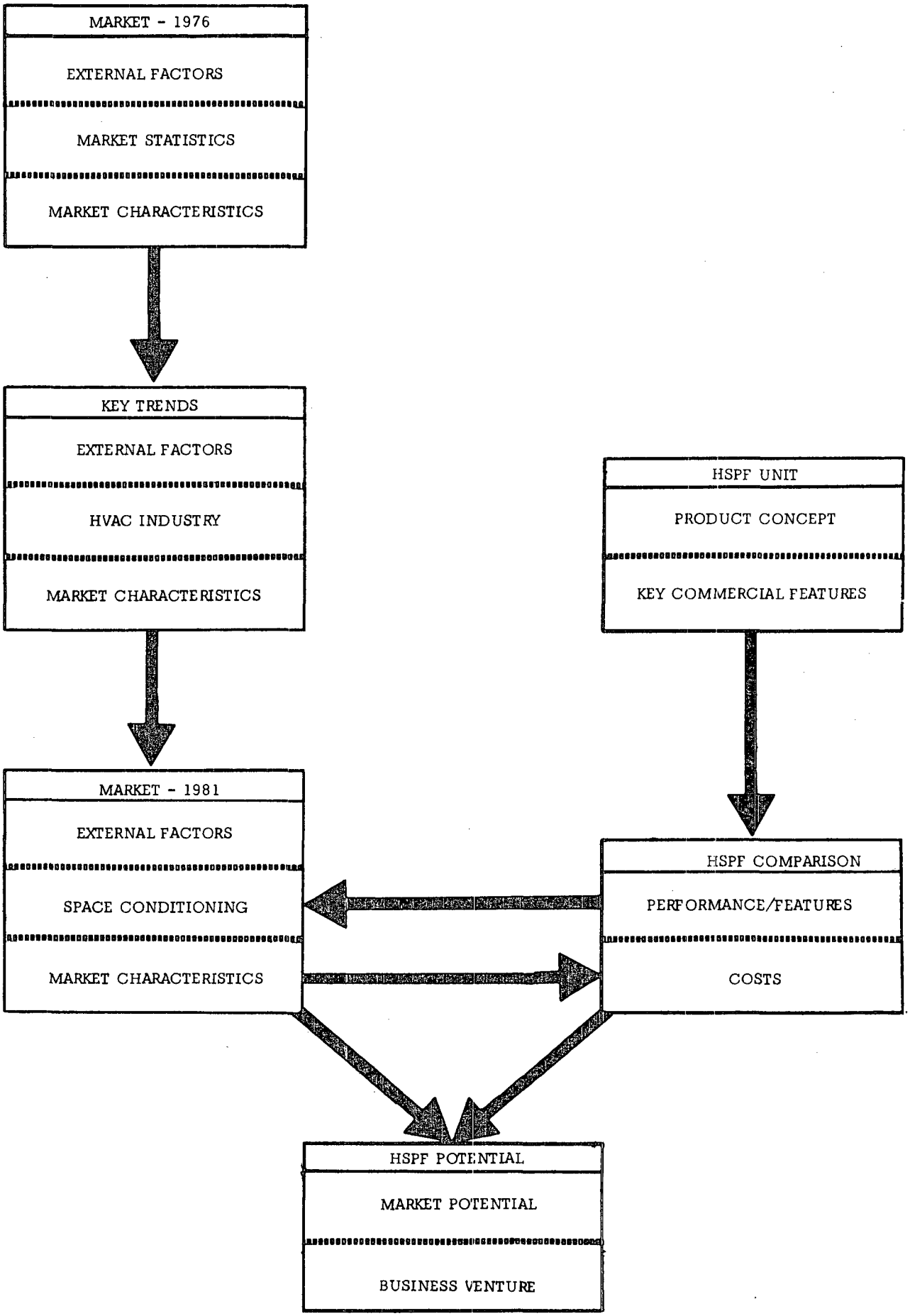


Exhibit I-2

KEY EXTERNAL OR UNDERLYING FACTORS AFFECTING HVAC MARKETS

Factor	Key Components	Nature of Impact
1. General Economy	- Level and growth - Interest rates - Corporate profits	- Need for expansion - Ability to finance investment - Level and return on investment
2. Construction	- Level and growth - Specific building segments	- Amount of equipment - Size and type of equipment
3. Product Saturation and Penetration of New Construction	- Product saturation level - Penetration of new construction	- Equipment growth rates - Relative importance of major markets (i.e. new construction) and channels
4. Government Activity	- Regulations - Tax policies - Research support	- Construction and equipment standards - Investment criteria - Energy availability and costs - Technological developments
5. Basic Technologies	- Basic research - Product development	- New products - Investment requirements
6. Energy	- Availability - Costs	- Types of equipment - Equipment quality (efficiency) - Equipment evaluation and selection processes

Exhibit I-3

MAJOR HVAC MARKETS

Major Markets	"Underlying or Driving" Forces	Degree of Projectability
New Construction	- Business activity - Investment environment	- Direction and level - relatively good
Major Remodeling	- Periodic renewal (time, use) - Cost versus new construction	- Direction and level - poor
Replacement	- Equipment life - Use levels	- Direction - good - Level - moderate
Efficiency Retrofit	- Equipment efficiency differentials - Perceived energy availability - Relative energy costs	- Direction - good - Level - poor

Exhibit I-4

TYPICAL MARKET INSTALLATION SIZES

Basic Equipment Market	Typical (total) Installation Size (1)	Approximate Sq. Ft. of Floor Space (2)
- Residential	1 – 5 tons	400 - 2,000
- Light Nonresidential	3 – 20 tons	900 - 6,000
- Medium Nonresidential	25 – 100 tons	7,500 - 30,000
- Large Nonresidential	100+ tons	30,000 +

(1) Nominal tons.
(2) Based upon estimated average of 400 sq.ft./ton for residential and 300 sq.ft./ton for nonresidential.

Exhibit I-5

FUNCTIONAL SUBSYSTEMS OF ALL HVAC SYSTEMS

Functional Subsystems	Description
Conditioned Medium DISTRIBUTION	Distribution of conditioned heat transfer medium (air and/or water) to space being conditioned
Heat Transfer Medium CONDITIONING	Basic heating and/or cooling of heat transfer medium (air and/or water)
Operating by-product REJECTION	Rejection of operating by-products (heat and/or combustion gases), generally to the atmosphere

Exhibit I-6

CENTRAL BUILT-UP (APPLIED) SYSTEMS

Definition: Centrally located equipment in which individual components are selected for specific applications and assembled in the field.

Conditioned Medium Distribution (1)

- Depends somewhat on zoning and extent of distribution
- DX (cool or warm):
  - Air circulated from central source
  - Extensive ducting
  - Terminal air volume or mixing control
- Water (chilled or hot):
  - Water circulated from central source
  - Extensive piping
  - Terminal water-to-air heat transfer
  - May require terminal ducting

Heat Transfer Medium Conditioning

- Typically one or a few centrally located units
- Chillers (cooling): (3)
  - Reciprocating
  - Hermetic centrifugal
  - Open centrifugal
  - Absorption
- Heating:
  - Boilers (major)
  - Furnaces (minor)
  - Space or decentralized heating

Operating By-Product Removal (2)

- Generally dissipated to atmosphere, some use for heating
- Exhaust of combustion gases:
  - Chimney
  - Vents, etc.
- Air-cooled condensing:
  - Direct air cooling of refrigerant
  - Condenser located outside
- Water-cooled condensing:
  - Water cooling of refrigerant
  - Condenser located inside
  - Outside cooling tower (to cool condensing water)

(1) Built-up systems typically use water distribution.
(2) Generally air-cooled below 150 tons; water-cooled above 150 tons.
(3) Typically packaged chillers up to 1,500 tons.

Exhibit I-7

COMMERCIAL UNITARY SYSTEMS

Definition: Central (or decentralized) units in which major components are sized and packaged at the factory with minimal field assembly

Conditioned Medium Distribution (1)	Heat Transfer Medium Conditioning	Operating By-Product Removal (2)
- Depends upon zoning, extent of distribution and number of units	- Typically several (or many) units often located on the roof	- Generally dissipated to atmosphere, some use for heating
- DX (cool and warm) • Air circulated from a few or 'directly' from a number of units • Amount of ducting depends upon number of units; zones • Some terminal air volume or mixing control • Can be single or multiple zoning	- Cool only:(3) • Horizontal • Vertical • Split system - Heat/cool: • YAC • Heat pump - Heat only • Furnace • Space or decentralized heating	- Air-cooled condensing: • Direct air cooling of refrigerant • Condenser located outside - Water-cooled condensing • Water cooling of refrigerant • Condenser located inside • Outside cooling tower, or other means (to cool condensing water)

(1) Typically single or limited zoning, duct work often minimized by using multiple rooftop equipment.
(2) Almost exclusively air cooled condensing.
(3) Cool only equipment generally require a separate heating system of some type.

Exhibit I-8

BASIC COMPARISON OF SYSTEM TYPES

System Type	Major Commercial Advantages	Major Commercial Disadvantages
Built-up Systems	· Flexible design for specific applications · High degree of control and zoning · Generally higher quality and better operating performance · Chilled water for high-rise buildings	· More extensive design-time and cost · Higher installation costs
Unitary Systems	· Reduced design time and costs · Lower installation costs · Equipment often outside-saves internal space	· Standardized sizes and capabilities · Somewhat limited zoning capabilities · Generally lower quality and operating performance · Limitations of DX air distribution

Exhibit I-9

BASIC LARGE-TONNAGE UNITARY EQUIPMENT CATEGORIES

Basic Product Categories (concepts)	Representative Manufacturers	Description
Standardized Units	- Trane - McQuay	- Standardized sizes available (extension of mid-tonnage unitary equipment) - Relatively low first cost, but limited flexibility
Modular Units	- Mammoth Division of Lear Siegler	- Standardized component sections which can be individually selected - Higher first cost than standardized, but increased flexibility
Customized Units	- Miller-Picking	- Custom built for specific applications - Highest first cost, but greatest flexibility

II. HISTORICAL ANALYSIS OF THE NONRESIDENTIAL AIR CONDITIONING EQUIPMENT MARKET

Over the past ten years, the nonresidential unitary market has grown at an average annual rate of 3.8 percent while built-up systems have declined at a 2.5 percent rate, producing a total market growth rate of 1.3 percent. Total installed value has grown at a 6.7 percent annual rate between 1967 and 1976, primarily reflecting the impact of inflation on equipment prices.

The primary markets for unitary equipment are selected commercial segments, apartments and nonhousekeeping residential where unitary equipment holds as much as 80 percent of the market. Built-up equipment is more frequently utilized in high-rise office buildings, industrial applications and institutional markets where its share may be as high as 60 percent.

The large-tonnage air conditioning market (as defined in this report) consists of all unitary equipment 50 tons and greater, and central built-up equipment between 50 and 400 tons. Large-tonnage unitary equipment represents 5.2 percent of total commercial unitary equipment tonnage, and built-up equipment in the 50-400 tonnage range represents 48 percent of total built-up equipment tonnage.

The primary market of interest for the HSPF is the 50 to 400 ton nominal size range which totaled approximately 738,000 thousand tons in 1976. The figures discussed in this report refer to the total U.S. domestic market and do not include exports.

A. Historical Construction Patterns.

Construction activity is a major determinant of the size and growth of the air conditioning market.

1. Historical Construction by Major Category. Exhibit II-1 shows historical construction activity in four major nonresidential building categories. All categories, except institutional, show marked cyclicality and poor average growth rates for the 1967 to 1976 period.

2. Construction and Air Conditioning. As shown in Exhibit II-2, unitary and built-up (chiller) unit shipments closely follow the cyclicality of total nonresidential construction.

   a) Built-up (chiller) Units. Built-up (chiller) equipment represents a more mature product category, and closely approximates the growth of the total market -- 1.9 percent average annual rate of growth versus 1.7 percent for total nonresidential floor space.

   b) Unitary Equipment. Unitary equipment represents a newer product category which has achieved considerable market penetration since 1960 -- thus the higher average growth rates. Over the past four years, unitary equipment has more closely followed construction growth rates indicating a maturing stage and reduced rates of market penetration.

B. Size and Growth of the Market -- U.S.

1. Total Market. The market for nonresidential air conditioning, including commercial unitary and central built-up equipment, peaked in 1973 at 5.1 million installed tons and stood at 3.9 million tons in 1976. Exhibit II-3 indicates the magnitude

and fluctuations of this market and the proportionate share held by each of the two basic types of equipment for the last ten years. From 1967 through 1976, the market grew at an average annual rate of 1.3 percent with a projected upturn in 1977. The unitary market expanded at an average annual rate of 3.8 percent, while the central built-up market declined an average 2.5 percent per year.

2. Total Unitary Market. Unitary equipment represented 2.7 million tons or 68 percent of the total nonresidential commercial market in 1976. The decline in installed tonnage between 1973 and 1976 reflected severely reduced construction levels during this period. Installed value of unitary equipment as shown in Exhibit II-4 represented about 69 percent of the total installed equipment value in 1976.

3. Total Central Built-up Equipment Market. The central built-up equipment market has been generally declining since 1970, from 3.3 million tons in 1970 to 1.2 million tons in 1976, when it represented 32 percent of total U.S. nonresidential air conditioning tonnage. This decline in tonnage and market share is due to lower construction levels in prime built-up equipment markets and increased use of large unitary equipment in traditional built-up equipment markets. Installed value of built-up equipment as depicted in Exhibit II-4 indicates that the built-up share of total installed value has increased from 25 percent to 31 percent between 1973 and 1976, while its share of installed tons has remained about the same. This reflects a more rapid relative increase in built-up equipment prices and installation costs, which has supported the sales growth of commercial unitary equipment.

4. Manufacturers Value. Exhibit II-5 shows the historical comparison of estimated manufacturers shipment value for nonresidential unitary and built-up equipment. In 1976, the value for unitary equipment was $700 million and for built-up equipment about $400 million.

C. Basic Types of Built-up and Unitary Equipment.

1. Built-up Equipment. Central built-up equipment is classified into major equipment types which are primarily based upon the method of compression. Hermetic compressors are sealed systems in which both the motor and compressor are contained within the same pressure vessel. In open type compressors,

the drive shaft extends through a seal in the crankshaft for an external drive.

a) Reciprocating Chillers -- Utilize a reciprocating compressor (either open or hermetic), either a flooded or direct expansion cooler and generally an air-cooled condenser. Reciprocating chillers are available from less than two tons to 200 tons cooling capacity, but are particularly competitive between 75 and 150 tons. Reciprocating equipment is generally more efficient than other systems between 75 and 150 tons, has a wider partial load performance range, and is less expensive. Its major drawbacks are noise and lower reliability than other types of chillers, as well as the need to use multiple compressors at larger tonnage sizes. Most reciprocating chillers above 75 tons contain at least two compressor units.

b) Centrifugal Chillers -- Are included in the family of turbomachines, which tend to have greater volumetric capacities than positive displacement devices. Centrifugal chillers utilize a compressor (either open or hermetic), generally a flooded cooler (evaporator) and a water-cooled condenser. Available hermetic type units range from 100 to 1,500 tons cooling capacity, but typically become commercially competitive above 150 tons. Open-type centrifugal chillers are available in units of 200 to 10,000 tons of cooling capacity. Centrifugals generally provide minimum vibration and good operating performance, but are not as effective on partial load conditions as reciprocating equipment. They are used in a wide variety of refrigeration and air conditioning installations.

c) Helical Rotary (or screw) Chillers -- A positive displacement compressor (either open or hermetic) with either a flooded or direct expansion cooler (evaporator) and an air or water-cooled condenser. Available packages range from about 100 to 1,000 tons cooling capacity, but the equipment generally becomes commercially competitive above 150 tons. The major advantages of screw machines are low vibration and noise, good, low temperature operations, and high reliability. Disadvantages are relatively high first-costs and poor manufacturer service reputation. Refrigeration and process applications are major markets for screw equipment.

d) Absorption Chillers -- Utilize an absorption machine, generally the indirect-fired lithium bormide water cycle, and are typically water-cooled. Available packages range from about 50 to 1,500 tons cooling capacity, but become commercially competitive above 150 tons. Absorption equipment shipments have declined over the past several years due to increased gas costs and concerns for gas availability. Sales are expected to stabilize at approximately the current level as waste-fueled and solar applications become more important. Absorption equipment is best utilized where there is a readily accessible low cost source of steam. This would include large institutional installations (such as hospitals and school complexes), industrial plants and other buildings in certain large cities where district steam is available.

2. Unitary Equipment. The unitary equipment is classified into five major types. The groupings are based upon configuration (single package and split package) and function (heat/cool and cool only).

a) Horizontal -- Single package, cool-only units which include a compressor, condenser, and fan-coil in one chassis. Horizontals are typically rooftop units which provide a low first-cost due to factory assembly and minimal installation costs. Horizontals are primarily used in low-rise buildings where limited zoning is required. They are generally used in conjunction with separate heating systems, and are often used in conjunction with combination heat/cool packaged units in commercial applications (1.e., department stores) where the core of the building only requires cooling. Horizontals have also become important in buildings that utilize heat reclamation systems for part or all of the required heating.

b) Heat Pumps -- Heat pump technology has been available for a number of years, and originally found its greatest application in the southern and western residential markets. Higher energy prices and uncertain availability of fossil fuels have encouraged technical development to adapt the concept to the requirements of other geographical areas and other major markets. 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 generally have a

coefficient of performance greater than one, operate in the heat pump mode down to about 20°F before supplemental heating is required, and provide equipment efficiencies (at moderate ambient temperatures) two to four times higher than conventional furnaces. Due to higher first-costs, availability of lower-cost natural gas (until the early 1970s), questionable reliability, and lack of sufficiently trained commercial maintenance services, heat pumps have historically had minimal penetration in nonresidential markets and cooler climatic areas. With continued increases in energy costs, concern for fossil fuel availability and technological improvements, heat pump sales will continue to increase in the nonresidential market. Heat pumps are available in both split and single package models.

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. Generally, gas is the preferred heating fuel, but the use of oil and electricity has increased due to the restricted availability of natural gas for new construction in many areas of the country. Although year-around equipment is often considered to be inefficient and of questionable "quality", it is widely used in the nonresidential market because it provides the lowest first-cost heating and cooling system. This is particularly significant in many commercial market segments and in speculative construction. Both single zone and multizone versions are available.

d) Split Systems -- Split systems are units in which the compressor-condenser is remote from the expansion coil and/or fan unit. They have historically represented a major portion of the nonresidential unitary market and have been applied in all building types as higher-quality, well-engineered, unitary air conditioning systems. Split systems are cool-only units, and where heating is required a separate heating system must be installed. Relatively high first-costs (equipment and installation), especially when a separate heating system is required, detract from the split system's inherent flexibility, quality, and performance, and affect its application in many nonresidential (first-cost sensitive) market applications.

e) Vertical and Remote -- Equipment of this type generally have a compressor, coil and fan unit in one chassis and a remote condenser. The primary market for this type of system is for replacement of similar worn out equipment. Over the past five or ten years the use of vertical and remote systems in new structures has greatly declined, and the primary market is for replacement of previously installed units. Vertical systems are cool-only and if heating is required, it must be provided by a separate system. Split systems incorporate the desirable aspects of verticals while offering a more desirable, generally superior configuration.

D. Air Conditioning Markets by Equipment Type.

1. Central Built-up Air Conditioning.

a) Built-up Market by Equipment Type. The total tonnage of built-up equipment has declined at an average annual rate of 2.5 percent since 1967, and represented 1.3 million tons of air conditioning in 1976. By tons, centrifugal equipment is the largest segment of the market with 68 percent of the total in 1976, Exhibit II-6. About one-sixth of this is open centrifugal, a figure that has remained relatively constant. Total reciprocating equipment tonnage has been growing since 1967, increasing from 18.3 percent of total tons in 1967 to 23.4 percent in 1976. Absorption equipment tonnage has declined from 17.5 percent of the total in 1967 to 8.7 percent in 1976, an average decline of 10 percent per year.

b) Distribution of Built-up Equipment by Size. Exhibits II-7, II-8 and II-9 show the distribution of built-up equipment by size range. Equipment in the 50 to 400 ton size range represented 48 percent of the total 1976 market. This percentage has fluctuated between 42 and 50 percent over the period examined. In 1976, 46.7 percent of the built-up equipment was above 400 tons representing a decline of 8 percentage points since 1970. Equipment in the 201-400 ton range declined from 28.3 percent in 1967 to 22.1 percent in 1976, while tonnage in the 101-200 ton range increased from 11.5 percent in 1967 to 13.4 percent in 1976. Tonnage in the 75-100 ton range grew from 5.1

percent of the total in 1967 to 8.0 percent in 1976, and the tonnage of equipment less than 75 tons in size declined slightly -- from 10 percent to 9.8 percent.

2. Unitary Air Conditioning. Over 7.6 million tons of unitary air conditioning were shipped in 1976, with approximately 35 percent (2.6 million tons) going to the nonresidential market. Exhibits II-10 and II-11.

   a) Unitary Tonnage by Size Range. Approximately 66 percent of the total unitary tonnage shipped to all markets was recorded by equipment of less than five tons nominal cooling capacity, and 28 percent by equipment in the 5 to 20 ton range. The size breakouts for the years 1970, 1973 and 1976 are shown in figure II-12. The small tonnage equipment (less than five tons) is primarily used in the residential market, and the large percentage shares in 1973 and 1976 reflect the strong housing markets in those years.

   b) Commercial Unitary Tonnage by Size Range. About 83 percent of total commercial unitary tonnage represents equipment of 20 tons or less, Exhibit II-13. The relative share of total commercial tonnage by selected size ranges has remained fairly constant over the last six years, with slight growth in 50 ton and above size range.

3. Unitary Air Conditioning (50 tons and above). Unitary equipment 50 tons and above represented 138 thousand tons of air conditioning or 5.2 percent of the total commercial market in 1976, Exhibit II-13.

   a) Unitary Market by Equipment Type. The equipment type mix changes in response to product availability and shifts in key market characteristics. Above 50 tons the most important type of equipment is split systems with 49.8 percent of the total. This share has been steadily declining since 1970 when it was 70.3 percent. Year-around (YAC) systems have gained an increasing share, from 10.1 percent of the total in 1970 to 27.1 percent in 1976, Exhibit II-14. Horizontal equipment has also increased its share, from 2.3 percent in 1970 to 16.0 percent in 1976. Heat pumps are currently a negligible portion of this large-tonnage market, but larger sizes are expected to be introduced in the future. Vertical systems have steadily lost share since 1970, declining to 7.1 percent of the total in 1976.

b) Unitary Market by Basic System Configuration. Single package units offer significant advantages in many non-residential applications. Foremost among these are ease of installation, lower installation costs, lower equipment first-costs and a configuration that lends itself to maximum utilization of internal space. Single package equipment represented 12.4 percent of the 50 ton and above nonresidential market in 1970 and 43.1 percent in 1976 as shown in Exhibit II-15.

c) Unitary Single Package Market by Function. Within the single package category, combination heat/cool systems (YAC) in the 50 ton and above size range have declined from 81.4 percent in 1970 to 62.9 percent in 1976. Conversely, horizontal equipment has increased from 18.5 percent to 37.1 percent during the same period. This is illustrated in Exhibit II-16. Some of the shift may be explained by the construction-type mix, but a significant portion is apparently due to an actual change in share. Field research suggests that larger-tonnage applications tend to have minimal heating requirements that do not favor the combination (YAC) unit approach. Often, relatively less heat is required and a separate (smaller) heating system can be more effective.

d) Combination Heat/Cool Market by Type. As depicted in Exhibit II-17, multi-zone equipment has declined from 56.1 percent in 1970 to 42.6 percent in 1976. This reflects disfavor with multi-zone equipment due to overall system complexity and energy inefficiencies. Single zone equipment coupled with variable-air-volume boxes is becoming increasingly popular in most applications.

E. United States Market by Major Markets and Market Segments.

Major markets and market segments are defined by differences in such market characteristics as types of systems used, selection processes used, key specifying influences and equipment selection criteria.

1. Major Markets. Major markets include new construction, major remodeling, replacement, and energy retrofit, Exhibit II-18.

a) New construction is the largest market, estimated at 65 to 70 percent of the total in 1976. Remodeling, replacement, and energy retrofit represented between 15 and 22 percent.

b) Replacement is a significant growth segment of the market, and to some extent a stabilizing influence relative to the swings in new construction. Replacement generally represents 15 to 20 percent of the total market.

c) Energy retrofit is defined as 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 only a small portion of the total market.

2. Market Segments. Exhibit II-19 indicates the share of the total market in 1976 for each building segment. It ranges from 8 to 10 percent for hotel and motel, to 32 to 36 percent for the commercial segment. This institutional segment represented 20 to 24 percent of the total and industrial 14 to 18 percent. Apartments were 17 to 19 percent of the total, primarily comprised of small-tonnage unitary equipment used in garden-type apartments. The industrial segment is most heavily influenced by economic conditions while the institutional market is least affected by general economic cycles. Exhibit II-19 also illustrates the equipment use pattern by major equipment type and market segment.

a) Unitary Equipment. Unitary equipment tends to be strongest in the first-cost sensitive markets (apartments, motels, and speculative commercial) and markets that require limited zoning (industrial, low-rise retail stores).

b) Built-up Equipment. Built-up equipment tends to be strongest in operating-cost sensitive markets (institutions, owner-occupied commercial) and markets that require extensive zoning and/or close temperature control (hospitals, high-rise office buildings, specialized industrial).

F. Prime Market Screening Approach.

The prime market of interest is 50 to 400 ton unitary and built-up equipment market estimated at 738 thousand tons of cooling capacity

in 1976, Exhibit II-20.

1. Unitary Equipment. Unitary equipment represents approximately 68 percent of total nonresidential tonnage, but only about 19 percent (138.000 tons) of the tonnage in the 50 - 400 ton size range. Of the 138 thousand tons, split systems represents 57 percent and roof tops or single package 43 percent.

2. Built-up Equipment. Built-up equipment represents 32 percent of total nonresidential tonnage, but 81 percent (600,000 tons) of the tonnage in the 50 to 400 ton size range. Of the 600 thousand tons, centrifugal equipment represents 57 percent, reciprocating 35 percent and absorption 8 percent.

3. Equipment Availability. The basic availability of equipment types by nominal tonnage size is shown in Exhibit II-21. This exhibit also indicates the tonnage ranges in which the various types of equipment are generally commercially competitive.

   a) Less Than 150 Tons. Below about 150 tons, competition is primarily between standard unitary, custom unitary, and reciprocating chillers. First-costs are of major importance and applications tend to be relatively simple and standardized.

   b) 150 to 200 Tons. Other types of chillers begin to become commercially competitive between 125 - 150 tons and all types of chillers compete between 150 and 200 tons. Limited numbers of custom unitary equipment are sold in the lower end of this range. First-costs are still important, but operating costs become increasingly important. Applications tend to be more complex and less standardized.

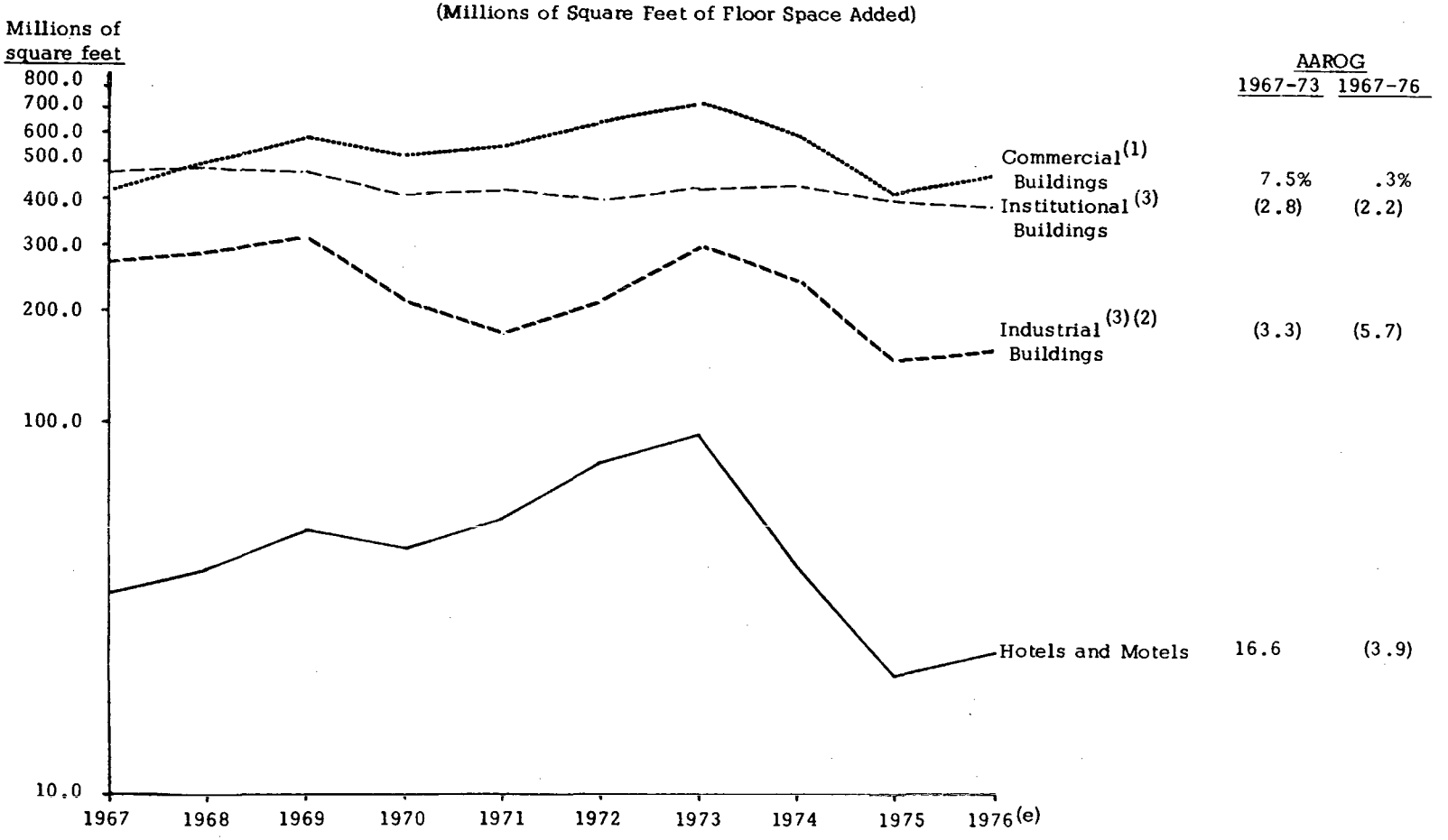
   c) Greater Than 200 Tons. Above 200 tons, competition is primarily between centrifugal,screw and absorption chillers -- with each having some advantages in particular markets. Applications tend to be relatively complex , and operating costs can be as important (and in some cases more important) than first-costs.

   d) Summary. In general, equipment costs per ton, for all types of equipment, tend to decrease with increasing equipment size, but total installation costs per ton may increase. While first cost sensitivity per se may decrease with increasing size and complexity of application, first-cost sensitivity for a given quality level (i.e., efficiency) remains relatively constant.

Exhibit II-1

NON-RESIDENTIAL CONSTRUCTION - SQUARE FEET OF FLOOR SPACE ADDED ANNUALLY BY TYPE, 1967-1976
TOTAL U.S.

(Millions of Square Feet of Floor Space Added)



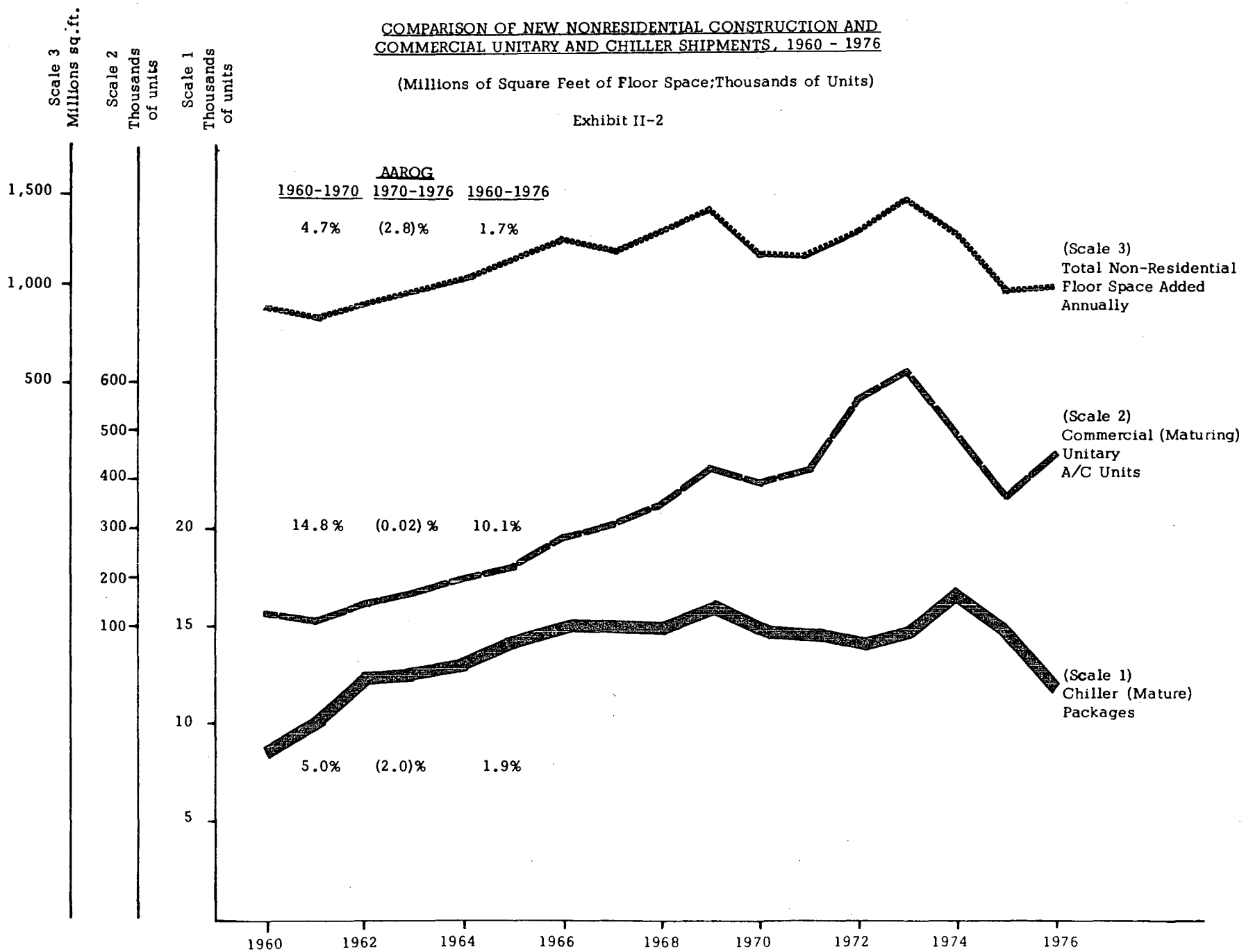
(1) Includes offices, banks, stores, restaurants and other.
(2) Includes factories, factory offices, labs and warehouses.
(3) Includes education, health, public, religious, social and recreational and miscellaneous.
(e) 1976 figures are estimated.

Sources: F.W. Dodge Construction Reports.

COMPARISON OF NEW NONRESIDENTIAL CONSTRUCTION AND COMMERCIAL UNITARY AND CHILLER SHIPMENTS, 1960 - 1976

(Millions of Square Feet of Floor Space;Thousands of Units)

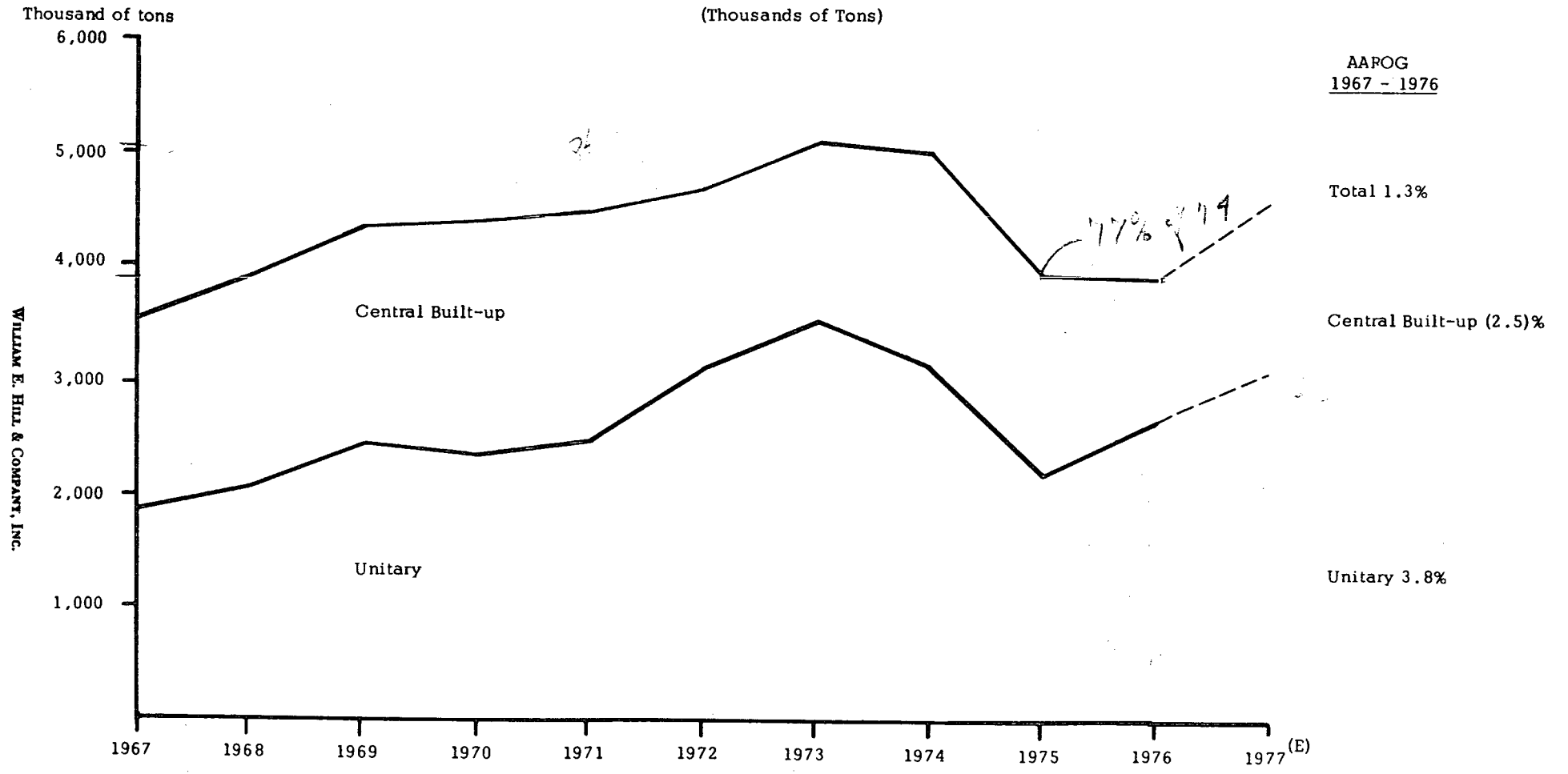
Exhibit II-2



Source: ARI; U. S. Department of Commerce

Exhibit II-3

COMPARISON OF NONRESIDENTIAL (1) AIR CONDITIONING TONNAGE
BY BASIC EQUIPMENT TYPE (2)
(Total U. S.: 1967 - 1977)



(1) Includes apartments and non-housekeeping residential.
(2) Unitary, ARI commercial definition. Central built-up equipment. includes: chillers, fan coil units, air handlers, air induction units, and cooling towers.

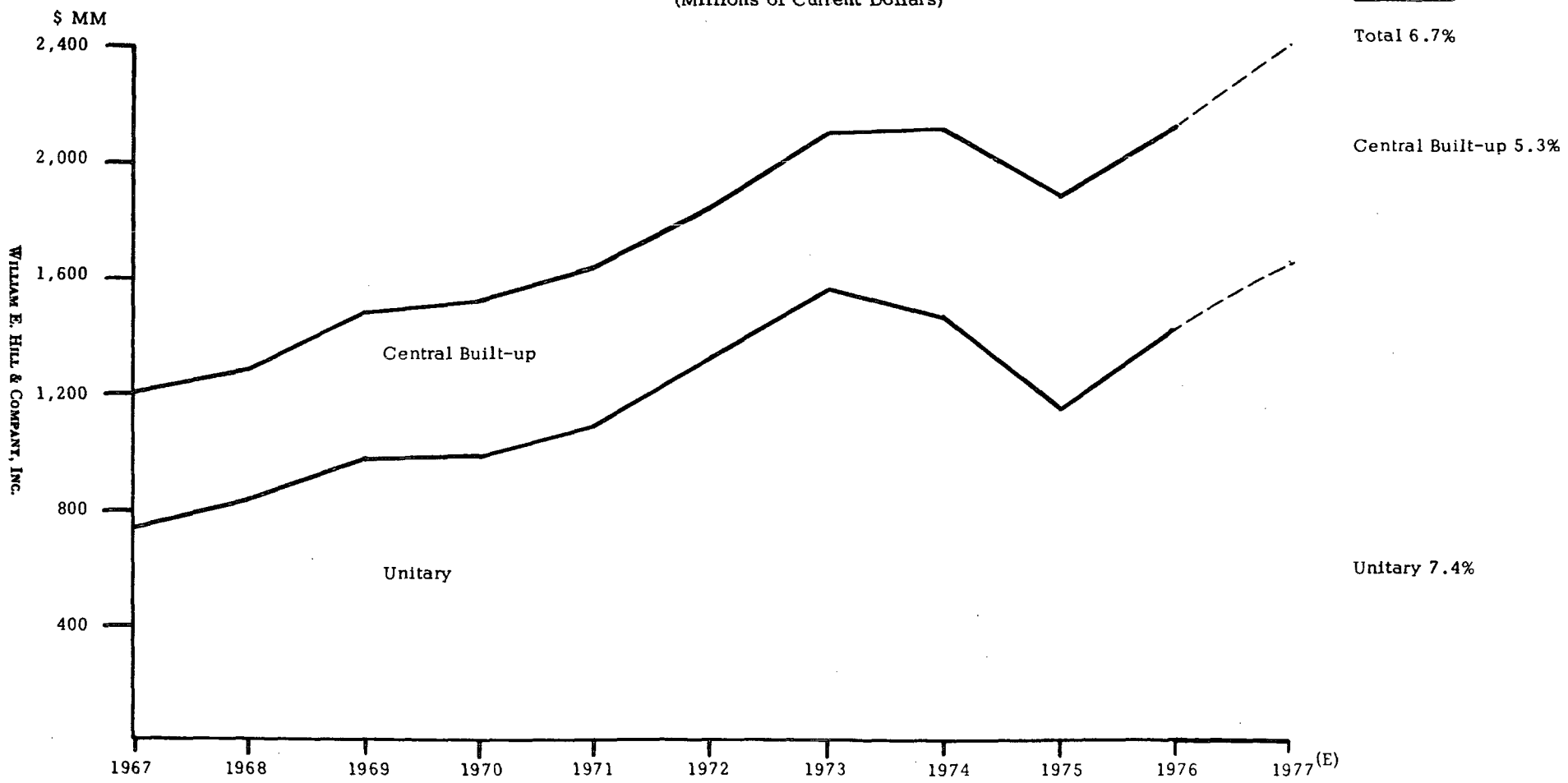
Source: William E. Hill & Co. estimates based on ARI data, Department of Commerce: Current Industrial Reports.

WILLIAM E. HILL & COMPANY, INC.

Exhibit II-4

COMPARISON OF NONRESIDENTIAL (1) AIR CONDITIONING INSTALLED VALUE BY BASIC EQUIPMENT TYPE (2) (3)
(Total U. S.: 1967 - 1977)

(Millions of Current Dollars)



(1) Includes apartments and non-housekeeping residential.
(2) Unitary, ARI commercial definition. Central built-up equipment includes: chillers, fan coil units, air handlers, air induction units, and cooling towers.
(3) Includes labor and other costs to install the equipment itself, but not labor and materials for air distribution, piping, and other parts of the system.

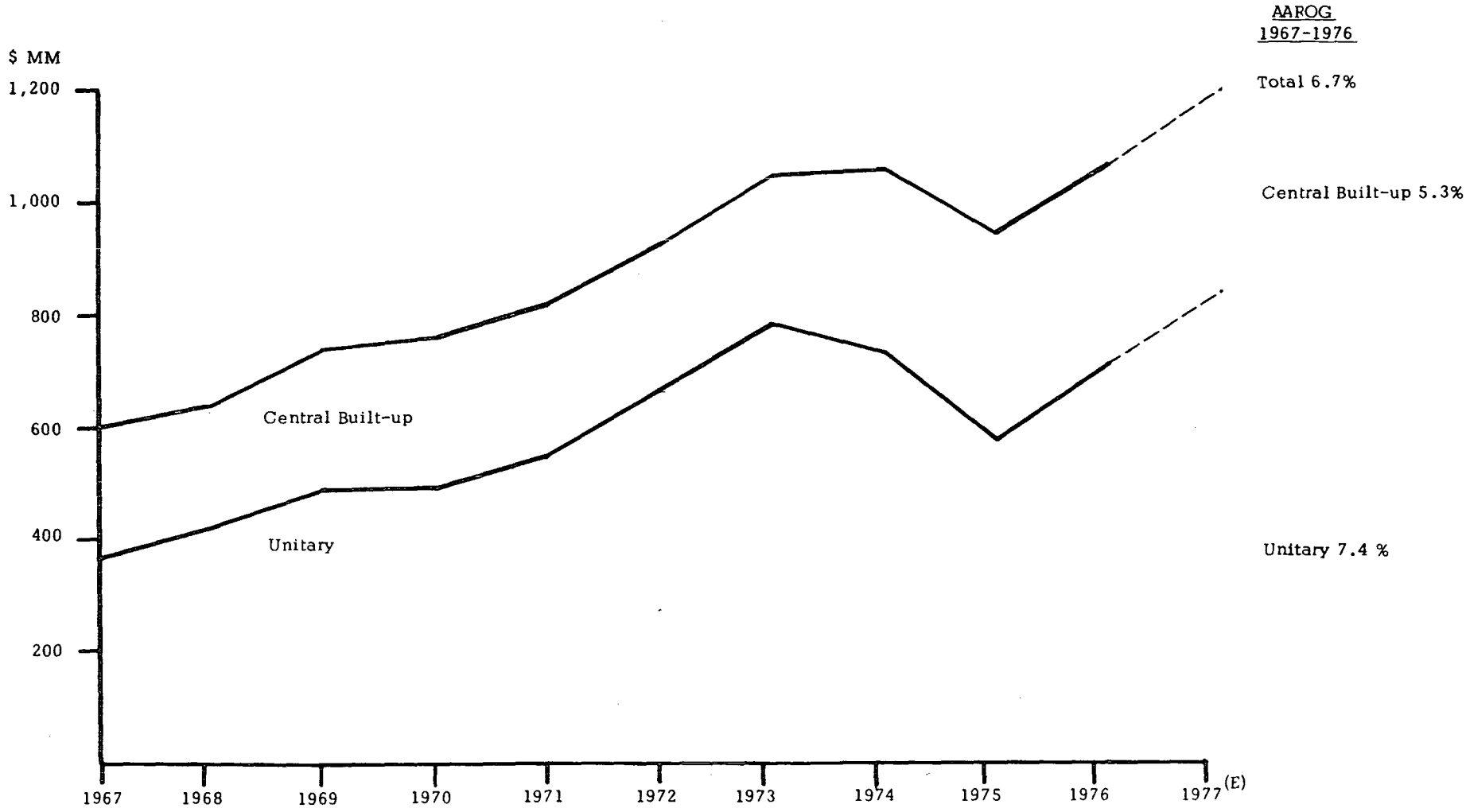
Source: William E. Hill & Co. estimates based on ARI data, Department of Commerce: Current Industrial Reports.

WILLIAM E. HILL & COMPANY, INC.

Exhibit II-5

ESTIMATED NONRESIDENTIAL[1] AIR CONDITIONING MANUFACTURERS' EQUIPMENT SHIPMENT VALUE BY BASIC EQUIPMENT TYPE[2][3]
(Total U. S.: 1967 - 1977)

(Millions of Current Dollars)



(1) Includes apartments and non-housekeeping residential.
(2) Unitary, ARI commercial definition; central built-up equipment value includes: chillers, air handlers, fan coil units, air induction units, and cooling towers.
(3) Estimated factory shipment value -- for domestic markets.

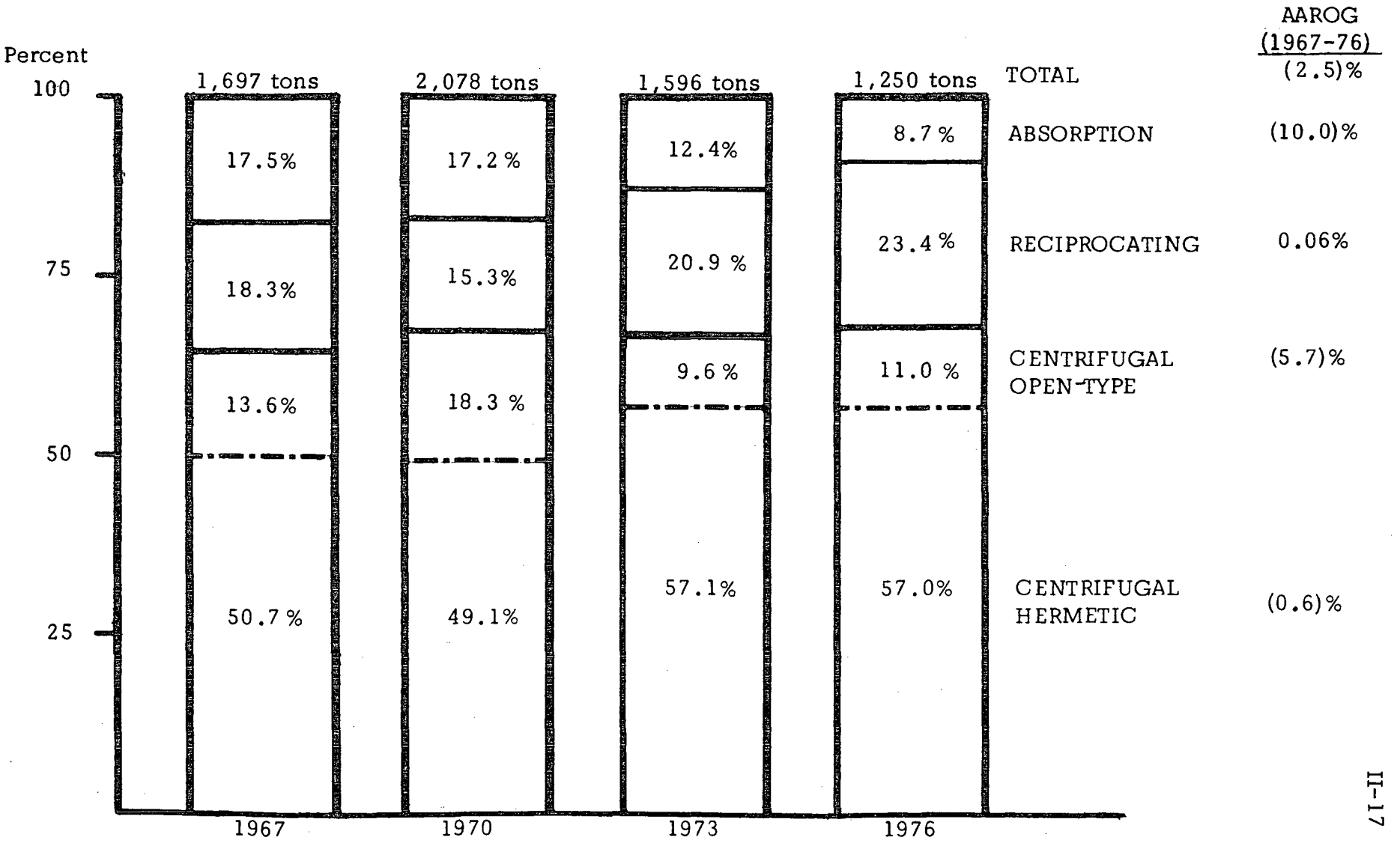
Source: William E. Hill & Co. estimates based on ARI data, Department of Commerce: Current Industrial Reports.

William E. Hill & Company, Inc.

Exhibit II-6

DISTRIBUTION OF CENTRAL BUILT-UP EQUIPMENT BY TYPE
(Total U. S.)

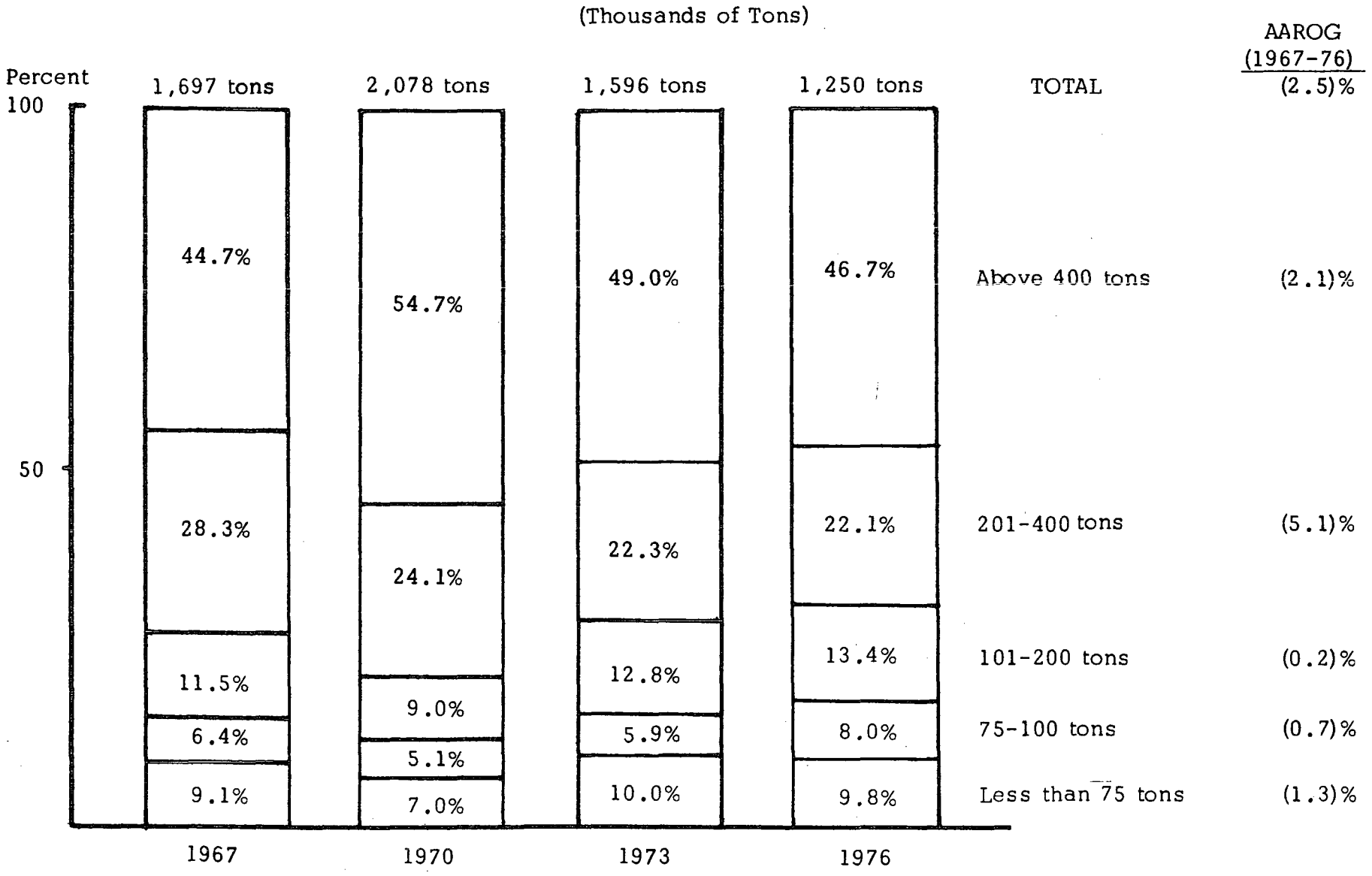
(Thousands of Tons)



Source: William E. Hill & Company estimates based on ARI data.

Exhibit II-7

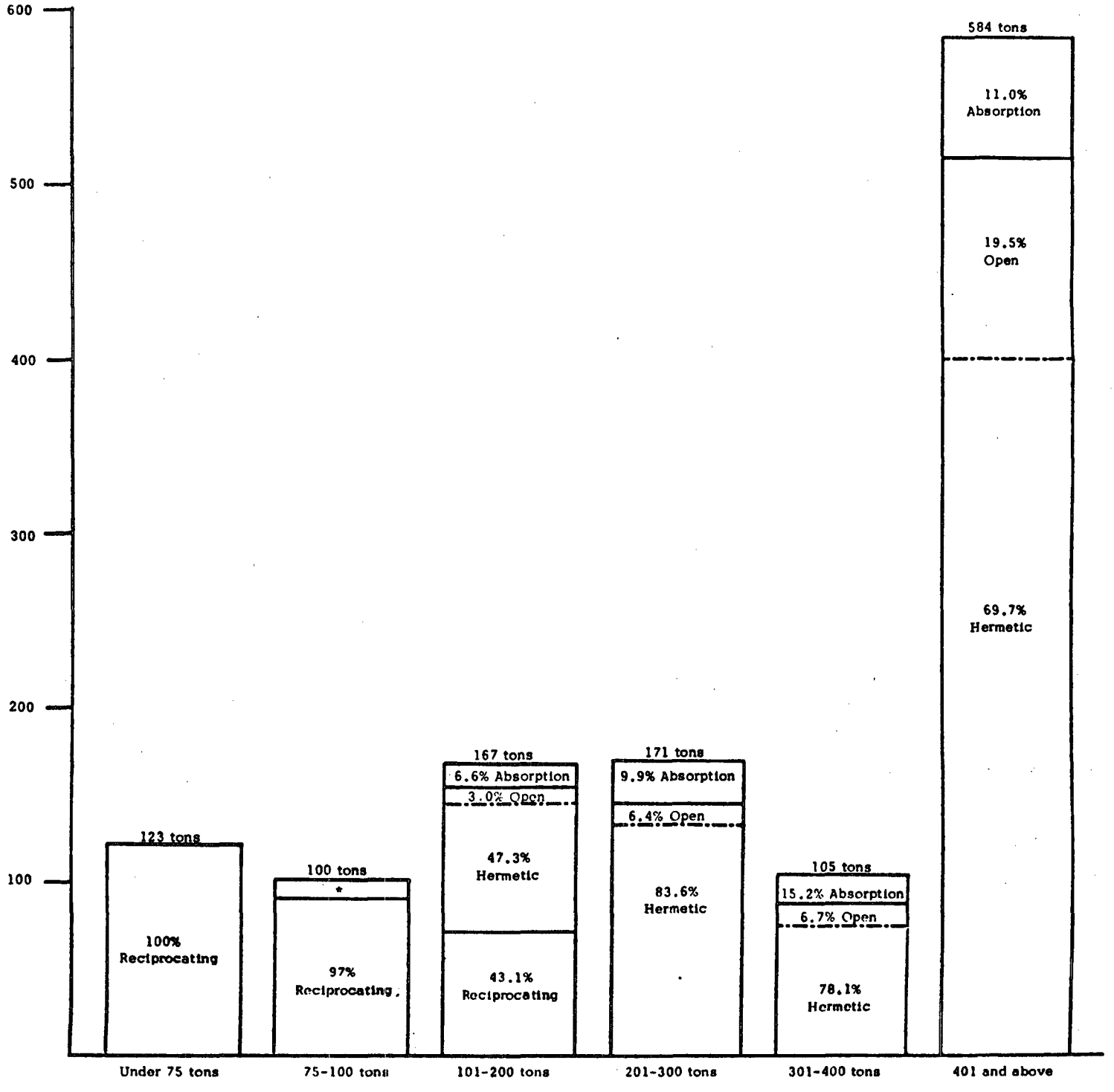
DISTRIBUTION OF CENTRAL BUILT-UP EQUIPMENT BY SIZE
(Total U. S.)



Source: William E. Hill & Company estimates based on ARI data.

Exhibit II-8

DISTRIBUTION OF CENTRAL BUILT-UP EQUIPMENT TYPE
BY SIZE RANGE IN TONS[1]
(Total U. S.)
1976
(Thousands of Tons)

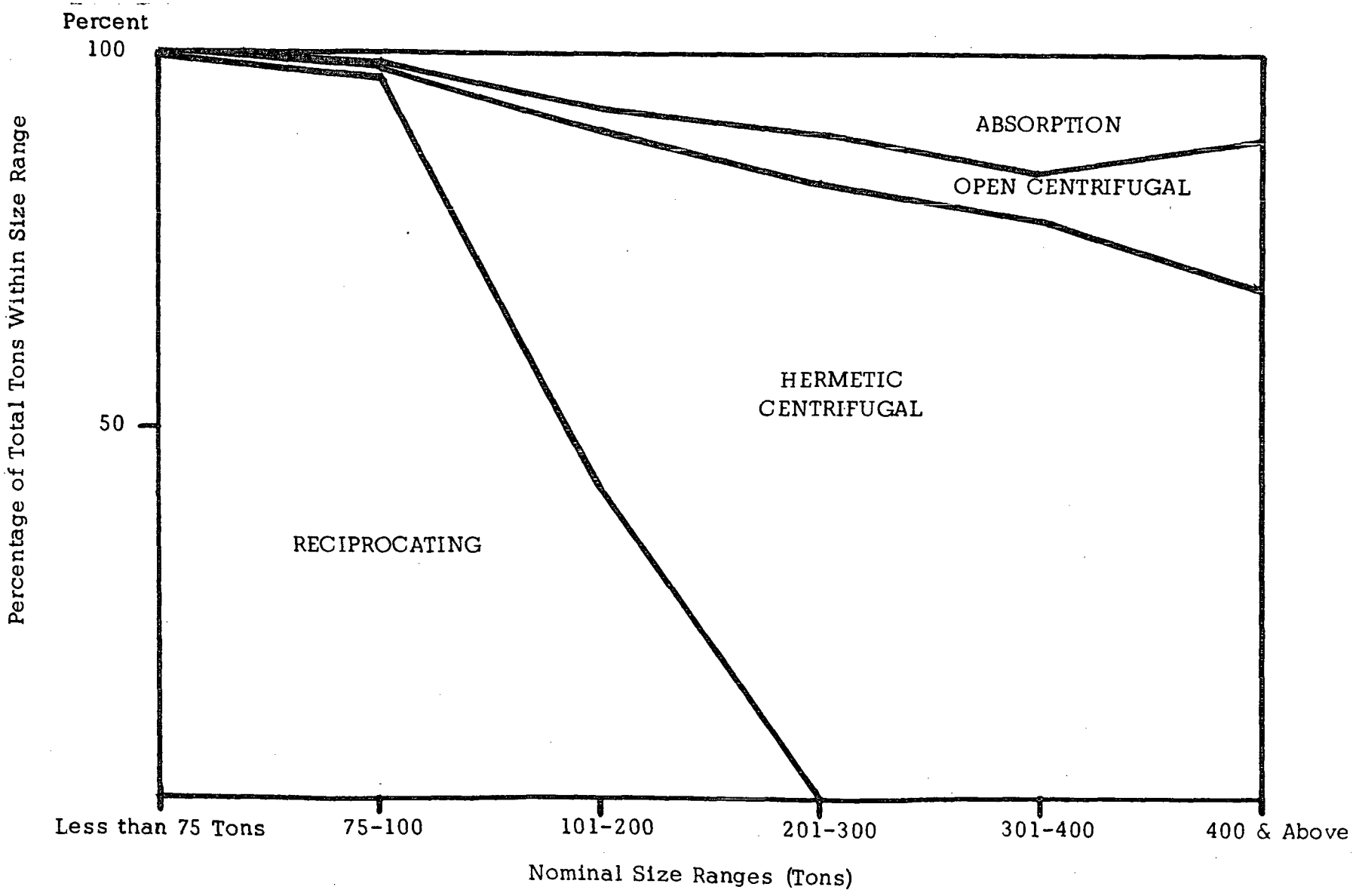


* 3% Absorption, Open and Hermetic.
(1) Central built-up: 0 tons and above.
Source: William E. Hill & Co., estimates based on ARI Data.

Exhibit II-9

DISTRIBUTION OF BUILT-UP EQUIPMENT TONNAGE
BY TYPE OF EQUIPMENT WITHIN SELECTED SIZE RANGES (TOTAL U.S.)

1976

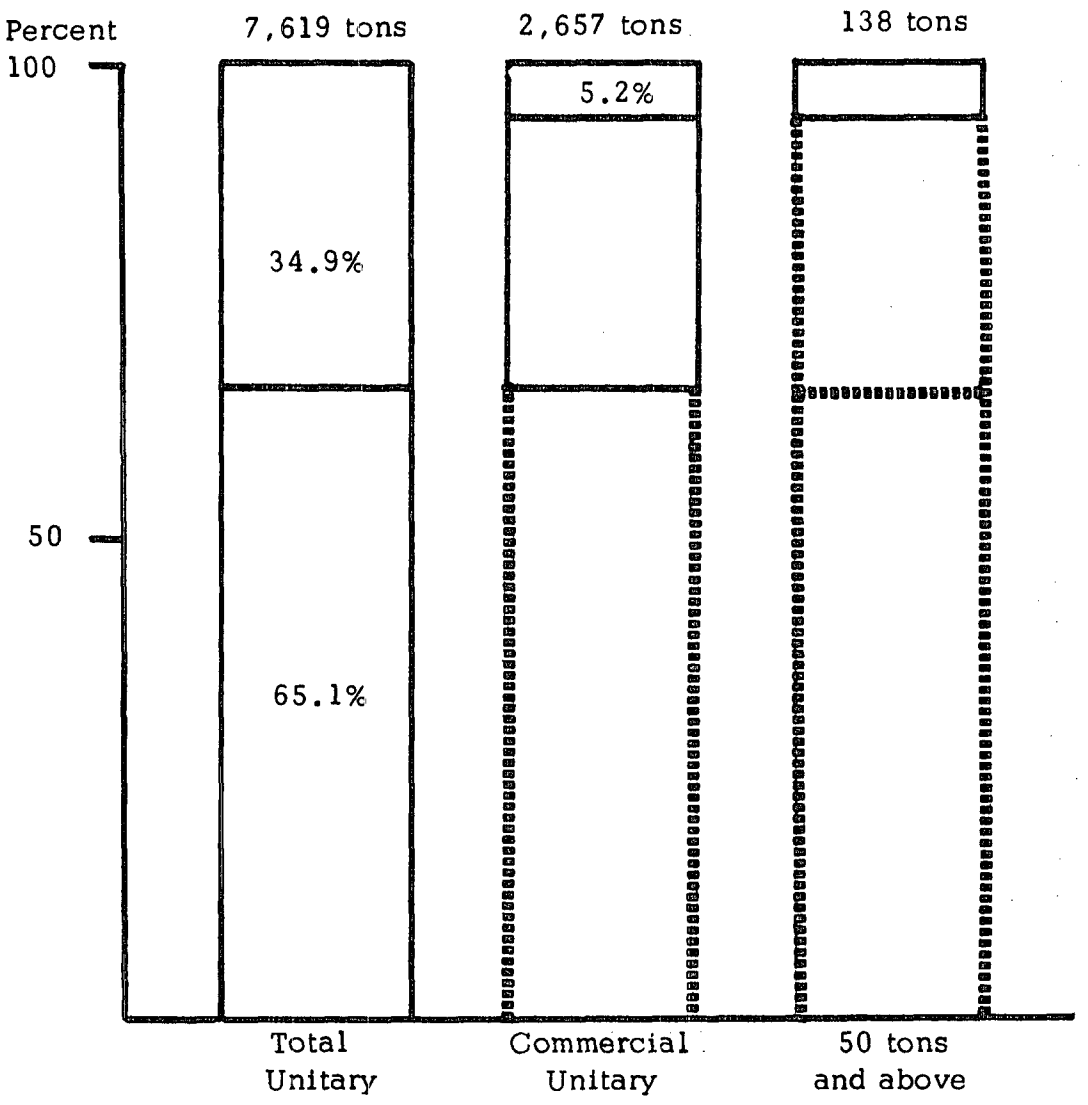


Source: William E. Hill & Company estimates based on ARI data.

Exhibit II-10

PRIME UNITARY MARKET OF INTEREST
EQUIPMENT 50 TONS AND ABOVE (U.S.)

(Thousands of Tons)
1976

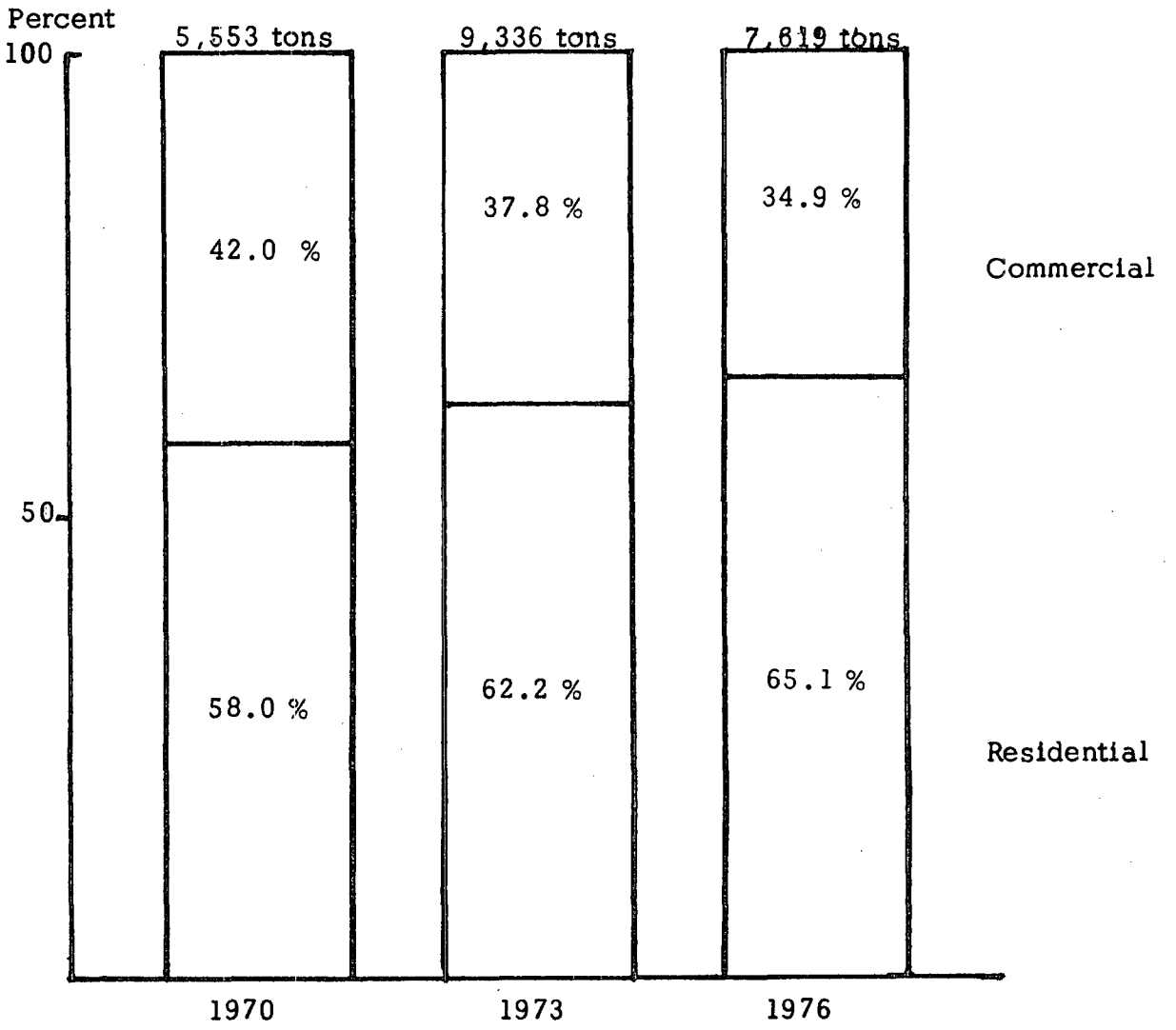


Source: William E. Hill & Co. estimates based upon ARI data.

Exhibit II-11

DISTRIBUTION OF UNITARY AIR CONDITIONING EQUIPMENT:
RESIDENTIAL VS. COMMERCIAL
(Total U. S.)

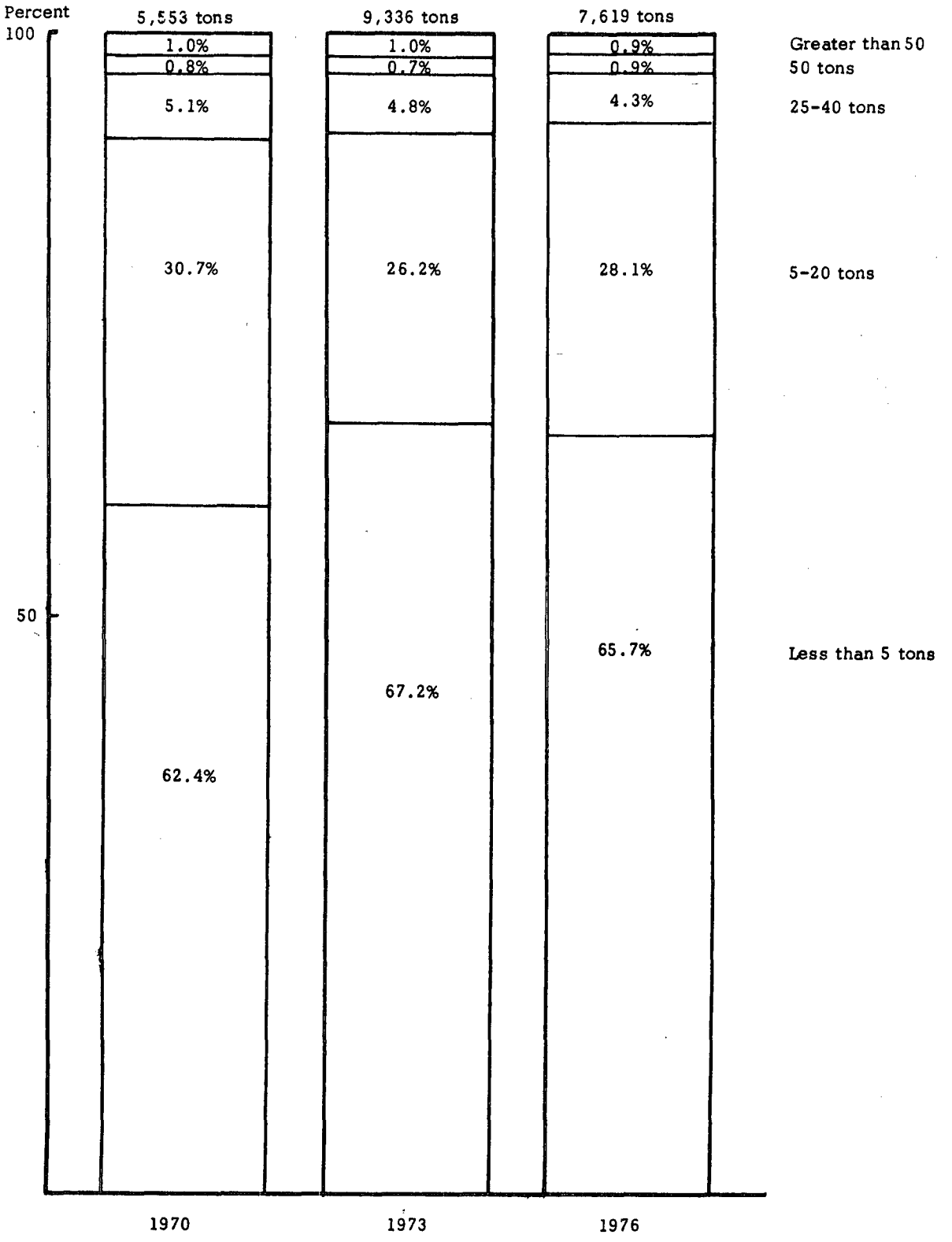
(Thousands of Tons)



Source: William E. Hill & Company estimates based on ARI data.

DISTRIBUTION OF RESIDENTIAL AND COMMERCIAL UNITARY AIR CONDITIONING EQUIPMENT BY NOMINAL SIZE RANGE
(Total U. S.)

(Thousands of Tons)

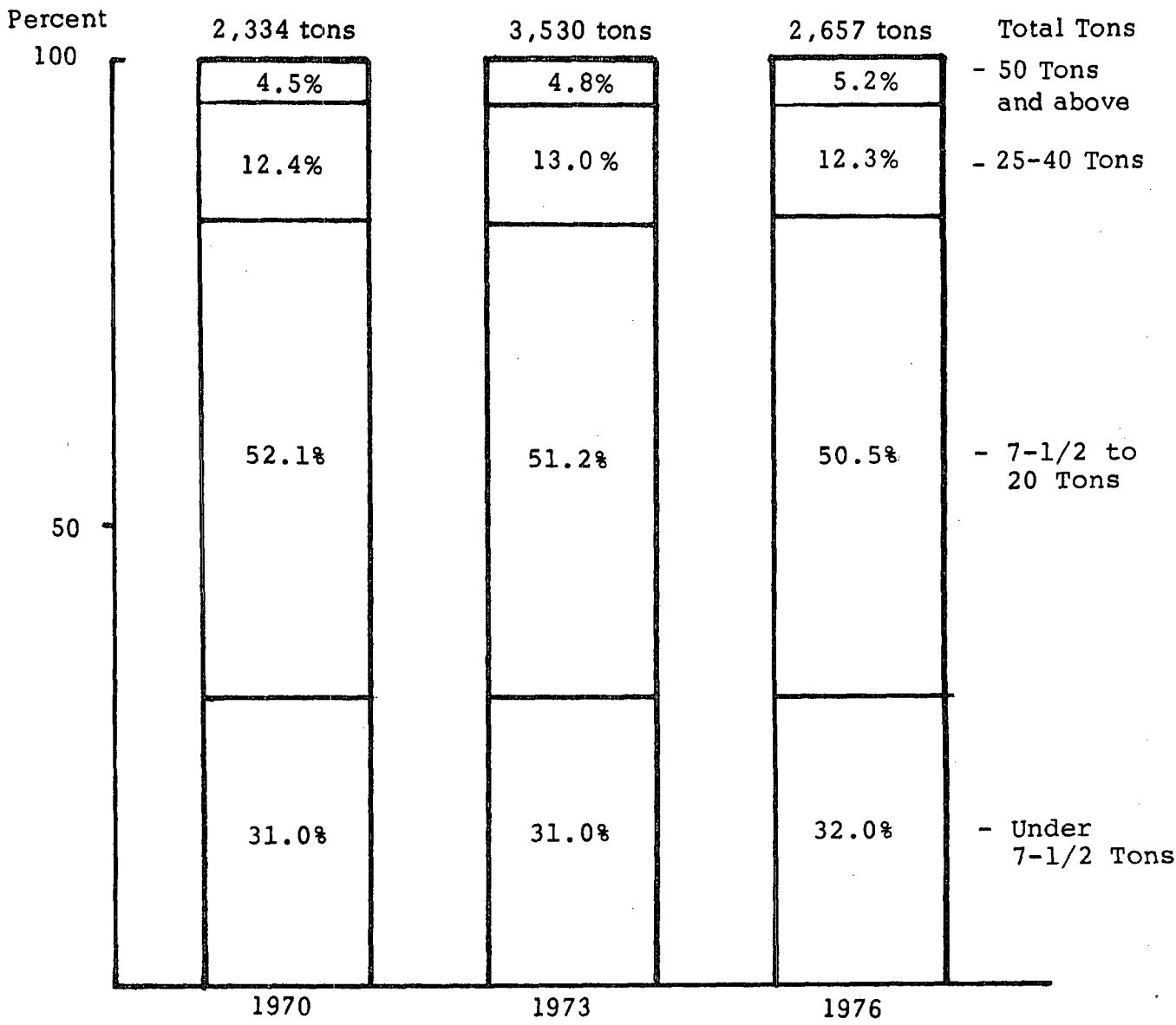


Source: William E. Hill & Company estimates based upon ARI data.

Exhibit II-13

DISTRIBUTION OF COMMERCIAL UNITARY EQUIPMENT SHIPMENTS BY NOMINAL SIZE RANGE
(Total U. S.)

(Thousands of Tons)

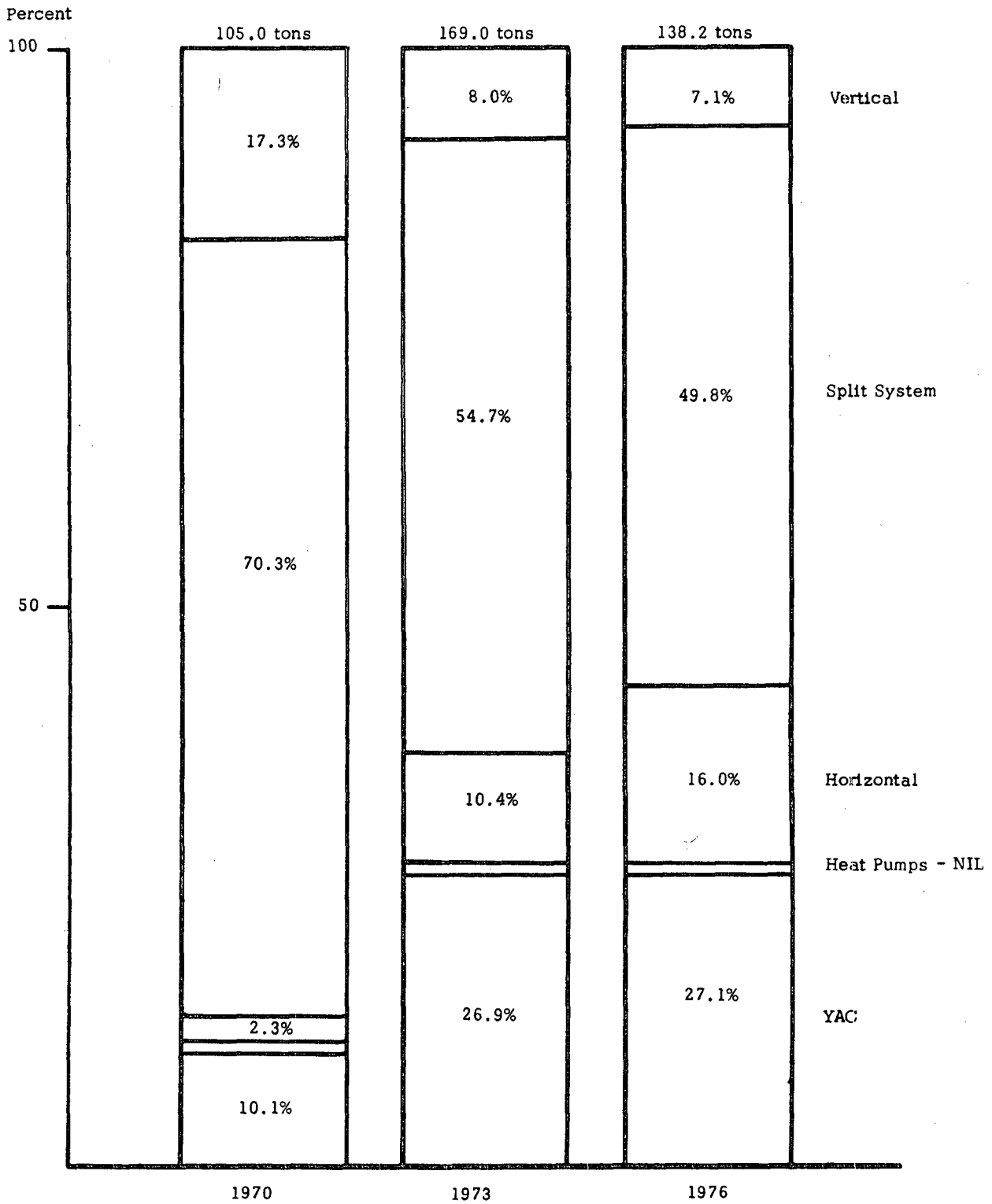


Source: William E. Hill & Company estimates based on ARI data.

Exhibit II-14

DISTRIBUTION OF UNITARY EQUIPMENT 50 TONS AND ABOVE BY TYPE
(Total U. S.)

(Thousands of Tons)

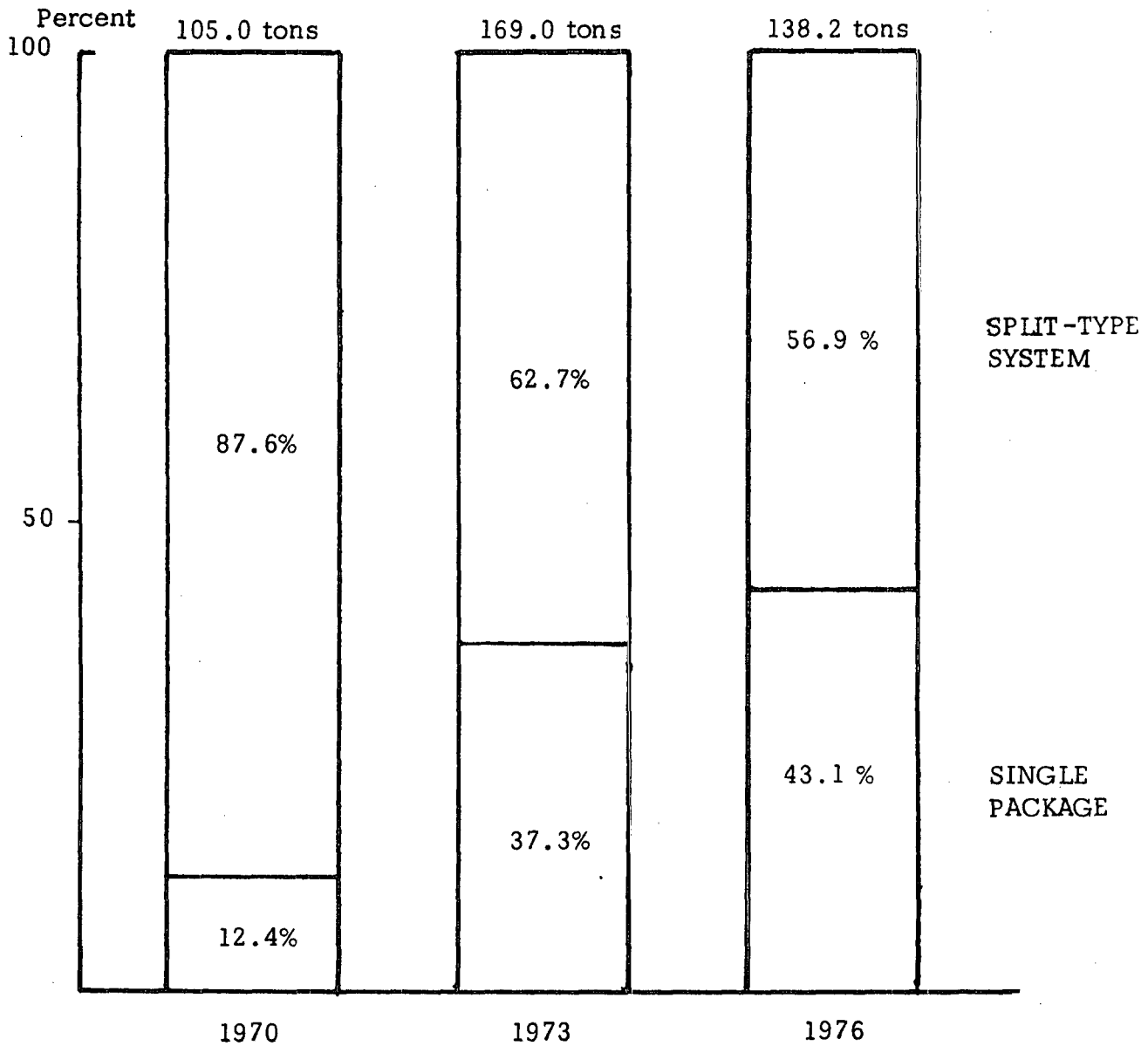


Source: William E. Hill & Company estimates based upon ARI data.

Exhibit II-15

DISTRIBUTION OF UNITARY EQUIPMENT 50 TONS AND ABOVE
BY CONFIGURATION
(Total U. S.)

(Thousands of Tons)



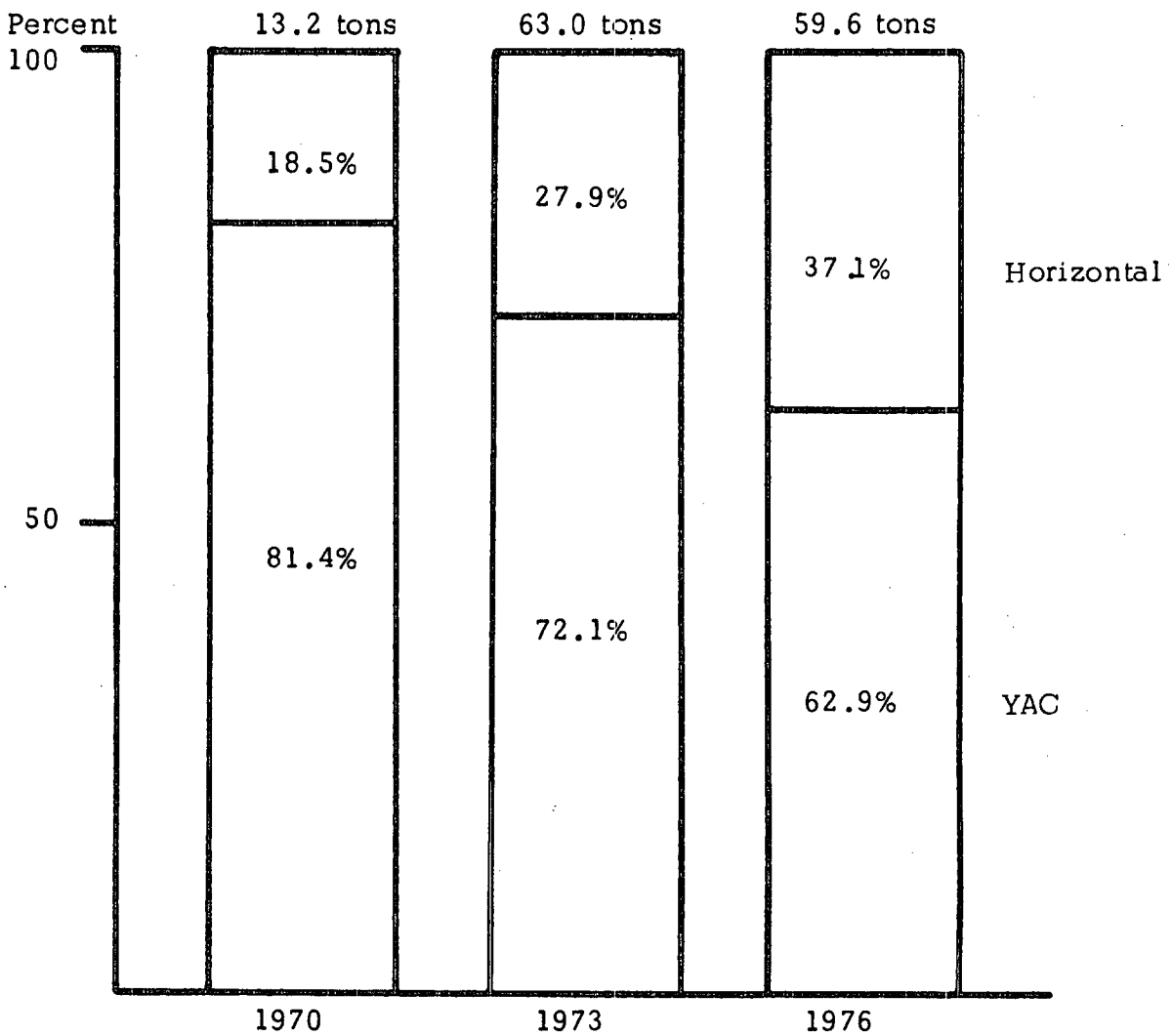
(1) Single package includes YAC, horizontal, and single package heat pumps. Split-type systems includes vertical and remote condenser, heat pumps (split) and split systems.

Source: William E. Hill & Company estimates based upon ARI data.

Exhibit II-16

DISTRIBUTION OF SINGLE PACKAGE UNITARY EQUIPMENT 50 TONS AND ABOVE BY TYPE
(Total U.S.)

(Thousands of Tons)

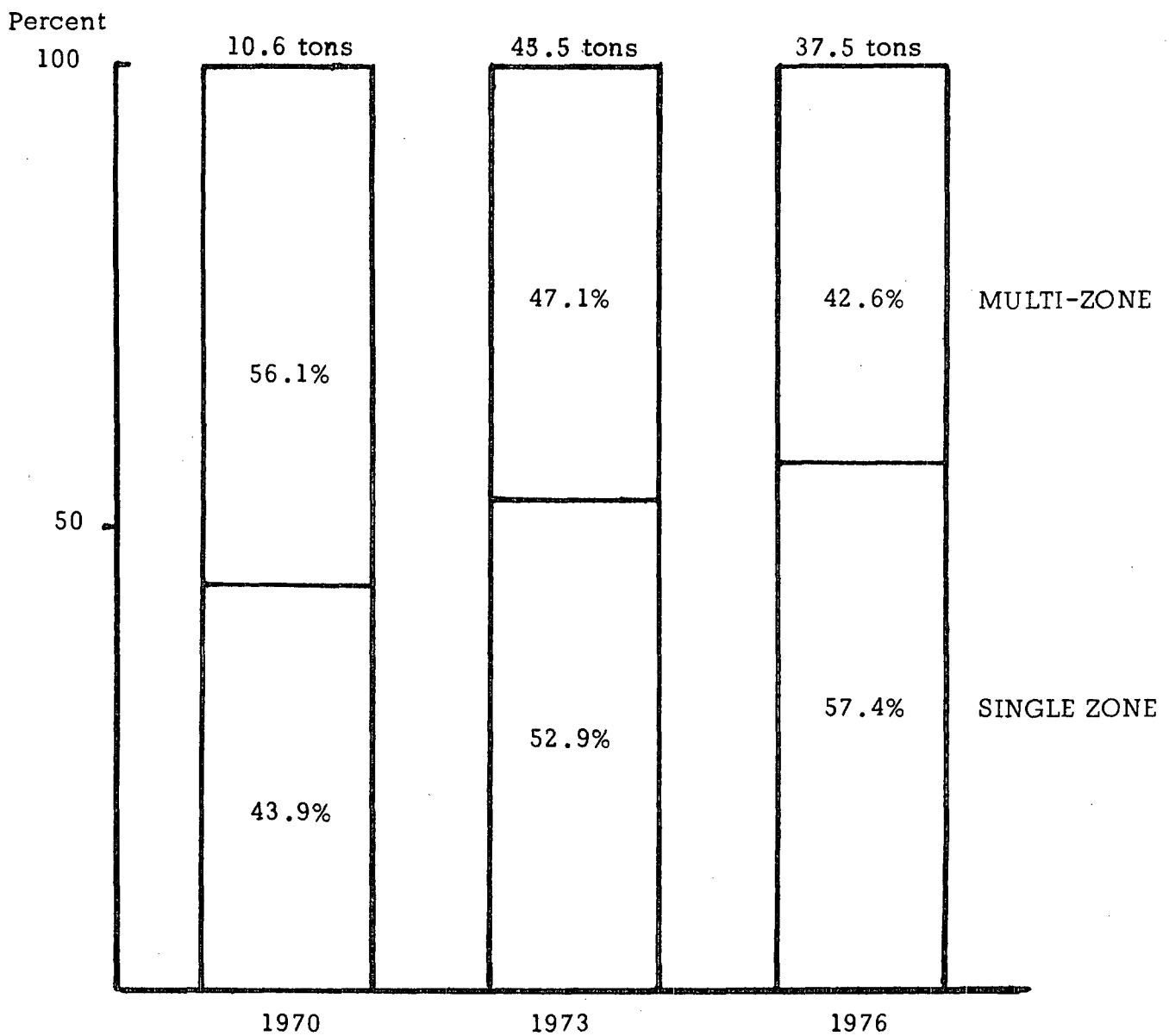


Source: William E. Hill & Co. estimates based upon ARI data.

Exhibit II-17

DISTRIBUTION OF YAC's 50 TONS AND ABOVE
BY ZONE CONFIGURATIONS
(Total U. S.)

(Thousands of Tons)

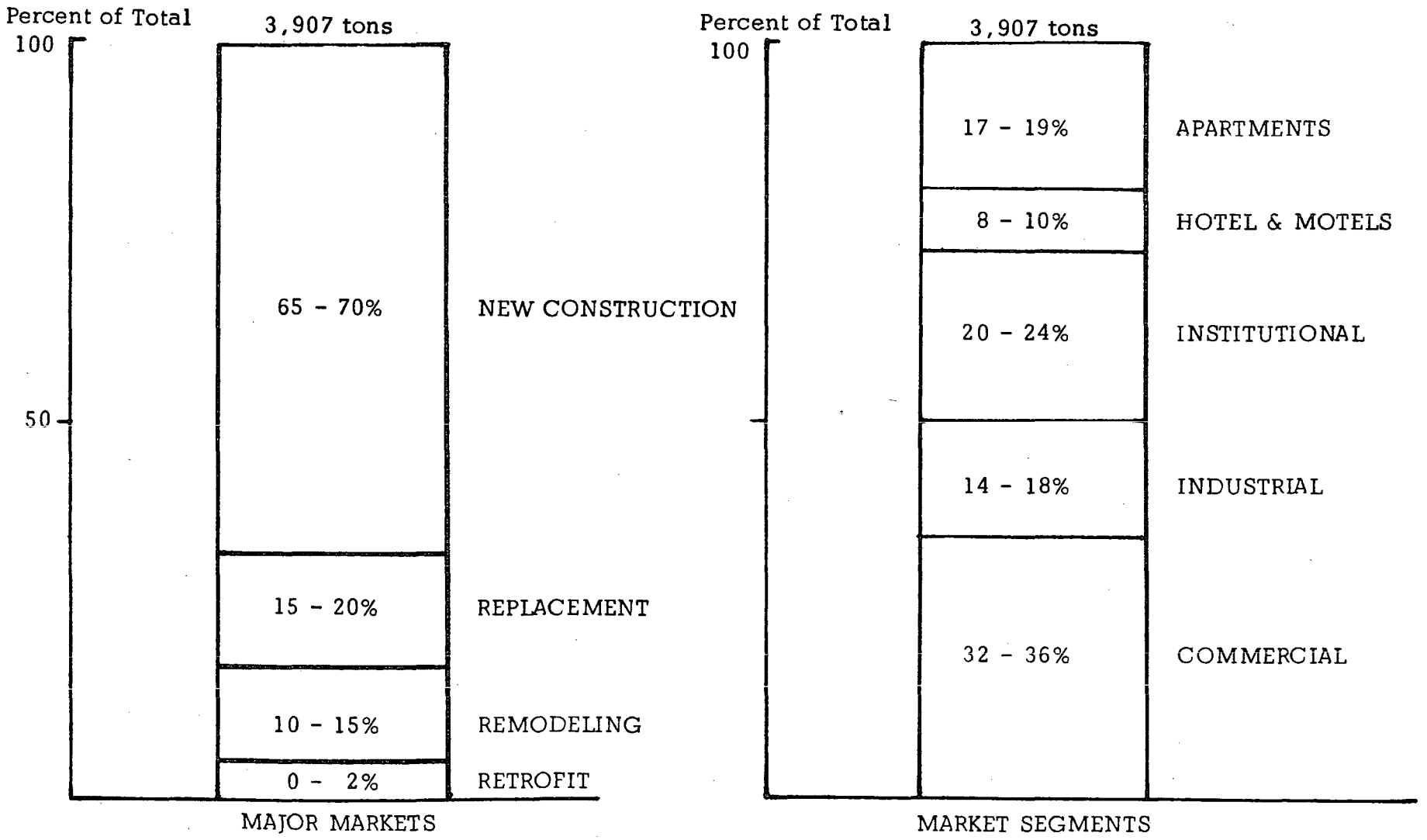


Source: William E. Hill & Company estimates based on ARI data.

Exhibit II-18

ESTIMATED DISTRIBUTION OF NONRESIDENTIAL AIR CONDITIONING[1] TONNAGE BY MAJOR MARKETS AND MARKET SEGMENTS
(Total U. S.)

(Thousands of Tons; 1976 Estimate)

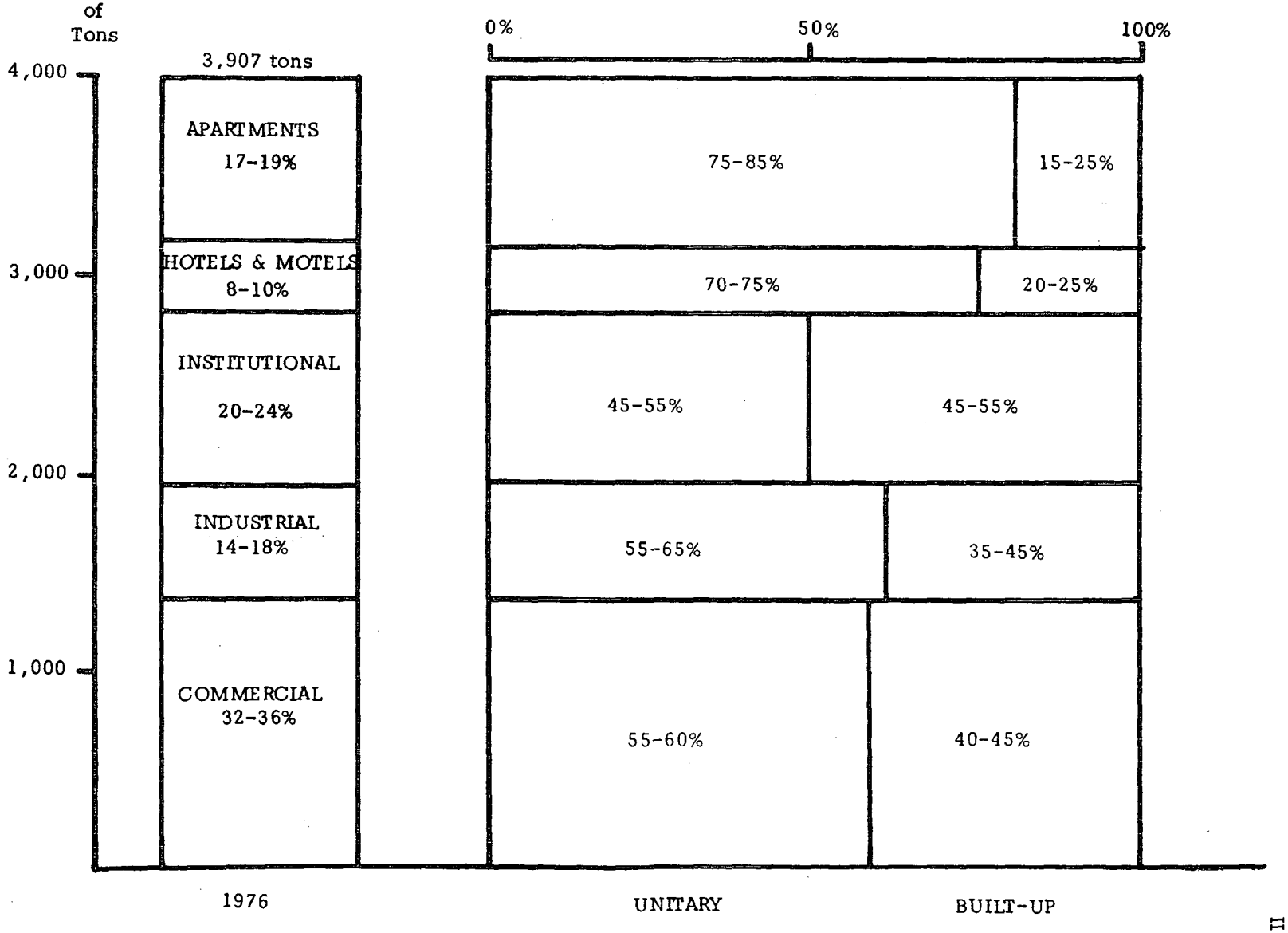


(1) Includes hotels, motels and apartments.

Source: William E. Hill & Company estimates.

DISTRIBUTION OF NONRESIDENTIAL[1] AIR CONDITIONING BY MARKET SEGMENTS AND MAJOR EQUIPMENT TYPE WITHIN SEGMENT (U.S.)
(Thousands of Tons)
1976

Exhibit II-19



(1) Includes hotels, motels and apartments.

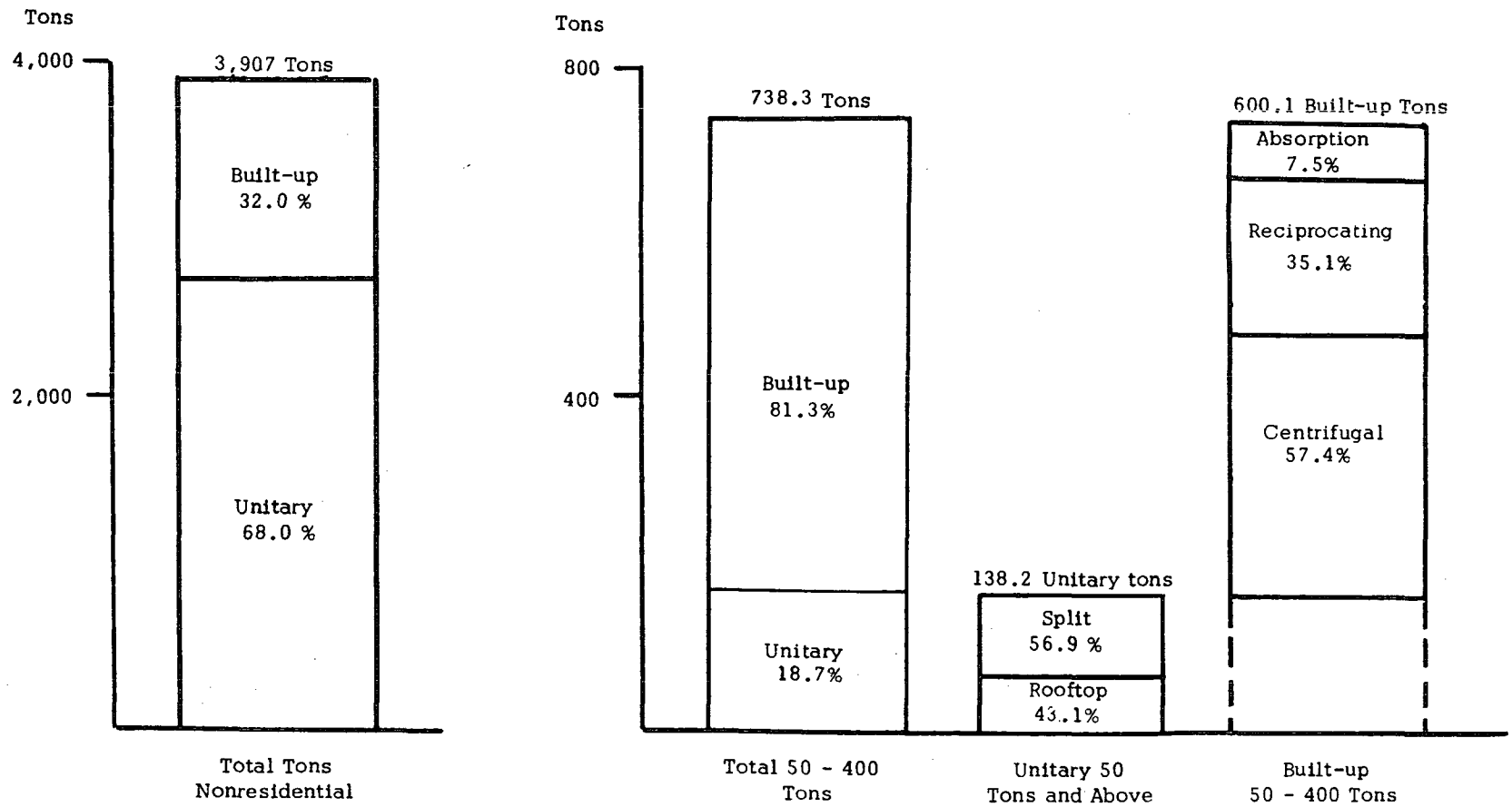
Source: William E. Hill & Co. estimates based upon HPAC and other trade data.

WILLIAM E. HILL & COMPANY, INC.

Exhibit II-20

EQUIPMENT SHIPMENTS BY BASIC TYPES AND SELECTED SIZE RANGES
(Total U. S.: 1976)

(Thousands of Tons)

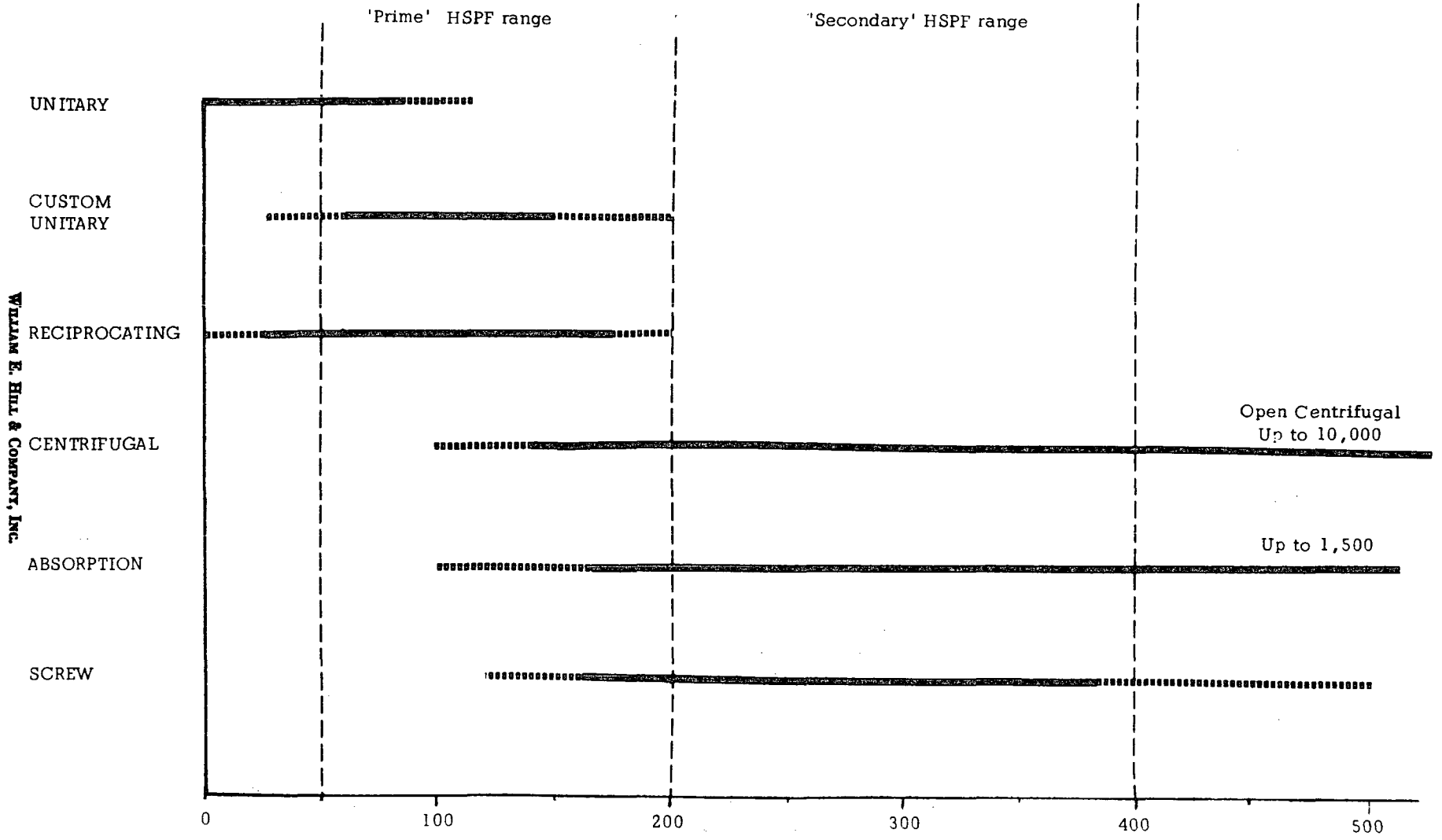


Source: William E. Hill & Company estimates.

William E. Hill & Company, Inc.

Exhibit II-21

SIMPLIFIED COMPETITIVE EQUIPMENT ENVIRONMENT BY BASIC EQUIPMENT TYPE AND NOMINAL TONNAGE SIZE(1)



(1) ▪▪▪▪▪▪▪▪▪▪▪▪▪▪▪▪ indicates equipment available.
▬▬▬▬▬▬▬▬ indicates primary commercial range.

Source: William E. Hill & Company estimates.

WILLIAM E. HILL & COMPANY, INC.

III. KEY MARKET CHARACTERISTICS IN THE LARGE-TONNAGE, AIR CONDITIONING BUSINESS

A good understanding of the market structure and key market characteristics in 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 III-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 which can be assembled in a variety of configurations to produce systems of several thousand tons fo cooling capacity. Of primary interest in this report are large-tonnage unitary equipment (50 tons and over) and built-up equipment in the 50 to 400 ton range.

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 most manufacturers tend to specialize or emphasize particular products or market segments. Smaller and/or specialized manufacturers compete in selected market segments and/or regional markets, and often are a major factor in their markets.

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.

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 may be influenced by architects, in-house or consulting engineers, and design/build contractors.

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

6. Markets. Major air conditioning end-use markets are: residential (single family), commercial, industrial, and insitutional. Although particular sizes and types of equipment may be used in all of these markets, each market has unique application requirements and equipment evaluation/selection characteristics.

B. Nonresidential, Large-tonnage Air Conditioning Business.

Exhibit III-2 shows a simplified structure of the large-tonnage air conditioning business, highlighting the major manufacturers and product categories.

1. Manufacturers. Only a limited number of manufacturers participate in the large-tonnage equipment market, and some of the most important of these are shown in Exhibit III-2. Carrier, Trane and York dominate the built-up equipment market with perhaps a 85 - 90 percent share of the total (built-up)market. Trane and McQuay are major factors in large-tonnage unitary equipment along with Mammoth (Division of Lear Siegler),

and Miller-Picking. Mammoth is generally considered to be the largest producer and the quality leader, while Miller-Picking is perpahs the leading producer of custom built, large-tonnage, unitary equipment.

2. Products. Built-up (chiller) equipment is primarily classified by type of compressor, with each type having certain technical and commercial characteristics and competitive advantages/disadvantages. Unitary equipment is classified by configuration, functional capabilities and degree of standardization. Custom units provide the greatest flexibility for specific applications, while standard units provide the lowest first-costs. Modular type equipment provides a range of price/flexibility combinations.

3. Equipment Service. Manufacturers are heavily involved in the servicing of built-up systems, and to a lesser extent, large-tonnage unitary equipment. In contrast to the residential and light commercial markets, where local independent firms provide most of the service and maintenance functions, built-up equipment manufacturers greatly influence the service business on their equipment and perform much of it through their own service organization.

C. Nonresidential, Large-tonnage Air Conditioning Market. Exhibit III-3 is a simplified structure of the nonresidential air conditioning market which shows the relative positions and interactions of the key participants in the market. The market elements shown in this exhibit include types of buyers, contract types, system designers, installers and manufacturers. Exhibit III-3 also contrasts the basic sales/marketing efforts required for the negotiated and plan and spec business segments.

1. Basic Contract Types. From the equipment manufacturers standpoint, there are two basic types of contracts -- negotiated and plan and spec. Exhibit III-4 analyzes these basic types by key equipment selection factors and the major markets and market segments where they are used. Also described in Exhibit III-4 is the turn-key contract which represents a specific decision-making/project management approach, but typically results in a combination of negotiated and plan and spec subcontracts.

   a) Plan and Spec. The plan and spec method implies that the system is designed by an in-house or consulting engineer, while installer is selected by competitive bidding. The key features are (1) design and installation performed by separate parties, and (2) the competitive bidding process. Equipment is selected by the buyer and the designing engineer. The major plan and spec markets include instutional (almost all), industrial (most), and larger the more-complicated commercial applications. Practically all built-up systems are designed on plan and spec basis. The major perceived advantage is a quality-designed system at a competitive price.

   b) Negotiated. In the negotiated contract, 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.

2. 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 properly 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. 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.

b) 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.

3. 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.

   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 installations 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.

4. 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.

5. Channels of Distribution. Numerous channels of distribution are available, and most manufacturers utilize a combination of approaches to reach various target markets. The two basic approaches are through independent distributors and through company owned factory branches. The independent distributor approach is most commonly used for residential and light commercial markets, while most manufacturers use the direct approach for built-up and large-tonnage unitary equipment.

a) Negotiated Business. Negotiated business is essentially a "one stage sale", since the designer who specifies the type of equipment is also the installer (who selects the specific brand of equipment). Sales/marketing support primarily involves influencing equipment selection and supporting design efforts (contractors typically require more design support).

b) Plan and Spec Business. Plan and spec business is a "two stage sale", since different parties specify the type and select the brand of equipment. Marketing efforts aimed at designers are intended to influence equipment specifications (specified brand or "as equal" brand), while efforts aimed at the bidding contractors are intended to influence the brand of equipment selected for the bid (primarily price and discount quotations).

D. Key Equipment Selection Characteristics.

Key equipment selection characteristics include functional use requirements, economic and non-economic evaluation factors, purchasing influences and practices and equipment-use patterns. Key differences in selection characteristics will be highlighted by market segments, types of buyers and contract type.

1. Functional-Use Requirements. Exhibit III-5 compares selected functional-use characteristics between market segments. Air conditioning penetration (of new construction), the amount of air conditioning required per given amount of floor space, and zoning requirements all vary considerably by market segment. Penetration of the total (new construction) nonresidential market is estimated at 72 percent with an average of 338 sq.ft./ton (300 - 320 sq.ft./ton excluding apartments). Hospital and other health facilities generally have the most stringent requirements. It should be noted that a relatively large portion of commerical construction (including warehouses, garages and miscellaneous) is not air conditioned -- thus the average 60 percent penetration of the "stores and other commercial" category.

2. Evaluation Factors. Exhibit III-6 highlights the most important equipment evaluation criteria, divided generally into economic and non-economic categories.

a) Economic Factors. The most important economic factors are equipment and installation first-costs, and system 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 sources, system performance/features, maintenance and attitudes/perceptions (on the part of the buyer or designer), may have profound effects upon the equipment selection decision. In many commercial applications, for example, space conditioning is viewed as essential to the functioning of the buildings activities; therefore, maintenance and reliability are primary considerations.

3. Purchasing Influences/Practices. Purchasing influences and practices vary considerably by market segment, type of buyer and contract type, as described in Exhibits III-7 and III-8. In general, the ultimate buyer has little direct involvement in selecting a particular type or brand of equipment, buy may indirectly affect the outcome by defining functional and financial constraints and by the selection of particular designers and/or installers.

4. Equipment-use Patterns. Overall system design, and the selection of specific types of equipment are based upon a number of factors, but functional-use requirements are perhaps the most important. Equipment-use patterns tend to develop in individual market segments and the market as a whole, due to specific functional requirements, market characteristics and the preferences of particular designers and/or buyers. Some applications definitely favor particular types of equipment, which others permit wide latitude in the design and selection of equipment. Selected examples are shown in Exhibit III-9.

5. HVAC Trade Analysis. Exhibits III-10 through III-14 provide a descriptive analysis of key air conditioning trade groups including manufacturers, designers, distributors, installation contractors and service contractors. In each case, the basic types of participants are described in terms of typical operations, general business strategies and key success factors.

Exhibit III-1

SIMPLIFIED STRUCTURE OF THE AIR CONDITIONING INDUSTRY

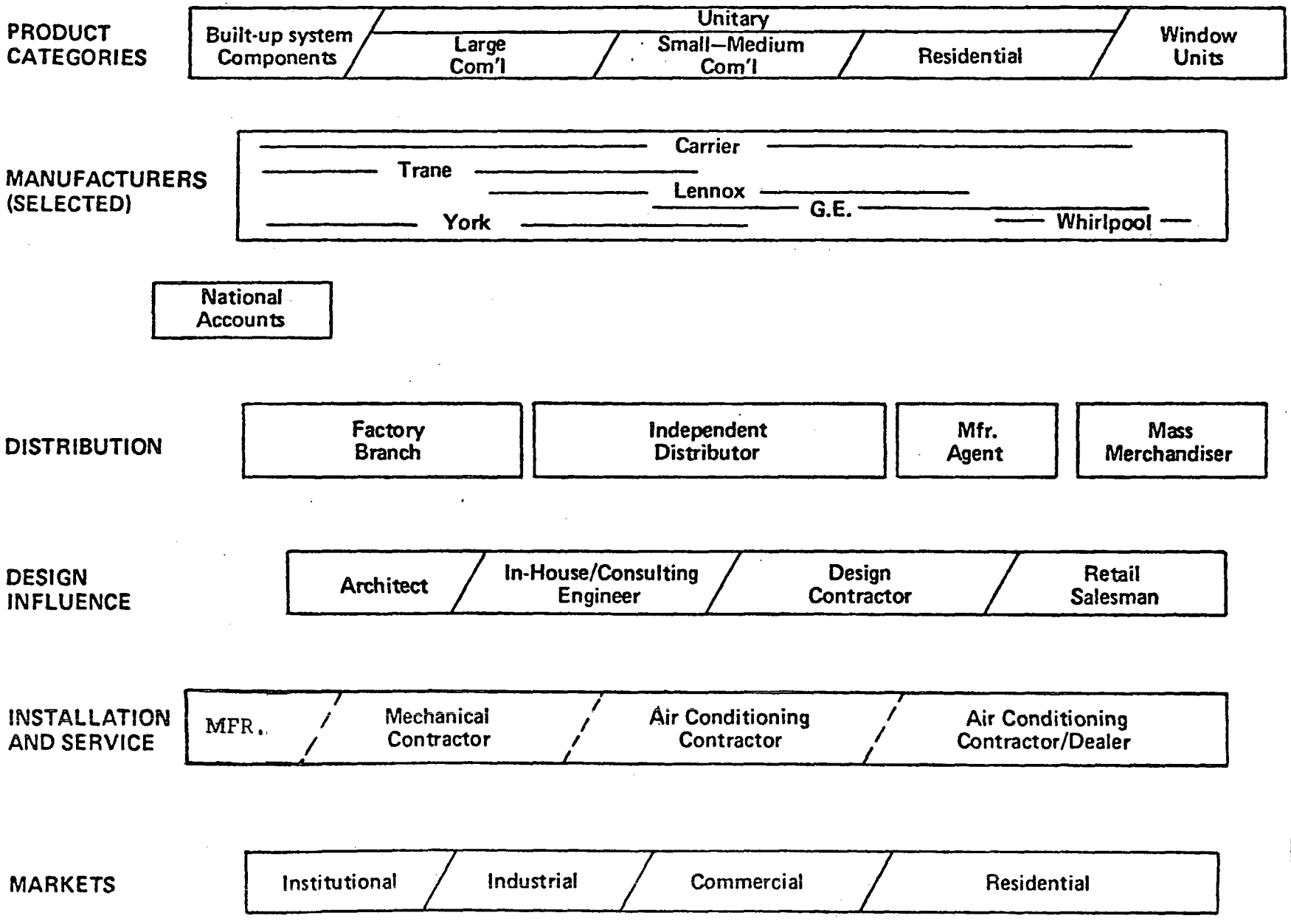


Exhibit III-2

STRUCTURE OF THE LARGE TONNAGE AIR CONDITIONING INDUSTRY

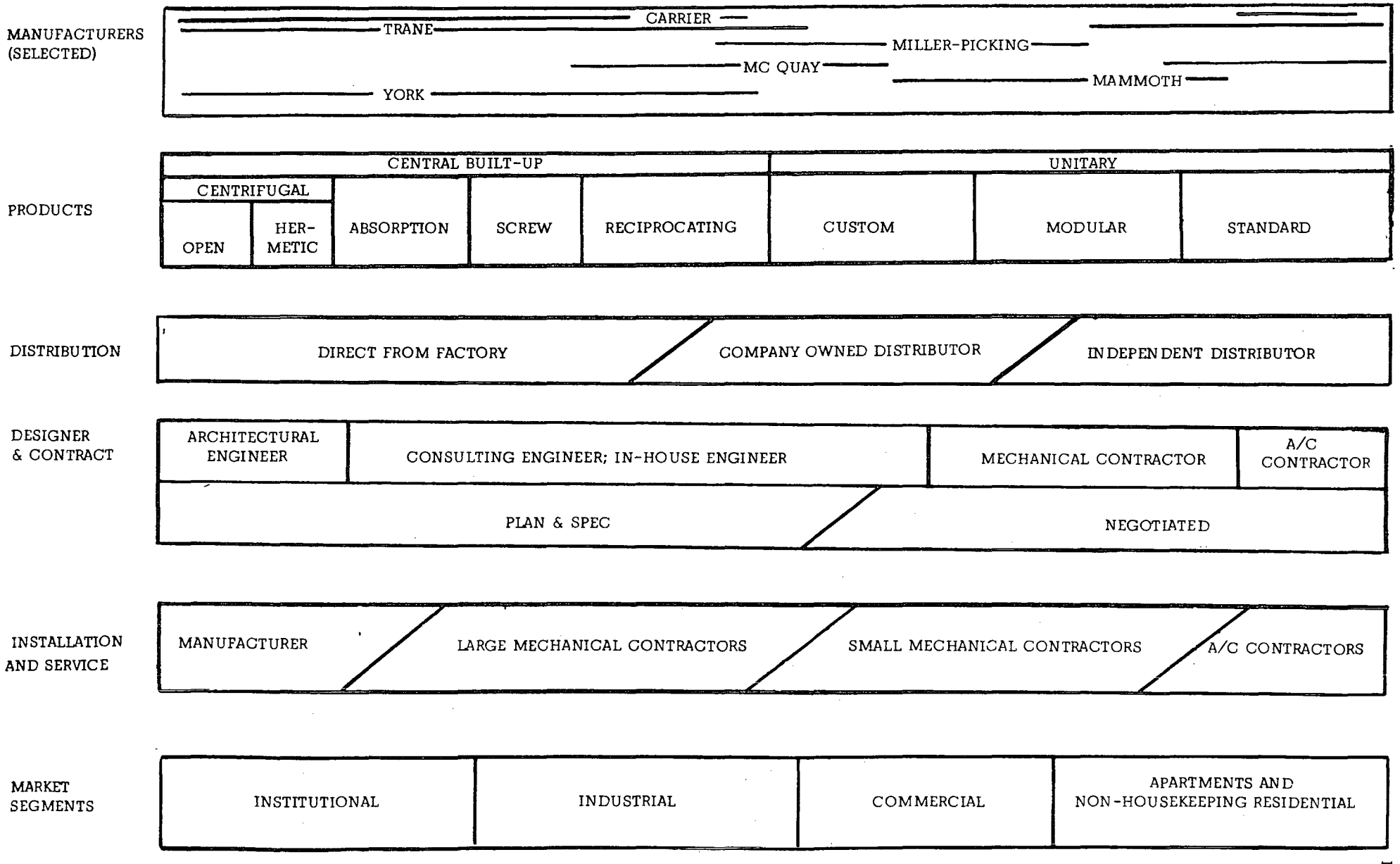
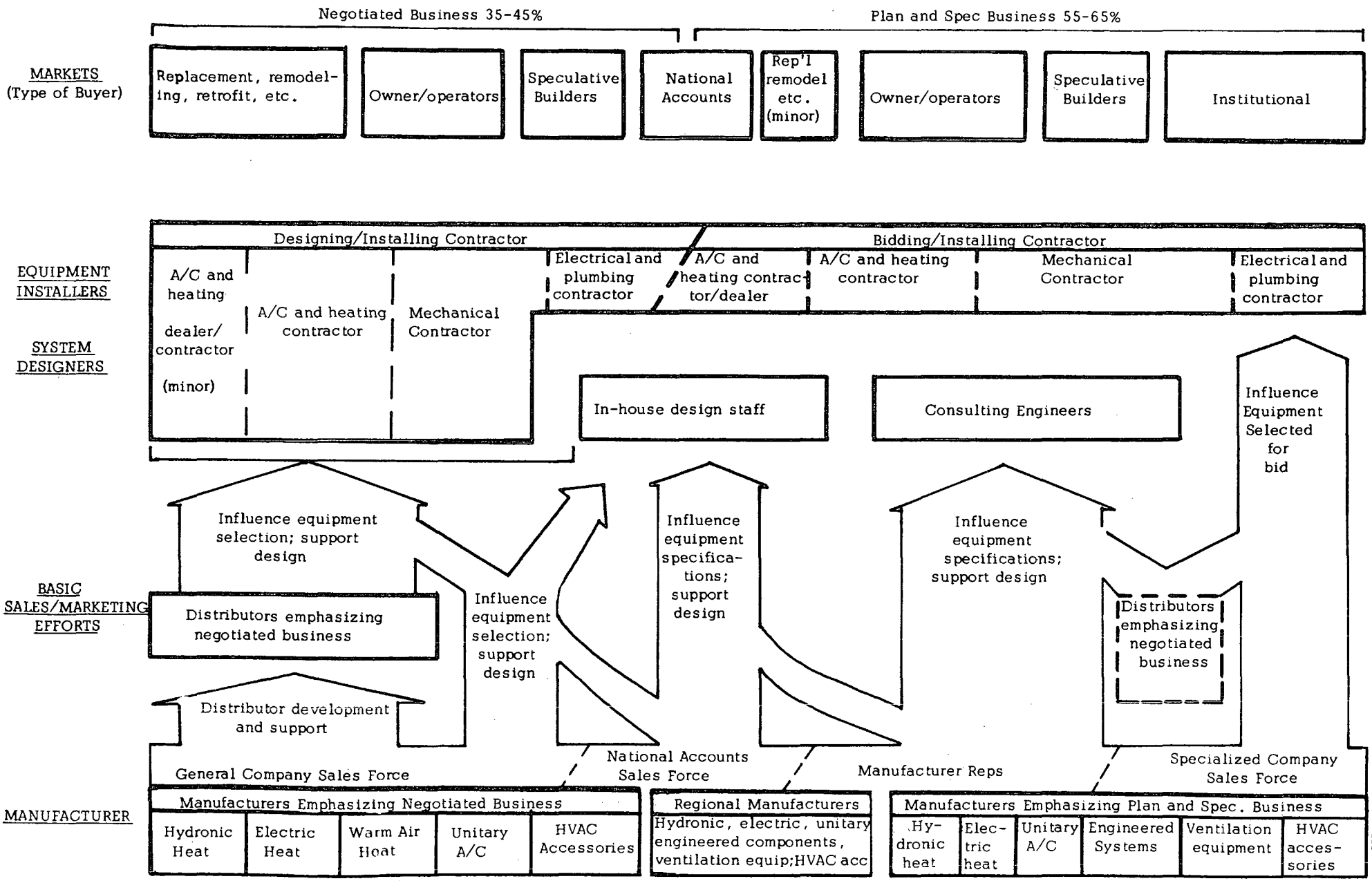


Exhibit III-3

SIMPLIFIED STRUCTURE OF THE NON-RESIDENTIAL HEATING AND AIR CONDITIONING MARKET - 1976



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

Exhibit III-4

CONTRACT METHODS ANALYZED BY KEY FEATURES, EQUIPMENT SELECTION AND MARKETS

	Plan and Spec	Turn-Key[1]	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	- Remodeling (about half)
	- New construction	- New construction	- Replacements (almost all)
	- Remodeling (about half)		

(1) Within an overall turn-key contract, subcontracts may be plan and spec and/or negotiated.

Exhibit III-5

TYPICAL AIR CONDITIONING USE CHARACTERISTICS BY MARKET SEGMENT
1976

Market Segments	Estimated Air Conditioning Sq.ft./ton A/C	Estimated A/C Penetration (%)	Typical Contract Types	Zoning	Qualitative Factors
Commercial	322	69.2 %			
Banks and Offices	318	100.0	P&S; some life cycle costing	Extensive	Central built-up equipment, large unitary equipment, and light to medium unitary
High rise	310	100.0			
Low rise	320	100.0			
Stores and other commercial	325	60.0	Speculative, negotiated	Moderate	
Industrial	285	36.0	P&S; life cycle costing	Limited	Central built-up, and some unitary, 5 year payback
Institutional	275	71.0	P&S life cycle costing		
Education and Science	260	65.0	P&S	Moderate	Central built-up, large unitary equipment. Payback as much as 10 years
Hospital and Health	250	100.0	P&S	Extensive	
Public Buildings	320	80.0	P&S	Extensive	
Religious	286	22.0	P&S, negotiated	Moderate	
Amusement and other	340	64.0	P&S, negotiated	Limited	
Apartments	450	90.0	Negotiated; speculative	Limited	PTAC, split systems. First cost conscious
Non-housekeeping Residential	300	91.0	Negotiated, P&S	Extensive	PTAC. First cost conscious
Total	338	72.2	----		----------

Exhibit III-6

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, required 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
- Ease 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 III-7

GENERAL PURCHASING INFLUENCES AND PRACTICES BY MARKET SEGMENT

	Commercial	Industrial	Institutional	Apartments and Non-housekeeping Residential
Purchase Influences:				
Market Type	- New construction - Major remodeling - Replacement - Retrofit	- Same	- Same	- Same
Equipment Type	- Unitary - Central built-up	- Central built-up - Large unitary	- Central built-up - Large unitary	- Unitary
Key Use Requirements	- High reliability - Fairly standardized applications - Both limited and extensive zoning - High concern for customer comfort	- High reliability - Often "custom" applications - Generally limited zoning - High concern for production environment	- Moderate to high reliability - Fairly standardized applications - Modest to high concern for comfort	- Moderate to high reliability - Standardized applications - Moderate concern for comfort
Key Equipment Evaluation Factors	- First-costs important - Operating costs often important	- Operating costs important - First-costs important	- Operating costs important - First-costs less important	- First-costs generally key
Typical Market Influences	- Mechanical contractor - Consulting engineer	- Consulting engineer - In-house engineer - Utilities	- Consulting engineer - Government agencies	- Mechanical contractor - Consulting engineer - Utilities
Purchase Practices:				
Equipment Purchaser	- Mechanical contractor - A/C contractor	- Mechanical contractor - Industrial purchase	- Mechanical contractor - Constructor	- A/C contractor - Mechanical contractor
Equipment Supplier	- A/C distributor - Manufacturer	- Manufacturer - A/C distributor	- Manufacturer	- A/C distributor

Exhibit III-8

NONRESIDENTIAL HEATING AND COOLING MARKET
TYPICAL BUYING PRACTICES BY TYPE OF BUYER AND CONTRACT

	Replacement and Modernization	Owner/Operator Negotiated	Owner/Operator Plan and Spec	Speculative Negotiated	Speculative Plan and Spec
Selector of the Type of Heating/Cooling System	-Owner	-Prospective owner or his general contractor	-Architect or CE with owners' concurrance	-Speculative builder	-Architect or CE with builder's concurrence
Key Factors in Selection of Heating/Cooling System	-Existing system -Demand for comfort upgrading -Operating costs of present system -Reliability	-Comfort required -Reliability -System operating costs -Equipment first-costs -Energy availability	-Load requirements -Reliability -System operating costs -Equipment first-costs -Energy availability	-Equipment first-costs -Effect on saleability, rentability -Energy availability	-Equipment first-costs -Effect on saleability, rentability -Energy availability
Selector of System Designer	-Redesign usually not needed	-Owner or his general contractor	-Owner or his architect	-Speculative builder	-Speculative builder or his architect
Selector of HVAC Contractor	-Owner	-Generally design contractor also installs	-CE and owner on competitive bid	-Generally design contractor also installs	-CE and builder, on competitive bid
Key Factors in Selection of HVAC Contractor	-Completion date -Quality of workmanship -Availability of service (1)	-Quality of workmanship -Availability of repair service -Installed cost	-Bid specs met -Bid price -General reputation	-Installation costs -Efficiency on job -Credit terms	-Bid Specs met -Bid price -General reputation
Selector of Brand of Equipment Used (2)	-HVAC contractor	-HVAC Contractor	-CE and HVAC contractor	-HVAC contractor and builder	-CE and HVAC contractor

(1) Having the owner's current service/maintenance contract is often the key factor.
(2) Owner may specify equipment desired.

Exhibit III-9

COMPARISON OF BASIC MARKET AND TRADE STRUCTURE -- UNITARY AND BUILT-UP EQUIPMENT

	Light Unitary	Large Unitary	Built-up
Markets	- Small commercial - Some institutional - Hotel-motel and apartment	- Large commercial - Industrial - Institutional - Some motel and apartment - Some hotel	- Large commercial - Industrial - Institutional - Some hotel
Service	- A/C contractor/dealer	- A/C contractor - Mechanical contractor	- Mechanical contractors - Manufacturers
Installation	- A/C contractor/dealer - A/C contractor	- A/C contractor - Mechanical contractor	- Mechanical contractors
Design	- Negotiated - Limited Plan & Spec	- Negotiated and Plan & Spec - A/C contractors - Mechanical contractors - Consulting engineer	- Plan & Spec - Consulting engineers - In-house engineers
Distribution and Sales	- Distributors: independent and factory owned - Distributors reps, some factory reps - General sales force	- Distributors; independent and factory owned - Some direct from factory - Distributor and factory reps - General and specialized sales force	- Direct from factory - Factory reps - Specialized sales force
Manufacturers (Selected)	- Carrier - York - Lennox - G. E. - Trane	- Trane - Mammoth - McQuay - Miller-Picking	- Carrier - Trane - York - McQuay - Dunham-Bush

Exhibit III-10

DESCRIPTIVE ANALYSIS OF AIR CONDITIONING MANUFACTURERS

Basic Types	Typical Operations	Business Strategy	Key Success Factors
Breadth of Product Line			
Full Line Manufacturers	- Diversified in terms of products, markets, and technologies - Widespread sales and distribution - May also produce component parts	- Large variety of markets - Broad product lines - Primarily volume assembly of standardized equipment - Price/quality range of products	- Market segmentation; product development/positioning - Reasonable position in a number of different markets - Cost control - Managing a diversified operation
Specialized Manufacturers	- Specialized in terms of products, markets and/or technologies - Concentrated sales and distribution - May produce specialized components - May have regional emphasis	- Selected markets, niches - Specialized product lines - Standard and/or custom-built products - Limited price/quality range	- Knowledge of specific markets - Specialized technical capabilities - Strong position in selected markets - Entrepreneurial/opportunistic management
Type of Equipment			
Standard Unitary Manufacturers	- Produces standard types and sizes of unitary equipment - Limited range of applications/technologies - Standardized mass assembly	- Selected large markets -- standard applications; price sensitive - Volume production at low cost - Lower price/quality equipment	- Ability to identify and reach cost-sensitive markets - Cost control and pricing flexibility - Wide spread distribution organization - Management of standardized operations
Custom Unitary Manufacturers	- Assembles unitary equipment utilizing custom component parts - Usually larger tonnage unitary with limited specialized application - Semi-standardized assembly	- Specialized markets and applications - Cost savings are on installation - Higher price/quality equipment - Low volume production	- Knowledge of specific markets - Cost advanrages of hybrid unitary/built-up equipment - Technical sophistication - Reactive/innovative management
Built-up Equipment Manufacturers	- Component assembly to design specifications - Specialized sales distribution and technology with broad large tonnage applications - Usually national distribution	- Selected large tonnage markets by company divisions - High quality/price equipment - Custom built equipment	- Extensive technical and market knowledge of large field engineered systems - Strong position within markets - Skilled marketing personnel - Management emphasis is on engineering

Exhibit III-11

DESCRIPTIVE ANALYSIS OF AIR CONDITIONING DESIGNERS

Type Designer	Typical Operations	Business Strategy	Success Factors
Consulting Engineer	- Designs large tonnage systems utilized in new construction and major remodeling - Primarily central built-up and large unitary equipment for industrial, institutional, and large commercial markets - Most designs are Plan & Spec - Designs usually sophisticated	- Specializes in complex systems requiring high technical competence - Each design is unique - Cost is high due to application	- Technical expertise - Knowledge of specialized markets - Reputation based on previous design work - Entrepreneurial management
In-House Engineer	- Designs specifically for parent organization's needs - Usually industrial, institutional, or anchor store applications - Primarily Plan & Spec for large systems - Greater knowledge of system needs than outside engineers	- Complex specific application equipment - Designs may be similar in each application - Engineers are salaried employees of owner-builder	- Cost savings to owner-builder - Superior technical knowledge of application needs - Symbiotic relationships of engineer and owner-builder - Line management
Mechanical Contractor	- Design unitary and small built-up equipment primarily for the industrial and commercial markets - Applications are in new construction, minor remodeling, and replacement markets - Designs are negotiated - Systems are simple	- Fills the market for basic design work that does not require complex engineering - Equipment is chosen from product list that may be used in several similar applications - Costs are lower due to less design time - Speculative markets	- Cost savings to speculative builders - Less technical sophistication - Greater flexibility - Boot strap management

Exhibit III-12

DESCRIPTIVE ANALYSIS OF THE AIR CONDITIONING DISTRIBUTION SYSTEM

Basic Types	Typical Operations	Business Strategy	Success Factors
Independent Distributor	- Supplies broad line of unitary equipment of various manufacturers - All major markets are served - Gives some technical assistance to customers	- Strategically located distribution points - Organized along trade lines - Sales are to mechanical contractors and air conditioning contractors - Price is based on discounts	- Adequate inventory - Trade rapport - Relative cost advantage - Product/service reputation - Small business/entrepreneurial management
Factory Owned Distributor	- Supplies broad line of manufacturers' unitary equipment - All major markets are served - Technical assistance is readily available	- Geographically spaced distribution points - Price is based on discounts - Sales are to mechanical contractors and air conditioning contractors - Sales force is factory trained	- Technical assistance of sales representatives - Greater knowledge of product line - Superior warranty position - Corporate line management
Direct Factory Shipments	- Supplies a broad line of factory built-up equipment direct to contractors - All major built-up markets are served - Technical assistance is extensive	- Shipments are direct from factory - Technical assistance to designer - Emphasis is on product features - Extensive discounts to purchaser - Component replacement market	- Technically superior sales/service - Brand loyalty - Price discount - Tightly controlled market - Corporate engineering oriented management

Exhibit III-13

DESCRIPTIVE ANALYSIS OF AIR CONDITIONING CONTRACTORS

Basic Types	Typical Operations	Business Strategy	Success Factors
Air Conditioning Contractors	- Installation and service of light unitary equipment - Primary markets light commercial Replacement market - Primarily sheet metal ducting - Some subcontracting	- Specializes in high volume low cost installations - Efficient installation practices - Aggressive competitive selling and negotiations - Labor force not technically sophisticated - Trade contacts and service contracts important business generators	- Low overhead and labor costs - Positioned in markets not profitable to larger contractors - Low technical requirements - Small business/entrepreneurial management
Small to Medium Mechanical Contractors	- Installation and service of ducted and hydronic systems - Mostly unitary equipment, some small built-up systems - Primarily commercial and industrial, new construction and modernization markets - Contracts are negotiated - Limited technical assistance	- Specialize in relatively complex systems moderate contract size and volume - Mechanical trade specialization - Technically less sophisticated than large contractors; accept jobs too small or unprofitable for large contractors - Aggressive selling and negotiations - Project management capability	- Good rapport with general contractors - Technical knowledge of specific markets - Cost control and effective bidding - Entrepremeurial/unsophisticated management
Large Mechanical Contractors	- Installation of hydronic systems - Commercial, industrial and institutional markets; primarily new construction and major remodeling - Equipment large unitary and central built-up - Technical assistance to builder - Works with consulting engineer	- Specialize in large complex installations - Technically superior labor force - Specialized by trade - Costs are higher due to sophisticated designs - Extensive project management	- Specialized in large tonnage technically sophisticated markets - High level of technical applied engineering knowledge - Competitive bidding based on efficient operation and leverage applied to equipment costs - Engineering/political marketing management

Exhibit III-14

DESCRIPTIVE ANALYSIS OF THE AIR CONDITIONING SERVICE INDUSTRY

Basic Types	Typical Operations	Business Strategy	Success Factors
Air Conditioning Contractors	- Service maintenance and repair of small to medium unitary equipment for the light commercial and industrial markets - Servicing and winterizing 2 - 4 times a year or as needed - Low level of technical sophistication - Marketing primarily to installation clients	- Markets are identified by equipment size and type - Competitive bids for contracts/ may operate at cost in hope of getting replacement contracts - Service personnel generally the same as installation personnel - Geographical proximity to service client	- Accessibility to markets - Cost control and dependable service - High volume/efficient personnel - Entrepreneurial management
Mechanical Contractors	- Service, maintenance and repair of large unitary equipment for the commercial, institutional, and industrial markets - Servicing and winterizing 2 - 4 times a year or as needed - Generally technically sophisticated service personnel - Primarily marketed to installation clients	- Markets are large tonnage equipment requiring technically sophisticated service personnel - Competitive bids for contracts usually for mechanical contractors' installations - May or may not be a profit center - Geographical proximity is a factor for smaller installations	- Markets are based on equipment type technically understood by contractor - Well trained personnel - Cost/reliability ratio - Entrepreneurial/autocratic management
Manufacturers' Technical Service Departments	- Service, maintenance and repair of built-up/field engineered systems - Service frequency depends upon equipment and seasonal factors or as needed - Technically sophisticated operation - Manufacturers are the only servicers of built-up equipment	- Markets limited to manufacturer's own built-up systems - Highly profitable aftermarket manufacturer dictates price - Highly trained technical service personnel - Close control of technical service specifications - Geographically dispersed	- Unique components of manufacturer's system - Manufacturers market share - Technical superiority of service personnel - Close control of market - Corporate/engineer management

IV. SIGNIFICANT TRENDS AND PROJECTED AIR CONDITIONING MARKETS

The development of appropriate air conditioning market projections is based upon the identification and analysis of significant trends, and the evaluation of the probable ramifications of these trends on the future air conditioning market. Expected construction activity provides the quantitative foundation, which is combined with projected equipment-use patterns and other market characteristics to yield specific market projections.

A. Significant Trends.

The nonresidential air conditioning market is undergoing pronounced changes in response to trends in key external factors. The general economy, construction, product penetration and saturation of markets, government activities, technology and energy will strongly influence future market characteristics and the market potential for the HSPF.

1. Key Trends Affecting HVAC Markets. The following six external factors heavily impact the size, growth and basic characteristics of the nonresidential air conditioning market. Exhibit IV-1 contrasts the historical impacts of these factors with their expected future trends.

   a. The General Economy. Long-term economic growth is expected to be somewhat slower than that experienced over the past ten years, and expected higher inflation and in-

terest rates will heavily impact the investment environment, business expansion and construction activity. Regional growth patterns favoring the south and west are expected to continue, but at a reduced relative rate compared to the past 10 - 15 years. Expected increases in the service and high technology sectors of the economy are generally positive factors for the increased use of air conditioning -- particularly in manufacturing facilities.

b. Construction. New construction will continue to be cyclical, and the remodeling of existing structures is expected to increase as a percentage of total construction activity. Exhibits IV-2 and IV-3 show historical and projected construction growth rates by building segments (IV-2) and regions (IV-3). All of the rates shown are affected by the severe construction recession between 1973 and 1976. The period from 1976 to 1981 shows excellent growth by historical standards, but actually represents the growth phase of the present construction cycle. Average long-term growth rates between building types and regions will affect the types and sizes of equipment required. Major changes in building codes and construction practices will result in greatly improved, energy-efficient building envelopes, and on average, a larger service area per ton of air conditioning capacity (or conversely -- smaller equipment per given area).

c. Product Saturation and Penetration. Relatively high penetration of new construction and high in-place saturation levels have been achieved in most nonresidential market segments. This suggests a maturing market situation where growth is primarily tied to the growth of the overall market (largely new construction activity). Replacement, and perhaps energy retrofit, markets should grow in importance, eventually representing 50 percent or more of the total air conditioning market by the mid-1980s.

d. Government. Government activities concerning energy availability and costs are increasing significantly in terms of both scope and degree. Coupled with proposed building and equipment efficiency standards, these activities will heavily influence the sizes and types of equipment and systems available for use in the 1980s. Increases in energy-use research funding should exert positive influences

on the development of new technologies and improved applications of existing technologies. Financial and other incentives are also expected to support the develment and acceptance of energy-efficient equipment and systems.

e. Basic Technologies. Many previously unacceptable technologies are being reexamined to evaluate their future potential in light of the dramatic changes that have occurred over the past several years. An increasing amount of effort is also being applied to combining functions and technologies to achieve higher overall efficiencies and effectiveness. Greater utilization of natural and/or available energy sources, often in conjunction with conventional technologies, is also receiving major attention. Examples include solar systems, economizer cycles and heat reclamation.

f. Energy. Continued increases in all energy costs are stimulating the introduction of energy efficient equipment, which often have sizable first-cost premiums. Energy costs are expected to continue escalating in the near-term, as are market reactions (which have been relatively slow to develop). Limited and/or controlled availability of energy sources are likely to continue in the near-term, based upon uncertainties in production and government actions.

2. Construction -- Historical and Projected. Exhibits IV-2 and IV-3 show historical and projected rates of construction growth by market segments and regions. The period from 1967 to 1976 represented a complete construction cycle -- expansion and decline -- in which total construction declined at an average annual rate of 2.3 percent per year. The period from 1976 to 1981 represents the growth phase of the next nonresidential building cycle, with total construction expected to increase at an average annual rate of 6.4 percent. The average rate during the 1980s should be about 2 percent per year.

3. Distribution of Unitary Equipment by Size. As discussed earlier, equipment-use patterns -- by type and size of equipment -- develop and change slowly over time due to changes in market characteristics and equipment availability.

a. Unitary Equipment 1970. Exhibit IV-4 indicates the distribution of unitary equipment by size and type in 1970.

Split type systems held a predominant share of the 50 ton and larger equipment market.

b. Equipment Size Shifts 1970 - 1976. Exhibit IV-5 shows the increasing share of the large tonnage unitary market captured by single package equipment over the six year period from 1970 to 1976. This shift is partially due to market changes and partially due to greater availability of large-tonnage single package equipment.

4. Key Equipment Trends -- Unitary and Built-up. Exhibit IV-6 highlights key trends in unitary and built-up equipment.

a. Unitary Equipment. Unitary equipment is expected to continue gaining market share, but at a diminished rate compared to the last ten years. Slight increases are expected in the use of rooftop and larger-sized units, along with reduced heating requirements for larger-tonnage applications -- due to heat reclamation and more energy-efficient buildings. The increased use of heat pumps is expected through greater availability of larger-tonnage units and increased use of water-source heat pump loops (small units on closed water loops). Rising energy costs will lead to increased concern for operating costs and equipment efficiencies, but first-costs will continue to be important. Finally, increased sophistication is expected as newer technologies and control systems are introduced to improve energy efficiencies and provide multi-functional capabilities.

b. Built-up Equipment. Built-up equipment is expected to retain its traditional markets (i. e., high-rise buildings, hospitals, etc.), and the use of reciprocating chillers and air cooled condensing should continue to increase. Additionally, the use of condenser heat for some space heating applications should increase along with multi-functional and control capabilities. Absorption unit sales should continue to decrease, except when used with solar systems or wast material as a heat source.

5. Key HVAC Trade Trends. Exhibit IV-7 highlights the expected key trends for major HVAC trade groups. Common expectations for all groups are slower market growth, continued concentration of participants, and a general increase in operational

complexity (management, marketing, technology, etc.). Most of the external factors impacting the market will lead to increasingly sophisticated requirements in terms of equipment, functional-use, system design, installation and maintenance. All trade groups will be forced to deal with a highly segmented, increasingly sophisticated and more-complex market environment.

6. Energy Prices. Future energy prices are difficult to project at this time since the administration's energy plan (which will directly affect prices) is still embroiled in Congressional debate. It can be expected, however, that prices for all forms of energy will increase significantly over the next three to five years. Exhibit IV-7a provides a projected range of reasonable average prices for electricity and natural gas by 1981.

   a. Electricity. Commercial electricity prices are expected to increase at an average annual rate of growth of 8 - 12 percent from a base of $8.80 per million Btus in 1977. This results in projected 1981 prices of $12.02 to $13.98 per million Btus.

   b. Natural Gas. Future natural gas pricing is clouded with uncertainties, but prices are expected to increase at an average annual rate of 12 - 20 percent for the next few years. The higher rate of increase for natural gas reflects "catch up" pricing due to the historical under-valuation of this energy source, and the higher costs of new gas sources. After the "catch up" phase, natural gas prices should generally increase in line with other energy sources. Average natural gas prices in 1981 are expected to range between $2.96 and $3.90 per million Btus -- versus a base of $1.88 in 1977.

B. Cost-Related Equipment Criteria.

Equipment evaluation criteria and processes are changing in response to shifting cost pressures -- primarily energy cost increases, and market concerns related to future energy availability. Market reactions to changing cost conditions is somewhat predictable,

and equipment that correctly reflects primary market requirements can achieve above average acceptance and growth.

1. Capturing Projected Operating Costs. Rapidly increasing energy costs may provide equipment manufacturers with the potential opportunity to capture (in equipment costs) dollars which would otherwise be spent for future operating costs (energy). This concept supports efforts to develop and market energy efficient equipment (which generally has higher first-costs), and is viable when operating cost savings are sufficient to cover higher first-cost premiums and provide savings to the customer.

   a. Basic Concept. This basic concept is depicted in Exhibit IV-8 which represents a simple, but realistic example. With standard equipment ($1,000 first-cost) and projected energy cost increases of 15 percent per year, five-year energy costs increase to $2,000 -- from $1,000 with no energy cost increases. If energy-efficient equipment (with first-costs of $1,200, or a 25 percent premium) is used, projected five-year energy costs are $1,500 -- or $500 less than the case using standard equipment. By selling the energy efficient equipment, the manufacturer in essence "captures" a portion of the projected energy costs in equipment first-costs and the customer saves $250 that he would otherwise have to spend on energy.

   b. General Guidelines. The market viability of a particular energy-efficient system depends upon the investment guidelines currently employed in the equipment selection process. The most important consideration is the balance between first-cost premium and premium payback period (the time required to recoup the first-cost premium through operating cost savings). Generally, there is significant market resistance to extremely high premiums (greater than 50 percent), and very long payback periods (greater than four years).

2. Equipment Costs Versus Operating Costs. Historically, most air conditioning markets have been first-cost oriented, but energy cost increases are producing greater concern for system operating costs and affecting equipment evaluation criteria.

   a. Mid-tonnage Market. Exhibit IV-9 highlights the information developed from the 1976 study of the 7-1/2 to 50

ton unitary market. This is a very first-cost sensitive market in which 80 - 85 percent of the speculative customers and 60 - 65 percent of the owner/operator customers are primarily first-cost oriented.

b. Large-tonnage Market. A similar analysis of the large-tonnage (unitary and built-up) market in 1977, shown in Exhibit IV-10, indicates a lower percentage of speculative customers and greater concern for operating costs. While 45 to 55 percent of the market is primarily first-cost oriented, operating costs are significantly more important in equipment evaluation decisions. Overall this market is less first-cost conscious, but still tends to be first-cost sensitive for a given equipment-quality range. The two studies are not directly comparable because they relate to two different market segments and were conducted a year apart. It is impossible, therefore, to infer that the difference in first-cost orientation relates solely to differences in the market segments or reflects attitudinal changes in response to increasing energy prices.

c. Projected Cost Orientation. Exhibit IV-11 represents a reasonable projection of cost orientation among commercial air condition customers in 1981. This projection is based upon historical data and the analysis of identifiable trends in the current market. The percentage of operating cost oriented customers is expected to increase from an estimated 30 - 40 percent of total customers in 1976 to 50 - 60 percent by 1981.

3. Gas Availability Perceptions. Until the early 1970s, there were few customer restrictions placed upon gas utilities. Between 1972 and 1976, increasing restrictions were applied to deal with short-term supply problems and by 1976, 50 - 55 percent of all gas utilities were restricted to some extent in the addition of new residential and/or commercial customers.

a. Industry Perception. Recent surveys indicate that gas industry executives expect an improvement in the general supply-demand situation which will result in the removal of selected customer restrictions over the next few years, Exhibit IV-12. By the early 1980s most (if not all) utilities are expected to be in a position to selectively add new residential and commercial customers.

b. Market Perception. The market, however, generally remains skeptical of future gas availability in the commercial market. This skepticism has not been measured quantitatively, but the general situation is depicted in Exhibit IV-13. While the gas industry expects increased future availability of gas and reduced customer restrictions, the market generally expects a continuation of the current situation or decreased future availability. This highlights the need to address market perceptions concerning the future availability of gas in the introduction of any new gas-using product.

4. Product/Market Match. Prevailing market requirements influence the types of products that are acceptable, and the growth potential for specific product concepts. Exhibit IV-14 compares market characteristics (in terms of first-cost orientation, energy costs and gas availability) with the acceptance of selected products for the period from 1960 to 1976. This includes equipment sold to both the residential and nonresidential markets.

a. Year-around Air Conditioning. YAC equipment (air conditioner and furnace in one package) achieved dramatic growth between 1960 and 1972 because it closely matched the prevailing market requirements of that period. Customers were primarily first-cost oriented and energy was widely available at relatively low prices. YAC units provided the lowest first-cost solution for many space conditioning applications.

b. Heat Pumps. Electric heat pumps have a first-cost premium versus YACs, but are energy efficient and are not negatively affected by gas availability restrictions. Heat pumps did not satisfy the market requirements of the 1960s and the early 1970s and displayed slow growth during this period. As market conditions changed in the early 1970s however, heat pumps became more acceptable, and have achieved dramatic growth over the last 4 - 5 years. This example demonstrates the impact of market requirements on the acceptability of specific types of equipment.

C. Market Projection Procedures.

Projecting the market potential for the HSPF concept is a complex task which first requires an evaluation of the key external factors, key trends and the projection of the total available market for nonresidential air conditioning. The key characteristics of this available market must then be analyzed relative to the expected characteristics of the HSPF unit to evaluate the degree of fit and expected potential for this type of equipment. This section includes a description of the projection method, a projection of the total nonresidential air conditioning market in 1981 and a projection of the total available market for equipment in the 50 to 400 ton (nominal cooling capacity) range.

1. Projection Methodology. The method utilized to project the nonresidential air conditioning market in 1981 is based upon the projection of construction activity, which is then adjusted for projected equipment-use characteristics. Exhibit IV-15 graphically depicts the projection sequence and Exhibit IV-16 indicates the adjustment factors utilized. Remodeling, replacement and energy retrofit markets are projected separately.

2. Projection of the Available Market. Exhibits IV-17, IV-18, and IV-19 represent the sequence of steps required to project the available market for equipment in the 50 to 400 ton size range.

   a. Construction Activity. Projected construction (new floor space added) by building segment in 1981 was developed from F. W. Dodge five-year construction forecasts.

   b. Air Conditioning Penetration. The amount of air conditioned space, and the nominal tonnage required for each building segment was estimated from air conditioning

penetration and usage/requirement data. Overall penetration of new construction is projected to increase from about 72 percent in 1976 to 76 percent in 1981. The average amount of space serviced by one ton of air conditioning is expected to increase about 15 percent from an estimated 338 square feet in 1976 to 388 square feet in 1981, due to improved building design and construction factors. Total air conditioning required in new construction is projected at 3.7 million tons. This includes thru-the-wall and residential size unitary equipment for the apartment and hotel segments which are not included in further analysis. Hence, unitary and built-up tonnage as described below do not equal the total of 3.7 million tons.

Note: Point estimates are used on these exhibits and in the explanatory text, but range estimates are preferable for general use.

c. Equipment in the 50 to 400 Ton Range. Equipment in the 50 to 400 ton size range is expected to represent approximately 26 percent of the new construction total, or 974 thousand tons.

d. Unitary Equipment. Unitary tonnage (less small residential-size equipment for apartments) is projected at 1.6 million tons. Of this amount, equipment in the 50 tons and over size range is projected at 126 thousand tons or 7.7 percent of the selected unitary market. The addition of estimated remodeling, replacement and retrofit markets for large-tonnage unitary equipment, 54 thousand tons, results in a total available market for unitary equipment (50 tons and over) of 180 thousand tons.

e. Built-up Equipment. Of the total projected built-up equipment tonnage, 1.3 million tons, 48 percent or 635 thousand tons falls within the 50 to 400 ton size range. The remodeling, replacement and retrofit market for 50 to 400 ton built-up equipment is estimated at 159 thousand tons for a total available market of 794 thousand tons.

3. Available Market -- 1981. Exhibits IV-20, IV-21 and IV-22 show the projected available market in 1981 by type of construction (new, other, total), size ranges and equipment types.

a. Available Market -- Construction. New construction is projected at 761 thousand tons (78 percent of the available large-tonnage market), while remodeling, replacement and retrofit represent 213 thousand tons (22 percent of the market).

b. Available Market -- By Type. The total available market is projected at 974 thousand tons with large-tonnage unitary representing 18 percent (180 thousand tons), 50 to 200 ton built-up equipment 44 percent (430 thousand tons) and 200 to 400 ton built-up equipment 37 percent (364 thousand tons), Exhibit VI-22. The unitary market is approximately equally divided between single package and split systems, while reciprocating chillers represent 70 percent (301 thousand tons) of the 50 to 200 ton built-up equipment market and hermetic centrifugal chillers dominate the 200 to 400 ton built-up equipment market with 82 percent (297 thousand tons).

c. Equipment Comparison -- 1976 vs. 1981. Exhibit IV-23 compares the estimated total available market in 1976, by size and equipment type, to the projected 1981 market. Large-tonnage unitary increases from 138 thousand tons in 1976 to 180 thousand tons in 1981, 50 to 200 ton built-up equipment increases from 325 thousand tons to 430 thousand tons and 200 to 400 ton built-up equipment increases from 275 thousand tons to 364 thousand tons.

d. Market Segment Comparison -- 1976 vs. 1981. As shown in Exhibit IV-24, the commercial and institutional market segments will continue to be the largest markets for large tonnage equipment. The industrial market is projected to show good growth, reflecting increased air conditioning penetration and recovery from the depressed construction activity of the mid-1970s.

Exhibit IV-1

KEY TRENDS IN EXTERNAL OR UNDERLYING FACTORS AFFECTING HVAC MARKETS

Factor	Historical/Current Impacts	Probable Future Trends
1. General Economy	- General long-term growth of 3-4% - Increasing inflation and interest rates - Generally deteriorating investment environment	- Slower than historical growth - Continued relatively high inflation and interest rates - Continued regional differential growth; and growth in service and high technology sectors
2. Construction	- Cyclicality - New design and construction standards	- Continued cyclicality - Increased energy efficiency of building envelope
3. Product Saturation and Penetration of New Construction	- Growing A/C penetration in all markets	- Slower penetration and overall growth (high penetration/saturation levels) - Increased importance of replacement and retrofit markets
4. Government Regulations, Codes and Standards	- Limited but increasing intervention - in scope and degree - Some support for product development - Primarily local building codes and standards	- Increasing control of energy availability and costs - Expanded support for product development - Financial and other incentives for energy efficient equipment - National building and equipment standards
5. Basic Technologies	- Generally minor, incremental product improvements - Generally slow introduction of new technologies and products	- Re-evaluation of existing technologies for new applications - Greater use of combined function heat reclamation technologies and 'natural' energy sources - Faster development and introduction of new technologies
6. Energy	- Low but increasing energy costs - Widespread to spotty availability - Operating costs of secondary importance	- Continued increases in costs - Controlled availability for specific applications - Increased importance of energy efficiency and operating costs - Changes in energy rate structures

Exhibit IV-2

U.S. CONSTRUCTION GROWTH RATES (1) BY MARKET SEGMENT
1967 to 1981

(Millions of sq.ft. of floor space added annually)

Market Segments	Historical Growth (AAROG) 1967-76	1967-73	1973-76	Projected Growth (AAROG) 1967-81	1976-81
Commercial:					
Office buildings	(2.5%)	6.3%	(20.0%)	0.5%	16.4%
Stores and other	1.5	8.0	(14.3)	1.4	3.7
Industrial	(5.7)	(3.3)	(21.5)	0.1	15.9
Institutional and Misc.	(2.2)	(2.8)	(4.2)	(0.8)	3.3
Apartments	(3.1)	16.1	(27.7)	(0.8)	2.8
Nonhousekeeping Residential	(7.8)	4.3	(31.1)	(2.5)	18.3
Total	(2.3%)	6.0%	(18.3%)	(0.2%)	6.4%

(1) Average annual physical rate of growth - millions of square feet of floor space added annually.

Source: F. W. Dodge Construction Data.

Exhibit IV-3

U.S. CONSTRUCTION GROWTH RATES (1) BY REGION
1967 to 1981

(Millions of sq.ft. of floor space added annually)

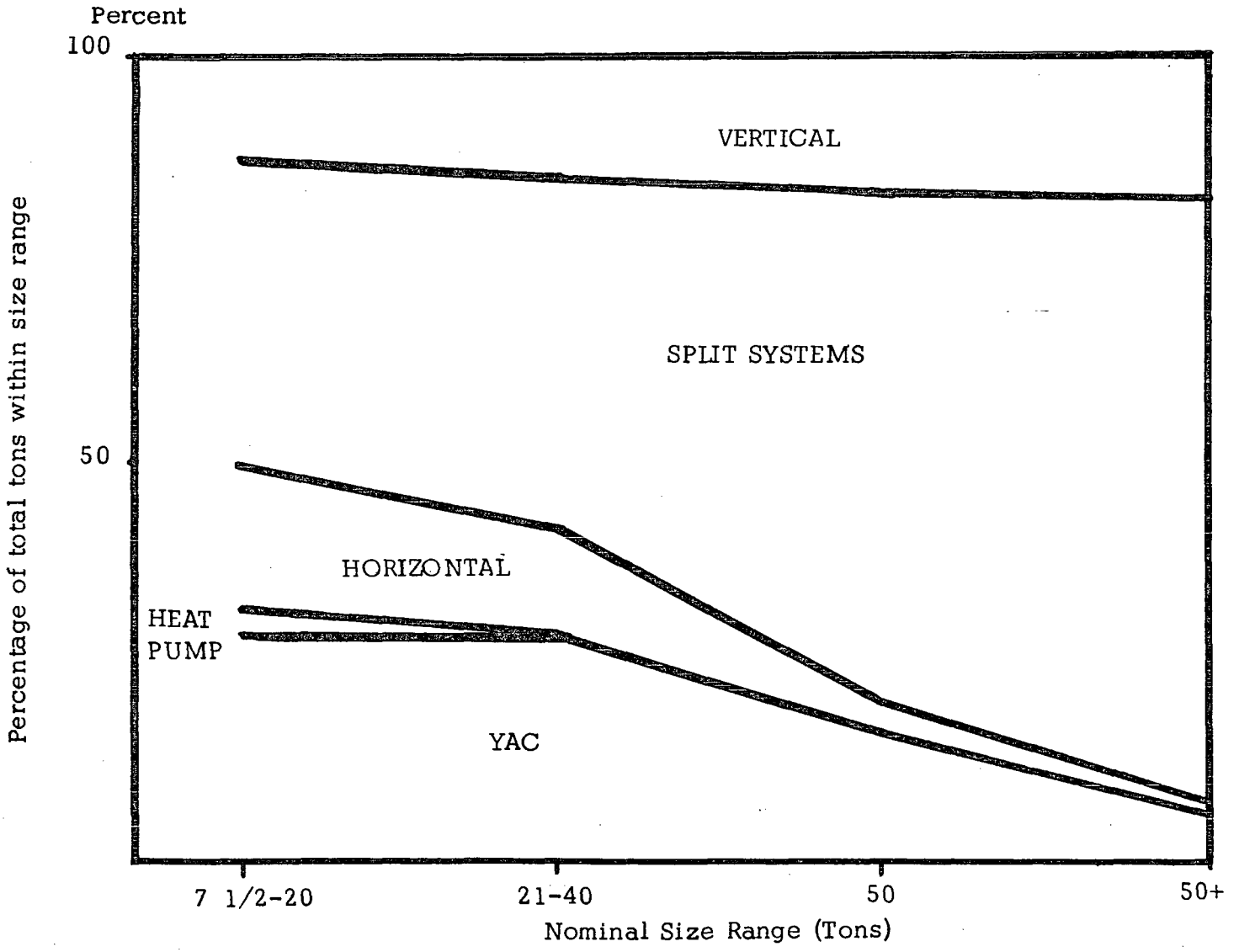
Region	1976 MM sq.ft.	Percent	Historical Growth (AAROG) 1967-76	1967-73	1973-76	Projected Growth (AAROG) 1967-81	1976-81
Northeast	219	16.2%	(6.8%)	1.9%	(22.6%)	(2.9%)	10.1%
Midwest	381	28.2	(2.6)	2.0	(12.7)	(0.6)	1.1
South	468	34.6	(0.8)	10.6	(22.7)	0.5	8.3
West	338	25.0	0.4	7.8	(13.3)	1.7	6.5
Total	1,353	100.0%	(2.3%)	6.0%	(18.3%)	(0.2%)	6.4%

(1) Average annual physical rate of growth - millions of square feet of floor space added annually.

Source: F. W. Dodge Construction data.

Exhibit IV-4

DISTRIBUTION OF COMMERCIAL UNITARY TONNAGE (7 1/2+ TONS)
BY UNIT SIZE RANGES AND TYPE OF EQUIPMENT
1970

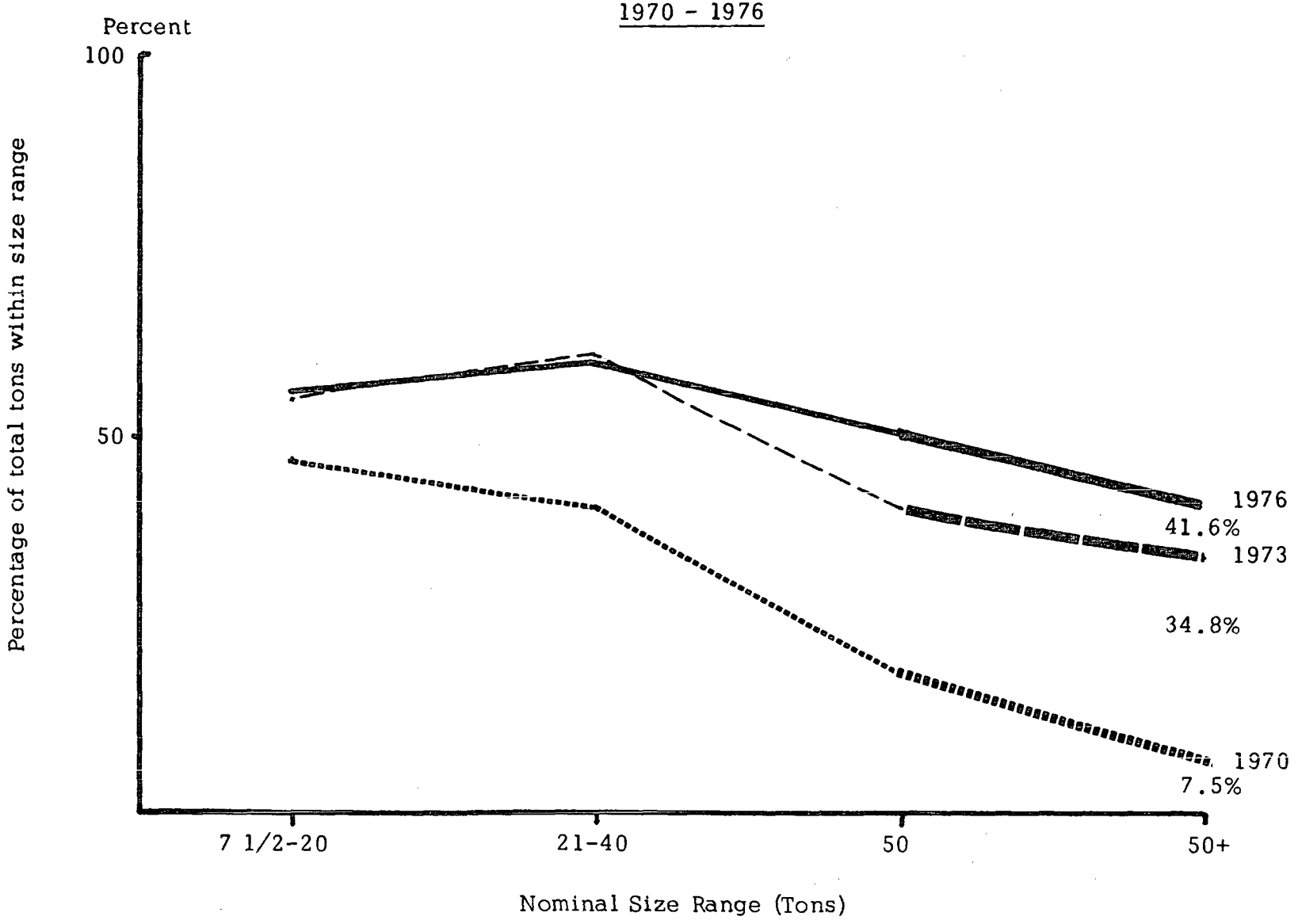


Source: William E. Hill & Co., estimates based upon ARI data.

Exhibit IV-5

TREND IN PERCENT DISTRIBUTION OF SINGLE PACKAGE (1)
UNITARY EQUIPMENT BY NOMINAL SIZE RANGE

1970 - 1976



(1) Single package includes YACS, Horizontal and Single Package Heat Pumps.
Source: William E. Hill & Co., Inc. estimates based upon ARI data.

Exhibit IV-6

KEY COMMERCIAL EQUIPMENT TRENDS-UNITARY AND CENTRAL BUILT-UP

Unitary

- Continued share penetration, but at a decreased rate
- Slightly increased availability and use of larger unit sizes
- Slightly increased use of rooftops (outside) units instead of split systems
- Reduced heating requirements for very large-tonnage unitary equipment (heat reclamation; energy efficient buildings)
- Greater availability of larger heat pumps, and/or use of water source heat pump loops in core-type buildings
- Increased concern for equipment efficiencies and operating costs, but first-costs still important
- Increased sophistication, multi-functional capabilities and energy efficiency.

Built-up (chillers)

- Increased use of air-cooled condensing
- Continued use in traditional "core" markets (i.e. high-rise, hospitals, etc.)
- Increased competitiveness of reciprocating compressors at larger tonnage sizes (up to 200 tons)
- Increased use of condenser heat for space heating
- Continued decrease in absorption unit sales, except when used with solar heating or waste material as heat source
- Increased multi-functional and control capabilities

Exhibit IV-7

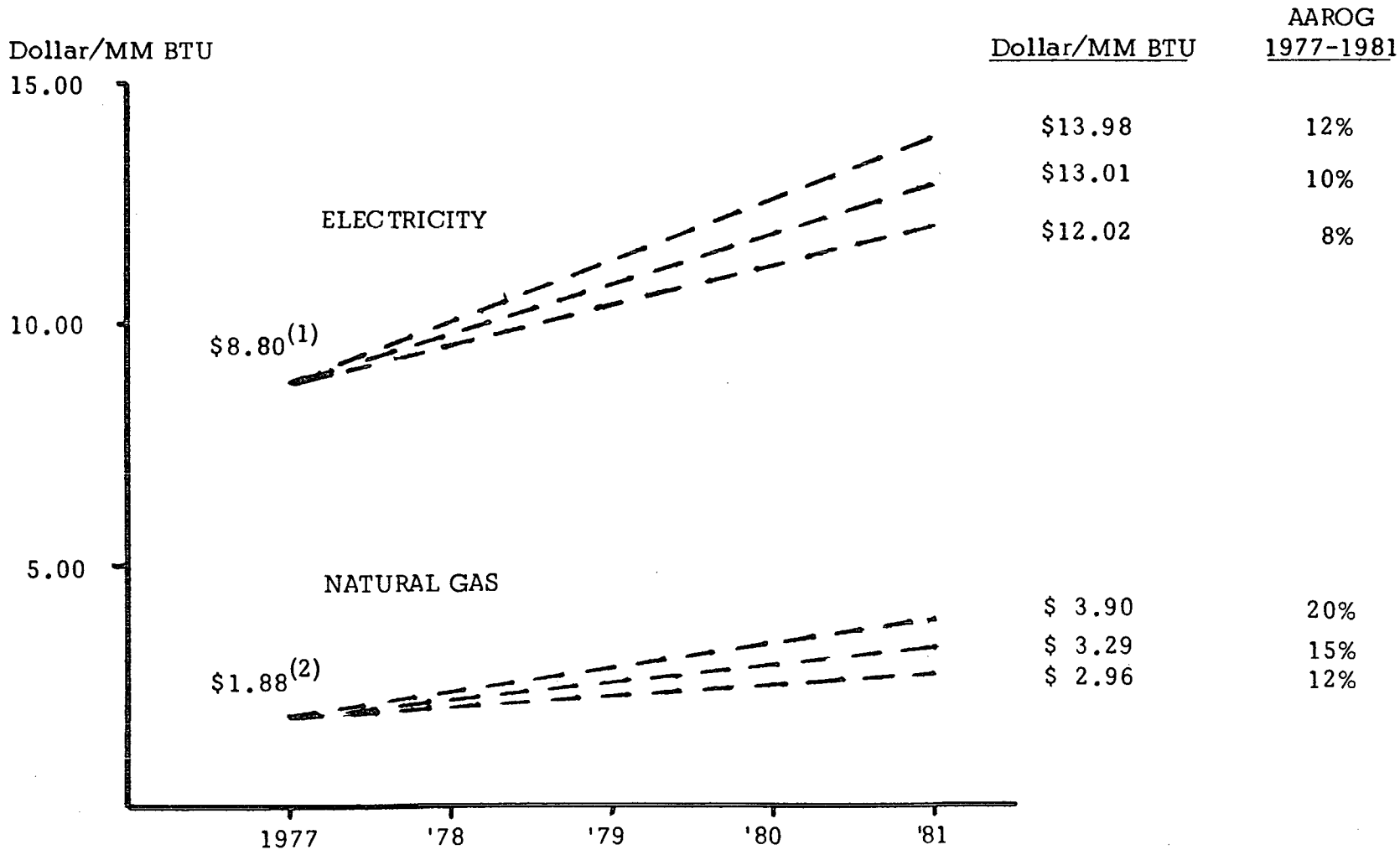
KEY HVAC TRADE TRENDS

Trade Groups	Key Trends
All	- Slower overall growth - Continued concentration of participants
Manufacturers	- Cost and profit pressures - Increasingly segmented and diverse markets
Distributors	- Increased sophistication; marketing requirements - Multi-branch, trade and product operations
Designers	- Return to more specific and/or sophisticated "design" - Increased contractor design
Contractors/Installers	- Increased sophistication; marketing requirements - Increased geographical and business diversification - Increased design and maintenance business
Contractors/Maintenance	- Increased sophistication; marketing requirements - Increased importance and growth in maintenance and retrofit (of parts/components) to increase system efficiency

Exhibit IV-7A

PROJECTED ENERGY PRICES FOR COMMERCIAL USERS

(Dollar/MM BTU)

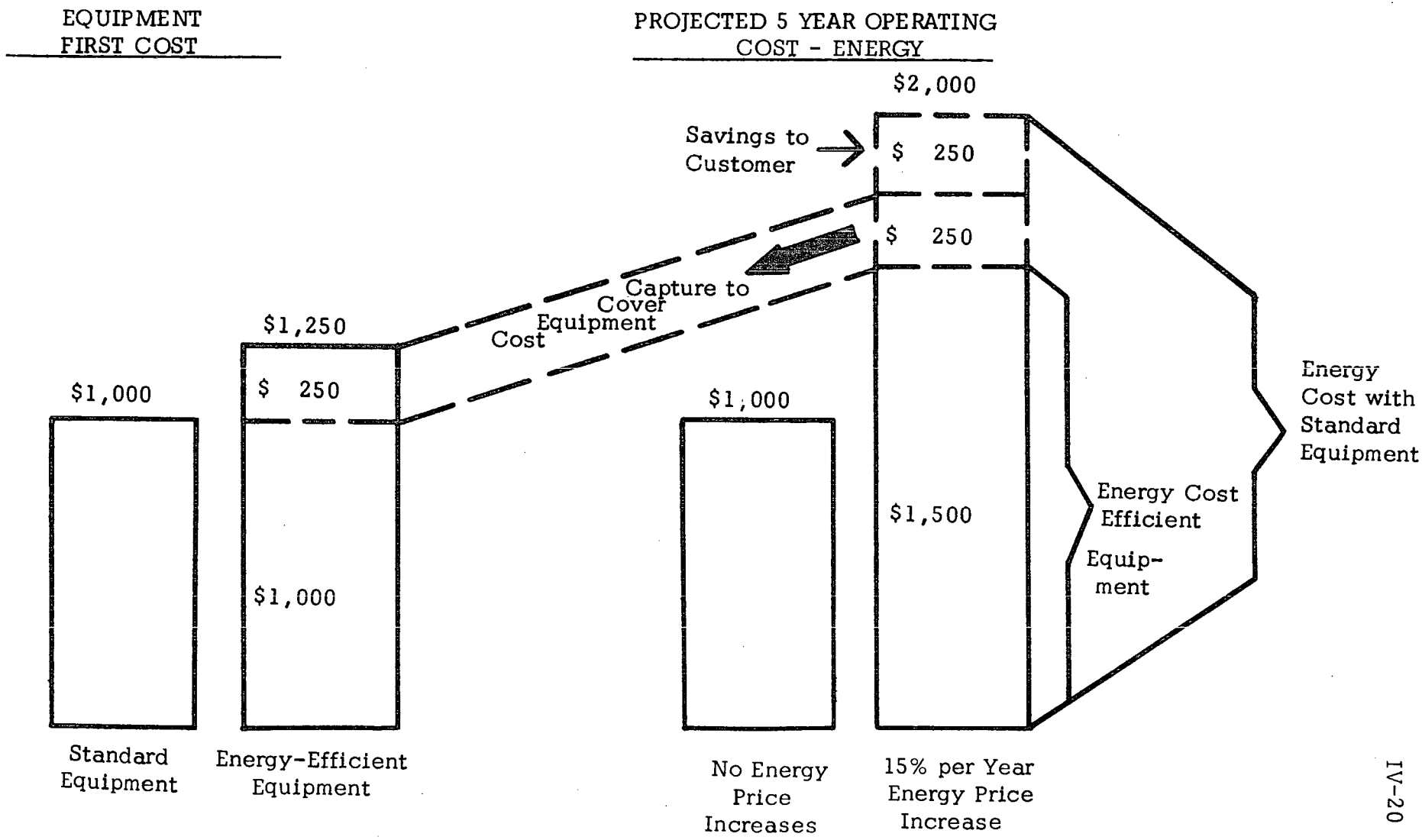


(1) Average of large commercial/industrial and small commercial/industrial.
(2) Commercial.

Source: William E. Hill & Co., Inc. projections based upon Edison Institute & AGA data.

Exhibit IV-8

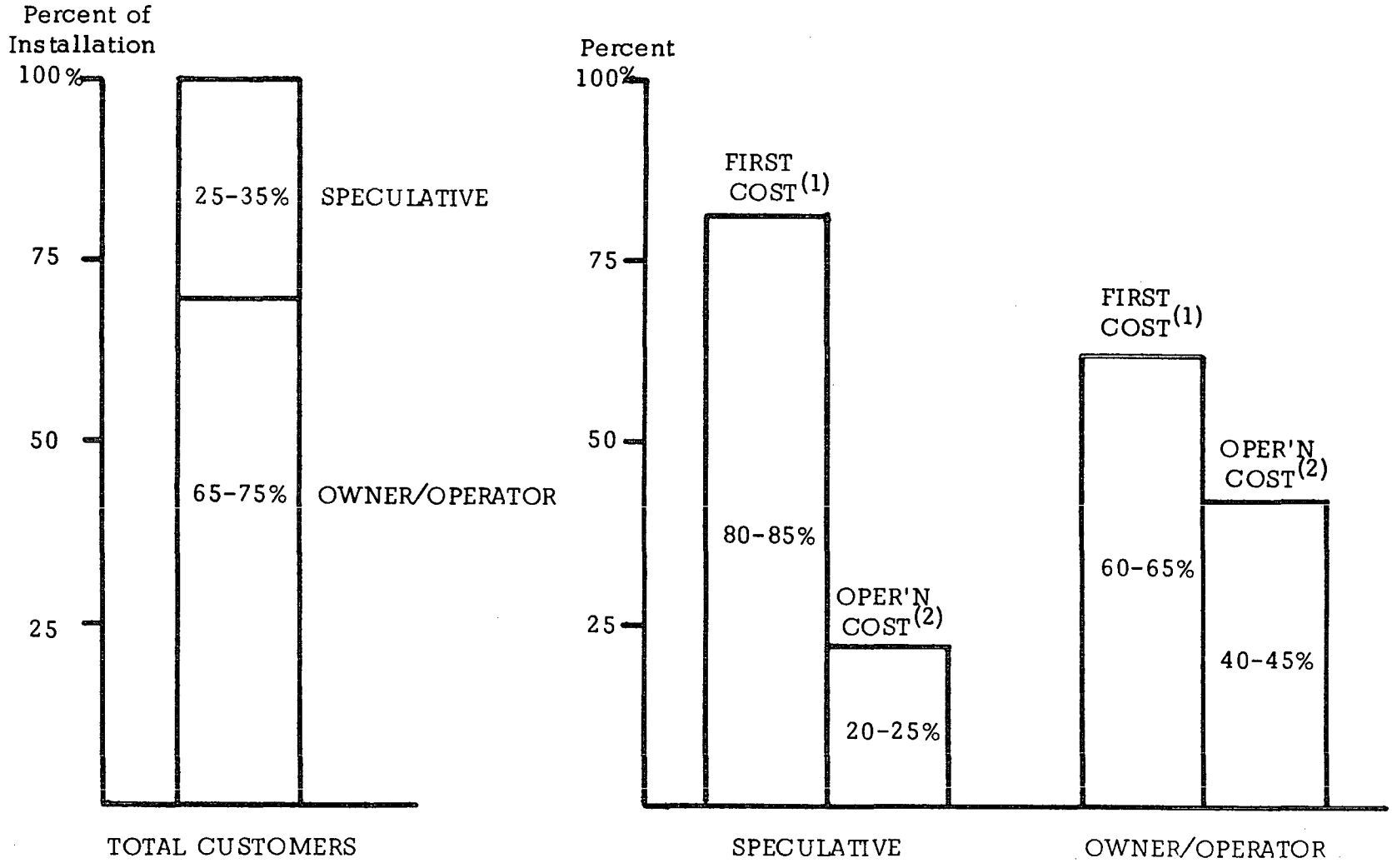
POTENTIAL FOR CAPTURING OPERATING COST INCREASES
IN EQUIPMENT COST
EXAMPLE



William E. Hill & Company, Inc.

Exhibit IV-9

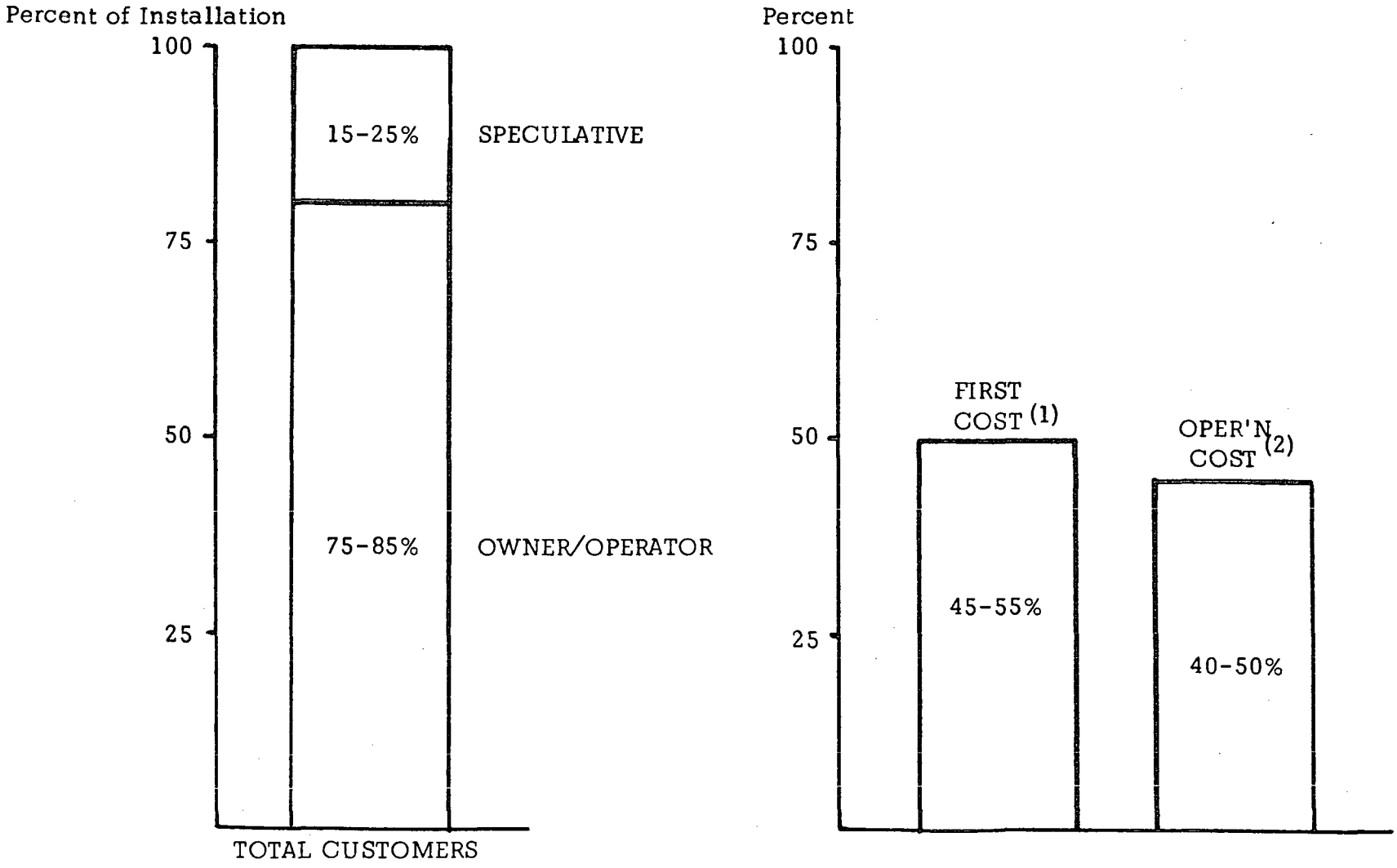
IMPORTANCE OF FIRST AND OPERATING COSTS BY CUSTOMER TYPE[3]
1976



(1) First cost sole or primary criterion.
(2) Operating cost an important criterion - not necessarily prime.
(3) Based on 1976 telephone survey data for the 7 1/2-50 ton unitary equipment market.
Source: William E. Hill & Co., Inc. estimates.

Exhibit IV-10

IMPORTANCE OF FIRST AND OPERATING COSTS BY CUSTOMER TYPE (3)
1977

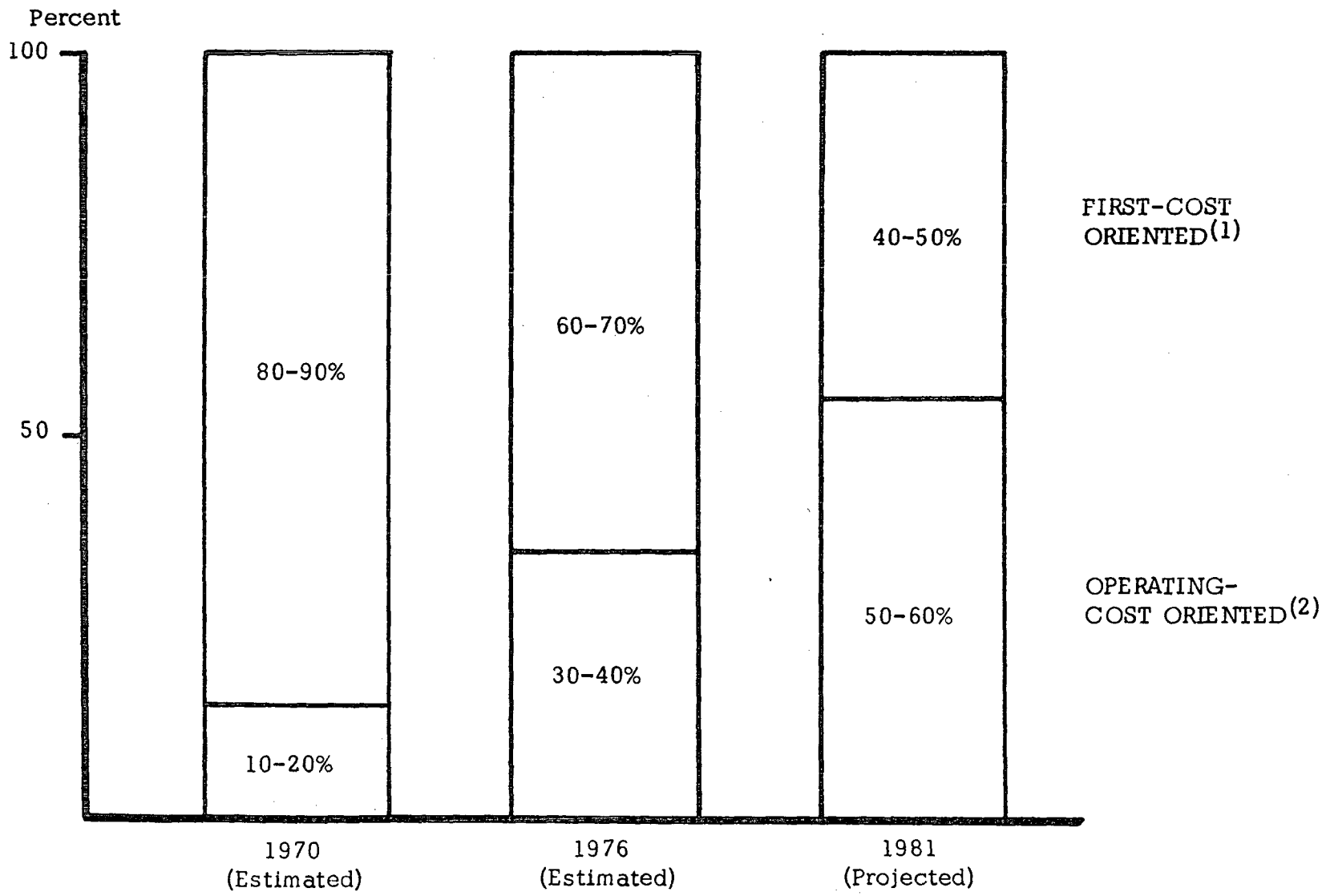


(1) First cost sole or primary criterion.
(2) Operating cost are important criterion - not necessarily prime.
(3) Based on 1977 telephone survey data for the 50+ ton unitary and central built up equipment market.

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

Exhibit IV-11

ESTIMATED COST-ORIENTATION AMONG COMMERCIAL AIR-CONDITIONING CUSTOMERS
(1970, 1976 estimated; 1981 projected)

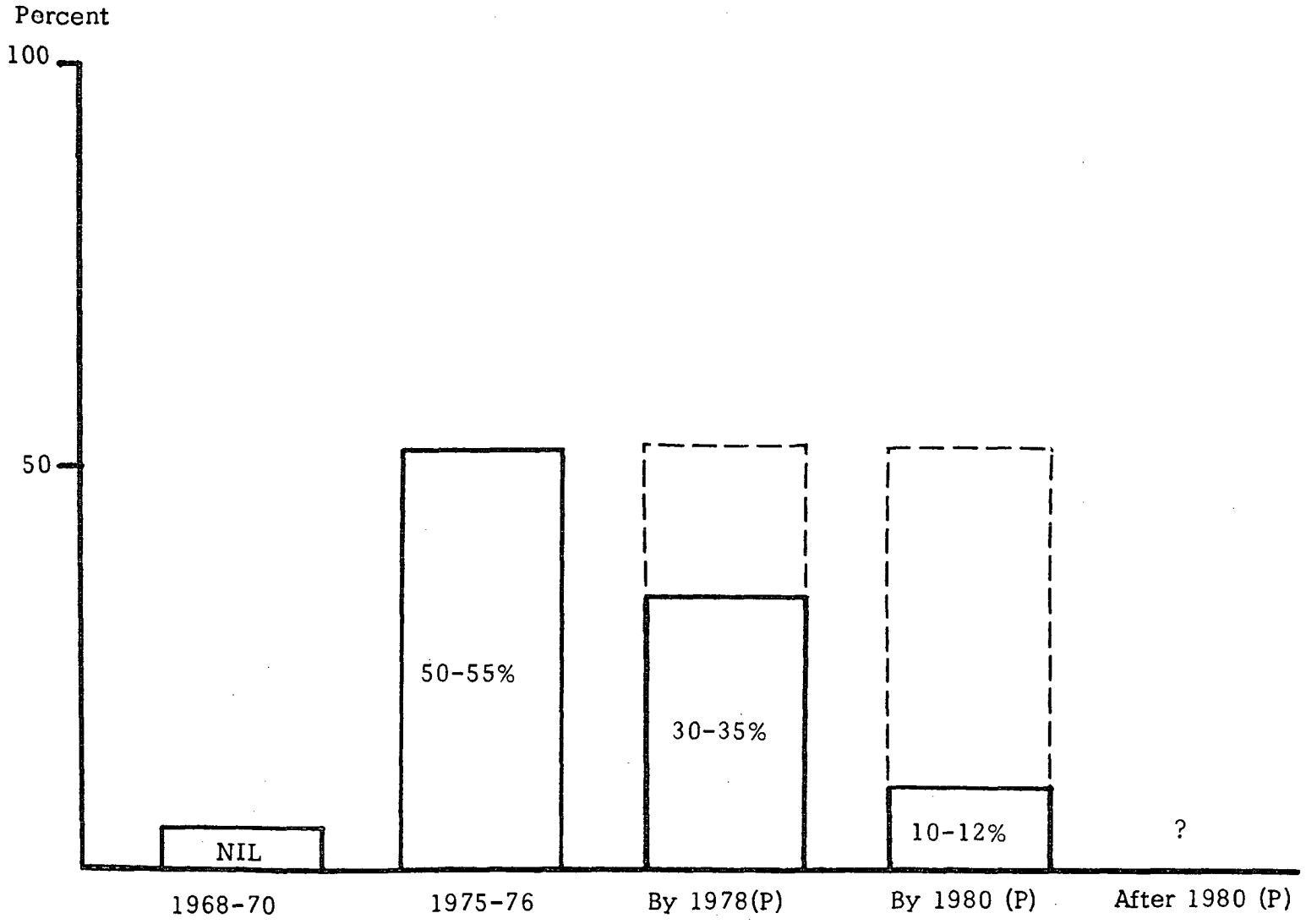


(1) First-costs are the sole or primary consideration.
(2) Operating costs are an important, not necessarily prime consideration.

Source: William E. Hill & Co. Inc.

Exhibit IV-12

GAS AVAILABILITY - UTILITIES WITH RESIDENTIAL AND COMMERCIAL CUSTOMER RESTRICTIONS(1)
(HISTORICAL & PROJECTED)

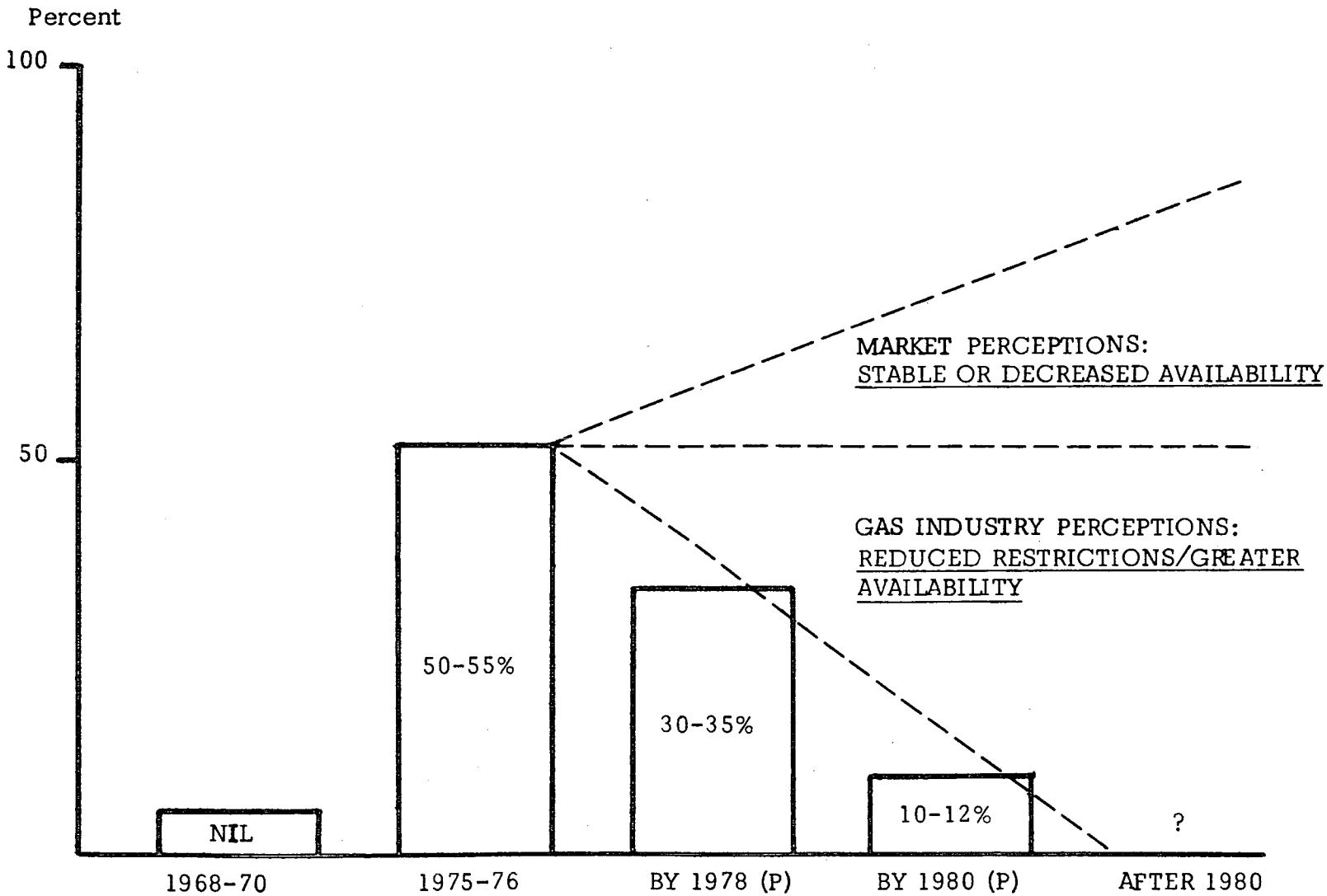


(1) Very limited or no addition of new residential and/or commercial customers.

Source: William E. Hill & Co. estimates based upon AGA Data.

Exhibit IV-13

GAS AVAILABILITY QUALITATIVE PERCEPTIONS - UTILITIES WITH RESTRICTIONS(1)



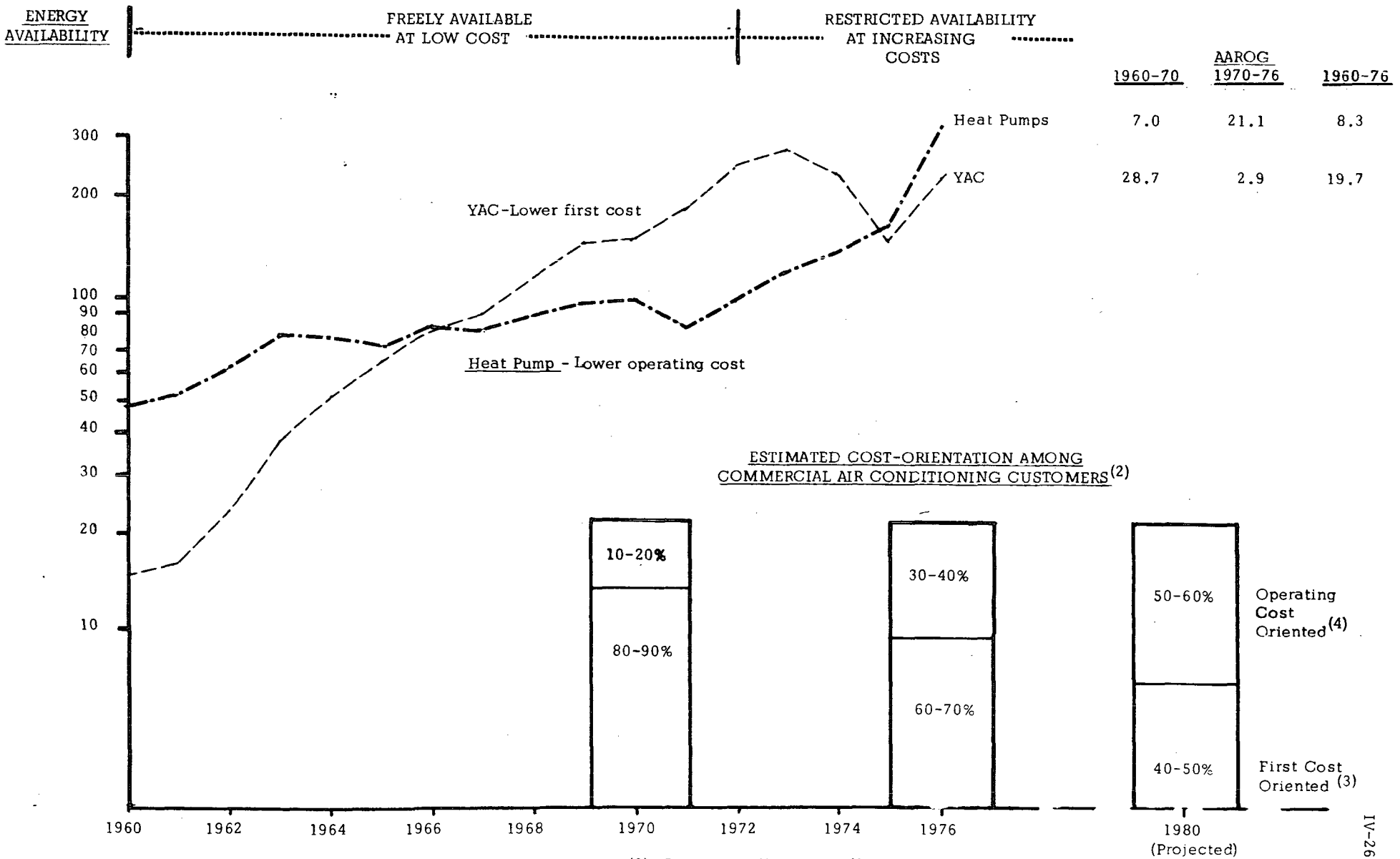
(1) Very limited or no additions of new residential and/or commercial customers.

Source: William E. Hill & Co. estimates based upon AGA Data.

Exhibit IV-14

COMPARISON OF YEAR-AROUND A/C (YAC'S) AND HEAT PUMP UNIT SHIPMENTS, AND MARKET COST ORIENTATION

(Thousands of Units)



	1960-70	AAROG 1970-76	1960-76
Heat Pumps	7.0	21.1	8.3
YAC	28.7	2.9	19.7

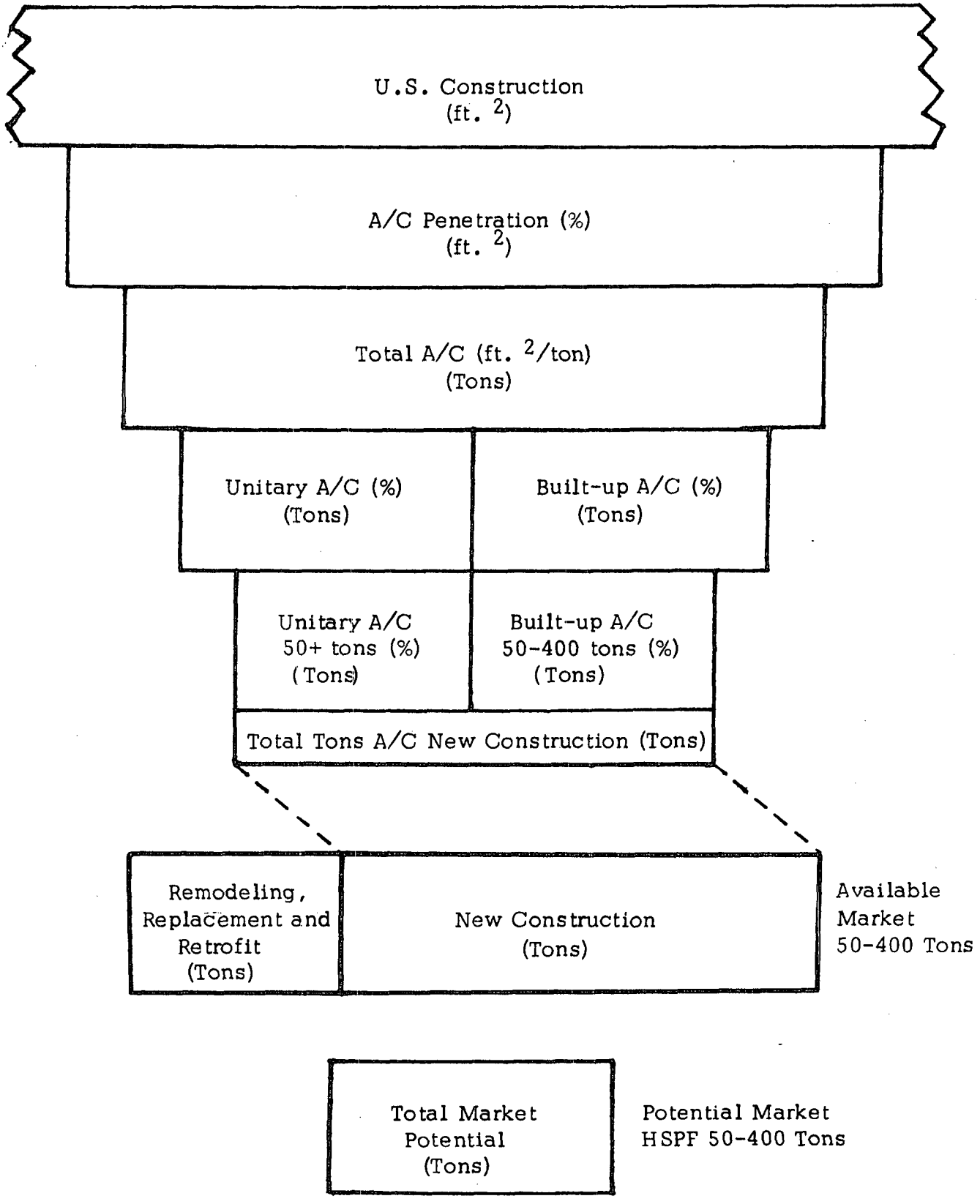
Source: Air Condition and Refrigeration Institute

(2) Source: William E. Hill & Co., estimates
(3) Equipment first-costs are the sole or primary equipment selection criterion
(4) Equipment operating costs are an important criterion, not necessarily prime.

Exhibit IV-15

ANALYSIS OF THE POTENTIAL MARKET FOR THE HSPF
50-400 Tons

1981



Source: William E. Hill & Co. estimates

Exhibit IV-16

ASSUMPTIONS - KEY PARAMETERS AIR CONDITIONING MARKET POTENTIAL FOR THE HSPF 50-400 TONS
United States

Parameter	1976 (E)	1981 (P)
U.S. Construction (1) (MM Sq. Ft.)	1,353	1,889
A/C Penetrations (2) (%)	72.2%	76.2%
A/C Ft^2/Ton (2)	338	388
Unitary A/C (2) (%)	46.1 (4)	44.5 (4)
Built-up A/C (2) (%)	35.3 (4)	35.7 (4)
Unitary A/C 50+ Tons (2) (%)	7.3%	7.65%
Built-up A/C 50-400 Tons (2) (%)	48.0%	48.0
Replacement, Remodeling & Retrofit Unitary (2) (% of total market unitary)	30%	30%
Replacement, Remodeling & Retrofit Built-up (2) (% of total market built-up)	20%	20%

(1) William E. Hill & Company estimates based on F. W. Dodge Data.
(2) William E. Hill & Company estimates.
(3) Thousands of tons.
(4) Percentage unitary and built-up doesn't equal 100 percent since unitary percentage is reduced for the apartment and nonhousekeeping residential segments by 80 percent to remove the tons of equipment that are through the wall units and small unitary.

(E) Estimated.
(P) Projected.

Exhibit IV-17

PROJECTION OF THE AVAILABLE AIR CONDITIONING MARKET FOR 50+ TON UNITARY EQUIPMENT AND 50-400 TONS BUILT-UP EQUIPMENT UNITED STATES - 1981

(Thousands of Tons)

Market Segments	Projected Construction Floor Space (1)	Air Conditioning Penetration(1)		Total Air Conditioning(2)		Total Air Conditioning 50-400 Tons (2)(4)(5)
		Percent	Ft.^{2}	Ft.^{2}/Ton	Tons	Tons
Commercial	635	73	465.0	371	1,254.9	389.0
Banks and Offices	210	100	210.0	365	574.9	226.4
High rise	50	100	50.0	357	140.1	84.0
Low rise	160	100	160.0	368	434.8	142.2
Stores and other Commercial	425	60	255.0	375	680.0	162.4
Industrial	320	40	128.0	328	390.2	119.1
Institutional	383	78	297.7	320	931.6	322.0
Education and Science	132	82	108.2	299	361.9	95.8
Hospital and Health Treatment	80	100	80.0	288	277.8	121.2
Public Buildings	55	80	44.0	368	119.6	43.0
Religious	33	30	9.9	329	30.1	10.9
Amusement and other	83	67	55.6	391	142.2	51.0
Apartments	475	100	475.0	518	917.0	110.5(3)
Non-Housekeeping Residential	76	98	74.5	345	215.9	33.1(3)
TOTAL	1,889	76	1,440.2	388	3,709.6	973.7

(1) Millions of square feet.
(2) Thousands of tons.
(3) Percentage unitary reduced by 80 percent for the apartment and nonhousekeeping residential segments projections to remove the tons of equipment that are through the wall units and small unitary equipment.
(4) Includes remodeling, replacement, and retrofit.
(5) New construction air conditioning tonnage.

Source: William E. Hill and Company projections based on F. W. Dodge data.

Exhibit IV-18

PROJECTED AVAILABLE AIR CONDITIONING MARKET:
UNITARY EQUIPMENT 50+ TONS
UNITED STATES - 1981

Market Segments	Unitary A/C (1)(5) Percent	Unitary A/C (1)(5) Tons	Unitary A/C 50+ Tons (1)(5) Percent	Unitary A/C 50+ Tons (1)(5) Tons	Estimated Unitary RRR 50+ Tons (1)(6) Tons	Estimated Total Unitary 50+ Tons (1)(4) Tons
Commercial	60.3	756.1	8.3	62.8	26.9	89.7
Banks and Offices	42.8	246.1	8.3	20.4	8.7	29.1
High rise	0.0	0.0	8.3	0.0	0.0	0.0
Low rise	56.6	246.1	8.3	20.4	8.7	29.1
Stores and other Commercial	75.0	510.0	8.3	42.3	18.1	60.4
Industrial	61.3	239.2	8.3	19.9	8.6	28.5
Institutional	52.9	492.4	8.3	40.9	17.7	58.6
Education and Science	69.7	252.2	8.3	20.9	9.0	29.9
Hospitals and Health Treatment	33.9	94.2	8.3	7.8	3.4	11.2
Public Buildings	50.0	59.8	8.3	5.0	2.2	7.2
Religious	50.0	15.1	8.3	1.3	0.6	1.9
Amusement and other	50.0	71.1	8.3	5.9	2.5	8.4
Apartments	16.1 (2)(3)	147.6	1.0	1.5	0.6	2.1
Non-Housekeeping Residential	15.9 (2)(3)	34.3	2.0	0.7	0.3	1.0
TOTAL	44.5 (3)	1,649.6 1669.6	7.7	125.8	54.1	179.9

(1) Thousands of tons.
(2) Percentage unitary reduced by 80 percent for the apartment and nonhousekeeping residential projections to remove the tons of equipment that are through the wall units and small unitary.
(3) Unitary and built-up percents do not add to 100.
(4) Includes remodeling, replacement, and retrofit.
(5) New construction air conditioning tonnage.
(6) RRR - Replacement, Remodeling and Retrofit.

Source: William E. Hill & Co. estimates based on F. W. Dodge data.

Exhibit IV-19

PROJECTED AVAILABLE AIR CONDITIONING MARKET:
CENTRAL BUILT-UP EQUIPMENT 50-400 TONS
UNITED STATES - 1981

Market Segments	Central Built-up Equipment (1)(5) Percent	Central Built-up Equipment (1)(5) Tons	Central Built-up Equipment 50-400 Tons (1)(5) Percent	Central Built-up Equipment 50-400 Tons (1)(5) Tons	Estimated Built-up RRR 50-400 Tons (1)(6) Tons	Estimated Total Built-up 50-400 Tons (1)(4) Tons
Commercial	39.7	498.8	48.0	239.4	59.9	299.3
Banks and Offices	57.2	328.8	48.0	157.8	39.5	197.3
High rise	100.0	140.1	48.0	67.2	16.8	84.0
Low rise	43.4	188.7	48.0	90.6	22.7	113.3
Stores and other Commercial	25.0	170.0	48.0	81.6	20.4	102.0
Industrial	38.7	151.0	48.0	72.5	18.1	90.6
Institutional	47.1	439.3	48.0	210.8	52.6	263.4
Educational and Science	30.3	109.7	48.0	52.7	13.2	65.9
Hospitals and Health Treatment	66.1	183.6	48.0	88.1	22.0	110.1
Public Buildings	50.0	59.8	48.0	28.7	7.1	35.8
Religious	50.0	15.1	48.0	7.2	1.8	9.0
Amusement and other	50.0	71.1	48.0	34.1	8.5	42.6
Apartments	19.7 (2)(3)	180.6	48.0	86.7	21.7	108.4
Non-Housekeeping Residential	24.8 (2)(3)	53.5	48.0	25.7	6.4	32.1
TOTAL	35.7 (3)	1,323.2	48.0	635.1	158.7	793.8

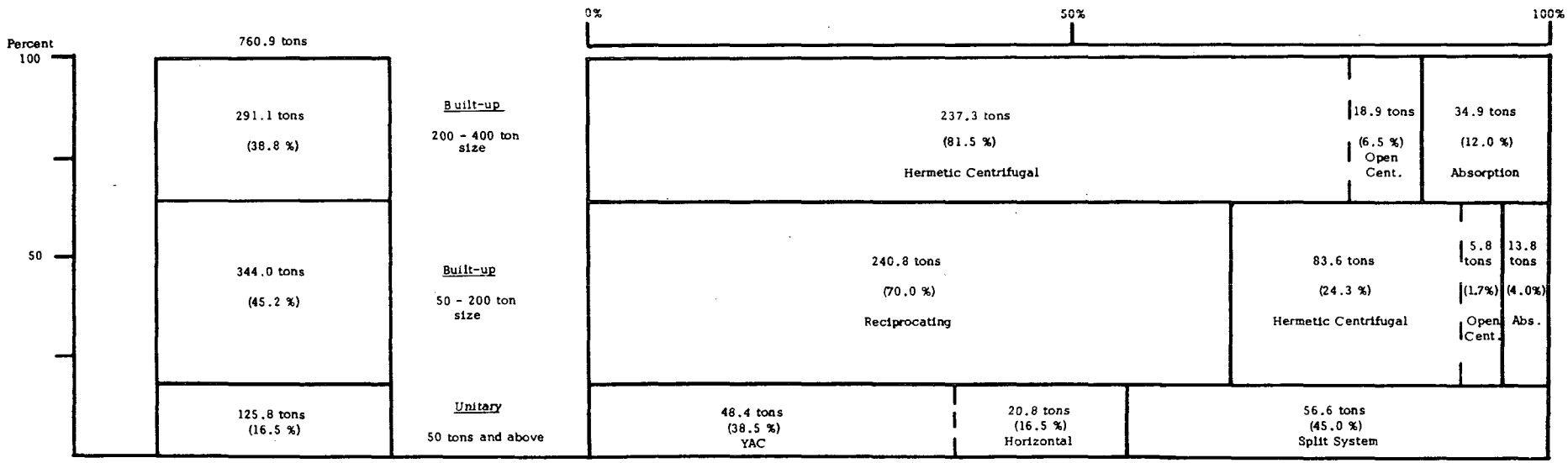
(1) Thousands of tons.
(2) Percentage unitary reduced by 80 percent for the apartment and nonhousekeeping residential segments projections to remove the tons of equipment that are through the wall units and small unitary.
(3) Unitary and built-up percents do not add to 100.
(4) Includes remodeling, replacement, and retrofit.
(5) New construction air conditioning tonnage.
(6) RRR - Replacement, Remodeling and Retrofit.

Source: William E. Hill & Co., estimates based on F. W. Dodge data.

Exhibit IV-20

PROJECTED AVAILABLE AIR CONDITIONING MARKETS IN 1981 -- UNITED STATES
(Thousands of Tons)

NEW CONSTRUCTION



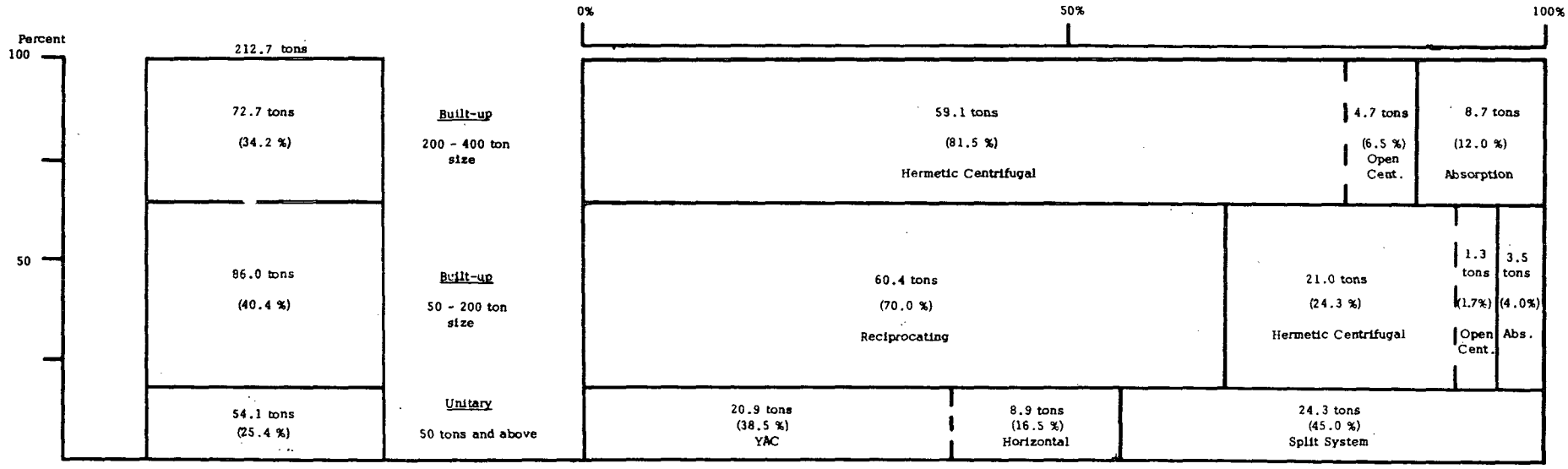
Source: William E. Hill & Co., estimates.

William E. Hill & Company, Inc.

Exhibit IV-21

PROJECTED AVAILABLE AIR CONDITIONING MARKETS IN 1981 -- UNITED STATES
(Thousands of Tons)

REMODELING, REPLACEMENT, RETROFIT



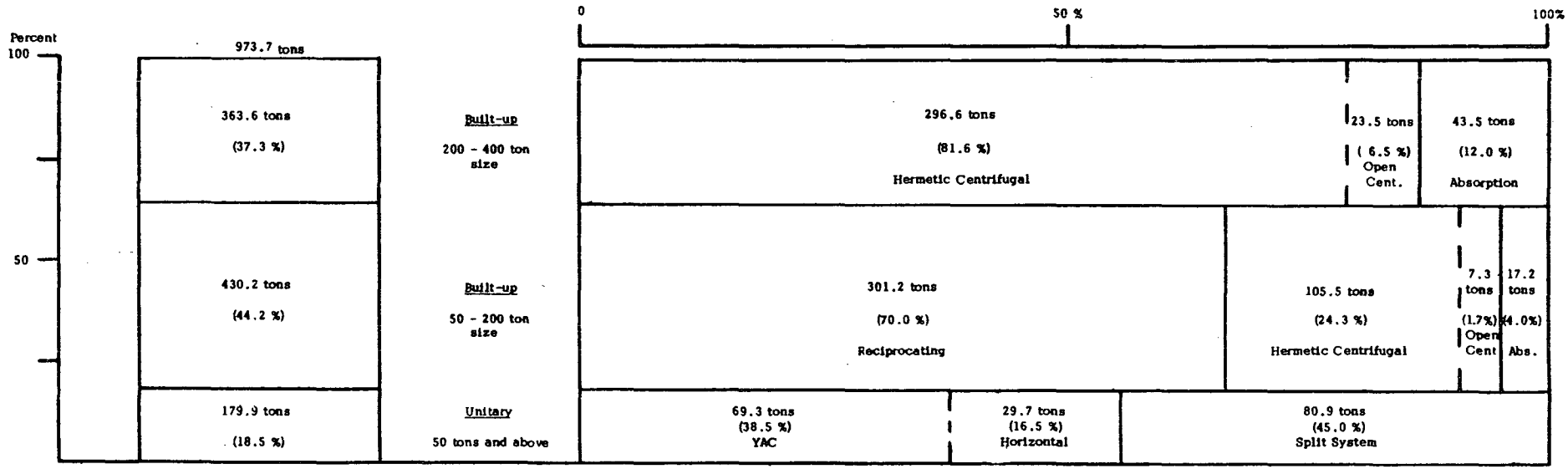
Source: William E. Hill & Co., estimates.

William E. Hill & Company, Inc.

Exhibit IV-22

PROJECTED AVAILABLE AIR CONDITIONING MARKETS IN 1981 -- UNITED STATES
(Thousands of Tons)

TOTAL MARKET



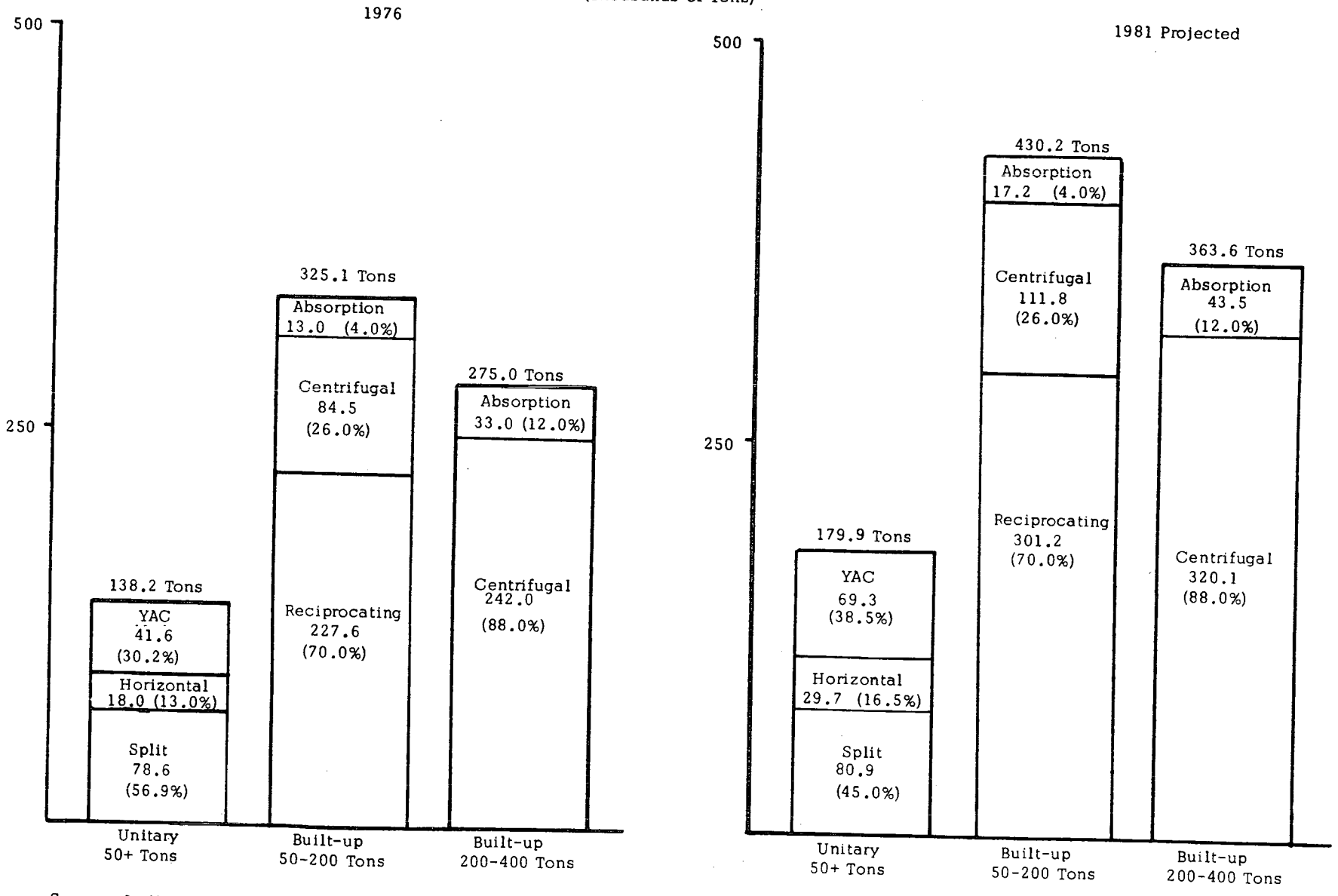
Source: William E. Hill & Co., estimates.

William E. Hill & Company, Inc.

Exhibit IV-23

DISTRIBUTION OF MAJOR EQUIPMENT TYPE BY SIZE RANGE
1976, 1981 PROJECTED

(Thousands of Tons)

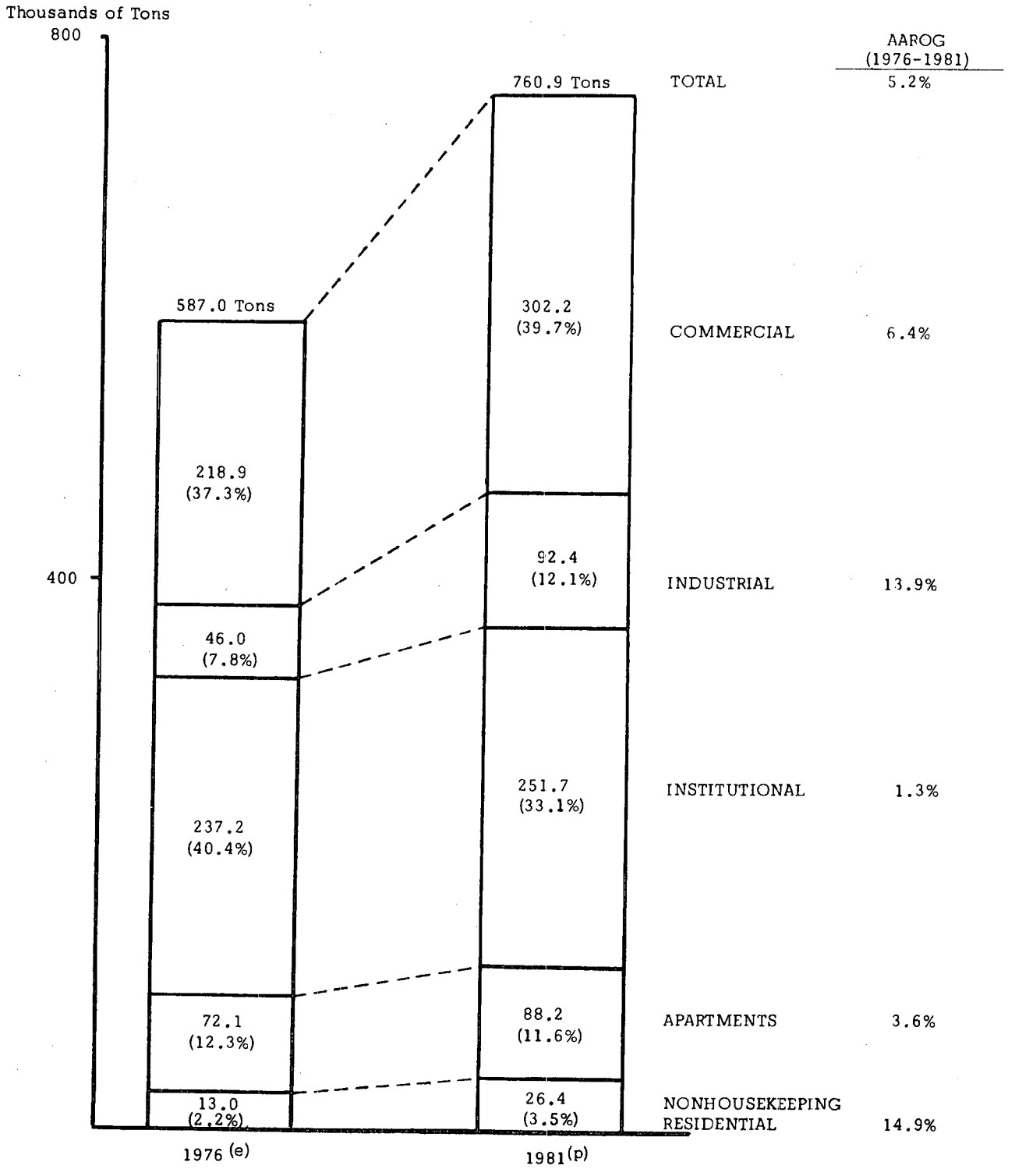


Source: William E. Hill & Co estimates based upon ARI and F.W. Dodge data.

Exhibit IV-24

AVAILABLE CONSTRUCTION MARKET - AIR CONDITIONING EQUIPMENT 50-400 TONS (1)
1976, 1981 PROJECTED

(Thousands of Tons)



(1) Including new construction and major remodeling.
(e) Estimated.
(p) Projected.

Source: William E. Hill & Co., Inc. estimates of tonnage based on F. W. Dodge data not equal to ARI shipments data.

V. THE LARGE-TONNAGE HSPF UNIT

The large-tonnage HSPF units are presumed to have a number of distinct advantages over currently-available large-tonnage space conditioning equipment. The unit is expected to have high reliability and good operating-cost performance is most applications and geographical areas.

A. The Large-tonnage HSPF Unit.

The HSPF is a fuel-fired machine that utilizes a steam-driven turbine/compressor and conventional heat exchange and miscellaneous components. The unit can provide both heating and cooling, features modulating performance (variable output/load) and generates its own power for auxiliaries.

B. Product Concept Statement.

1. Objective. The primary objective is the development and commercialization of a reliable, gas-fired heating/cooling device which combines an efficient refrigeration/heating cycle, the heat pump concept and the clean-burning qualities, lower cost and prime energy efficiency of gas.

2. Supporting Market Factors. A number of significant market, and 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 escalating in cost, and increasing emphasis is being placed on improving the efficiency of space conditioning devices on a performance and/or a cost performance basis.

c) Energy is seen as a valuable resource, which should be utilized as efficiently as possible.

d) The basic heat pump technology offers significant performance advantages, but has not been available in larger-tonnage equipment.

e) Large-tonnage (built-up) systems have typically been electrically-driven, with high energy costs to the user.

3. Physical Characteristics. The HSPF concept has been expanded to include a number of configurations in tonnages of greater than 50 tons cooling capacity.

a) Configurations. The current technology permits the HSPF to be designed as single package or split-package unitary equipment, or as a built-up chiller/heater.

b) Sizes. For the unitary configurations, the technologically feasible size range seems to be between 50 and 150 nominal tons. For the built-up (chiller) configurations, 50 to 200 nominal tons is viewed as the prime range, and 200 to 400 tons the secondary range. Unit size could possibly extend above 400 tons, but the technical feasibility of this has not been proven.

4. Performance Characteristics.

a) General. A major objective is to provide high reliability with a minimum of field maintenance. The technology permits modulation -- with good partial load performance, the self-generation of power required for auxiliaries and simultaneous heating and cooling.

b) Heating. In the heat pump mode, the HSPF is expected to have considerably higher efficiency than advanced fossil-fuel furnaces and boilers. In the chiller configuration it can provide heat from the condensing operation and the return steam loop.

c) Cooling. The HSPF is expected to have significantly better cooling performance than current gas absorption air conditioners and better cost/performance than available electric equipment.

5. Cost Characteristics.

a) Equipment First Costs. Although sound cost estimates are not available, the HSPF is expected to have a 25-50 percent first cost premium versus unitary equipment and a 10-25 percent premium versus built-up (chiller/broiler) equipment.

b) Installation Costs. The installation costs for the unitary configurations should be comparable to those for a gas/electric YAC. For the built-up version, the installation costs could be slightly less than electric equipment due to the reduced electric conduit requirements, (perhaps as much as $60 per ton).

c) Operating Costs. Technical design and development stresses low maintenance requirements and costs and ease of service. Operating performance is expected to provide a payback period of three years or less.

C. Key Factors of Commercial Significance.

A number of specific characteristics and features of the HSPF unit have key commercial significance with regard to the evaluation and acceptance of the unit.

1. New Technology. The technology of the HSPF includes a complex combination of sophisticated devices somewhat new to the trade, but in some aspects it is similar to centrifugal chiller equipment. Acceptance of such a new technology is a critical factor, and reliability and ease of maintenance are often the most important non-economic factors in equipment selection.

2. System First Costs. Total system first-costs include the costs of both equipment and installation. Installation cost differentials can be a consideration when evaluating different systems, but they are often hard to document and may not provide an

effective selling point. Comparative first-costs are an important equipment selection factor, 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. System Operating Costs. Generally, operating costs are an important consideration in large-tonnage applications and are becoming more significant in equipment selection decisions. Although energy costs are the prime component of annual operating costs, maintenance (preventive and repair) can be an important factor in the larger-tonnage equipment market.

4. Size and Configuration. Unit sizes, flexibility of configurations, and the mix of sizes in the product line are important factors impacting commercial success. Usually more than one unit is installed to provide flexibility of operation and redundancy, with the mix of sizes depending upon the design peak load and normal operating load of the building.

5. Relative Heating/Cooling Performance. Relative heating/cooling requirements are influenced by the climate, type of construction, building type and building management practices. The HSPF's relative performance versus competitive equipment will be affected by these factors, as well as, comparative equipment efficiencies for heating and cooling service and comparative energy prices. Generally, the HSPF is expected to have better relative performance on heating than on cooling, but in most large-tonnage applications cooling service is usually more important.

VI. HSPF MARKET AND BUSINESS POTENTIALS

Projecting the market potential for the HSPF concept is a complicated task requiring a thorough evaluation of the market and product characteristics described in the previous sections. Penetration of the projected market potential (sales potential) and the vialibility of the HSPF concept as a business venture will be affected by market characteristics, the effectiveness of the HSPF marketing program, the competitive environment, and the HSPF cost/price situation. The degree of controllability of, or influence on, these factors is an important issue in commercialization planning.

The total market potential for the HSPF concept is projected to be 400 to 500 thousand tons in 1981. This includes 40 to 80 thousand tons for unitary configurations, 190 to 230 thousand tons for 50 to 200 ton built-up configurations and 160 to 200 thousand tons for 200 to 400 ton built-up configurations.

A. Factors Affecting Market Potential and Market Penetration.

The key issues in determining the market potential and rate of market penetration are the degree to which the HSPF concept satisfies the market requirements of the early 1980's, and the effectiveness of the market development program. From a project management

standpoint, it is important to realize that the HSPF market potential is affected by both "controllable" and "uncontrollable" factors, Exhibit VI-1.

1. "Uncontrollable" Factors. The uncontrollable factors are those which are generally "market given" and beyond the direct action of the HSPF development program. These include the key external factors described in previous sections; customer and market characteristics; and the structure and actions of the HVAC industry.

2. "Controllable" Factors. The controllable factors are those which can be influenced by the direct action of the HSPF development program. These include the technical, physical and economic characteristics of the HSPF units; pricing, distribution and other marketing strategies; and specific market development activities. Market perceptions regarding gas availability and comparative prices are a critical issue, which should be given appropriate attention. This is not controllable to the same degree as the other factors mentioned above, but can be influenced by concerted industry efforts.

3. Market Descriptions. Exhibit VI-2 describes the terms available market, market potential and penetration (or sales) potential as used in this report, and indicates the primary influences on each.

   a) Available Market. This represents a given (or actual) total market for a specifically defined functional and/or product category (i.e. unitary heat/cool equipment). The available market is primarily influenced by external factors and market characteristics.

   b) Market Potential. This represents a portion of an available market that could be served by a particular product type (i.e. single package heat pumps). The market potential is primarily influenced by market characteristics and product characteristics.

   c) Penetration (Sales) Potential. This represents the portion of a potential market that is (or is likely to be) actually realized for a given product. The penetration potential is primarily influenced by market characteristics and product marketing activities.

4. Product Life-Cycle. Exhibit VI-3 describes the basic product life-cycle concept and illustrates the market terms defined above. 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. Most products display some type of S shaped life-cycle curve (as illustrated), which reflects slow growth/acceptance during the market development stage, a higher growth/acceptance stage and finally a slow growth/mature stage. Market potential and penetration potential are affected by end-use market characteristics and specific elements of the product marketing program.

   a) End-Use Market. Exhibit VI-4 indicates the key market characteristics that impact market potential and market penetration. Market potential is primarily affected by functional-use patterns, the size of the available market, product-use patterns and cost/quality sensitivity. The characteristics that primarily affect market penetration include willingness to accept new ideas and products, and purchasing influence and practices.

   b) Product Marketing Program. Of the four basic marketing elements, product and price primarily affect market potential; while promotion and distribution affect market penetration (or sales), Exhibit VI-5. This implies that the product and pricing elements are the key (and primary) marketing elements, which must sufficiently satisfy market requirements to provide a suitable market potential. The effectiviness of the promotion and distribtuion elements determine market penetration (or sales levels), but only within the framework originally established by market potential.

5. Changes in Potentials. Basic shifts in underlying factors can result in significant changes in avilable markets, market potential and/or penetration potential. Possible examples of such changes are shown in Exhibit VI-6. Thus these three market levels are dynamic rather than static, and can change in response to shifts in the underlying product or market characteristics, as shown in Exhibit VI-7.

6. New Technologies/Products. The possibility (or probability) of shifts in market potential is an extremely important consideration in the introduction of new products and technologies. 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 profitability.

B. Market Potential for the HSPF Concept.

Based upon the objectives of the technical development program, it is assumed that the HSPF unit will be at least as effective as competitive technologies in meeting the non-cost requirements of the early 1980's available market. The relative potential for the HSPF will therefore depend upon its cost comparison with alternative technologies.

1. Cost Sensitivities. Air conditioning systems are evaluated on two basic types of costs -- first-costs and operating costs and a premium-priced product must present compensating advantages (usually operating costs) to be acceptable in the market. This evaluation process for premium equipment is extremely complex--particularly when qualitative factors, such as new technologies, are involved.

   a) First-cost Premiums. The first-cost premium represents the initial or investment cost differential between alternative equipment and systems. It can be based upon equipment value alone, or total installed cost.

   b) Premium/Payback. Although life-cycle costing and other more sophisticated analytical techniques are gaining acceptance, simple payback (or discounted payback) is perhaps the most common method currently in use. This method analyzes the length of time required for operating savings to equal (or payback) the first-cost premium.

   c) Premium/Payback Analysis. The premium/payback curves shown in Exhibit VI-8 were developed from the collective judgment of consulting engineers and contractors in the large-tonnage air conditioning market. The curves represent the acceptability of various first-cost premium and payback period combinations. The curves indicate that lower premiums with longer payback periods are generally more acceptable than very high premiums with shorter payback periods. This reflects the time-value of money, uncertainties with regard to future projections and expected savings, and perhaps limitations in the total amount of investment funds available.

d) Premium/Payback Customers. Exhibit VI-9 combines the cost sensitivities of Exhibit VI-8, with a selected market structure range (percentages of operating cost sensitive customers). This exhibit can be used to estimate the percentage of total customers willing to consider selected premiums and payback periods, for a given market structure of first-cost and non-first-cost (or operating cost) oriented customers. In the 1977 survey, non-first-cost (or operating cost) oriented customers were estimated at 48 percent of the total. The cost sensitivity data has been extrapolated to the 36 and 60 percent levels on a straight-line basis. The data should not be extrapolated beyond these points without further research.

2. Analysis of HSPF Market Potentials - 1981. Exhibits VI-10 and VI-11 show the previously projected available markets for 1981, HSPF market potentials for various premiums and payback periods, the expected HSPF market potential ranges for 1981. The latter are based upon a preliminary evaluation of the most likely premium/payback combination for each equipment-type and size range. The cost of ownership study currently being conducted by CNG should provide some very useful price comparison information to confirm or adjust these assumptions.

a) Expected Premium/Payback Combinations. The shaded blocks in Exhibits VI-10 and VI-11 represent the most likely combinations of premium and payback periods based upon the limited cost information available at this time. Generally the HSPF units are expected to have a 25 to 50 percent premium and 2 to 3 year payback for unitary configurations; and a 10-25 percent premium and 1 to 2 year payback for built-up configurations.

b) Summary HSPF Potential. Exhibit VI-12 summarizes the projected market potential for the HSPF in 1981 based upon the analysis described above.

- The Total Projected Market Potential, at the 48 Percent Customer Level, is 390 to 400 Thousand Tons in 1981. This includes 40 to 50 thousand tons for unitary configurations, 180 to 190 thousand tons for 50 to 200 tons built-up configurations and 150 tp 160 thousand tons for 200 to 400 ton built-up configurations.

- The Total Projected Market Potential, at the 60 Percent Non-First-Cost Customer Level, is 495 to 505 Thousand Tons in 1981. This includes 70 to 80 thousand tons for unitary con-configurations, 230 to 240 thousand tons for 50 to 200 ton built-up configurations and 190 to 200 thousand tons for 200 to 400 ton built-up equipment.

- The Total Projected Market Potential for the 48 to 60 Percent Non-First-Cost Customer Range is 400 to 500 Thousand Tons in 1981. This includes 40 to 80 thousand tons for unitary configurations, 190 to 230 thousand tons for 50 to 200 ton built-up configurations and 160 to 200 thousand tons for 200 to 400 ton built-up configurations.

C. Selected Analytical Tools.

Exhibits VI-13 through VI-17 are provided as possible analytical tools. They can be used to evaluate energy price ratios, the affects of these ratios on comparative equipment performance, operating cost comparisons and the expected results of various alternative courses of action.

1. Projected Energy Price Ratios. Exhibit VI-13 shows projected 1981 electric and gas prices for selected rates of price increase, and five cases of specific price increase combinations. The electric to gas price ratio ($ per million Btu basis) in 1977 is estimated at 4.68. Each of the five price increase cases produces a different 1981 price ratio, ranging from 4.68 to 3.47.

2. Price Ratios and COP. Exhibit VI-14 shows, for each of the five price ratios, a line which indicates the equivalent coefficient of performance (COP) for electric and gas equipment. This can be used to judge the approximate competitiveness of various types of gas and electric equipment based upon their COP and expected energy price ratios. Exhibit VI-15 has a similar purpose, but can be used for a full range of energy price ratios (rather than the five selected cases shown in Exhibit VI-14).

3. Premium and Operating Cost Analysis. The curves in Exhibit VI-16 represent annual operating cost per ton for various equipment COP's and energy rates (based upon 3,000 operating hours per year at 100 percent capacity). This type of chart can be used to do a number of simple analyses:

a) Annual Operating Costs. Annual energy operating costs can be estimated by selecting a particular equipment COP moving vertically (up) to the actual (or expected) energy price and then horizontally to the left-hand (vertical) axis--dollars per ton per year.

b) Equivalent COP. Starting with a particular electrical equipment COP it is possible to determine the equivalent gas equipment COP (to provide equal annual energy costs). To do this, move vertically (up) from the electric COP to the selected electric rate and then horizontally (left) to the actual (or expected) gas rate and vertically (down) to the equivalent gas equipment COP required.

c) Equivalent COP -- Including Premium. Using a method similar to item b) above it is possible to estimate the gas COP required to meet a specific premium/payback requirement. Electric COP and rate, annual dollar savings required to meet payback period requirements and gas rate must be known or assumed. For example: start with an electric COP, move vertically (up) to the electric rate ($.04/Kwh) and then horizontally to the vertical exis to determine annual energy costs ($105). The annual savings required to meet premium/payback requirements ($50) is then subtracted from the annual operating cost ($105-$50=$55) to determine the allowable annual gas cost. Move horizontally from this ($55) to the actual (or expected) gas rate ($3.00/mcf) and then vertically downward to the required gas COP (1.8).

4. Alternative Decision Analysis. At various stages of the program, technical and marketing trade-offs or decisions will be required. Decision-tree analysis as shown in Exhibit VI-17 can be utilized to evaluate, on a probability basis, the expected ramifications of specific technical and marketing decisions on market potential and/or market penetration potentials. This type of analysis can be applied where reasonable estimates can be made regarding the outcomes of specific sequences of events and the probability of each event. In the example, the probability of each even was arbitrarily assigned as 75 percent or 25 percent, and the outcomes for each sequence given values ranging from x to xxxx.

D. The HSPF as Business Venture.

1. Unresolved Issues. A number of key strategic issues, which are central to the potential of the HSPF as a viable business venture, are still unresolved:

   a) Successful Technical Development and Operation of a Large-Tonnage HSPF Unit (components and total unit).

   b) Manufacturing Feasibility -- to Meet Expected Market Requirements in the 1980's (particularly costs, reliability and performance requirements).

   c) Establishment of Suitable Business Agreements with Appropriate Manufacturer(s)/Marketer(s).

   d) The Level and Type of Commercialization Support Expected from the Gas Industry, Government and Other Groups.

   e) The Full Ramifications of Expected Changes in Key External Factors and Market Characteristics (particularly in specific market segments).

2. Revenue/Profit Stream. When the appropriate information is available, the commercial viability of the HSPF should be evaluated on the total potential revenue/profit stream (not just new unit sales). This includes direct equipment sales, maintenance operations (net of contract maintenance and warranty provisions), future expected sales of replacement parts and materials (including replacement units) and the net overall effects on present products, revenues, profits and market/competitive positions.

3. Other Factors. While the HSPF should primarily evaluated on its commercial merits, other factors should be considered, Exhibit VI-18.

   a) Potential Impacts on CNG's and the Gas Industry's Marketing and Business Position.

   b) Potential Impacts on Energy Conservation Efforts (private and public sectors).

   c) Effective/Efficient Utilization of Energy Resources

Exhibit VI-1

HSPF MARKET POTENTIAL

Key Determinants

"Uncontrollable" Factors (Generally Market Given)	"Controllable" Factors (Development Program Can Influence)
- Construction environment	- Perceptions - gas availability, relative prices
- Investment environment	- Retrofit of inefficient equipment (benefits)
- Relative energy prices and availability	- HSPF configurations
- Building codes, construction practices and mandated energy efficiency (building; equipment)	- HSPF performance and features (i.e. reliability)
- First-cost versus operating cost sensitivities Percentage of premium/payback customers Acceptable first-costs and operating costs	- HSPF costs - first-costs; operating costs
- Space conditioning and equipment-use requirements	- HSPF - ease of application design, installation and maintenance (i.e. modular approach)
- Availability of competitive equipment types	- Ability to make good life-cycle cost comparisons between HSPF and other types of equipment
- Basic structure of markets and trade	

Exhibit VI-2

COMPARISON OF AVAILABLE MARKET, MARKET POTENTIAL AND PENETRATION (SALES) POTENTIAL

	Description	Primarily Determined By
Available Market	A given (or actual) total market for a specifically defined function and/or product category	- External Factors · Construction activity · Investment environment - Market Characteristics · Functional patterns · Purchasing patterns
Market Potential	Portion of an available market that could be served by a particular product type	- Market Characteristics · Functional requirements · Economic requirements - Product Characteristics · Features (physical; performance) · Economic (costs)
Penetration (Sales) Potential	Portion of a potential market that is (or is likely to be) actually realized for a given product	- Market Characteristics · Knowledge (awareness) · Acceptance - Product Marketing · Promotion · Distribution

Exhibit VI-3

BASIC PRODUCT LIFE CYCLE CONCEPT

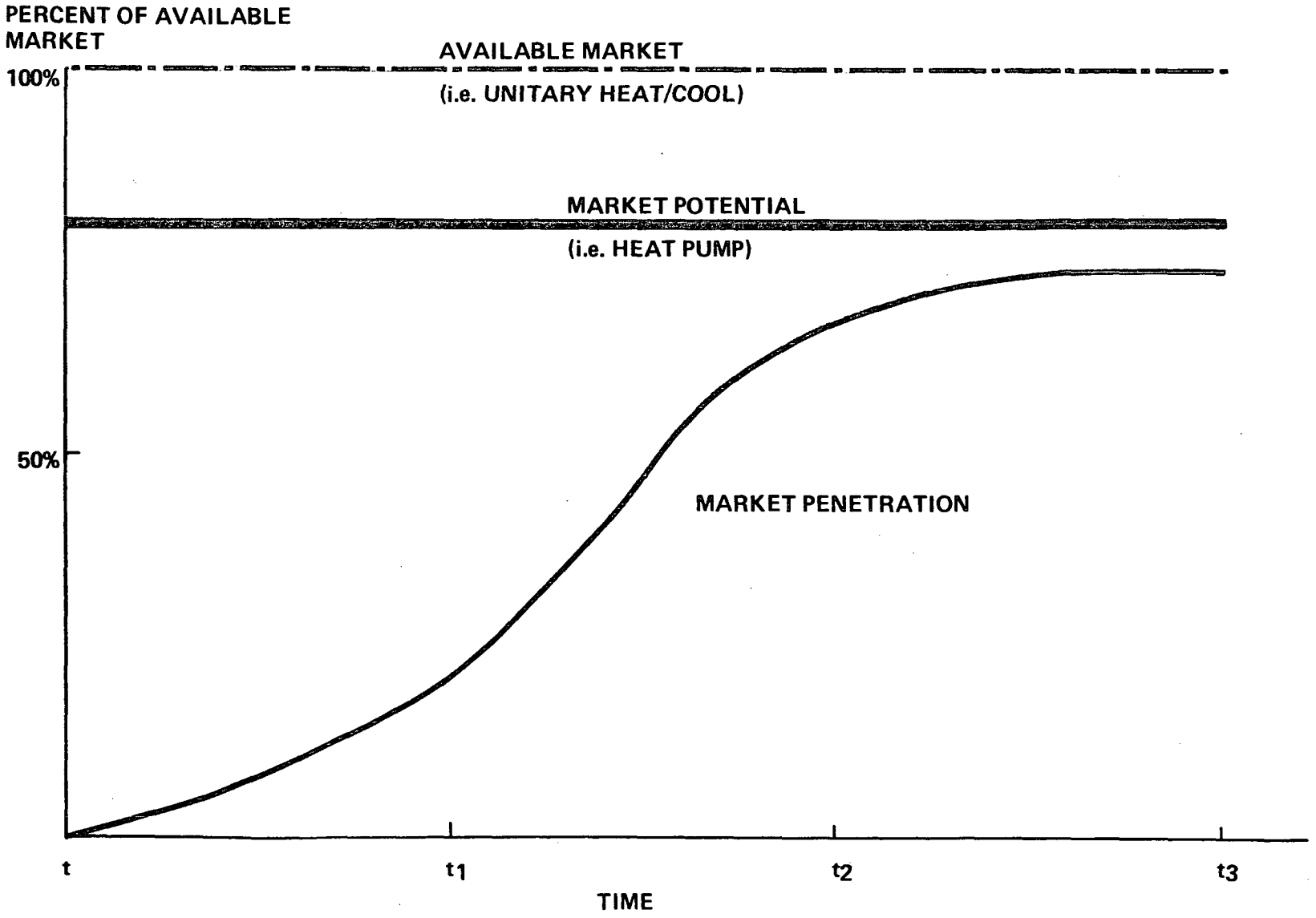


Exhibit VI-4

END-USE MARKETS -- EFFECT ON MARKET POTENTIAL AND MARKET PENETRATION (SALES POTENTIAL) FOR A NEW PRODUCT

Primarily Affect Market Potential

- Functional Use Patterns (segments)
  - Functions required (i. e., heating; cooling)
  - Relative importance (i. e., heat to cool)
- Available Market Sizes
  - Total Market
  - Relevant market segments
- Product Use Characteristics (segments)
  - Physical (size; configuration)
  - Performance (Controlability; zoning; reliability)
- Cost/Quality Sensitivity (segments)
  - Initial or first-costs
  - Operating costs
  - Total owning/operating costs

Primarily Affect Market Penetration (1)

- Innovativeness
  - Actively seek new ideas/approach
  - Willingness to accept new products
- Purchasing Influences/Practices
  - Sources of information
  - Awareness of product and capabilities
  - Reputation of manufacturer-product guarantees; back-up
  - Comparison vs. similar competitive products
  - Ease of purchase, delivery, etc.
  - Service availability

Exhibit VI-5

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 VI-6

POSSIBLE CHANGES IN MARKET POTENTIAL AND PENETRATION DETERMINANTS OVER TIME

Changes/Effects	Possible Examples
- Changes in External Factors	- Level of construction activity - Investment environment - Energy prices and availability - Building and construction standards
• Available market • Impacts on market characteristics	
- Changes in Market Characteristics	- Operating cost sensitivity - Acceptable first-cost premiums - Acceptable premium payback periods - Functional requirements
• Available market • Market potential	
- Changes in Product	- Physical features - Performance - First and operating costs
• Market potential	
- Changes in Product Marketing	- Expanded or more effective distribution - Expanded or more effective promotion - Increased in-use data
• Penetration potential	

Exhibit VI-7

PRODUCT LIFE CYCLE - MARKET WITH VARIABLE STRUCTURAL CHARACTERISTICS

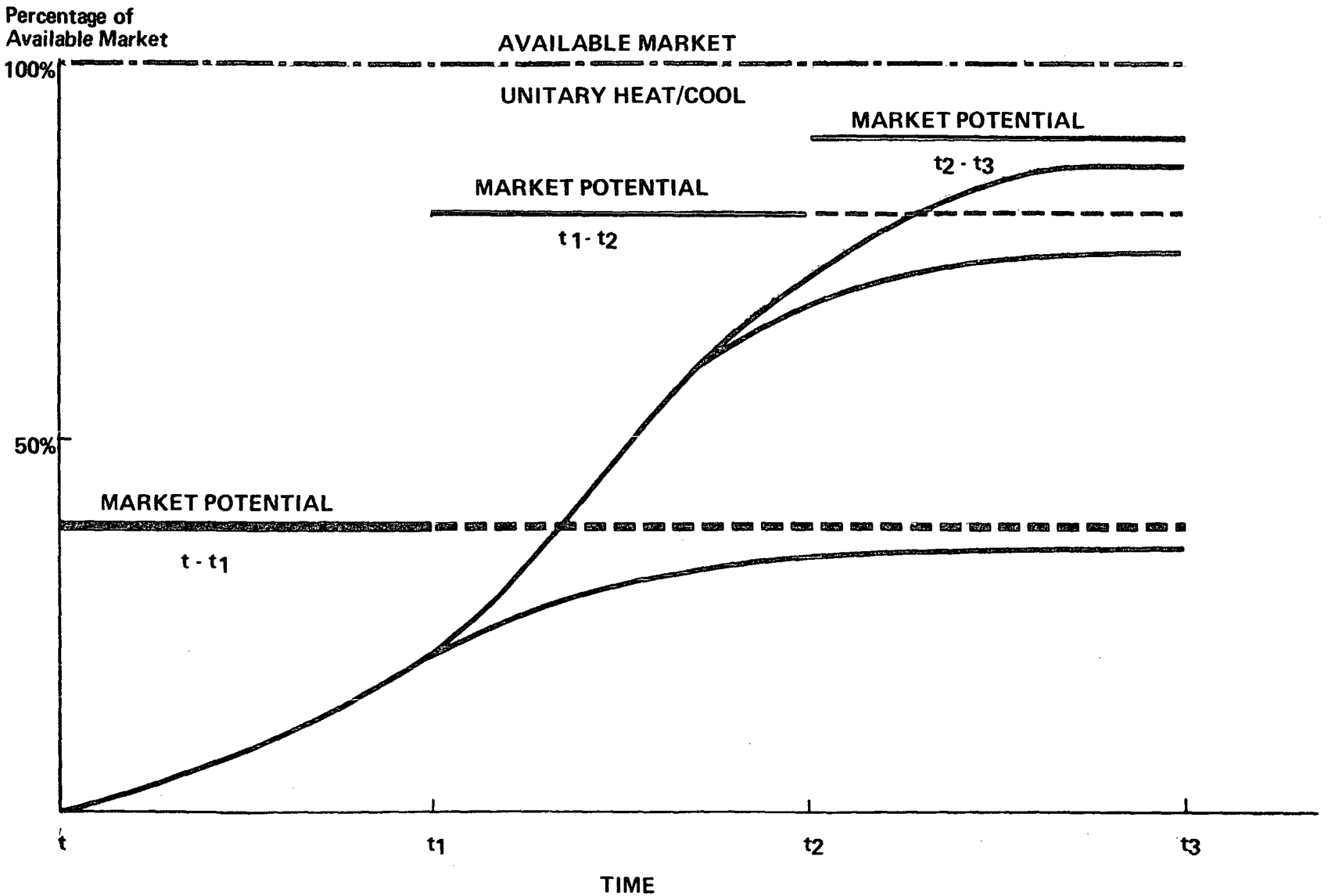
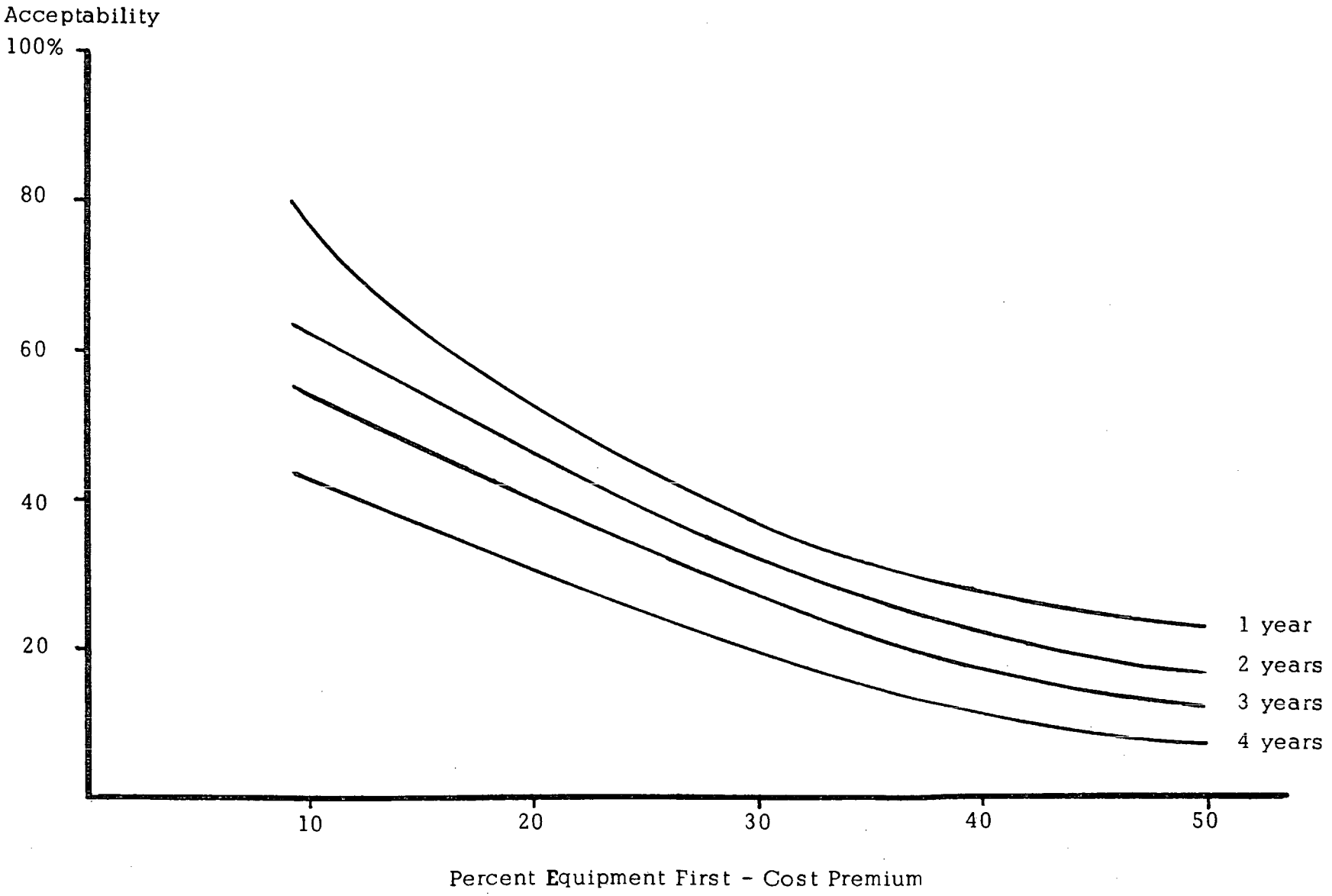


Exhibit VI-8

OPERATING COST SENSITIVITIES - PREMIUM PAYBACK ANALYSIS
1977(1)



(1) Of total large tonnage equipment (unitary; built-up) customers.

ANALYSIS OF MARKET POTENTIALS
PREMIUM/PAYBACK CUSTOMERS - LARGE TONNAGE EQUIPMENT
1977 SURVEY

Exhibit VI-9

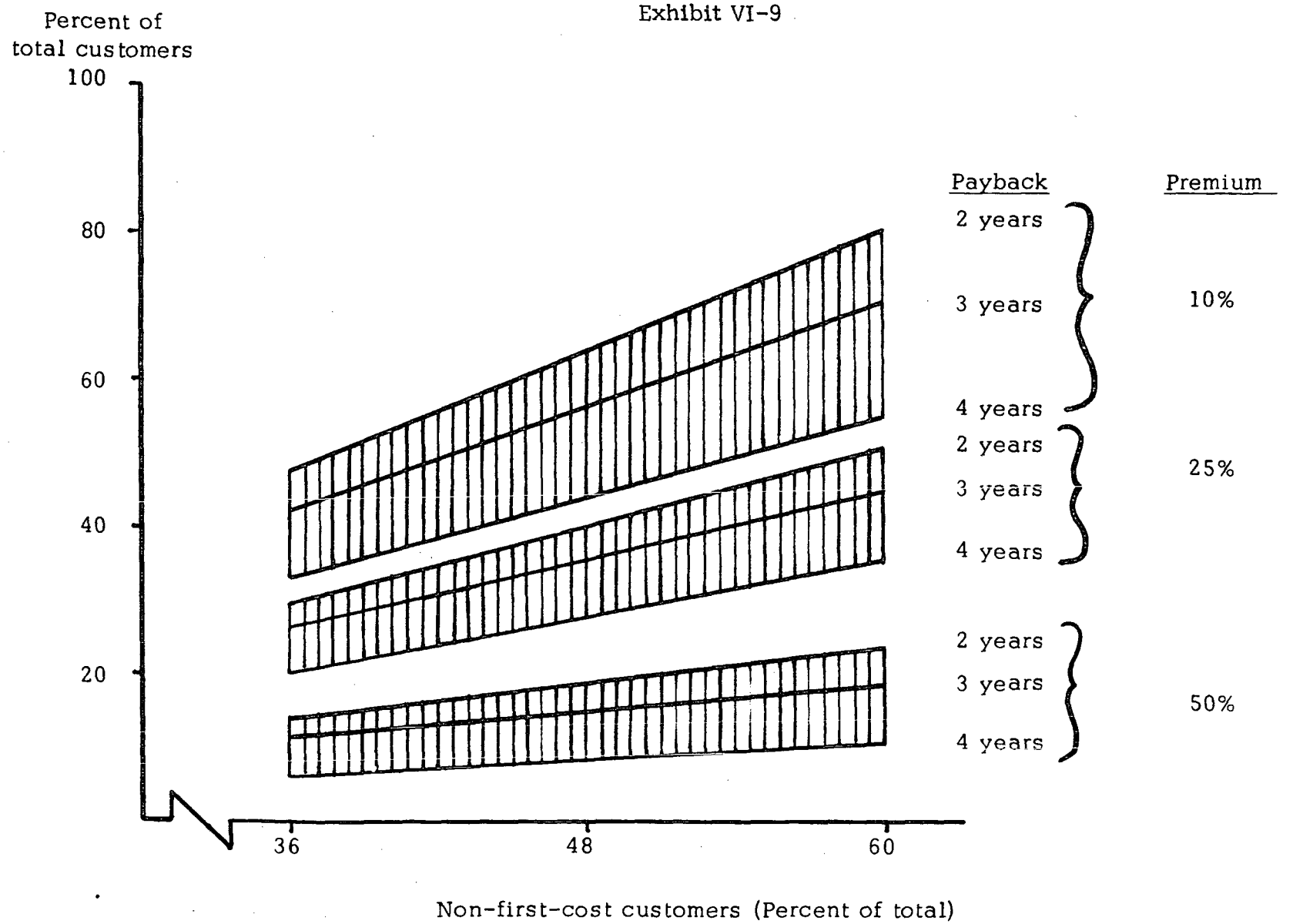


Exhibit VI-10

ANALYSIS OF HSPF MARKET POTENTIAL - 1981 FOR VARIOUS PREMIUM/PAYBACK COMBINATIONS[1][2]

Operating Cost Sensitive Customers = 48%

(Thousands of Tons)

	1981 Available Market	1981 Potential Market HSPF	1st. Cost Premium	Payback Period 1 Yr.	2 Yr.	3 Yr.	4 Yr.
BUILT-UP 200-400 Tons	973.7	390-400					
	363.6	282 - 292	10%	287.2	232.7	203.6	160.0
		151 - 161	25%	167.2	145.4	127.3	101.8
		57 - 67	50%	90.9	69.1	54.5	32.7
BUILT-UP 50-200 Tons	430.2	335 - 345	10%	339.8	275.3	240.9	189.2
		180 - 190	25%	197.9	172.0	150.6	120.4
		68 - 78	50%	107.5	81.7	64.6	38.8
UNITARY 50+ over Tons	179.9	137 - 147	10%	141.8	114.8	100.4	79.0
		72 - 82	25%	82.6	71.7	62.8	50.2
		25 - 35	50%	44.8	34.0	26.9	16.1

(1) Operating cost sensitive customers, 48% of total (1977 survey).
(2) Shading represents what is believed to be the most-likely payback period for a specific premium based upon available data.
Source: William E. Hill & Co., Inc.

William E. Hill & Company, Inc.

Exhibit VI-11

ANALYSIS OF HSPF MARKET POTENTIAL - 1981 FOR VARIOUS PREMIUM/PAYBACK COMBINATIONS[1][2]

Operating Cost Sensitive Customers = 60%

(Thousands of Tons)

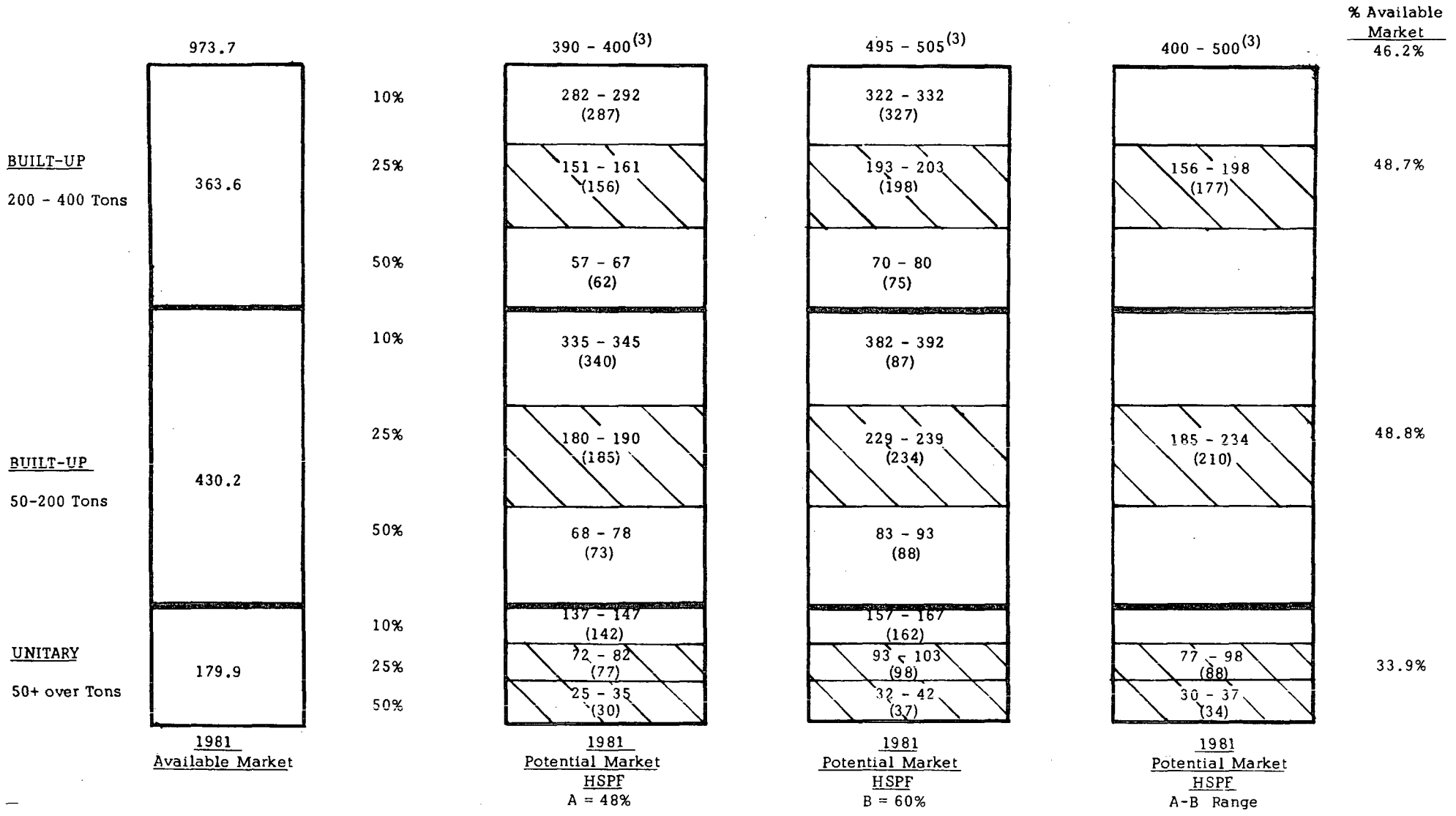
	1981 Available Market	1981 Potential Market HSPF	1st Cost Premium	Payback Period: 1 Yr.	2 Yr.	3 Yr.	4 Yr.
BUILT-UP 200-400 Tons	973.7	495 - 505					
	363.6	322 - 332	10%	327.2	290.9	254.5	200.0
		193 - 203	25%	210.9	185.4	160.0	123.6
		70 - 80	50%	116.4	83.6	65.4	40.0
BUILT-UP 50-200 Tons	430.2	382 - 392	10%	387.2	344.2	301.1	336.6
		229 - 239	25%	249.5	219.4	189.3	146.3
		83 - 93	50%	137.7	98.9	77.4	47.3
UNITARY 50+ over Tons	179.9	157 - 167	10%	161.9	143.9	125.9	98.9
		93 - 103	25%	104.3	91.7	79.2	61.2
		32 - 42	50%	57.6	41.4	32.4	19.8

(1) Operating cost sensitive customers 60% of total (projected from 1977 survey).
(2) Shading represents what is believed to be the most-likely payback period for a specific premium based upon available data.
Source: William E. Hill & Co., Inc.

Exhibit VI-12

SUMMARY ANALYSIS OF HSPF MARKET POTENTIAL - 1981 FOR SELECTED LEVELS OF OPERATING COST SENSITIVE CUSTOMERS (1)(2)

(Thousands of Tons)



(1) Two cases: Operating cost sensitive customers as a percent of total customers - 48% and 60%
(2) Summary of previous detail charts, selecting the percentage premiums thought to be most likely at this date.
(3) Based upon mid-points of ranges.
Source: William E. Hill & Co., Inc.

Exhibit VI-13

PROJECTED COMMERCIAL ENERGY PRICES (1)

	Estimated 1977 Avg.	1981 Price at Selected AAROG				
		8%	10%	12%	15%	20%
Electric						
¢/KWH	3.03¢	4.10¢	4.44¢	4.77¢	5.30¢	6.28¢
$/MM BTU	$ 8.80	$ 12.02	$13.01	$13.98	$15.53	$18.40
Gas						
$/MM BTU	$1.88	$ 2.56	$ 2.75	$ 2.96	$ 3.29	$ 3.90

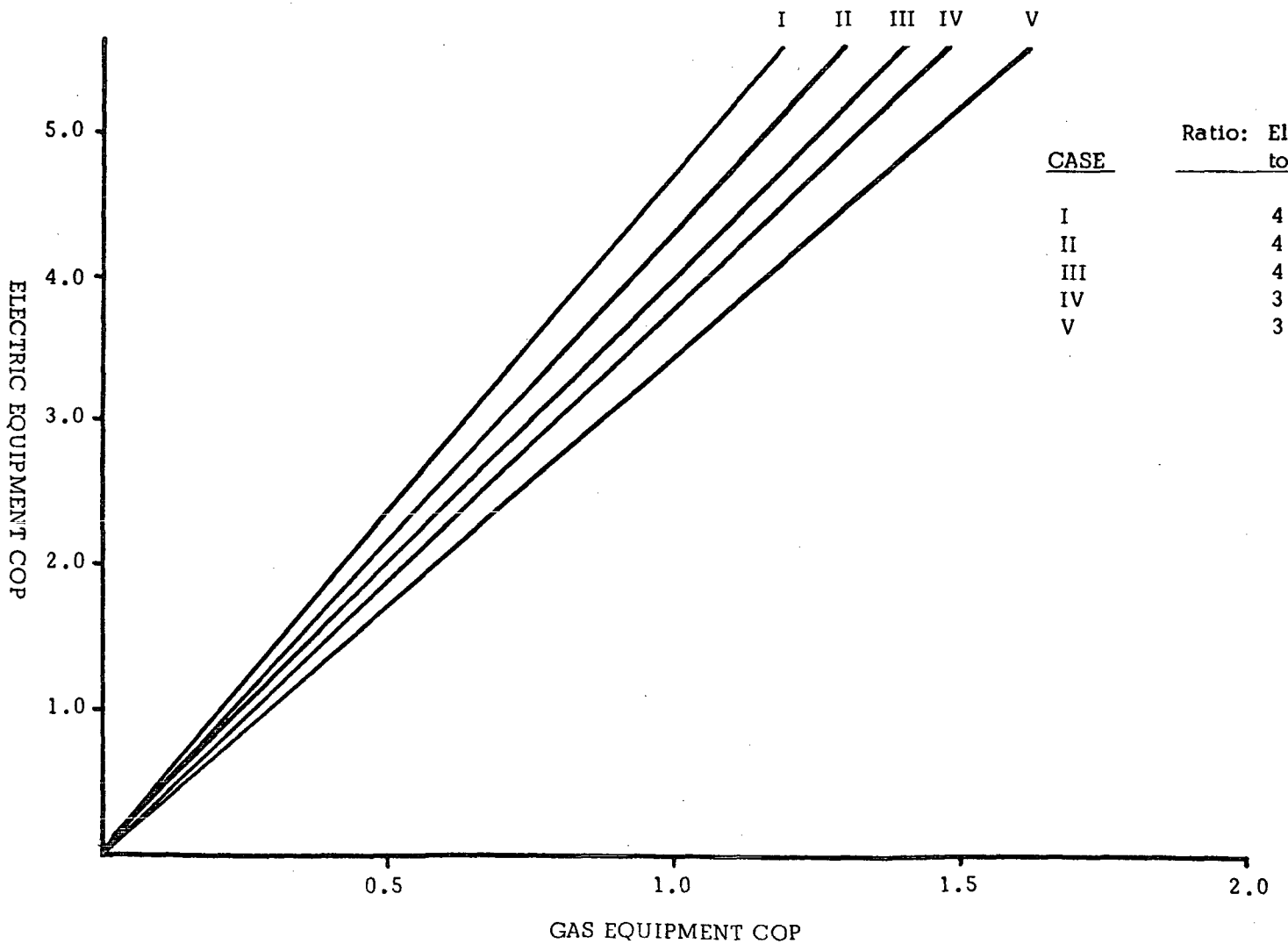
SELECTED GROWTH RATE COMBINATIONS

CASE	Ratio 1977 (2)	AAROG 1977 - 1981 Electricity Price	AAROG 1977 - 1981 Gas Price	Ratio 1981 (3)
I	4.68	increase at same rate		4.68
II	4.68	10-12%	12-15%	4.32
III	4.68	8-10	12-15	4.01
IV	4.68	10-12	15-20	3.75
V	4.68	8-10	15-20	3.47

(1) William E. Hill & Co., Inc. projections based upon Edison Institute and AGA data.
(2) Ratio of electric to gas price.
(3) Ratio of electric to gas price, based upon midpoints of projected ranges.

Exhibit VI-14

ANALYSIS OF SELECTED ENERGY PRICE RATIOS AND EQUIVALENT EQUIPMENT COPS (1)



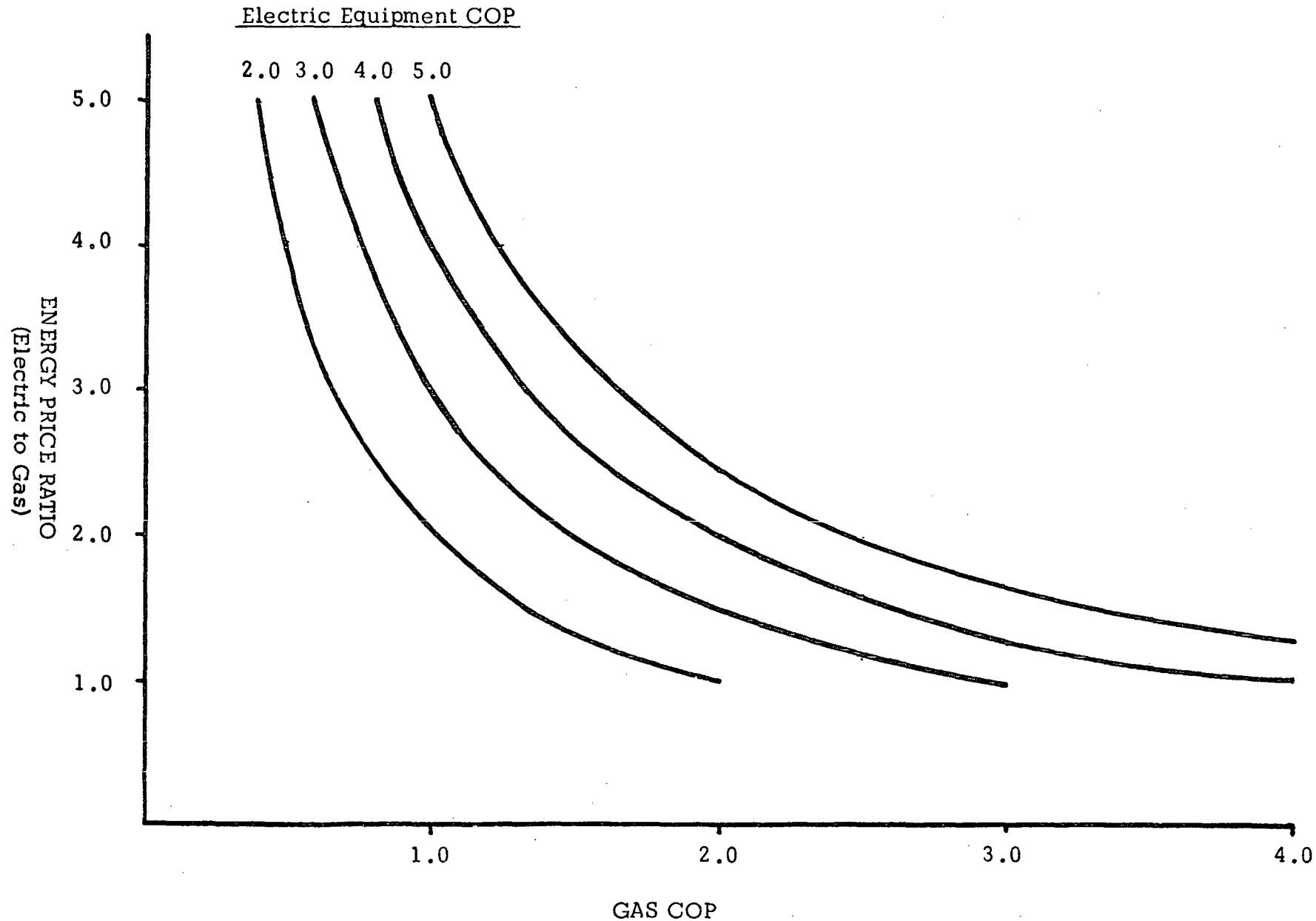
CASE	Ratio: Electric Price to gas price.
I	4.68
II	4.32
III	4.01
IV	3.75
V	3.47

(1) Indicates required gas equipment COPS to provide equivalent cost for selected electric equipment COPS and energy price ratios.

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

ANALYSIS OF ENERGY PRICE RATIOS AND EQUIVALENT EQUIPMENT COPS (1)

Exhibit VI-15

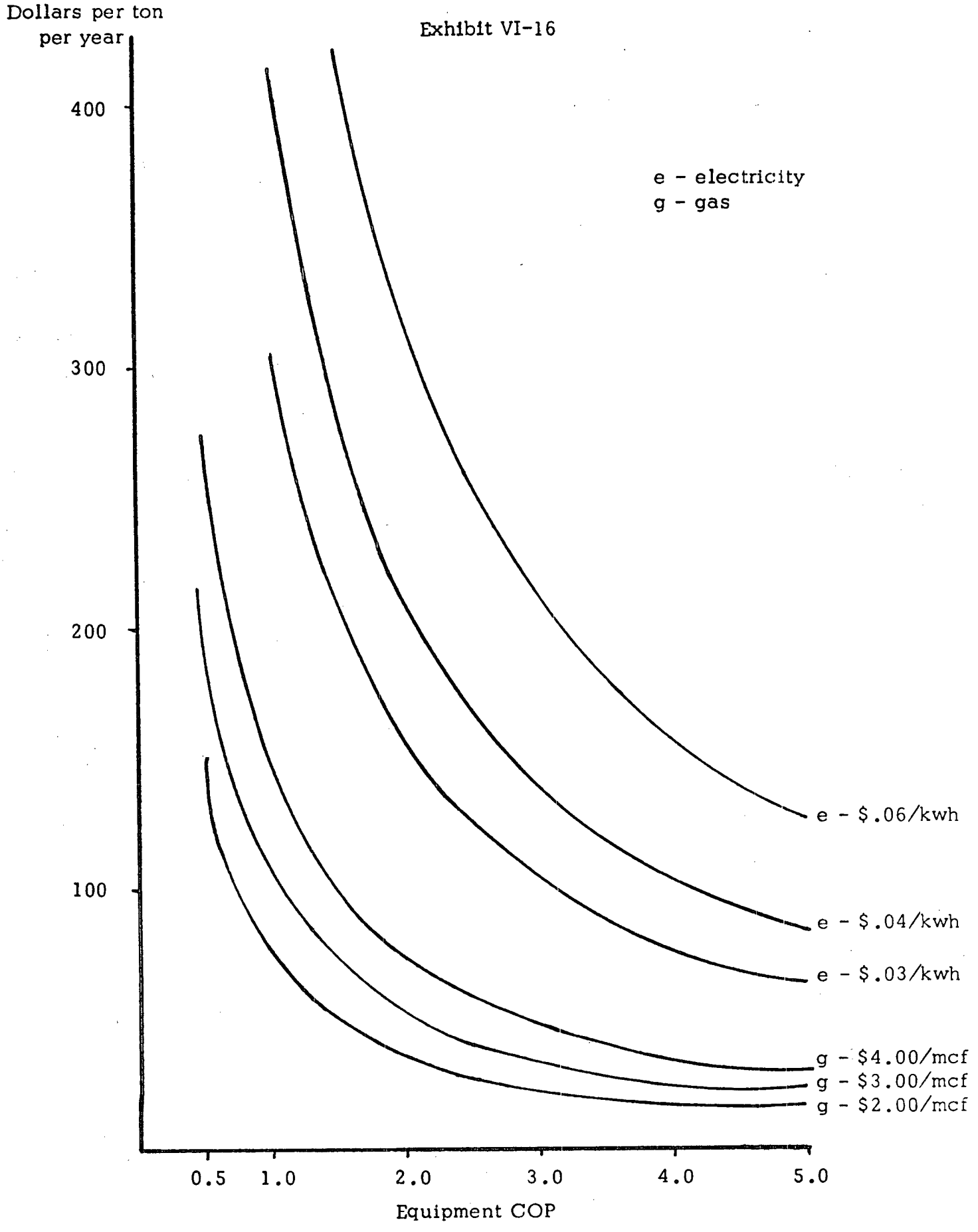


(1) Indicates required gas equipment COPS to provide equivalent for selected energy price ratios and electric equipment COPS.

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

ANNUAL OPERATING COST (1) PER TON FOR VARIOUS EQUIPMENT COP'S AND ENERGY RATES

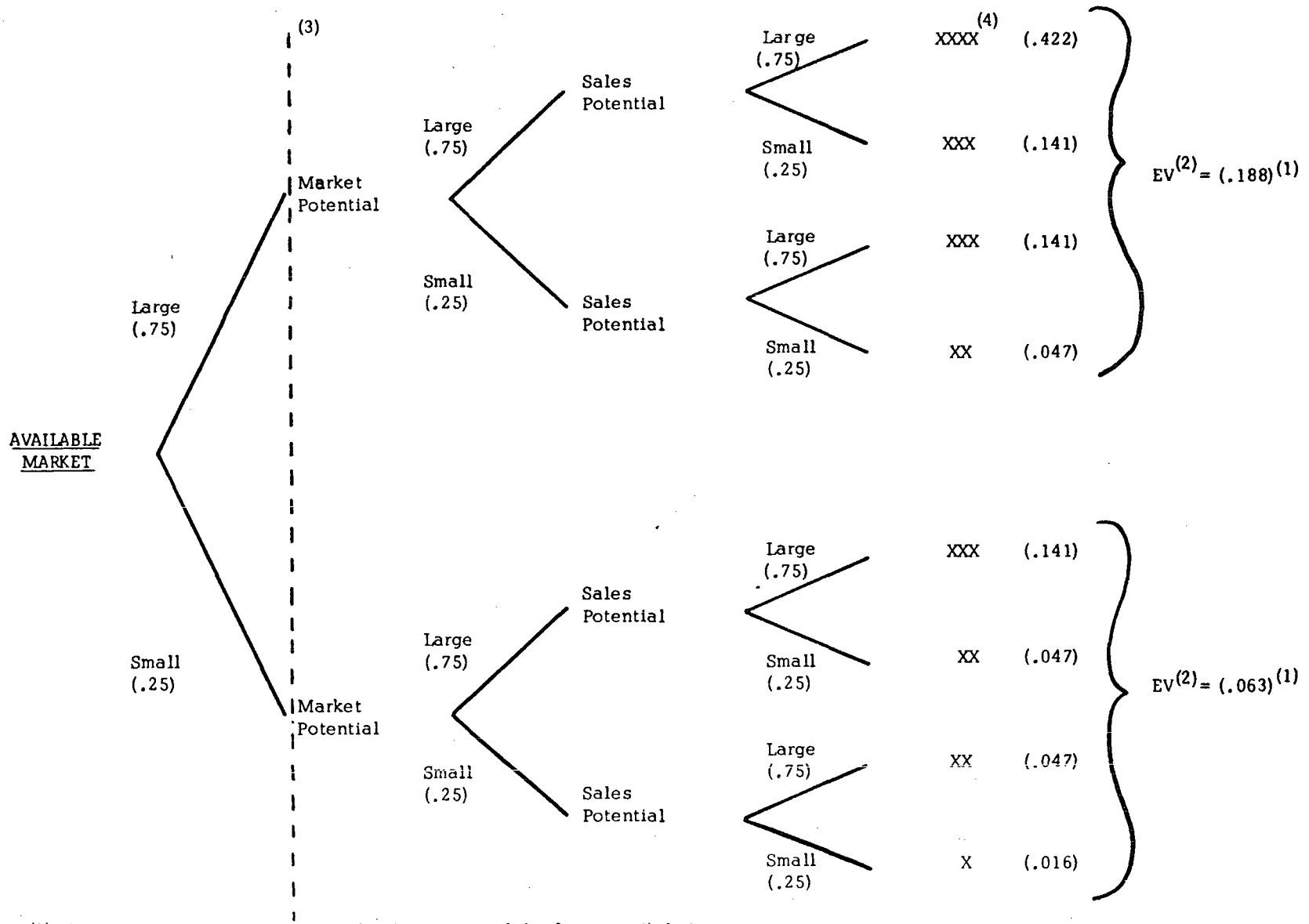
Exhibit VI-16



(1) Based upon 3,000 operating hours per year; 100% capacity.

Exhibit VI-17

DECISION - TREE DIAGRAM SHOWING POSSIBLE COMBINATIONS OF AVAILABLE MARKETS, POTENTIAL MARKETS AND SALES POTENTIALS
BASIC CONCEPT - EXAMPLE



(1) Assuming an equal probability (.25) for each of the four possibilities.
(2) Expected value (for this example) which indicates the comparative sales penetration potential (assuming 25% probability for each path).
NOTE: In this example the expected values do not represent percentage potential of available market since available market is not stated (given).
(3) If an available market size is stated, the EV calculated from this point is a percentage potential of the available market.
(4) Indication of relative sales level.

William E. Hill & Company, Inc.

Exhibit VI-18

HSPF AS A BUSINESS VENTURE
KEY EVALUATION CONSIDERATIONS

-CNG

- Conservation; efficient use of gas
- Product innovation -- improve position in large tonnage market
- Licensing revenues
- Gas sales

-Gas Industry

- Conservation; efficient use of gas
- Product innovation; improve position in large tonnage market
- Gas sales

-Equipment Manufacturer

- Competitive advantage -- efficient new product; market position
- Net incremental revenue and profit -- after adjusting for cannibalization of present businesses
- Potential to expand total market, i.e. energy retrofit based upon demonstrable benefits

-Federal Government

- Promotion of energy conservation
- Effective and efficient use of energy resources

VII. COMMERCIALIZATION PERSPECTIVES

The projected market potentials for the HSPF are based upon a number of assumptions concerning key external and industry trends, and the expected characteristics of large-tonnage space conditioning markets in the 1980's. The important distinctions between available market, market potential, and market penetration (or sales potential) and the key determining factors for each, were discussed in the previous section. It is appropriate at this point to highlight some of the factors that will affect the market potential of the HSPF unit.

A. Factors That Will Affect the Market Potential of the HSPF Unit.

As stated previously, market potential is affected by the size of the available market, key market characteristics and the features of the HSPF itself.

1. Equipment-use Patterns Related to Built-up and Large-tonnage Unitary Equipment. Certain trends in equipment-use patterns were considered in projecting the HSPF market potential. Unforseen dramatic shifts in these patterns could affect the available market for large-tonnage unitary and 50 to 400 ton built-up equipment.

2. Key External Factors Affecting Market Characteristics with Respect to Investment Criteria and Operating Requirements. Changes in these factors affect the size of the available market and the acceptability of various specific product types and equipment features.

3. Premium/payback Sensitivities and Market Concerns Regarding First-costs and Operating Costs. The acceptability of premium payback situations and specific levels of premiums and payback periods, are among the most important determinants of the market potential for the HSPF. Although general trends has been identified and incorporated in the HSPF market potential, this is a complex decision variable that can be affected by a number of external and market factors.

4. The Degree to Which the HSPF Concept Meets the Projected Requirements of the Selected Markets in the 1980's. Products features other than costs will have an important impact upon market potential. Such features as physical dimensions, keep control, zoning and other capabilities; reliability; ease of maintenance; and system flexibility are also of considerable importance.

5. The Amount of Potential Energy Savings Available to the HSPF. Simple system modifications and improved building efficiencies could preempt the energy efficiencies that the HSPF is expected to achieve. This could also reduce the total energy costs and the potential HSPF dollar savings below the amount required to recoup its first-cost premium.

B. Factors That Will Affect the Sales Potential of the HSPF Unit.

Sales potential is primarily determined by the extent of market coverage, the effectiveness of the overall marketing program and actual market acceptance of the product concept.

1. The Effectiveness of the Selected Marketer(s) in Terms of Market Coverage and Market Development. The choice of equipment marketer(s) may be the single most important marketing decision, and one which will influence all phases of the marketing plan, and ultimately, the rate and level of market penetration.

   a) Numbers. 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.

b) Size. 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. A small company marketer, on the other hand, may not have resources and/or market position to effectively market such a sophisticated new technology.

c) Competitive Position. 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. This is particularly important in the built-up equipment market where a limited number of participants have a very strong market position.

2. Competing Equipment in the 1980's. In addition to currently available equipment, new (as well as previously discarded) technologies are being investigated, which could impact the space conditioning market and compete with the HSPF unit. Among these developments are high-efficiency furnaces and air conditioners, other gas heat pumps, solar and heat reclaimation systems, and advanced electric heat pumps. The market potential for the HSPF concept might have to be shared with other energy-efficient devices.

3. Market Perceptions of Relative Energy Costs, Energy Availability and Acceptability of New Products. Many users, designers, installers and manufacturers of space conditioning equipment have experienced rapidly increasing energy prices and gas supply limitations which have affected equipment choices. Generally, the willingness to consider new product concepts has increased in the last few years, but the trade and potential customers must be provided with realistic energy price comparisons and assured of future gas availability -- for their particular applications.

4. Extreme Importance of Reliability/Maintainability. Reliability and ease of maintenance are often the most important non-cost equipment selection factors. The introduction of new technologies requires extensive efforts to demonstrate reliability and ensure the availability of maintenance service.

5. Degree and Type of Support Provided by the Gas Industry, Federal Government and Others. Although the desirable specific support from the gas industry, federal government and others has not been addressed at this point, the activities of these groups will be important in the successful commercialization of the HSPF unit. Utilities could provide marketing support, technical assistance and assurance of gas availability. Government 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, equipment selection processes and the acceptability of specific technologies.

6. Trade Acceptance. To achieve optimal market share, the HSPF unit must gain the acceptance of the air conditioning trade -- particularly with respect to design and installation. The unique features of the technology will require significant technical and design support, and due consideration should be given to efforts to simplify the requirements for the design, bidding and installation of a system using HSPF units.

C. Key Technical and Business Decisions Required in Development Program.

A number of key technical and business decisions will be required as the development program approaches the commercialization stage. The timing and sequencing of these decisions must be considered in advance to insure the proper coordination of the technical and marketing aspects of the program.

1. Selection of Equipment Configurations and Initial Sizes. Although it is not desirable to attempt the introduction of too many models initially, the product line should be sufficiently

broad so as not to restrict overall acceptability in the marketplace. The initial product line should be limited to the configurations and sizes that provide the greatest design and applications flexibility, and the largest, most readily attainable market potential. Other configurations and sizes can be added at a later date as required.

2. Degree of Component Modularization and Flexibility of Design/Assembly/Installation. Applications flexibility is an important consideration, and careful thought should be given to the appropriate modularization of components to provide maximum ease of design, installation and field maintenance. This approach might also result in certain manufacturing efficiencies and cost reductions.

3. Possible First-cost/Performance (operating cost) Design Trade-offs. At various stages of the equipment design, testing and commercial introduction process, cost/performance trade-offs may be required. In addition to the purely technical considerations, market characteristics, and the affects of these trade-offs on market potential should be included in the decision process.

4. Selection of Equipment Marketer(s), Business Relationships and Overall Marketing Strategies. As stated previously, the selection of equipment marketer(s) is perhaps the most important business/marketing decision. This will require decisions as to the business relationships acceptable to CNG, the development of overall marketing strategies and the preparation of basic venture plans -- prior to approaching prospective marketers. There are a limited number of potential marketers in the built-up and large-tonnage unitary markets, and a well-developed approach strategy is essential.

5. Thorough Field-testing and Collection of Actual In-use Operating Data. The availability of well-documented field test data will be an important factor in the acceptance of operating performance claims, and an important marketing tool for product introduction. Considerable attention should be given to the selection of test situations that are reflective of the functional requirements of high potential markets.

D. Overall Control and Planning of Product Development and Commercialization.

As the HSPF program approaches the crucial stages of technical development, field testing and market introduction, comprehensive planning and coordination will be required to assure the proper flow of information and activities. Many of the following items may be included in the present plan, but are listed here for completeness.

1. Technical Product Development and Testing. In addition to the direct interaction of these activities, information on technical specifications and operating performance are crucial inputs to market potential analyses, the evaluation of alternative marketing strategies and the development of the basic venture plan.

2. Market Analysis and Product Introduction Planning. The analysis of key market trends and the evaluation of specific market segments, are basic inputs for strategy evaluations and the development of market development plans. They should also provide guidance for technical product development and field testing.

3. HSPF Concept/Potentials Presentation and Promotional Program. At some point, it will be necessary to prepare and implement a program to acquaint potential marketers, the gas industry, trade groups and others with the HSPF product concept, market potentials, and the basic marketing strategies. The timing of this program is crucial, as it must present a reasonably well-defined (soon to be available) product and yet; provide sufficient time to incorporate constructive suggestions into the program and allow these key groups to determine and implement their support programs.

4. Development of Basic Business Strategies and a Preliminary Business Plan. There is an important interdependence between the technical-related and marketing-related aspects of the development program. The early development of alternate business strategies and a preliminary business plan can provide guidance to technical efforts and focus attention on the key commercialization and market development issues. These items will also be required for negotiations with prospective marketers and presenting the HSPF concept to other selected groups as mentioned above.