NEW JERSEY RESIDENTIAL HVAC BASELINE STUDY

Prepared for

New Jersey Residential HVAC Working Group
Morristown, NJ

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E

EXECUTIVE SUMMARY

The Executive Summary for the New Jersey Residential HVAC Baseline Study presents the objectives, methods and key results from the full research project. The baseline study project was conducted for the New Jersey Residential HVAC Working Group (the Working Group) by a team of organizations lead by XENERGY, Inc.

E.1 STUDY OBJECTIVES AND METHODS

This baseline study assesses key markets and market participant practices for HVAC equipment in existing New Jersey homes and also includes a technical assessment of installed equipment characteristics. The research presents findings on the size and structure of the residential HVAC market, provides insight into HVAC product performance and reliability, and identifies barriers to adoption of energy efficient HVAC equipment and installation practices. The Study's objectives were to:

- Develop information on how the New Jersey market for residential HVAC equipment functions. The Working Group will use this information to refine the existing programs that promote the adoption of energy efficient equipment and installation practices.
- On the supply side of the market: identify key sets of actors in the market and characterize barriers to the promotion of efficient equipment and installation practices. Characterize supply-side actors' motivations to promote and install efficient equipment.
- On the demand side of the market: identify key customer segments and estimate their size. Characterize the barriers customers face to purchasing efficient equipment and installation services. Identify potential motivations that can be tapped to increase demand for cost-effective, energy-efficient equipment.

The XENERGY team for this study included Easton Consultants (Easton), Atlantic Market Research (AMR), Honeywell DMC (Honeywell) and Advanced Energy Corporation (AEC). To accomplish these objectives, the study team carried out the research and analysis tasks summarized in Table E-1.

Table E-1
Research and Analysis Activities

Target Population	Survey Type	Sample Size	Analytical Objective and Study Contractor
Recent residential HVAC purchasers (random sample)	Screening calls	816	Assess awareness and purchase of efficient HVAC (AMR).
	Complete Interviews	170	Characterize experience with contractors (XENERGY). Identify barriers to purchase of efficient equipment (XENERGY).
	On-site surveys	70	Estimate market penetration of efficient equipment and efficient installation / maintenance practices (AMR, Honeywell, AEC, XENERGY)
Contractors (random sample)	In-depth interview	30	Characterize contractor efforts to sell and install efficient equipment (XENERGY). Identify barriers deterring contractors from marketing efficiency. Assess utility program impacts on installation and marketing practices.
Manufacturers/ Distributors (non-random sample)	In-depth telephone	13 mfg 16 dist	Estimate state-wide market share of efficient equipment (Easton). Characterize national efforts to promote efficient equipment.

E.2 KEY FINDINGS

E.2.1 Market Size and Segmentation: Customers

Annual purchases of HVAC equipment. XENERGY's project team contacted sample of 816 New Jersey owner-occupied households to identify a sufficient number of recent HVAC purchasers for the study. Of this total, 170 or 21 percent reported purchasing a central air conditioner, heat pump, gas furnace, or gas boiler for use in an existing home within the period covered by the study (1998-2000). These respondents made a total of 217 equipment purchases during this period.

Table E-2 shows the estimated annual percentage of households that purchased HVAC equipment for existing homes and the annual number of units purchased. Drawing on sample results for number of equipment purchases (from Table 2-4), these data provide estimates for only a portion of the HVAC market. The results refer to the owner-occupied housing share of the HVAC market, due in part to the fact that renters do not typically purchase HVAC equipment since the landlord actually owns and maintains the property. In addition, this study underestimates the "total" HVAC target market because it only includes existing buildings and excludes new construction completed during the last three years of the study period. Thus, the size of the HVAC (i.e. central air conditioning, heat pump, gas furnace and gas boiler) homeowner market for existing homes within the past 3 years is about 178,000 units per year.

Table E-2
Estimated Annual Volume of HVAC Purchases for Existing Homes

	Percent of Owner-occupied Households Purchasing	Number of Units Purchased
Central AC	4.21%	84,683
Heat Pump	0.78%	15,689
Gas Furnace	2.82%	56,724
Gas Boiler	1.06%	21,322
Total		178,418

Source: based on 2,011,473 owner-occupied housing units, New Jersey 2000 (Table DP-1, U.S. Census Bureau, Census 2000)

Reasons for purchase. Table E-3 shows that, overall, 61 percent of the survey respondents indicated that the unit was installed to replace an existing unit in their homes[1]. Half of the central air conditioner and heat pump purchasers reported that they bought their units as replacements. The other half reported buying units for other reasons, mainly to improve economics or amenities, which reflects the discretionary nature of central air conditioning in cooler climates. A lower percentage of furnace (26%) and boiler (17%) purchases were for economics or comfort. For gas furnaces, 43 percent of the replacement purchases (or 32% of all purchases) were due to failure. The portion of all units purchased that was for replacing failed equipment ranged from 30 percent for air conditioners to 62 percent for boilers.

E.2.2 Market Size and Segmentation: Contractors

Based on the survey results and the sample stratification structure, Table E-4 shows an estimate of how the population of 2,532 HVAC contractors in New Jersey is distributed within four market activity size categories and the corresponding average number of employees. Estimates are also given for the average number of homes served and corresponding market share, expressed as a percentage of total homes served in the particular existing or new home market type shown. This table shows that the residential HVAC installation and service market is somewhat concentrated in terms of homes served. The top 39 firms (less than 2 percent of the total) account for 28 percent of total annual installations and 28 percent of all projects in existing homes. Moreover, there are nearly 1,400 HVAC contracting firms in New Jersey with five or fewer employees. These companies serve an average of 24 homes per year and account for only 10 percent of total installations.

[1] *Note:* Where appropriate, the "Overall" or "All Firms" column of several tables in this chapter include information on the confidence intervals for sample means. In these cases, a "±" interval value is included in parentheses following the mean estimate. This is the amount to be subtracted from or added to the sample means to produce the lower and upper bounds of the 90% confidence interval for the mean. For example, in Table E-3, the average number of respondents reporting replacement as a reason for HVAC purchases is 61% (±6%) at the 90 percent confidence level.)

Table E-3
Reasons for HVAC Purchases in Existing Homes by Equipment Type

	Type of Equipment			Overall (± 90% CI)
	Central AC & Heat Pump	Gas Furnace	Gas Boiler	
Replacement	50%	74%	83%	61% (± 6%)
Better comfort or economics	49%	26%	17%	38% (± 6%)
Don't Know	1%	0%	0%	1% (± 1%)
Number of observations	100	47	23	170
Percent of replacements due to failed unit	60%	43%	63%	55% (± 8%)

Table E-4
Volume of Contractor Installation Activity by Size Category

	Market Activity (number of homes served / year)				
	Smallest	Small	Medium	Large Firms	All Firms
Maximum Installations/Year	38	200	550	2,250	N/A
Population Information					
Number of firms	1,343	1,026	124	39	2,532
Average number of employees	4	9	19	78	30(±17)
Installation Volume: New and Existing Homes					
Average number of homes served	24	147	358	2,210	748 (±484)
Average Market Share	10%	48%	14%	28%	100%
Installation Volume: Existing Homes Only					
Average number of homes served	23	121	347	1,928	661
Average Market Share	11%	45%	16%	28%	100%

The figures only include HVAC equipment installations (gas boilers, furnaces, etc.) and do not include service-only jobs.

E.2.3 Market Share of Energy-Efficient Equipment and Installation Practices

The market share of high efficiency residential HVAC equipment in New Jersey is slightly higher than the national average.

Table E-5 summarizes the results of three different inquiries into the market share of high-efficiency HVAC equipment. The results of the on-site survey were developed from direct observation of nameplate efficiencies in a sample of homes. Contractors and manufacturers reported the market shares for their individual firms, without the benefit of reference to records. Because manufacturers sometimes reported their high efficiency sales share results with all equipment groups lumped together, definitive averages could not be calculated for each equipment type.

- ***Central Air Conditioners and Heat Pumps.*** Twenty-eight percent of the air conditioners and heat pumps observed on-site met program standards (SEER 13 and 14), compared to an estimated 20 percent national market penetration for SEER 12 and higher. Sixty percent of the high-efficiency models observed in New Jersey met the Tier 2 standards (SEER 14). Contractors appear to have significantly over-reported the market share of program-qualifying equipment.
- ***Gas Furnaces.*** Fifty two percent of heating systems in the on-site sample were gas fired furnaces. Twenty-seven percent of the gas furnaces observed in the on-site met program standards versus about 30 percent reported nationwide. Again, contractors appear to have over-reported the market share of efficient equipment.
- ***Gas Boilers.*** Seventeen percent of all heating systems observed on-site were gas boilers. None of the boilers met program efficiency standards of 85 percent efficiency.

Table E-5
Market Share of Efficient Equipment

Type of Equipment	Standard	On-site	Contractor Survey	Manufacturers (US)
Central AC/Heat Pumps	Tier 1: SEER 13	11%	18%	~20%* for SEER 12 and greater
	Tier 2: SEER 14	17%	34%	
Gas Furnaces	AFUE 90 or greater	27%	42%	~30%
Gas Boilers	AFUE 85 or greater	0%	18%	<10%

*Includes 12 SEER and higher—manufacturer definition of high-efficiency HVAC. Manufacturers sometimes reported high efficiency sales share results with all equipment groups lumped together so definitive averages could not be calculated for each equipment type.

The on-site surveys identified patterns of equipment over-sizing and problems in duct installation. A summary of the key findings is presented in Table E-6. Overall, the analysis showed that the conditions of the HVAC equipment are well within the ranges found in other similar studies, with the exception of equipment sizing for cooling.

- ***Cooling equipment sizing.*** Cooling equipment capacity exceeded total cooling load in all but fourteen of the homes in the on-site sample. On average, systems were oversized by

23 percent when compared to Manual J load calculations[2]. The average equipment cooling capacity is 0.37 tons greater than the Manual J determined capacity[3]. Interestingly, this average oversizing is considerably less than results from other similar studies for New Jersey that showed an oversizing of approximately 65 percent compared to Manual J. The cooling capacity in this previous study found that systems were oversized an average of 1.6 tons greater than the Manual J determined capacity. This new finding may be directly related to the age of the cooling systems studied in this project, which were less than 3 years old. This result suggests that the industry is sizing cooling systems more accurately now than in the past.

- ***Heating equipment sizing.*** Allowing a "safety margin" of 25 percent, the heating equipment in 93 percent of the sample homes was oversized. On average, systems capacity exceeded estimated heating load by 100 percent. Contractors are likely to have a bias toward over sizing heating equipment because they do not want to face customer complaints of insufficient heat during cold weather. Interestingly, surveyed contractors (especially large firms) indicated that they changed their sizing practices as a result of participation in the NJ HVAC program.
- ***Airflow over cooling coils.*** Thirty percent of measured airflows over cooling coils were within manufacture recommendation of 350 to 450 cfm per ton. Fifty three percent of measured airflows were less than the manufactures recommendation of 350cfm per ton.
- ***Duct sealing and insulation.*** Duct leakage data analysis for this study estimated an average outdoor air leakage rate of 329 CFM_{25}. On average, the outdoor air leakage airflow is 34 percent of supply airflow. The average total duct leakage measured is 608 CFM_{25} with 38 percent of all systems having a leakage greater than 608 CFM_{25}. Only eight percent of ducts had an attempt made to stop leaks. Duct tape was used for these systems.

  The greatest impact of poor duct insulation occurs when the ducts are in unconditioned spaces like attics, crawl spaces, and basements. For the houses analyzed (n=56), eighty nine percent had a significant portion of the duct distribution in unconditioned spaces. Of these homes, 46 percent had no insulation on ducts. Thirty-two percent of the homes had the program-prescribed level of duct insulation (R6). The unconditioned areas that were considered to have the greatest impact on energy use, attics and crawl spaces, had the highest incidence of duct insulation. Eighty three percent of attics and 100 percent of crawl spaces inspected were insulated.
- ***Refrigerant Charging***. Sixty eight percent of systems inspected were not charged properly. Forty seven percent of systems were undercharged and 21 percent of systems inspected were overcharged.

[2] This value was determined by calculating the percent difference between the actual equipment size and the Manual J sizing, using Manual J as the reference. This calculation was performed for each of the homes in the study and the average of these values was then determined to be 23 percent.

[3] This value was determined in the same manner as percent oversizing. The oversizing was determined by the difference between the actual system capacity and the Manual J determined capacity. Oversizing was determined for each home and the average for all homes was then determined to be 0.37 tons.

Table E-6
Summary of HVAC On-Site System Data Analysis

Category		Analysis
Sizing		
	Cooling	43 % of systems are oversized 0.5 ton or more
	Heating	93 % of systems are oversized by more than 25 %
Air Flow		
	Supply	30 % of supply air flows are between 350-450 CFM per cooling ton
	Supply	53 % of supply air flows are less than 350 CFM per cooling ton
Duct Leakage		
	Outdoor	34 % of supply air flow is estimated to be outdoor air leakage
	Outdoor	329 CFE_{25} is the estimated outdoor air leakage flow rate
	Total	608 CFE_{25} is the average leakage for the supply and returns
	Sealing	8 % of ducts inspected were partially sealed with duct tape
Duct Insulation in Unconditioned Areas		
	Attic	83 % of ducts were insulated (n=25)
	Crawl Space	100 % of ducts were insulated (n=4)
	Basement	6 % of ducts were insulated (n=18)
	Garage	33 % of ducts were insulated (n=3)
Refrigerant Charge		
	Under Charged	47 % of systems
	Over Charged	21 % of systems
	Fixed Orifice	57 % of systems
	TXV	43 % of systems

E.2.4 Contractor Practices: Promotion of Energy Efficient Equipment

Fifty-nine percent of contractors reported that they discussed high efficiency options with customers in *all* sales situations. An additional 22 percent reported that they discussed high efficiency options with customers in most sales situation.

These findings are at odds, however, with the recollection of recent purchasers. Seventy-one percent of respondents to the customer survey reported that the contractor recommended only one unit. The relatively low market share of high-efficiency equipment suggests that the recommended units were predominantly standard efficiency. Finally, the customers' general

lack of understanding of HVAC efficiency standards and differences among models suggests that contractors' efforts at consumer education were fairly casual.

E.2.5 Contractor Practices: Sizing and Other Installation Practices

Table E-7 shows the portion of contractors who reported using a variety of installation practices that increase or maintain energy efficiency. The percentage figures in Table E-7 refer to the portion of all installations made, either by contractors in the specific size strata or by all contractors. Generally, the larger companies were more likely to report that they had adopted those practices

Table E-7
Reported Adoption of Efficient Installation Practices

Market Activity (number of homes served / year)					
	Smallest	**Small**	**Medium**	**Large**	**All**
Sizing					
Use of Manual J for sizing	14%	31%	93%	100%	67%
Use of computer programs for sizing.	2%	14%	16%	0%	10%
Duct Installation					
Install ducts in conditioned space	6%	6%	43%	26%	23%
Use special duct mastic	50%	11%	7%	41%	21%
Insulate cold air returns	6%	1%	0%	26%	8%
Replacement of operable indoor coils					
Always	64%	56%	8%	0%	26%
In most cases	13%	35%	51%	80%	50%
Methods to check refrigerant charge*					
Weigh refrigerant	0%	9%	23%	80%	31%
Superheat method	35%	25%	56%	80%	50%
Supercool method	9%	7%	57%	55%	35%
Other methods	50%	64%	58%	0%	44%

* Multiple methods accepted from a single respondent.

The key findings with regard to contractor installation practices were as follows.

- ***Sizing.*** Most contractors reported taking a responsible approach to unit sizing. Seventy-seven percent of contractors reported that they prepared documentation of sizing decisions using Manual J calculations (67%) or other software programs that incorporate heat load calculations (10%). Conversely, 9 percent report sizing to the previous unit, and 26 percent report use rules of thumb, such as tons/square foot. In this case, customer reports of purchase experience match contractor claims in regard to sales practices. Specifically, 85 percent of customers reported that they received documentation of their contractor's equipment sizing applications prior to signing a contract for installation.
- ***Duct Installation.*** Contractors serving roughly 75 percent of the market reported that they had adopted at least one practice to maintain or enhance the energy efficiency of duct installations. In addition to the three measures called out in Table E-5, these included use of Manual D or equivalent methods for sizing ducts, using separate returns for all rooms, and optimizing static pressure in the system. However, very few contractors reported employing the full complement of duct efficiency measures.
- ***Replacement of operable indoor coils when replacing central AC or heat pump units.*** Contractors in all size ranges report this is a common practice.
- ***Measurement of refrigerant charge.*** Eighty percent of large contractors report using the direct method of weighing refrigerant to check the refrigerant charge. Most of these contractors also report using indirect measurement approaches such as the superheat or supercool method. Roughly one-half of the contractors in the medium size range use one of these three methods. In the smaller size categories, virtually none of the contractors weigh the refrigerant charge, and relatively few use any form of measurement when checking the charge as part of normal maintenance.

E.2.6 Barriers to broader adoption of energy-efficient equipment and practices

Customer-side barriers: HVAC systems are expensive and critical to the safety, comfort, and general utility of the home. However, most homeowners purchase central air conditioning equipment or heating equipment no more than once during their tenure in a house. Thus, we would expect customers' knowledge of HVAC products and services to be fairly limited and their reliance on "experts" to be high. This is exactly what we found. Moreover, customers do relatively little shopping to compare the relative merits of different contractors, relying largely on word of mouth to identify potential contractors. Thus, the customers' pattern of searching for contractors is relatively isolated from commercial advertising or public relations efforts. Specific findings are as follows.

- ***Low level of product knowledge.*** Only 20 percent of recent central AC and heat pump purchasers correctly identified SEER as the index of efficiency used for those types of equipment. Virtually none of the recent heating equipment purchasers identified AFUE as the proper index for the efficiency of heating equipment. Among the cooling equipment

purchasers who knew about SEER, only one third correctly identified SEER 13 and 14 as designations for high efficiency equipment.

- ***Low level of knowledge regarding proper installation.*** About 45 percent of sample customers were able to name at least one element of energy efficient HVAC system installation without prompting from the interviewer. The most frequently-mentioned factor was proper sizing (17 percent), followed by duct insulation (14 percent) and proper air flow (12 percent).
- ***Heavy reliance on contractor for equipment selection decision.*** Seventy-one percent of the respondents reported that their contractor was the only source of information the used in making their equipment selection decisions. Ninety-one percent of the customers reported that they selected the model recommended by the contractor.
- ***Limited comparison of alternative equipment.*** Nearly three-fourths of the sample customers reported that their contractor proposed only one model. Among the customers who received proposals for alternative equipment from their contractors, ninety percent reported that the contractors identified at least one of the options as high efficiency.
- ***Limited search effort for contractors.*** Sixty-two percent of sample customers reported that they solicited bids from only one contractor. Fifty-five percent of customers reported that they identified their contractors through recommendations from friends and family. An additional 16 percent hired the contractors who serviced their old units and 13 percent identified contractors through the Yellow Pages.
- ***High level of satisfaction with contractors' work.*** Ninety-four percent of sample customers reported that they were satisfied with the equipment installation services they received. Given the results of the on-site survey, this high level of satisfaction is more likely to result from lack of appropriate quality criteria than the from the actual merit of the work. However, this widespread perception of high quality installations may pose an additional barrier in getting customers' attention in regard to HVAC efficiency issues.

Contractor-side barriers. Contractors reported that promotion of high efficiency equipment was only moderately important to the overall success of their businesses. In addition, they mentioned a number of conditions or barriers that deterred them from increasing promotional efforts for high efficiency equipment. These were as follows.

- ***Insufficient savings to justify customer interest.*** Contractors representing one-half the market reported that the biggest barrier to greater promotion of high efficiency equipment was lack of sufficient benefit to the customer in terms of energy or cost savings.
- ***Reliability concerns and callbacks.*** Many industry spokesmen cite the added complexity of energy-efficient heating cooling equipment and speculate that this leads to greater unreliability in the field and more frequent contractor callbacks to perform maintenance and repairs. We asked the sampled contractors whether the energy efficient central air conditioners and gas furnaces and boilers required more frequent maintenance calls than the standard models. Almost all respondents reported no difference in the frequency of callbacks for central air conditioners, but 36 percent reported more callbacks for efficient gas furnaces and boilers. This is consistent with the nature of condensing boiler technologies, which are more complicated and that give rise to different exhaust requirements.

- ***Timing problems caused by emergency replacements.*** Some industry observers suggest that the short time frame required for emergency installations precludes special ordering and hence the opportunity to use high efficiency equipment. It has also been rumored that time constraints often prevent contractors from replacing both condenser and indoor coil. This could be a barrier to energy efficient performance since high efficiency condensers do not function well with older, inefficient indoor coil units. According to the contractors, emergency installs account for only 12 – 26 percent or so of installations, depending on type of equipment. Most manufacturers have highly decentralized depot and warehouse systems to facilitate quick delivery. None of the contractors themselves mentioned lack of quick availability or time constraints as a barrier to greater penetration or complete installation of high-efficiency equipment. Therefore, we do not characterize this barrier as being particularly decisive.

E.2.7 Utility Program Awareness and Effects

Customers. HVAC customers reported high awareness of energy efficiency and of programs to promote these systems and practices. However, reported levels of free ridership are also high.

- ***Relatively high level of utility program awareness.*** Sixty-eight percent of the sampled recent HVAC purchasers reported that they were aware of the residential HVAC program operated by their local utility.
- ***Participation level.*** About two-thirds of the customers who were aware of the program reported participating in it, for a participation rate of 39 percent.
- ***High level of reported free ridership.*** All but 14 percent of program participants report that they would have purchased a high-efficiency unit in the absence of the program. Given the generally low level of knowledge and adoption of efficient equipment among recent purchasers, this self-report must be taken with a grain of salt.
- ***Recognition of ENERGY STAR.*** Recent surveys in New Jersey and the nation at large have found that roughly 40 percent of all residential consumers are aware of the ENERGY STAR label and that most of those individuals understand the label's message. However, only 19 percent of recent HVAC equipment purchasers were aware of the use of the ENERGY STAR label in association with heating and cooling equipment. Among utility program participants, 40 percent reported being aware of ENERGY STAR-labeled HVAC equipment.

Contractors. Utility or other programs to promote energy efficiency tended to have a smaller effect on contractors than on customers. However, contractors claim high participation in programs once awareness occurs.

- ***Modest levels of awareness and participation.*** Of the sampled contractors, 52 percent had heard of the NJ high-efficiency electric HVAC program and 40 percent were aware of gas utility programs (For electric programs, all of large, half of smallest, but only one third of the small and medium categories). On average, the program-aware contractors serve roughly half of the residential HVAC market. As many as 80 - 90 percent of contractors who were aware of the programs actually participated in them. For the electric program,

all contractors in the large tier participated in the program. Those contractors in the smallest and medium categories claimed the fewest participants.

- ***Reasons why contractors chose not to participate.*** Just over one-third of the contractors cited "rebate hassles" with energy-efficient products, 16 percent of firms saw energy efficient HVAC as a non-profitable enterprise, and 14 percent of the firms cited insufficient energy savings in high-efficiency HVAC.
- ***Program effect on selling and installation practices.*** All of the sample contractors in the large and medium size strata reported that they changed their equipment sizing procedures as a result of participation in the program. Changes included using various kinds of sizing software to produce more accurate results for rebate applications and not using existing units as a gauge for proper sizing. Other reported changes in installation practices included checking of air flow and charge level on *all* as opposed to *some* projects.
- ***Low recognition and promotional use of ENERGY STAR.*** Roughly two-thirds of the sample contractors had heard of the ENERGY STAR label in connection with HVAC equipment, but only 38 percent of sample contractors realized the label was associated with higher efficiency standards. Only 9 percent reported using the ENERGY STAR label as a point of reference in selling high-efficiency equipment.

E.2.8 Estimated HVAC Energy Savings Potential

XENERGY used the data collected through the on-site surveys, heating and cooling degree data from the locations of the survey, and "bin"-type engineering models to estimate energy usage of the sample systems and potential energy savings from a number of measures. The measures included reduction of air leakage to the outdoors, refrigerant charge correction, sizing correction, air flow correction, and addition of duct insulation.

Savings were calculated based on results of previous studies found in the literature. Table E-8 and Table E-9 display the results of these calculations for cooling and heating energy savings, respectively. The savings are presented as a percentage of either the cooling or heating energy utilized and are the average results for the population where the savings is applicable. Thus, systems with no deficiencies were tallied along with systems with deficiencies. Systems without ducts were not included in the heating savings analysis for duct leakage and air flow measure since the savings are not applicable. Additionally, the individual measure savings in these tables are not additive if all measures were implemented concurrently. It is estimated that the interactive cooling and heating savings of implementing all measures is 27 and 29 percent of base usage, respectively. If the savings are analyzed for the entire population of homes in the study, with and without heating ducts, then the heating savings potential is reduced from 29 percent to 22 percent.

Table E-8
Cooling Energy Data Analysis Set

Measure	Energy Savings Potential	± 90% CI	n	SE
OA Leakage Reduction	18.4 %	±3.5 %	46	2.1 %
Refrigerant Charge Correction	11.4 %	±3.6 %	19	2.1 %
Sizing Correction	2.9 %	±0.8 %	69	0.5 %
Air Flow Correction	2.3 %	±1.0 %	38	0.6 %
Additional Duct Insulation	1.5 %	±0.9 %	56	0.5%
Total[2]	36.4 %			

Notes:
1. Insulation measure does not include insulation of ducts in unconditioned basements
2. Actual total savings are not additive
3. Savings are relevant for homes with central AC split systems

Table E-9
Heating Energy Data Analysis Set

Measure	Energy Savings Potential	± 90% CI	n	SE
OA Leakage Reduction[5]	22.3 %	±4.1 %	34	2.4 %
Refrigerant Charge Correction[3,5]	0.0 %	±0.0 %	19	0.0 %
Sizing Correction[4]	6.8 %	±1.6 %	58	1.0 %
Air Flow Correction[3,5]	0.0 %	±0.0 %	38	0.0 %
Additional Duct Insulation[1,5]	2.0 %	±1.3 %	35	0.8%
Total[2]	31.1 %			

Notes:
1. Insulation measure does not include insulation of ducts in unconditioned basements
2. Actual total savings are not additive
3. One unit was a heat pump which had no savings potential due to correct sizing. Charge and air flow data were not available to analyze for savings.
4. Savings are relevant for heating systems with and without ducts for distribution
5. Savings are based on the heating system population that utilized ducts for distribution

Of all the HVAC deficiency corrections, outdoor air leakage reduction and refrigerant charge correction have the greatest potential for saving energy in the population analyzed. Duct leakage reduction is a simple procedure for exposed ducts; even ducts that are hidden in exterior walls can be treated with available products. Refrigerant charge correction can be achieved through

extraction of refrigerant and direct weighing, or superheat or subcooled methods can be used for new or existing systems.

Sizing correction savings may be very difficult to achieve. HVAC contractors will be very cautious about installing smaller systems than what already exist at a home. Also, if contractors need to size a new system they may also be conservative and oversize to eliminate the number of comfort callbacks. This is probably the case because calculation methods such as Manual J do not take into account all of the characteristics of a home that can lead to higher infiltration and poor insulation.

Airflow corrections could be achieved by numerous methods such as: improving the return and/ supply ducting, installing a smaller air conditioner, or increasing the fan speed. The first two changes are the most expensive but may save some additional fan and cooling energy. Increasing the fan speed is usually the easiest method, however, fan energy will increase, which may offset the cooling energy savings.

Duct insulation in unconditioned areas is an excellent idea for savings energy; it is both easy to install and offers significant savings benefits. However, the population of homes that were visited typically already had insulation on ducts, which is why the savings potential is estimated to be low.

E.3 CONCLUSIONS AND IMPLICATIONS FOR PROGRAM DESIGN

E.3.1 Key conclusions

Based on the findings summarized above, we draw the following conclusions to guide recommendations for program design.

- ***Contractors are clearly the gatekeepers to the residential HVAC equipment market.*** Customers purchase central HVAC equipment very infrequently. This makes it difficult for programs to find customers within the purchase decision frame. Customers also have little chance to learn about the products and services through repeated exposure. Rather than expending a great deal of effort to become educated on the topic, they rely on the contractor's judgment in making equipment choices. Moreover, few customers go to the effort of getting information from multiple contractors. Given this pattern of customer behavior, it is clear that utility programs must focus on providing contractors with the motive and the means to sell up to high efficiency, and to install high efficiency equipment correctly. Customer education elements may be useful as a supplement to the contractor-targeted effort.
- ***Currently, contractors are making only modest efforts to sell high-efficiency equipment and to improve installation practices.*** Findings from the consumer survey strongly suggest that most contractors make only inconsistent efforts to inform customers of the benefits of high-efficiency equipment or to sell them over standard efficiency products.

Consistent with this finding, the market share of efficient equipment is only slightly higher in New Jersey than it is nationwide. The results of the on-site system inspections suggest that oversizing of heating and cooling units is remains common practice, and that best practices in regard to installation, duct sizing, insulation, and sealing have not been widely adopted.

- ***Many contractors are not convinced that high-efficiency equipment provides significant benefits to customers, or that promotion of high-efficiency equipment is a high priority for business success.*** The most commonly reported barrier to increased high efficiency sales was insufficient energy or cost savings to stimulate significant consumer interest. Other reported barriers included rebate hassles, lack of customer interest in high-efficiency equipment, inadequate consideration of high efficiency during emergency replacements and the added complexity of energy-efficient heating cooling equipment (possibly leading to poorer system reliability and more frequent contractor callbacks for maintenance and repairs.
- ***The largest contractors, who service about 28 percent of the market, tend to already be enrolled in the sponsors' programs, especially for electric utilities.*** For the largest contractors, all stated they were aware of and participated in electric programs and about 60 percent said they were aware of and participated in gas utility programs.
- ***Results of the on-site visits clearly show that the greatest potential to save energy is through reduction of duct leakage to outdoors and refrigerant charge correction***. Eighty nine percent of homes analyzed had substantial duct distribution in unconditioned spaces and nearly half of these homes had no insulation on ducts. Sixty eight percent of systems inspected were not charged properly.
- ***System sizing, airflow correction, and duct insulation did not show significant savings from on-site visits.*** However, these measures can still yield significant savings on a home-by-home basis if they can be identified and corrected effectively. They should be appropriately addressed in efficiency improvement programs along with reducing duct leakage and off-optimum refrigerant charging.
- ***The energy savings possible from use of high efficiency equipment may not be fully realized unless contractors and customers work together to ensure proper implementation of all feasible efficiency measures.*** Conservatively, interactive cooling and heating savings from implementing all efficiency improvements was estimated to be about 20% of base energy use. This suggests that, overall, typical HVAC purchase, installation and maintenance practices can be improved considerably.

E.3.2 Recommendations

In light of the key findings, the XENERGY team makes the following recommendations with regard to further development of the sponsors' residential HVAC programs. The overall goals of the suggestions are to:

- Strengthen the motivation of contractors who are already participating in the program to be more consistent and thorough in their promotion of high efficiency equipment and best installation practices; and,

- Provide tools and materials to reduce the cost of selling up to high efficiency equipment and to increase the probability of success of such efforts.

Strengthen contractor motives to sell high efficiency equipment and adopt best installation practices. There are a number of strategies the sponsors could pursue to strengthen contractor motives to sell high efficiency equipment. These include the following.

- ***Recognition programs.*** Given the increasingly concentrated nature of the residential HVAC contracting sector, it is likely that many contractors are looking for ways to distinguish themselves from their competition. Utility recognition as a firm dedicated to energy efficiency could provide such a form of differentiation. To earn recognition, the contractor would need to meet or exceed goals for sales of program-qualifying equipment and quality of installations negotiated periodically with the program(s). Recognition could take the form of an ENERGY STAR partnership or other trademark. To support the designation, the utility could list the approved firms on its web site, provide funds and copy for co-advertising, and mention the firms in public relations events.
- ***Financial incentives.*** Utilities have operated programs that provide incentives to vendors for selling qualified equipment. These incentives have taken the form of "spiffs" to individual salespersons for each qualifying item sold, as well as lump sum payments to participating firms for achieving or surpassing sales goals. The results of such programs have been mixed. Programs featuring dealer incentives for efficient motors are currently operating fairly successfully in New York and Southern California after considerable periods of low participation and adjustment of incentive schemes.

Help Contractor's reduce the cost of sales for efficient equipment. To achieve this goal, the programs could provide the following kinds of support:

- Training to contractors in how to anticipate and counter customer objections to spending more for high efficiency equipment;
- Financial scenario software to detail the long-term financial benefits of using high-efficiency equipment;
- A checklist of best practices in sizing and installation to be provided to the customer by the contractor (the current GPU customer guide is a good step in this direction);
- Case studies of benefits featuring local houses.

The ENERGY STAR High Efficiency Heating and Cooling Equipment program has already developed many of these materials, has trained thousands of HVAC salespersons, and established relations with many distributors. It will be worthwhile to coordinate contractor training and recognition efforts with this program.

Offer training in proper duct installation. The results of the on-site survey clearly indicate that the general quality of duct installation is low. Moreover, analysis of the on-site results and studies in other jurisdictions suggest that proper duct sealing to reduce leakage to outside air offers the largest potential energy savings of all installation measures.

Maximize marketing efforts by combining high efficiency gas and electric programs. The data analyzed showed that 60% of homes with furnaces had both a new AC and furnace installed at the same time. This suggests an opportunity to integrate marketing efforts by contractors or utilities for these programs to achieve economies of scale and greater impact.

Support whole building approaches to energy efficiency improvement to ensure potential gains are realized. Whole building approaches to energy use combine envelope infiltration and insulation measures (not discussed in this report) with system sizing, duct design and leakage sealing, and airflow correction. This integration would result in a maximization of comfort, health, and energy savings for the homeowner. The whole building approach is recommended because of the airflow interactions that occur between the envelope and the duct system. Also, a home with properly installed insulation and low infiltration can have a properly sized AC or heating unit specified with more confidence, thus over sizing can potentially be reduced.

1 INTRODUCTION

This report presents the Residential HVAC Baseline Study to assess the nature of key HVAC markets and participants in New Jersey. The study was prepared for the New Jersey Residential HVAC Working Group (the Working Group). The research produced findings on the size and structure of the New Jersey residential HVAC market for existing homes, provides insight into HVAC product performance and reliability, and identifies real and perceived barriers to the adoption of energy efficient HVAC equipment and installation practices.

The study incorporates two main research elements. First, a Market Assessment was completed based on surveys of the four key market participant groups that comprise the HVAC supply chain—manufacturers, distributors, dealers and customers. Second, a Technical Assessment was conducted to focus on in-home HVAC equipment characteristics and performance. On-site visits were made to qualified houses for equipment inspection and testing. Integration of findings from these components satisfies the GPU Working Group's program requirement to establish a baseline picture of the key elements of HVAC industry as it currently exists in New Jersey.

1.1 STUDY BACKGROUND

The Residential High Efficiency HVAC Initiative began in New Jersey where central air conditioning systems are now used in the majority of homes built over the last 15 years, and increasingly so in older homes. A Residential HVAC Working Group was formed comprised of New Jersey investor-owned electric and gas utilities, trade allies, regulatory staff and environmental and consumer groups. Key representatives include GPU and PSE&G, Vermont Energy Investment Corporation, and the Natural Resources Defense Council.
One of the goals of the Working Group was to initiate plans for market research and baseline studies in 1998 to document current practices regarding HVAC system installation and specification practices in existing homes. The project was initiated during July 2000.

1.1.1 Goals And Objectives

The study focuses on the market for HVAC equipment that was installed in existing houses during the past three years. The Study's three main objectives are:

- Develop information on how the New Jersey market for residential HVAC equipment functions. The Working Group will use this information to refine the existing programs that promote the adoption of energy efficient equipment and installation practices.

- On the supply side of the market: identify key sets of actors in the market and characterize barriers to the promotion of efficient equipment and installation practices. Characterize supply-side actors' motivations to promote and install efficient equipment.
- On the demand side of the market: identify key customer segments and estimate their size. Characterize the barriers customers face to purchasing efficient equipment and installation services. Identify potential motivations that can be tapped to increase demand for cost-effective, energy-efficient equipment.

The Working Group will use this information to refine the existing programs that promote the adoption of energy-efficient equipment and installation practices.

1.1.2 Study Team

XENERGY worked with a team of subcontractors to complete the study. These included Easton Consultants (Easton), Atlantic Market Research (AMR), Honeywell DMC (Honeywell) and Advanced Energy Corporation (AEC). Easton leads the distributor and manufacturer interviews and analysis. AMR was responsible for administering the customer telephone surveys and recruiting customers for the Honeywell DMC on-site assessments. XENERGY conducted the contractor interviews. AEC developed the on-site survey instrument, trained the Honeywell survey staff and was responsible for quality control of on-site staff. Honeywell scheduled and completed on-site survey assessments. XENERGY handled analysis and reporting of the on-site survey findings.

1.2 RESEARCH METHODOLOGY

To accomplish the program objectives, the study team carried out the research and analysis tasks summarized in Table 1-1. This section contains additional detail on the survey design and research methods to analyze each of the four key HVAC market actors—manufacturers, distributors, contractors and customers.

Table 1-1
Research and Analysis Activities

Target Population	Survey Type	Sample Size	Analytical Objective and Study Contractors
Recent residential HVAC purchasers	Screening calls	816	• Assess awareness and purchase of efficient HVAC (AMR).
	Complete Interviews	170	• Characterize experience with contractors (XENERGY). • Identify barriers to purchase of efficient equipment.
	On-site surveys	70	• Estimate market penetration of efficient equipment and efficient installation/maintenance practices. (AMR, Honeywell, AEC, XENERGY)
Contractors	In-depth interview	30	• Characterize contractor efforts to sell and install efficient equipment (XENERGY). • Identify barriers deterring contractors from marketing efficiency. • Assess effect of program on installation and marketing practices.
Manufacturers, Distributors	In-depth telephone	13 mfg 16 dist	• Estimate market share of efficient equipment at the national level (Easton) • Characterize national efforts to promote efficient equipment.

1.2.1 Customer Survey (Chapter 2)

Research Objectives

The customer survey examined the level of customer awareness and use of efficient HVAC products, customers' perceptions of contractor marketing, and the criteria customers use to make their equipment selection. The survey also characterizes consumer-level barriers to the purchase and use of high efficiency equipment, and identifies utility activities that may mitigate such

obstacles. Finally, the customer survey assesses customer awareness of and participation in energy efficiency programs, including the EPA's ENERGY STAR and local utility programs.

Survey Design

The New Jersey HVAC customer research was based on a short phone survey to investigate customer awareness, selection, and use of high efficiency heating and cooling equipment in residential homes. Participants were selected from a simple random sample of homeowners[1] in the Working Group's service territory using a random-digit-dialing technique. The survey consisted of 170 interviews with customers in the state of New Jersey: one hundred with respondents who had a central air conditioner or heat pump installed in 1998, 1999, or 2000, and 70 who had a gas furnace or boiler installed in that time period.

Of the individuals contacted, approximately 21 percent (170 out of 816) qualified for participation in the survey. Of the completed survey total, 100 were conducted with respondents who had recent central air conditioner or heat pump installations, 47 were conducted with respondents who had recent gas furnace installations, and 23 were conducted with respondents who had recent gas boiler installations.

1.2.2 Contractor/ Dealer Survey (Chapter 3)

Research Objectives

The contractor survey identified characteristics of the sample firms and their business operations, and determined the market share of energy-efficient equipment. Company marketing approaches with emphasis on promotion of energy-efficient products and the use of energy efficiency in firm marketing were analyzed. Potential communication and marketing channels for utility-sponsored energy efficiency efforts were identified and participating firms' awareness of and participation in utility- and government-sponsored energy efficiency programs were assessed. Finally, the contractor survey investigated technical aspects of HVAC system design, sizing, performance and reliability, with an assessment of current installation practices. This was done to determine how frequently energy-efficient design criteria were employed in system sizing and installation practices.

Survey Design

XENERGY designed a sampling approach that would produce a representative random sample of residential air conditioning and heating installation contractors and dealers. A stratified sampling approach, with size of the firm as the stratification variable, was used. The IMarket database of Dun & Bradstreet establishment records was used to obtain the sample frame. Records for New Jersey boiler and furnace contractors and heating and air conditioning contractors were selected in standard industrial classification (SIC) codes 1711-01 and 1711-04

[1] According to 1990 figures from the United States Census Bureau, the home ownership rate in New Jersey are 64.9 percent, which slightly higher than the national average (64.4 percent).

respectively. The number of employees at the location was used as the measure of firm, which is relatively accurate and consistent, in the aggregate, with establishment statistics from other sources.

The initial goal of the analysis was to complete 45 surveys, split among different size strata and type of business (whether the firm worked only on existing homes, or on projects in both existing homes and on new construction). Sample contractors were offered a $100 incentive to participate in the survey. Despite this offer, recruitment proved difficult and XENERGY was able to complete only 30 interviews.

1.2.3 Distributor Survey (Chapter 4)

Research Objectives

The HVAC distributor interviews gathered information on market share of energy efficient HVAC equipment, determined distributor impressions of manufacturer and dealer effort to market high efficiency equipment, and identified potential availability problems for high efficiency equipment.

Survey Design

The distributor research was organized around a set of detailed telephone surveys (not a random sample) designed to investigate distributor perceptions of the market for high efficiency heating and cooling equipment. The survey consisted of 16 in-depth interviews with representatives from distribution firms supplying a range of heating and cooling equipment, including air conditioners, heat pumps, gas furnaces, gas boilers, and programmable thermostats. These individuals held various positions at their firms but were generally owners or operations managers. The distributors contacted are representative of the national HVAC market in terms of manufacturer share. They also roughly align with New Jersey utility high-efficiency equipment rebate rankings.

1.2.4 Manufacturer Survey (Chapter 5)

Research Objectives

The equipment manufacturer survey gathered information on market share and regional variations in shipment of energy efficient HVAC equipment, identified barriers to the sale of high-efficiency equipment to both contractors and customers, and determined activities that utilities companies could pursue to mitigate such barriers. From a marketing standpoint the study examines motivations and practices for promoting high-efficiency equipment, including participation in and use of ENERGY STAR and utility-sponsored high efficiency programs. The position of energy efficiency in priorities for new product development was assessed, along with manufacturers' perceptions of future trends in the HVAC equipment market.

Survey Design

The manufacturer research was based on 13 in-depth telephone surveys designed to investigate manufacturer perceptions of the market for high efficiency air conditioners and gas boilers. The respondents, which were not a random sample, held various positions at their firms but all had technical knowledge regarding high efficiency equipment marketing and sales. Interviews included 3 central air conditioning (CAC)-only manufacturers, 3 gas boiler-only manufacturers and 7 manufacturers with multi-line, multi-brand (MLMB) products. In general, the MLMB firms produce CACs, heat pumps and furnaces. The firms represented by participating individuals account for more than 85 percent of all central air conditioning units shipped and more than 60 percent of residential-sized gas boilers.

1.2.5 On-Site Visits – Technical Assessment (Chapter 6)

Research Objectives

The purpose of the on-site surveys was to produce data for the Technical Assessment of recently installed HVAC equipment. The two technical objectives of the visits were to (1) assess the physical and measured performance characteristics of HVAC equipment, and, (2) document house characteristics that can affect energy consumption and occupant discomfort. The on-site data were also used to identify areas of difference in HVAC characteristics between measured results and perceptions of performance and comfort obtained through the contractor and customer interviews.

Survey Design

The survey methods for the on-site visits included a random sample of houses meeting the study selection criteria. The total sample size for the on-site inspection visits was 70 houses, which was selected from the population of houses that had a new installation of HVAC equipment in the past 3 years (after July 1997). AMR chose the sample from a list of customer houses that had recent construction or renovation, including HVAC installations (contact list from the customer survey). To qualify sites, telemarketing calls were made to candidate homes to ensure they met the study criteria. Although data were obtained on 70 homes, two homes had two separate HVAC systems in different zones or floors of the house (a 2-zone HVAC system). In these cases, each of the two zones in the houses was simply considered to be a separate house. Thus, these two houses actually produced 2 extra data points, making 72 the total number of houses where data was collected.

The site visits were made by two trained field auditor staff from Honeywell DMC. Data in the sample homes was documented using a customized version of a Residential Survey document designed by Advanced Energy. Each participating was paid $ 50 for allowing the data to be collected from their property.

1.3 DOCUMENT ORGANIZATION

As shown below, the Baseline New Jersey HVAC Study incorporates an Executive Summary, several chapters and an appendix.

- Chapter E: Executive Summary
- Chapter 1: Introduction
- Chapter 2: HVAC Customer Survey Analysis
- Chapter 3: HVAC Contractor Survey Results
- Chapter 4: Interview Analysis—HVAC Equipment Distributors
- Chapter 5: Interview Analysis—HVAC Equipment Manufacturers
- Chapter 6: Results from On-Site Visits
- Appendix: Survey Instruments

The body of the study is comprised of six chapters. Four of the chapters focus on one of the key market actors that make up the HVAC equipment supply chain—manufacturers, distributors, contractors / dealers and customers. The sixth chapter presents the main Technical Assessment results, which were obtained from the customer on-site visits.

2 HVAC CUSTOMER SURVEY ANALYSIS

2.1 OBJECTIVES

The primary objectives of the New Jersey Residential HVAC Customer Survey were to:

- Estimate the levels of customer awareness and use of efficient HVAC products;
- Examine customer perceptions concerning contractor marketing of efficient equipment; and
- Determine the criteria and processes used by customers in selecting heating and cooling equipment.

In addition, the survey gathered information to characterize barriers to purchase and use of high efficiency equipment and activities utilities could pursue to mitigate such barriers. The survey also gauged customer awareness of and participation in energy efficiency programs including the EPA's ENERGY STAR program and local utility programs.

2.2 SURVEY METHODS

The New Jersey HVAC customer research was organized around a short phone survey to investigate customer awareness, selection, and use of high efficiency heating and cooling equipment in residential homes. The survey consisted of 170 interviews with customers in the state of New Jersey: one hundred with respondents who had a central air conditioner or heat pump installed in 1998, 1999, or 2000, and 70 who had a gas furnace or boiler installed in that time period. These survey participants were selected from a simple random sample of homeowners[1] in the Working Group's service territory using a random-digit-dialing technique. Potential participants were screened based on four criteria:

1) The respondent had to pay his or her own utility bills;
2) The respondent had to own the heating and cooling equipment in his or her home;
3) The respondent's home must have been built prior to 1997; and
4) The respondent must have purchased a new central air conditioner, heat pump, gas furnace, or gas boiler in 1998, 1999, or 2000.

[1] According to 1990 figures from the United States Census Bureau, the home ownership rate in New Jersey are 64.9 percent, which slightly higher than the national average (64.4 percent).

Of the individuals contacted in the sample, approximately 21 percent (170 out of 816) qualified for participation in the survey. Of the completed surveys, 100 were conducted with respondents who had recent central air conditioner or heat pump installations, 47 were conducted with respondents who had recent gas furnace installations, and 23 were conducted with respondents who had recent gas boiler installations. Table 2-1 presents selected details of the sample disposition.

Table 2-1
Call Details

Calling Information	Number of Calls	Percent of Total
Screeners:		
1. Does not pay bills	11	1%
2. Does not own equipment	54	7%
3. Home built after 1997	49	6%
4. No install in 1998, 1999, or 2000	532	65%
Total Screen-outs	646	79%
Completed Surveys:		
Central Air Conditioner	84	11%
Heat Pump	16	2%
Gas Furnace	47	6%
Gas Boiler	23	3%
Total Completed	170	21%
Total Calls	816	100%

2.3 RESPONDENT CHARACTERISTICS

2.3.1 Household Income

Annual household income varied among respondents, but survey data yielded the following information:

- 42 percent indicated an annual household income of less than $75,000;
- 20 percent of respondents indicated an income of greater than $75,000; and
- 36 percent of respondents refused to answer the question.

The United States Census Bureau cites $47,903 as the median household income in the state of New Jersey for 1997, and the national median household income as $37,005[2]. The median household income for survey data falls into the range of $50,000 to $74,000, which is slightly higher than the median census figure for New Jersey. Median household incomes among survey respondents may be slightly higher than state and national incomes because qualifying participants must have purchased HVAC equipment in the three years prior to the survey. The survey is thus focused on respondents who are affluent enough to have purchased HVAC equipment in 1998, 1999, or 2000.

Further details of household income are provided in Table 2-2.

Table 2-2
Household Income

Income	Percent of Total
Less than $35,000	10%
$35,000-49,999	11%
$50,000-74,999	21%
$75,000-99,999	9%
$100,000 or more	11%
Don't Know	2%
Refused	36%
Total	100%
Number of Observations	170

2.3.2 Other Demographic and Housing Characteristics

Based upon survey data, the following characteristics also describe the survey respondents and their homes:

- 92 percent lived in detached single-family homes. In 1990, 67 percent of New Jersey's population lived in single-family homes, as did 71 percent of the nation's population. The higher than average rate of single-family homes among respondents is partially explained by the homeownership criterion for study participation and also by the higher than average income level of study participants.
- average home size: 2,200 square feet
- average number of rooms per home: 10

Education levels also varied a great deal among survey respondents:

[2] These figures are model-based estimates from the United States Census Bureau.

- Approximately 60 percent of respondents completed high school or trade school. Some of these went on to pursue higher education. According to the 2000 census, 47% of the New Jersey's population are high school graduates over the age of 25. Twenty-nine percent of the respondents indicated that high school was the highest level of education they completed.
- Approximately 26 percent of respondents indicated that they had a college degree. Some of these respondents also went on to pursue additional schooling. According to the 2000 census, 15% of New Jersey's population over the age of 25 has a college degree.

The percentage of survey respondents' who hold college degrees is higher than the percentage for the state as a whole. This is likely because (as explained above) survey respondents were slightly wealthier than the average resident of New Jersey, and education levels are expected to increase with wealth.

Additional detail about respondents' education levels is provided in Table 2-3.

Table 2-3
Education Levels of Survey Respondents
(Highest Level of Education Completed)

Level of Education	Percent of Total
Some high school / trade school	3%
High school / trade school diploma	29%
Some college	19%
College degree	26%
Some graduate school	6%
Graduate degree	9%
Refused	8%
Total	100%
Number of Respondents	170

2.4 EQUIPMENT CHARACTERISTICS

2.4.1 Equipment Purchases

The 170 survey participants reported purchases of a total of 217 units of HVAC equipment in 1998, 1999, and 2000.[3] Among these, air conditioners (AC) were the most popular at 47 percent (103 units) of the total units. Thirty-two percent of the total was comprised of gas furnace purchases (69 units), followed by gas boilers and heat pumps at 12 and 9 percent of the total (26 and 19 units) respectively. This information is provided in Table 2-4 where data on joint equipment purchases (two types of equipment purchased by one respondent in 1998-2000) also appears. The table shows, for instance, that of the 103 AC units purchased, 35 were obtained by respondents that also purchased a gas furnace at some time within the study time period. Also, 4 of the 19 heat pump purchases were made by respondents who also bought a gas furnace in the period 1998 - 2000; while a separate group of 4 hear pump purchasers also bought a gas boiler. This implies that 11 heat pumps were single purchases during 1998-2000.

Table 2-4
Number of Purchases by Equipment Type

Equipment Type	Total Number of Purchases	% of Total	# Joint Purchases (Gas Furnace)	# Joint Purchases (Gas Boiler)
Air Conditioner	103	47%	35	4
Heat Pump	19	9%	4	4
Gas Furnace	69	32%	N/A	N/A
Gas Boiler	26	12%	N/A	N/A
Total	217	100%	39	8

2.4.2 Reasons to Purchase

Survey respondents were asked whether the unit they had installed was a replacement for an existing unit. Overall, 61 percent of the survey respondents indicated that the unit was installed as a replacement for an existing unit in their homes. Among the three equipment groupings, central air conditioners and heat pumps were installed as replacements 50 percent of the time, making them the type of equipment least frequently installed as replacements. Gas boilers were the type of equipment most frequently installed as replacements, with eighty-three percent of survey respondents indicating that their boilers were installed to replace existing units. This

[3] The total number of units purchased by survey participants is greater than the total number of surveys completed. If an individual respondent reported purchasing more than one type of equipment in 1998, 1999, or 2000, the computer guiding the CATI survey was programmed to randomly select one type of equipment as the focus for the survey. Each of the 170 completed surveys provides data for only one type of equipment.

finding suggests that a large portion of air conditioner purchases for existing homes are discretionary, prompted by customers' motivation to improve system-related comfort or economics. Additional detail is provided in Table 2-5 where the air conditioner and heat pump findings are combined because of small sample size concerns for heat pump data.

Also shown in the table for is the percentage to be subtracted from and added to the "overall" figures to produce the lower and upper bounds of the 90 percent confidence interval (CI). These data are included in parentheses following the overall estimate. For example, overall 61 percent (± 6%) result indicates that the 90 percent confidence interval for the estimated percentage is the range of 55 – 67 percent.

Table 2-5
Reasons for HVAC Purchases in Existing Homes by Equipment Type

Response	Type of Equipment			Overall (± 90% CI)
	Central AC & Heat Pump	Gas Furnace	Gas Boiler	
Replacement	50%	74%	83%	61% (± 6%)
Better comfort or economics	49%	26%	17%	38% (± 6%)
Don't Know	1%	0%	0%	1% (± 1%)
Total	100%	100%	100%	100%
Number of Observations	100	47	23	170

Among the 104 respondents (61 percent of total) who indicated that their equipment was installed to replace existing equipment, 55 percent indicated that they were replacing units that had failed. Forty-five respondents (forty-three percent of respondents) replaced operating equipment with new equipment. Further breakdown of failed and operating equipment replacements is provided in Table 2-6.

Table 2-6
Replacement of Failed and Operating Equipment by Equipment Type

Response	Type of Equipment			Overall (± 90% CI)
	Central AC & Heat Pump	Gas Furnace	Gas Boiler	
Failed	60%	43%	63%	55% (± 8%)
Operating	36%	57%	37%	43% (± 8%)
Don't Know	4%	0%	0%	2% (± 1%)
Total	100%	100%	100%	100%
Number of Observations	50	35	19	104

Among the 45 survey respondents indicating that they replaced operating units, the most common reason for replacement was that the unit was old. Seventy-three percent of these respondents indicated that they replaced their operating unit for this reason. The second most common reason was that the new unit was more efficient than the old one, with 24 percent of respondents citing this as the replacement reason. Eighteen percent of respondents indicated that better performance of the new unit was their reason for replacement. Consistent with the finding that half of central air conditioner purchases are discretionary, a higher percentage of these buyers are seeking higher efficiency and increased performance. Further detail of reasons for replacing operating equipment is provided in Table 2-7.

Table 2-7
Reasons for Replacing Operating Equipment by Equipment Type

Response	Type of Equipment			Overall (± 90% CI)
	Central AC & Heat Pump	Gas Furnace	Gas Boiler	
Unit was old	61%	75%	100%	73% (± 11%)
Higher efficiency	33%	20%	14%	24% (± 11%)
Better performance	22%	15%	14%	18% (± 10%)
Lower operating costs	11%	0%	0%	4% (± 4%)
Other	0%	0%	14%	2% (± 2%)
Greater comfort	6%	0%	0%	2% (± 2%)
Number of Observations	18	20	7	*

* Multiple Responses Allowed. May total more than 100%.

2.5 CONTRACTOR SELECTION AND CHARACTERISTICS

2.5.1 Contractor Selection

Word of mouth proved to be the most important factor in contractor selection, with fifty percent of respondents indicating that they selected their HVAC contractors based on a recommendation given by a friend or family member. Sixteen percent of respondents indicated that they selected a contractor who had serviced a unit previously installed in their homes, and 14 percent indicated that their choice of contractors was based upon listings in the yellow pages[4]. Table 2-8 details the methods survey respondents used to select their contractors.

[4] Individuals who were referred to specific contractors by word of mouth or other methods may also have used the Yellow Pages to find telephone numbers for these contractors.

Table 2-8
Method of Contractor Selection by Equipment Type

Method	Type of Equipment			Overall (± 90% CI)
	Central AC & Heat Pump	Gas Furnace	Gas Boiler	
Recommended by friend or family member	44%	55%	65%	50% (± 6%)
Contractor previously serviced the old unit	17%	17%	13%	16% (± 5%)
Yellow page listing	14%	17%	9%	14% (± 4%)
Other	14%	4%	4%	10% (± 4%)
Saw newspaper ad	5%	2%	0%	4% (± 2%)
Direct mail	1%	0%	0%	< 1% (± 1%)
Saw Internet ad	1%	0%	0%	< 1% (± 1%)
Saw TV ad	1%	0%	0%	< 1% (± 1%)
Don't Know	8%	4%	13%	8% (± 3%)
Number of Observations	100	47	23	*

* Multiple Responses Allowed. May total more than 100%.

Among the "other" responses in the table above, 6 respondents in the central air conditioner and heat pump category indicated that either they or a spouse installed the units, rendering this question irrelevant to these respondents. One respondent in the gas boiler category indicated that he installed his own unit as well.

Survey respondents indicated that the contractors' reputation was by far the most important reason in deciding who would install their heating and cooling equipment, with 58 percent of respondents indicating reputation as their primary reason for choosing their contractor. Cost and qualifications were among the other reasons customers indicated as most important (9 percent and 7 percent respectively). Additional detail is provided in Table 2-9.

Table 2-9
Reasons for Contractor Selection by Type of Equipment Installed

Reason	Type of Equipment			Overall (± 90% CI)
	Central AC & Heat Pump	Gas Furnace	Gas Boiler	
Reputation	52%	62%	74%	58% (± 6%)
Installed cost of unit	13%	4%	4%	9% (± 4%)
Qualifications	6%	11%	4%	7% (± 3%)
Ability to install within required time frame	6%	2%	4%	5% (± 3%)
Availability of a maintenance contract	4%	6%	9%	5% (± 3%)
Operating cost of unit(s) offered	4%	6%	0%	4% (± 3%)
Efficiency of unit(s) offered	4%	2%	0%	3% (± 2%)
Warranty length and / or features	2%	0%	0%	1% (± 1%)
Refused	1%	0%	0%	< 1% (±1 %)
Don't Know	8%	6%	4%	7% (± 3%)
Total	100%	100%	100%	100%
Number of Observations	100	47	23	170

2.5.2 Brand Significance

A small proportion (approximately one-fifth) of customers were looking for a specific brand of HVAC equipment when choosing contractors, but 81 percent of survey respondents were not searching for specific brands. Table 2-10 provides further detail of brand importance in contractor selection.

Table 2-10
Customers Seeking Specific Equipment Brand by Equipment Type

Response	Type of Equipment			Overall (± 90% CI)
	Central AC & Heat Pump	Gas Furnace	Gas Boiler	
Not looking for a specific brand	73%	77%	83%	75% (± 5%)
Looking for a specific brand	19%	21%	17%	19% (± 5%)
Don’t Know	8%	2%	0%	5% (± 3%)
Total	100%	100%	100%	100%
Number of Observations	100	47	23	170

2.5.3 Quotes

Thirty-eight percent of survey respondents indicated that they received quotes from more than one contractor when shopping for heating and cooling equipment. Fifty-nine percent of respondents got only one quote. Three percent of survey respondents were not sure how many quotes they received. Additional detail of quotes by equipment type is provided in Table 2-11.

Table 2-11
Detail of Multiple Quotes by Equipment Type

Number of Quotes	Type of Equipment			Overall (± 90% CI)
	Central AC & Heat Pump	Gas Furnace	Gas Boiler	
More than one quote	39%	45%	22%	38% (± 6%)
One quote	57%	53%	78%	59% (± 6%)
Don't Know	4%	2%	0%	3% (± 2%)
Total	100%	100%	100%	100%
Number of Observations	100	47	23	170

2.5.4 Contractor Credentials

Survey respondents indicated that overall, 31 percent of contractors offered to provide them with both evidence of certification to handle refrigerants and evidence of liability insurance. Four percent of respondents indicated that contractors offered to provide evidence of refrigerant certification only, and 10 percent indicated that contractors offered to provide evidence of liability insurance only. Twenty-eight percent of survey respondents indicated that contractors did not offer to produce evidence of either, and another 27 percent were not sure whether contractors had offered or not. Additional breakdown is provided in Table 2-12.

Table 2-12
Contractors Offering to Produce Credentials by Type of Equipment Installed

Credentials	Type of Equipment			Overall (± 90% CI)
	Central AC & Heat Pump	Gas Furnace	Gas Boiler	
Both	34%	34%	13%	31% (± 6%)
Certification to handle refrigerants only	6%	2%	0%	4% (± 3%)
Evidence of liability insurance only	8%	6%	26%	10% (± 4%)
Neither	21%	34%	43%	28% (± 6%)
Don't Know	31%	23%	17%	27% (± 6%)
Total	100%	100%	100%	100%
Number of Observations	100	47	23	170

2.5.5 Contractor Performance

The vast majority of respondents (94 percent) indicated that they were satisfied with the HVAC equipment and the installation performed by their contractors. Four percent indicated that they were not satisfied with their new equipment, citing noise as the primary reason, and 2 percent were not sure. Detail of responses is provided in Table 2-13.

Table 2-13
Customer Satisfaction with Equipment Installation by Equipment Type

Response	Type of Equipment			Overall (± 90% CI)
	Central AC & Heat Pump	Gas Furnace	Gas Boiler	
Satisfied	95%	98%	83%	94% (± 3%)
Not satisfied	4%	0%	13%	4% (± 3%)
Don't Know	1%	2%	4%	2% (± 2%)
Total	100%	100%	100%	100%
Number of Observations	100	47	23	170

2.6 AWARENESS AND UNDERSTANDING OF HIGH EFFICIENCY RATINGS AND EQUIPMENT

2.6.1 Awareness of High Efficiency Equipment Availability

Overall, 68 percent of survey respondents indicated knowing that high efficiency equipment was available prior to purchasing a new unit in 1998, 1999 or 2000. Twenty-two percent were not aware of high efficiency equipment prior to purchasing their new units, and 10 percent were not sure whether or not they were aware prior to their purchases. Awareness of performance and efficiency advantages is highest among respondents in the central air conditioner and heat pump category. Further detail is provided in Table 2-14.

Table 2-14
Customer Awareness of Availability of High Efficiency Equipment Prior to Installation by Equipment Type

Awareness	Type of Equipment			Overall (± 90% CI)
	Central AC & Heat Pump	Gas Furnace	Gas Boiler	
Aware	75%	68%	61%	71% (± 6%)
Not Aware	16%	26%	22%	19% (± 5%)
Don't Know	9%	6%	17%	9% (± 4%)
Total	100%	100%	100%	100%
Number of Observations	100	47	23	170

Of the 121 survey respondents (71 percent of total) who indicated that they were aware that high efficiency equipment was available prior to the installation of their new equipment in 1998, 1999, or 2000, 60 percent reported that they requested information about high efficiency equipment from their contractors. Thirty-seven percent of these respondents did not request information on high efficiency equipment even though they were aware of high efficiency equipment. Reasons for this included cost, reliability concerns, and worry that the energy-related savings would not justify the extra costs of high efficiency equipment. Table 2-15 provides further detail of customer requests for high efficiency equipment.

Table 2-15
Customer Requests for Information About High Efficiency Equipment Among Those Aware of High Efficiency Equipment by Equipment Type

Awareness	Type of Equipment			Overall (± 90% CI)
	Central AC & Heat Pump	Gas Furnace	Gas Boiler	
Did Request Information	61%	69%	36%	60% (± 7%)
Did Not Request Information	35%	31%	64%	37% (± 7%)
Don't Know	4%	0%	0%	2% (± 2%)
Total	100%	100%	100%	100%
Number of Observations	75	32	14	121

2.6.2 Awareness of Benefits of Energy-Efficient Equipment

In order to determine the accuracy of customers' impressions about high efficiency equipment, survey respondents were asked to identify the benefits of installing high efficiency equipment. Of the 121 survey respondents (71 percent of total) who indicated that they were aware of high

efficiency equipment, 73 percent indicated that lower operating costs were among the benefits of high efficiency equipment, and 55 percent indicated that less energy use was a benefit. Other benefits mentioned included improved performance, utility rebates, and less pollution or environmental impacts. Seven percent of respondents could not name any benefits of installing high efficiency heating and cooling equipment. Generally, customers were not aware of the non-energy benefits associated with high efficiency equipment such as increased comfort, reduced noise, higher quality materials, and better controls. Manufacturers consider these non-energy benefits to be important potential selling points for high efficiency equipment. Customer impressions of benefits are detailed in Table 2-16.

Table 2-16
Respondents' Impressions of Benefits of High Efficiency Equipment Among Those Aware of High Efficiency by Equipment Type

Benefit	Type of Equipment			Overall (± 90% CI)
	Central AC & Heat Pump	Gas Furnace	Gas Boiler	
Lower operating costs	72%	72%	79%	73% (± 7%)
Less energy use	61%	47%	43%	55% (± 8%)
Improved performance	17%	2%	0%	17% (± 6%)
Greater comfort	9%	9%	0%	8% (± 4%)
Received utility rebate	8%	6%	0%	7% (± 4%)
Less pollution/environmental impacts	4%	3%	7%	4% (± 3%)
Increased reliability	1%	0%	0%	< 1% (± 1%)
Don't Know	5%	13%	7%	7% (± 4%)
Number of Observations	75	32	14	*

* Multiple Responses Allowed. May total more than 100%.

2.6.3 Customer Knowledge of Energy Efficiency Rating Systems

In order to determine the accuracy of customers' impressions of how energy efficiency is rated, survey respondents were asked to explain how the efficiency of their new HVAC equipment was rated. Overall, 78 percent of the 121 survey respondents who were aware of high efficiency equipment did not know how the efficiency of their equipment was rated. These customers are thus unable to distinguish among products with different efficiency ratings because they do not know about efficiency rating systems.

In total, there were only 18 respondents (15 percent of the 121 respondents) who correctly stated how the efficiency of their HVAC equipment is measured. Fifteen of these respondents correctly stated that air conditioner or heat pump efficiency is measured in SEER or seasonal energy efficiency ratio, and 3 respondents correctly stated that gas boiler efficiency is measured in terms

of AFUE or annual fuel utilization efficiency. Table 2-17 provides further detail of respondents' impressions of how high efficiency equipment is rated.

Table 2-17
Respondents' Impressions of How High Efficiency Equipment is Rated by Equipment Type

Measure	Type of Equipment			Overall (± 90% CI)
	Central AC & Heat Pump	Gas Furnace	Gas Boiler	
Don't Know	71%	97%	71%	78% (± 6%)
SEER	12%	3%	7%	9% (± 4%)
Seasonal energy efficiency ratio	8%	0%	0%	5% (± 3%)
AFUE / Annual fuel utilization efficiency	4%	0%	11%	3% (± 3%)
Percent (%) Efficiency	4%	0%	0%	2% (± 2%)
Refused	1%	0%	0%	1% (± 1%)
Total	100%	100%	100%	100%
Number of Observations	75	32	14	121

Only 12 percent of respondents correctly identified the measurement of energy efficiency for the units they purchased. Of these, only a few had detailed knowledge of standards for efficient equipment. Table 2-18 shows that the majority of respondents thought a higher SEER was necessary for air conditioners and heat pumps to earn a high efficiency designation, and that for gas boilers, most respondents were not sure what rating would earn a high efficiency designation. It is thus obvious that customer knowledge of high efficiency is lacking.

Table 2-18
Respondents' Estimations of Efficiency Ratings Defining High Efficiency by Equipment Type

Efficiency Rating	Type of Equipment		Overall
	Central AC & Heat Pump	Gas Boiler	
Don't Know	53%	67%	60%
SEER 13	13%	0%	7%
SEER 14	20%	0%	10%
SEER 15	7%	0%	4%
SEER 20	7%	0%	4%
AFUE 80	0%	33%	17%
Total	100	100%	100%
Number of Observations	15	3	18

2.6.4 Customer Knowledge of Installation Factors Affecting Efficiency

The 121 respondents who indicated awareness of high efficiency equipment prior to their purchase were asked what factors other than the equipment itself would affect the performance of their heating and cooling systems. Overall, 35 percent of respondents did not know what other factors would affect the performance of their HVAC systems. Seventeen percent stated that proper equipment sizing would affect system performance[5], and 14 percent stated that duct insulation would affect system performance. Fourteen percent of the respondents stated that there were no other factors that would affect performance other than the HVAC equipment itself. Additional detail is provided in Table 2-19. Overall, awareness of installation factors and their effects on efficiency were higher than one might expect given the lack of awareness of efficiency ratings.

Table 2-19
Factors Other Than HVAC Equipment Affecting System Performance by Equipment Type

Measure	Type of Equipment			Overall (± 90% CI)
	Central AC & Heat Pump	Gas Furnace	Gas Boiler	
Don't Know	39%	28%	36%	35% (± 7%)
Duct insulation	20%	16%	7%	17% (± 6%)
Proper equipment sizing	9%	22%	21%	14% (± 5%)
None	15%	16%	7%	14% (±5%)
Other	15%	3%	21%	12% (± 5%)
Adequate airflow over the indoor coils	9%	13%	14%	11% (± 5%)
Duct leakage	3%	13%	14%	7% (± 4%)
Proper refrigerant charge	3%	0%	7%	2% (± 2%)
Number of Observations	75	32	14	*

* Multiple Responses Allowed. May total more than 100%.

[5] The survey did not elicit information as to whether respondents thought it important that units were not over-sized or whether "proper sizing" indicated the importance of the unit's being *large enough*. It is likely that this response incorporates both views.

2.7 EQUIPMENT SELECTION

2.7.1 Contractor Influence

The survey examined how customers choose their heating and cooling equipment. Results from this section demonstrate the influence that contractors have on customers' choice of high efficiency equipment. More than two-thirds (68 percent) of survey respondents reported that their contractors recommended high efficiency equipment, and of these, more than 90 percent reported installing the unit recommended by their contractors (see Table 2-20). Contractors thus had great influence on the efficiency of equipment purchased by homeowners in the study.

Table 2-20

Contractor Influence on Customer Selection of High Efficiency Equipment by Equipment Type

Response	Type of Equipment			Overall (± 90% CI)
	Central AC & Heat Pump	Gas Furnace	Gas Boiler	
Installed Recommended Unit	89%	94%	100%	91% (± 4%)
Did Not Install Recommended Unit	7%	6%	0%	6% (± 4%)
Don't Know	4%	0%	0%	3% (± 2%)
Total	100%	100%	100%	100%
Number of Observations	71	34	12	117

In addition, 71 percent of survey respondents indicated that their contractor was the only source of information upon which they relied for information to help choose the heating and cooling equipment for their homes. This information is detailed in Table 2-21.

Table 2-21

Customer Reliance on Contractor as Information Source in Equipment Selection Decision

Response	Type of Equipment			Overall (± 90% CI)
	Central AC & Heat Pump	Gas Furnace	Gas Boiler	
Contractor was the sole source of information	67%	74%	83%	71% (± 6%)
Contractor was not the sole source of information *	25%	19%	17%	22% (± 5%)
Don't Know	8%	6%	0%	6% (± 3%)
Total	100%	100%	100%	100%
Number of Observations	100	47	23	170

* Contractor may or may not have been a source of information.

2.7.2 Information Sources

The most common source of information other than contractors was respondents' family and friends; one third of the respondents who reported relying on additional information sources reported that recommendations from these were important factors in their decision-making processes. Additional sources of information cited by respondents were manufacturer advertisements, utility program information, and past experience with the same brand of equipment. The highest proportion of respondents seeking additional information were in the central air conditioner and heat pump category, indicating that individuals purchasing these types of equipment are likely to conduct more extensive product research than respondents in the gas furnace or gas boiler categories. Because central air conditioners and heat pumps are discretionary purchases, customers are more likely to become actively involved in the process of selecting equipment.

2.7.3 Equipment Options

Nearly three-fourths (71 percent) of survey respondents indicated that their heating and cooling contractors recommended only one unit for them to consider. Of the 39 respondents reporting that their contractors recommended more than one unit, 35 respondents (90 percent) indicated that contractors mentioned that some of the units were more efficient than others. A small percentage of respondents indicated that their contractors discussed the different prices and operating costs for units of different efficiencies. Of the respondents whose contractors discussed units of differing efficiency, 63 percent (22 respondents) indicated that their contractors defined a specific efficiency level as "high efficiency." As shown in Table 2-22, more than 90 percent of these respondents were unable to report the efficiency defined by their contractors as "high efficiency." In addition, only 9 percent of the total survey respondents (14 individuals) indicated that they knew the efficiency of the new unit or units they had installed in 1998, 1999, or 2000. Of these, several respondents reported efficiency ratings that were invalid or on an incorrect rating scale. This is further evidence that customers generally do not understand efficiency designations and are thus unable to distinguish among units of differing efficiency.

Table 2-22
Customer Ability to Specify Contractor-Defined High Efficiency Level by Equipment Type

Ability to Specify Level Defined by Contractor	Type of Equipment			Overall
	Central AC & Heat Pump	Gas Furnace	Gas Boiler	
Could Specify	15%	0%	0%	9%
Could Not Specify	85%	100%	100%	91%
Total	100%	100%	100%	100%
Number of Observations	13	34	1	22

2.8 SYSTEM INSTALLATION

This section of the survey further examined the relationship between HVAC contractors and their customers in terms of contractor influence on customer decisions, as well providing information on the level of communication between contractors and customers regarding equipment size and capacity, ductwork, thermostats, and equipment efficiency.

2.8.1 Sizing

This section of the survey revealed that three-fourths (75 percent) of contractors discussed the size and / or capacity of the heating and cooling systems in customers' homes, and that 85 percent of these contractors provided documentation to support the size of the units recommended by the contractors, compared to 8 percent of contractors who did not provide any supporting documentation (see Table 2-23). It is likely that the increased credibility provided by this documentation contributes to customers' willingness to trust their contractors and install the equipment their contractors recommend.

Table 2-23
Contractors Providing Documentation to Support Size of Recommended Equipment by Equipment Type

Documentation Provided	Type of Equipment			Overall (± 90% CI)
	Central AC & Heat Pump	Gas Furnace	Gas Boiler	
Yes	84%	86%	87%	85% (± 5%)
No	6%	9%	7%	7% (± 4%)
Don't Know	9%	6%	7%	8% (± 4%)
Total	100%	100%	100%	100%
Number of Observations	77	35	15	127

2.8.2 Central Air Conditioners and Heat Pumps

For central air conditioners and heat pumps installed to replace existing units, 56 percent of survey respondents indicated that contractors replaced both the outdoor compressor and indoor fan coil unit when installing the new equipment. Twenty-six percent indicated that contractors replaced the outdoor compressor only, and 18 percent did not know. This information is provided in Table 2-24.

Table 2-24
Contractor Replacement of Indoor and Outdoor Units During Central Air Conditioner and Heat Pump Replacements

Equipment	Central AC & Heat Pump
Outdoor compressor only	26%
Outdoor compressor and indoor fan coil unit	56%
Don't Know	18%
Total	100%
Number of Observations	50

Forty-seven percent of respondents in the central air conditioner and heat pump category recalled that their contractors discussed with them the need to ensure proper refrigerant charge in the unit, and 56 percent indicated that contractors discussed the need to ensure proper airflow in the indoor part of their systems.

2.8.3 Ductwork

Seventy-one percent of respondents who had recent central air conditioner, heat pump, or gas furnace installations indicated that their contractors checked their ductwork to see that it was adequately insulated. This information is broken down by equipment type in Table 2-25.

Table 2-25
Respondents' Reporting of Contractors Checking for Adequate Duct Insulation by Equipment Type

Response	Type of Equipment		Overall (± 90% CI)
	Central AC & Heat Pump	Gas Furnace	
Yes	69%	74%	71% (± 6%)
No	14%	17%	15% (± 5%)
Don't Know / Refused	17%	9%	14% (± 5%)
Total	100%	100%	100%
Number of Observations	77	35	127

Of the 104 respondents who indicated that their contractors checked for adequate duct insulation, 30 percent indicated that their contractors recommended that additional insulation be added, and 67 percent indicated that their contractors did not recommend additional insulation. Thirty-eight percent of respondents indicated that contractors discussed the impact of ductwork leakage on

the efficiency of their heating and cooling systems and of these, half of the respondents indicated that contractors offered to measure the leakage of their ductwork. None of these respondents refused to allow contractors to measure ductwork leakage in their homes, and 23 percent had additional ductwork added as part of their installations.

2.8.4 Programmable Thermostats

Approximately half (49 percent, or 81 respondents) of survey respondents indicated that they had programmable thermostats in their homes prior to the installation of HVAC equipment in 1998, 1999, or 2000. Of the 79 respondents (51 percent of total) who indicated that they did not have programmable thermostats in their homes prior to the new equipment installation, 51 percent (40 respondents) indicated that their contractor recommended installing programmable thermostats. Eighty percent of these respondents installed programmable thermostats in their homes based upon contractor recommendations (see Table 2-26). This is further evidence that contractor recommendations are important factors in customers' choice of heating and cooling equipment.

Table 2-26
Respondents Installing Programmable Thermostats per Contractor Recommendation by Equipment Type

Response	Type of Equipment			Overall (± 90% CI)
	Central AC & Heat Pump	Gas Furnace	Gas Boiler	
Yes	84%	83%	33%	80% (± 11%)
No	16%	17%	67%	20% (± 11%)
Total	100%	100%	100%	100%
Number of Observations	77	35	15	127

2.9 UTILITY PROGRAM AWARENESS AND PARTICIPATION

2.9.1 Utility Program Awareness

The 100 customers who purchased new central air conditioners or heat pumps in 1998, 1999, or 2000 may have been eligible for participation in a high efficiency rebate program offered by their local electric utility. This section of the survey gauged customer awareness of and participation in these programs and identified the ways in which customers heard about the programs, customer satisfaction with the programs, and their impressions of the benefits of the programs and the high efficiency equipment these programs promote. Sixty-four percent of the respondents who had recent central air conditioner or heat pump purchases indicated that they were aware of the high efficiency programs offered by their local electric utilities.

2.9.2 Participation in Utility Programs

Of the 64 air conditioner or heat pump customers who were aware of utility rebate programs, thirty seven respondents (58 percent of aware respondents) participated in one of these programs. Twenty four respondents (38 percent) did not participate in the programs, and the primary reasons for non-participation included respondents thinking that participation was too much of a bother or they did not have the time to participate. Further breakdown is provided in Table 2-27.

Table 2-27
Reasons for Non-Participation in Rebate Programs

Reason	Central AC & Heat Pump
Not enough time	25%
Savings not worth it	13%
Rebate too small	8%
Contractor did not recommend it	4%
Contractor recommended against it	4%
Didn't understand the benefits	4%
Other	4%
Don't Know	25%
Total	100%
Number of Observations	24

Of the survey respondents who reported purchasing their central air conditioners or heat pumps in 1998, 1999, or 2000 to replace existing units, 16 participated in their electric utilities' high efficiency rebate programs. Eight-eight percent of these respondents indicated that they had noticed positive changes since replacing their old equipment with high efficiency equipment. These changes include lower utility bills, improved comfort, and quieter equipment operation.

2.9.3 Customer Satisfaction with Utility Programs

Of the 37 respondents who participated in one of the programs, 62 percent stated that they were "very satisfied" on a scale of 1 to 5 where 1 is "not at all satisfied" and 5 is "very satisfied." Nearly 90 percent of respondents gave the programs one of the two highest ratings, indicating a high level of participant satisfaction with electric utility high efficiency rebate programs. Only 2 respondents were "not at all satisfied," and one of the reasons given was that the rebate had not yet been received. Table 2-28 details respondent ratings of the programs.

Table 2-28
Respondent Ratings of Electric Utilities' High Efficiency Programs

Rating	Central AC & Heat Pump
5 – Very satisfied	62%
4	27%
3	3%
2	0%
1 – Not at all satisfied	5%
Don't Know	3%
Total	100%
Number of Observations	37

Eighty six percent of utility program respondents indicated that they would have installed a high efficiency unit even if they had not participated in the program. Only 3 percent indicated that they would not have purchased a high efficiency unit if they hadn't participated in the program.

2.10 ENERGY STAR PROGRAM AWARENESS

Of 170 survey respondents, only 19 percent reported that they had heard of the ENERGY STAR program for air conditioners, gas furnaces, or gas boilers. Details are provided in Table 2-29.

Table 2-29
Respondent Awareness of ENERGY STAR Program by Equipment Type

Response	Type of Equipment			Overall (± 90% CI)
	Central AC & Heat Pump	Gas Furnace	Gas Boiler	
Aware of Program	14%	26%	26%	19% (± 5%)
Not aware of Program	78%	72%	74%	76% (± 5%)
Don't Know	6%	2%	0%	4% (± 3%)
Refused	2%	0%	0%	1% (± 1%)
Total	100%	100%	100%	100%
Number of Observations	100	47	23	170

Of the 32 respondents reporting awareness of the Program, more than 40 percent identified that the program promotes high efficiency HVAC equipment. A small proportion of respondents recognized that ENERGY STAR is a marketing and labeling program designed by the Federal

Government, Department of Energy, or Environmental Protection Agency. Only 6 percent of respondents were able to correctly identify two or more characteristics of the Program.

2.11 CONCLUSIONS

Analysis of the New Jersey residential customer survey results yields the following conclusions:

- Nearly two thirds of customers installed HVAC units as replacements for an existing unit with central air conditioners and heat pumps being least frequently installed as replacements.
- Contractor selection by customers is not an "open" process and is based primarily on word of mouth.
- Contractors are the greatest influence on customers in terms of model selection and generally present only one model
- Customers are generally ignorant about efficiency and find rating systems confusing.
- Customers are generally aware that lower operating costs and less energy use are benefits of high efficiency HVAC equipment. However, customers were generally not aware of non-energy benefits from these systems like increased comfort, reduced noise, higher quality materials, and better controls.
- Of the air conditioner or heat pump customers who were aware of utility rebate programs, over half were participants. The main reasons for non-participation included respondents thinking that participation was too much of a bother or they did not have the time to participate.
- Nearly all respondents participating in utility high efficiency rebate programs gave the programs one of the two highest ratings, indicating a very high level of participant satisfaction with electric utility rebate programs.

3 CONTRACTOR SURVEY RESULTS

3.1 OBJECTIVES

The major objectives of the contractor survey were to gather information on:

- Characteristics of the sample firms and their business operations;
- Market share of energy-efficient equipment;
- Current installation practices, especially with respect to energy-efficiency;
- Marketing strategies, with emphasis on promotion of energy-efficient products and the use of energy efficiency in marketing the firm;
- Awareness of and participation in utility and government-sponsored energy efficiency programs; and,
- Potential communication and marketing channels for utility-sponsored energy efficiency efforts.

3.2 SURVEY METHODS

3.2.1 Sampling

The sampling approach was designed to produce a representative random sample of residential air conditioning and heating installation contractors and dealers. It is well known that the contractor segment of residential HVAC industry is characterized by a wide range of establishment sizes, ranging from single tradesmen/owners to large regional firms employing hundreds of workers. The sample was a stratified, with size of the firm as the stratification variable. The sampling plan is described below:

- ***Sample frame***. Sample frame was drawn from the IMarket database of Dun & Bradstreet establishment records – for New Jersey boiler and furnace contractors and heating and air conditioning contractors (standard industrial classification codes 1711-01 and 1711-04 respectively). Dun & Bradstreet records offer fairly complete coverage for firms with 10 employees or more. Below that size coverage is good but less universal. However, contractors employing fewer than 10 employees account for a relatively small share of the market.
- ***Measure of size*** Due to potential problems with sales related for specific firm locations, number of employees at the contractor location was chosen as the measure of size. This information is generally accurate and consistent, in the aggregate, with establishment statistics from other sources.

- ***Stratification.*** Overall target sample size was 45 interviews with the sample broken into seven size strata and three types of business as shown in Table 3-1. Type of business in this case refers to the type of market served by the business – i.e. whether the firm worked only on existing homes for replacement systems, only new construction or on projects in both existing and new homes. The sample frame for each stratum is also shown.

Table 3-1
HVAC Contractors Sample Plan and Results

Size Stratum: Number of Employees	Number of Firms				
	Sample Frame	Target and Actual Completes (actual)			
		Replacement and New Construction	Replacement	New Construction	Total (Actual completes)
1: 1	590	(1)	1 (1)	1	2 (2)
2: 2 to 4	1168	(1)	7 (2)	4	11 (3)
3: 5 to 9	408	(1)	6 (3)	3	9 (4)
4: 10 to 24	263	(6)	8 (6)	4	12 (12)
5: 25 to 49	70	5 (5)			5 (5)
6: 50 to 99	23	3 (3)			3 (3)
7: 100 to 249	10	3 (1)			3 (1)
Total	2532	11 (18)	22 (12)	12 (0)	45 (30)

3.2.2 Recruitment and Interviewing

Sample contractors were offered a $100 incentive to participate in the survey. Despite this offer, recruitment proved difficult, perhaps due to the timing of the research during one of the most active construction seasons in recent memory. XENERGY was able to obtain 30 actual complete interviews. As shown in Table 3-1, all of these firms did projects in existing buildings and 18 of them did work in both new and existing buildings. None of the respondents did only new construction. The interviews were conducted by qualified XENERGY professional staff.

3.2.3 Data aggregation, Weighting, and Reporting

To permit the market-oriented analysis of survey data required by the objectives of this research, the 30 respondents were regrouped into size categories that differ from the employee strata on which the sample design was based. Each respondent was assigned to one of four new size categories defined by the contractor's annual volume of market activity or business volume (e.g. number of installations made). Market activity is measured as the "number of homes where

HVAC installations were completed per year" by responding firms (which is an indication of annual sales volume for a firm).

Data from the survey on the "number of homes served per year" for the years 1999 and 2000 were used to construct the size categories and assign the sample firms to them. Since the firm size measure (number of employees) does not necessarily correlate with firms having large annual sales (e.g. some medium sized firms may have a large number of installations), all firms in a single firm size stratum may not all be in the same market activity category.

The allocation of sample firms to market categories is presented in Table 3-2, which shows, for instance, that 8 of the 30 responding firms fall into the "smallest" category, which is defined as firms that complete a maximum of 38 home installations per year (or "homes served / year" in the table). The four firms in the "large" category have somewhere between 551 and 2,250 homes served / year.

Table 3-2
Volume of Market Activity by Size Category

	Market Activity (number of homes served / year, 1999-2000)				
	Smallest	**Small**	**Medium**	**Large Firms**	**All Firms**
Maximum Installations/Year	38	200	550	2,250	
Number of sample firms	8	11	7	4	30
Population Information (year 2000)					
Number of firms	1,343	1,026	124	39	2,532
Average number of employees (at the respondent location)	4	9	19	78	30(±17)
Installation Volume: New and Existing Homes					
Average number of homes served	24	147	358	2,210	748 (±484)
Average market share	10%	48%	14%	28%	100%
Installation Volume: New Homes Only					
Average number of homes served	1	26	11	282	87(±65)
Average market share	3%	66%	3%	27%	100%
Installation Volume: Existing Homes Only					
Average number of homes served	23	121	347	1,928	661
Average market share	11%	45%	16%	28%	100%

The figures only include HVAC equipment installations (all HVAC equipment) and do not include service jobs.

3.3 ESTABLISHMENT CHARACTERISTICS AND BUSINESS OPERATIONS

3.3.1 Establishment Characteristics

Market Activity Distribution and Market Share. Based on the survey results, Table 3-2 shows an estimate of how the population of 2,532 HVAC contractors in New Jersey are distributed by market activity size category. This distribution was determined using both market activity results from each respondent and the stratification characteristics of the 30-firm sample. Estimates for the corresponding average number of employees in the firms of each category are also given.

For the firms in each size category, the table also gives an estimate of the average number of homes served and corresponding market share, expressed as a percentage of total homes served in the particular existing or new home market type shown. These results are given separately by type of market served – the upper portion of the table shows total projects in both new and existing homes and the lower part presents information on work in existing homes only. (*Note:* Where appropriate, the "All Firms" or "Total" column of several tables in this chapter include information on the confidence intervals for sample means. In these cases, a "±" interval value is included in parentheses following the mean estimate. This is the amount to be subtracted from or added to the sample means to produce the lower and upper bounds of the 90% confidence interval for the mean. For example, in Table 3-2, the average number of new and existing homes served by all firms is 748±484 at the 90 percent confidence level.)

The table shows that the residential HVAC installation and service market is somewhat concentrated in terms of homes served. The top 39 firms (less than 2 percent of the total) account for 28 percent of total annual installations (as measured by homes served) and 28 percent of all HVAC projects in existing homes. Moreover, there are nearly 1,400 HVAC contracting firms in New Jersey with five or fewer employees. These companies serve an average of 24 homes per year and account for only 10 percent of total installations.

Number of Employees and Staff Configuration. Table 3-3 displays findings concerning the numbers of employees in various field and sales positions in the sample firm. In the smallest and medium size strata, the average number of employees in field and sales positions exceeds the average total employment of firms within the size category. This indicates that sales and field staff are likely to be doing double duty and that field technicians do both installation and service. This pattern is reflected in the responses to the question on maintenance of separate installation and service staffs. Only 6 percent of the smallest firms and 47 percent of the medium firms maintain separate installation and service staffs. Among firms with more than 25 employees, the ratio of field to total staff declines to 75 percent, with the remaining positions presumably assigned to administrative functions. The small stratum (5-9) employees does not fit the pattern of declining percentage of field staff with larger firm size. One possible explanation for this discrepancy is that we obtained interviews with only 3 firms in this size category.

Table 3-3
Staff Configuration by Size Stratum

	Market Activity (number of homes served / year, 1999-2000)				
	Smallest (max 38)	Small (max 200)	Medium (max 550)	Large (max 2250)	All Firms
Average number of employees	4	9	19	78	30 (±17)
Average number of installers	3	3	12	37	15 (±9)
Average number of service techs	2	1	6	11	6 (±5)
Percent with separate installation and service staffs	6%	70%	47%	100%	65%
Average number sales associates	1	1	4	6	3 (±1)

Area Served. The sample contractors were asked to characterize the extent of the geographic area they served. Table 3-4 summarizes the responses to this question. The larger the firm, the more likely it is to serve an extended geographic area. Again, the three firms in the 5-9 employee category show a break in this pattern. None of the firms claimed to serve the entire state of New Jersey.

Table 3-4
Geographic Extent of Operations

	Market Activity (number of homes served / year, 1999-2000)				
	Smallest (max 38)	Small (max 200)	Medium (max 550)	Large (max 2250)	All Firms
Local city or town	73%	3%	28%	20%	22%
Metropolitan area	0%	14%	42%	0%	18%
Significant portion of NJ	18%	68%	14%	55%	43%
Multi-state region	0%	16%	16%	26%	17%
Other	9%	0%	0%	0%	0%

3.3.2 Installation Activity

Volume of equipment installations. Table 3-5 summarizes information on the sample contractors' annual volume of installation for various kinds of heating and cooling equipment. The following observations can be made based on this table.

- *Products installed.* All sample contractors reported that they had installed residential gas furnaces during the past year. Of the 30 companies interviewed, 29 had installed central air conditioners and 26 had installed gas boilers. Roughly half of the respondents had

installed heat pumps and bulk fuel heating equipment. Finally, two-thirds of the respondents had installed programmable thermostats in the past year.

- *Unit volumes by equipment type.* On average, the sample firms installed central air-conditioning in 81 percent of the homes in which they worked; and gas furnaces in 66 percent of the homes. Gas boilers, bulk fuel heating equipment, and heat pumps accounted for much smaller portions of the contractors' business. The data on programmable thermostats suggests that larger contractors make a practice of installing those devices whereas smaller ones generally do not.

- *Pattern of specialization.* Installation of gas boilers and, to a lesser extent, furnaces seem to be concentrated in the medium size category (10 – 24 employees). Most of the contractors who sold head pumps *did not* sell oil or propane heating equipment.

Table 3-5
Volumes of Unit Installations by Establishment Size Category

n = 30	Market Activity (number of homes served / year, 1999-2000)				
	Smallest (max 38)	Small (max 200)	Medium (max 550)	Large (max 2250)	All Firms
Central A/C: n = 29					
Mean units installed: 2000	11	76	222	673	274 (±154)
Mean portion of all homes served	47%	78%	58%	89%	81%
Gas Furnaces: n = 30					
Mean units installed: 2000	9	41	121	741	249 (±158)
Mean portion of all homes served	17%	50%	96%	67%	66%
Gas Boilers: n = 26					
Mean units installed: 2000	6	16	92	51	56 (±53)
Mean portion of all homes served	3%	12%	44%	13%	16%
Heat Pumps: n = 15					
Mean units installed: 2000	0	5	11	85	33 (±35)
Mean portion of all homes served	0%	1%	2%	5%	4%
Oil & Propane Heating: n = 17.					
Mean units installed: 2000	6	14	17	16	15 (±8)
Mean portion of all homes served	3%	12%	20%	9%	11%
Programmable T-stats: n = 20					
Mean units installed: 2000	3	73	272	794	320 (±207)
Mean portion of all homes served	23%	34%	91%	91%	81%

Brands carried. The range of brands that a contractor carries or represents is significant in that it may reflect their level of interest in marketing energy efficiency. Most major manufacturers of residential heating and cooling equipment produce and ship high efficiency equipment and participate in the ENERGY STAR labeling program, although the degree of participation varies. Goodman holds the second largest market share of residential HVAC equipment (slightly trailing Carrier), with approximately one fifth of the market for central air conditioning systems, gas furnaces, and air source heat pumps. However, Goodman's product line also includes the fewest energy Star compliant products. Carrying Goodman, or second line brands of the major manufactures such as American Standard may indicate a lack of interest in energy efficiency.

Table 3-6 displays the percent of firms in the various size categories that carry equipment made by manufacturers listed in the left-most column. The table includes rows only for manufacturers carried by at least 10 percent of all sample contractors. Most contractors carry only two lines of equipment. In most cases where contractors carry multiple lines, at least one is a specialty item such as Weil-McLain boilers.

All seven of the manufacturers listed in Table 3-6 produce energy-efficient HVAC products that meet standards set forth by EPA Energy Star. Trane and Carrier are perhaps the most enthusiastic in their support of the program and Goodman appears to offer the fewest certified products. A large percentage of the smaller HVAC contractors carry the Goodman products. The larger contractors carry the Goodman products as a lower line while also carrying a fuller selection of the other major manufacturers. Table 3-7 lists the various high-efficiency HVAC products by type for each of the manufacturers.

Table 3-6
Brands Carried

	Market Activity (number of homes served / year, 1999-2000)				
	Smallest (max 38)	Small (max 200)	Medium (max 550)	Large (max 2250)	All Firms
Median number of brands carried	1	2	2	3	2
Trane	2%	22%	49%	55%	37%
Ruud	0%	68%	42%	0%	35%
York	0%	5%	53%	26%	25%
Carrier	0%	5%	24%	41%	20%
Rheem	0%	17%	0%	55%	20%
Goodman	53%	9%	0%	41%	19%
Lennox	12%	8%	16%	24%	15%

Table 3-7
Energy Star Participation by Manufacturer and Product Category

	AC	Gas furnaces	Gas boilers	Air source heat pumps	Programmable Thermostats
Trane	Yes	Yes	No	Yes	
Ruud	Yes	Yes	No	Yes	
York	Yes	Yes	No	Yes	
Carrier	Yes	Yes, condensing furnaces	No	Yes	Yes
Rheem	Yes	Yes	No	Yes	
Goodman	Yes, limited	Yes, condensing	No	Yes, limited	
Lennox	Yes	Yes	No	Yes	Yes
Rheem-Ruud	Yes	Yes	No	Yes	

3.4 INSTALLATION OF ENERGY EFFICIENT EQUIPMENT

3.4.1 Market Share for Efficient Equipment

Sample contractors were asked to estimate the percentage of New Jersey utility program-qualifying equipment they installed in 2000 for each of the major equipment categories. In asking the questions, qualifying efficiency criteria were specifically identified. For central air conditioners and heat pumps, market share of both Tier 1 and Tier 2 efficiency levels was checked.

Table 3-8
Share of High Efficiency Equipment Installed

	Market Activity (number of homes served / year, 1999-2000)				
	Smallest (max 38)	Small (max 200)	Medium (max 550)	Large (max 2250)	All Firms
Central A/C: ≥ SEER 13/EER11					
Existing Homes	10%	28%	80%	74%	56% (±23%)
New Homes	0%	19%	77%	57%	42% (±25%)
Central A/C: ≥ SEER 14/EER12					
Existing Homes	6%	18%	62%	28%	34% (±21)
New Homes	0%	13%	46%	5%	16% (±12%)
Gas Furnaces: ≥ AFUE 90%					
Existing Homes	56%	40%	39%	42%	42% (±8%)
New Homes	0%	28%	56%	12%	27% (±9%)
Gas Boilers: ≥ AFUE 85%					
Existing Homes	40%	12%	14%	21%	18% (±11%)
New Homes	0%	13%	50%	0%	13% (±12%)
Heat Pumps: ≥ SEER 13/EER11					
Existing Homes	0%	67%	14%	0%	25% (±22%)
New Homes	0%	37%	50%	0%	27% (±18%)
Heat Pumps: ≥ SEER 14/EER12					
Mean units installed: 2000	0%	21%	11%	0%	11% (±12%)
Mean portion of all homes served	0%	12%	44%	0%	15% (±14%)
ENERGY STAR T-Stats					
Mean units installed: 2000	30%	20%	47%	8%	25% (±22)
Mean portion of all homes served	0%	12%	100%	12%	17% (±19%)

Contractors report a very high share of efficient equipment in their recent installations. These results do not conform to several previous studies. National estimates of high-efficiency HVAC adoption rates are also much lower than the results of this contractor study. A survey performed by Easton Consultants puts national market penetration at a much more modest range of 10 to 45 percent with a median around 20 percent. Finally, a study by EPA shows a 10 percent national adoption percentage for new construction.

The market penetration figures obtained for gas furnaces and boilers are also rather high in comparison to the earlier studies mentioned. The adoption of energy efficient gas furnaces ranges from 39 to 56 percent for existing homes and up to 56 percent for new homes. The market penetration figures for gas boilers range from 12 to 40 percent for existing homes and up to 50 percent for new homes. These figures are even more out of line with previous studies that put national adoption of energy efficient boilers at mere 10 percent.

It is possible that the sample size of our survey at 30 was too small to produce reliable market penetration figures. The more likely explanation is that contractors systematically over-reported the share of high efficiency equipment they installed.

3.4.2 Adoption of Efficient Sizing and Installation Procedures

Choosing the optimum size heating and cooling equipment for a given residential installation is key when trying to maximize energy efficiency. Over-sizing is perhaps the most common mistake resulting in higher purchase price, and operation and maintenance costs. The survey sought to clarify what methods the contractors used to properly size residential systems and when during the purchase process they made this decision.

The timing of the sizing decision during the sales process may indicate the thoroughness of the contractor's sizing approach. Contractors were asked if they made their sizing decision during or after the initial sales call, or after a contractor had already been authorized. According to the survey results contained in Table 3-9, the smallest and medium tiers of sample contractors generally made the sizing decision during the initial sales call whereas the small and large firms were more likely to make the sizing determination after initial contact with the consumer. Overall, slightly more than one-third of the contractors (37 percent) made the sizing decision during the initial sales call and more than half (53 percent) made the decision after the initial call. The remainder waited until the contract was in place or some combination of the above. These results indicate that over half of the contractors sampled gave themselves additional time for a more thorough load analysis before equipment was specified.

Table 3-9
Equipment Sizing Determination Made During the Sales Process

Sizing Determination	Market Activity (number of homes served / year, 1999-2000)				Total
	Smallest (max 38)	Small (max 200)	Medium (max 550)	Large (max 2250)	
Initial Sales Call	83%	4%	57%	41%	37%
After the sales call	11%	84%	27%	59%	53%
When contract authorized	2%	7%	0%	0%	2%
Other	3%	5%	16%	0%	7%

The methods used to size the customer's heating and cooling system is vital to achieve optimum energy efficiency. Contractors were asked to select from a list of common sizing techniques, recording all the methods that they used. The sampled contractors showed strong support of the Manual J standards published by the Air Conditioning Contractors of America. (See Table 3-10) Overall, 67 percent of the contractors used Manual J to calculate heating/cooling loads and size residential HVAC systems. The next most common method employed was to use a tons/square feet estimate method at 26 percent. The small and smallest firms were far less likely to use Manual J than their larger counterparts and instead used the tons/square foot method or other rules of thumb. The larger firms used Manual J nearly 100 percent of the time whereas the smaller firms used it no more than a third of the time. Computer software was utilized by approximately 15 percent of the small- and medium-tier contractors. Software used included Res-Calc, Lennox Logic, Wright Soft, and Elite. One respondent noted that two sizes of equipment were used in all residential situations.

Table 3-10
Sizing Methods Employed

Sizing Methods Employed	Market Activity (number of homes served / year, 1999-2000)				Total
	Smallest (max 38)	Small (max 200)	Medium (max 550)	Large (max 2250)	
Size to previous unit	21%	0%	23%	0%	9%
Tons/sq ft estimate	23%	59%	15%	0%	26%
Other rules of thumb	3%	0%	0%	0%	<1%
Manual J	14%	31%	93%	100%	67%
Computer Program	2%	14%	16%	0%	10%
Other	63%	2%	49%	0%	22%

Though the use of Manual J was nearly universal among the larger sampled contractors, it met with only modest support from their smaller counterparts. When asked why another method might be substituted in place of Manual J, the most common reason given 33 (±1) percent was that other methods work (more effectively) in these situations. Less than 20 percent of the contractors felt that the use of Manual J was too time consuming. The contractors were also asked to provide specific reasons why Manual J might not be used. Some indicated that the information required by the method was too hard to obtain ("How can I measure insulation thickness if it is already in the wall?") but most felt that other methods simply worked better in their estimation.

Manual J has lately drawn some criticism from energy efficiency advocates. Some studies have shown that Manual J overestimates building heating/cooling loads and results in the over-sizing of air conditioners and heat pumps. A study conducted by the Proctor Engineering Group found that the method typically overestimates heating/cooling loads by 24 percent. This is of particular concern since contractors frequently incorporate their own "safety factor" when they size equipment. The safety factor is usually added because the majority of new and existing houses are not particularly energy efficient and thus systems are oversized to account for this. In addition, contractors probably want to minimize the likelihood of callbacks due to under-performing hearing and cooling equipment during weather extremes.

Table 3-11
Reasons for Not Using Manual J

Reasons for not using Manual J	Market Activity (number of homes served / year, 1999-2000)				Total
	Smallest (max 38)	Small (max 200)	Medium (max 550)	Large (max 2250)	
Too time consuming	24%	5%	100%	0%	17%
Results inaccurate	0%	0%	0%	0%	0%
Other methods work	82%	5%	100%	0%	33%
Other	41%	95%	0%	0%	74%

According to the data, the larger builders were much more likely to have revised their sizing practices as a result of participation in the NJ HVAC program. Less than 20 percent of the smallest builders said they changed their sizing techniques. On the other hand, 100 percent of the large builders said they changed their techniques due to program participation. The small and medium builders fell somewhere within that range.

Some of the sampled contractors cited other specific ways in which they had changed their sizing of HVAC equipment:

- Use Wright-Soft software due to stricter rebate requirements
- Checking and documenting the air flow and charging of the system
- Use different, up-to-date selling methods to take rebates into account
- With regard to heating and air conditioning: don't just size to previous unit but take appropriate measurements and calculate size for every unit
- Perform work only on 5 Star houses

Duct installation. According to HVAC experts interviewed in conjunction with this study, sealing ductwork in a home can provide energy savings on the order of 25 percent. We asked the sampled contractors to select from a group of measures commonly employed to improve duct performance. The results are contained in Table 3-12. Almost three-quarters of the contractors cited other duct installation procedures. These include:

- Insulate ductwork and use silicon seams
- Optimize duct and return sizes/designs using Manual D or equivalent methods

- Make sure returns are adequate and use separate returns in all rooms
- Optimize the static pressure within the duct system.
- Use sheet metal main trunk lines, streamline branch connections, and make minimal use of flexible branch lengths
- Use balancing dampers to adjust different airflows to different rooms (determined by room size and use)
- Use Internally lined sheet metal instead of fiberboard
- Ductulator

Table 3-12
Duct Installation Procedures

Duct Installation Procedures	Market Activity (number of homes served / year, 1999-2000)				Total
	Smallest (max 38)	Small (max 200)	Medium (max 550)	Large (max 2250)	
Install ducts uncond spaces	6%	6%	43%	26%	23%
Special duct mastic	50%	11%	7%	41%	21%
Insulate cold air returns	6%	1%	0%	26%	8%
Other	79%	91%	65%	55%	72%

Replace operable heating coil. HVAC contractors were asked how routinely they replaced the operable indoor heating coil unit when they installed new HVAC equipment in new and existing homes. This procedure is usually done to make sure that the capacity of the evaporator coil is compatible with and/or matches the speed of the fan unit. It may also be done if warrantee issues are involved. Three-quarters of the contractors said that they always or usually replaced the operable unit. The results are contained in Table 3-13.

Table 3-13
Replace Operable Indoor Coil Unit

	Market Activity (number of homes served / year, 1999-2000)				Total
	Smallest (max 38)	Small (max 200)	Medium (max 550)	Large (max 2250)	
Always	64%	56%	8%	0%	26%
Usually	13%	35%	51%	80%	50%
Sometimes	23%	9%	42%	20%	23%
Never	0%	0%	0%	0%	0%

Methods to check refrigerant charge. Cooling equipment works most efficiently when it has the optimum level of refrigerant and proper maintenance requires that levels be checked accurately. Weighing the refrigerant is the most accurate approach but is not always feasible. The superheating and subcooling methods are indirect approaches to checking refrigerant charge, and one or the other is used depending on the climate. Contractors were asked which one of several popular methods they used to check refrigerant charge. The results to our question are contained in Table 3-14. The superheating method was used 50 percent of the time and the weighing and sub-cooling methods were each used by about a third of the contractors.

Table 3-14
Methods to Check Refrigerant Charge

	Market Activity (number of homes served / year, 1999-2000)				Total
	Smallest (max 38)	Small (max 200)	Medium (max 550)	Large (max 2250)	
Weigh refrigerant	0%	9%	23%	80%	31%
Superheat method	35%	25%	56%	80%	50%
Subcooling method	9%	7%	57%	55%	35%
Other	50%	64%	58%	0%	44%

3.5 MARKETING AND SELLING OF ENERGY EFFICIENCY

3.5.1 Marketing Methods

Contractors were asked to select from a group of methods that they use to promote the sale of high-efficiency HVAC equipment to their customers. More than three-quarters of the contractors surveyed found "word of mouth" to be the most effective method to spread this message. This is consistent with customer "contractor search" behavior. That is, these customers have already decided to purchase high-efficiency HVAC equipment and are seeking out contractors that carry and install these systems. Nearly 60 percent of the contractors felt that word of mouth was the most important way to advertise their high-efficiency product offering and installation options. Chapter 2.5.1 notes that at least 50 percent of customers surveyed claimed they selected contractors based on a referral by a friend or family member. Thus, it seems word of mouth is important to both customers and contractors.

The contractors also made extensive use of the yellow pages, newspaper and print ads to make customers aware that they offered high-efficiency products. In all, 60 percent of the contractors make use of the yellow pages and 20 percent believe that it was the second most important method of promoting efficient products after "word of mouth". Newspaper and print ads were employed by nearly 50 percent of the contractors and this method, ranking third of the marketing strategies listed in the survey. Prior customer relationships were considered an important by nearly one-third of contractors (26%) but apparently did not materialize into sales very effectively. Radio ads, direct mail, telemarketing, and truck decals were also identified as common marketing techniques each by less than 20 percent of the contractors but were not deemed very effective.

Table 3-15
Methods Used to Promote High-Efficiency HVAC Equipment and Installations

Methods Used to Promote High Efficiency Installations	Market Activity (number of homes served / year, 1999-2000)				Total
	Smallest (max 38)	Small (max 200)	Medium (max 550)	Large (max 2250)	
Newspaper/print ad	25%	15%	49%	100%	49%
Prior customer relationship	28%	23%	32%	20%	26%
Word of mouth	100%	99%	74%	41%	76%
Yellow pages	67%	43%	93%	41%	60%
Radio ads	15%	0%	16%	41%	17%
Direct mail	3%	15%	0%	21%	11%
TV ads	0%	2%	18%	0%	7%
Other	6%	3%	9%	45%	16%

Table 3-16
Marketing Methods Most Effective and Others Mentioned

	Method Most Effective	Other Methods Mentioned
Newspaper/print ad	11%	22%
Prior customer relationship	4%	29%
Word of mouth	57%	57%
Yellow pages	20%	34%
Radio ads	2%	5%
Direct mail	<1%	7%
TV ads	1%	6%
Other	4%	23%

Sampled contractors were asked whether they incorporated information about energy-efficient HVAC equipment in the various advertising options that they used. The "medium" tier firms were most likely to add such product information in their ads as a whole. Newspaper/print ads were most common at 38 percent, followed by the yellow pages at 33 percent, and word of

mouth and prior customer relationship tied at 25 percent. Less than a quarter of responses went to radio, direct mail or TV ads.

Among the small and smallest tiers, the methods most likely to display this information were word of mouth (25 and 20 percent respectively for smallest and small tier firms). The small tier firms also made use of newspaper/print ads (14 percent), yellow pages (18 percent), and direct mail (18 percent). The large firms were the least likely, overall, to advertise these products. They primarily used newspaper/print ads (80 percent) and radio ads (20 percent). The data suggest that the sampled contractors overall do not frequently incorporate information about energy efficient HVAC products in their marketing materials.

3.5.2 Personal Selling

Promotional effort for energy efficient models.

According to the data contractors report selling and giving bids for energy-efficient equipment much more frequently than customers interviewed for a companion study. The smallest and large tier firms claimed that they discussed high-efficiency products with their customers 100 percent of the time. (Table 3-17)

Table 3-17
Discuss High Efficiency HVAC With Customer

Discuss High Efficiency HVAC with Customer	Market Activity (number of homes served / year, 1999-2000)				Total
	Smallest (max 38)	Small (max 200)	Medium (max 550)	Large (max 2250)	
In all/most cases	100%	26%	47%	100%	59%
In some cases	0%	15%	53%	0%	22%
In relatively few	0%	3%	0%	0%	1%
In no cases	0%	56%	0%	0%	18%

These figures seem a bit high considering related questions that indicated lukewarm contractor interest in high-efficiency equipment and other studies that put the figure much lower. The 26 to 47 percent range reported by the small and medium tier contractors would seem to be a more likely figure.

The survey also asked the contractors if there were certain customers to which they were more likely to market high-efficiency products. It is clear from the results that the contractors were far more likely to market energy efficient equipment to high-income consumers than to customers defined by their housing type. This would indicate that contractors perceive high-income

consumers to be the market segment most willing to pay the cost premiums associated with high efficiency equipment.

Although the energy-saving potential of these products is the primary feature pitched to consumers, we wanted to discover any other non-energy benefits that might also make the technologies attractive from the vendor's standpoint. Table 3-18 shows that the contractors tended to emphasize aspects such as quieter operation, superior warrantees, comfort considerations, and the available utility rebates in about equal measure. Their incorporation of non-energy benefits like these into their sales approach mirrors the strategy of manufacturers to package operating features and efficiency into premium packages.

Table 3-18
High Efficiency HVAC Features Emphasized to Customers

High efficiency features emphasized	Market Activity (number of homes served / year, 1999-2000)				Total
	Smallest (max 38)	Small (max 200)	Medium (max 550)	Large (max 2250)	
Quieter operation	0%	13%	28%	55%	31%
Greater reliability	0%	44%	9%	0%	11%
Longer Service Life	50%	7%	0%	0%	7%
Better warranty	50%	19%	0%	59%	28%
Comfort	0%	13%	86%	0%	36%
Utility rebate	52%	38%	7%	45%	30%
Availability of financing	50%	0%	0%	0%	6%
Safety	0%	13%	32%	0%	15%
Other	6%	37%	7%	20%	16%
No others	33%	6%	0%	0%	5%

Nearly 60 percent of the contractors sampled claimed to have presented bids for energy-efficient HVAC equipment in all or most cases and 40 percent said they had in some situations. The smallest tier contractors claimed that they presented bids for energy efficient models in all or most cases 100 percent of the time. Small tier contractors were close behind, presenting bids in all or most cases 87 percent of the time. Among the medium tier firms, the energy-efficient bids were given in all or most cases 31 percent of the time and the remaining 69 percent claimed in some cases. The large tier gave bids for efficient products firms in 56 percent of cases and 44

percent of the time in some cases. 69 percent of respondents said that the bids are presented in some cases and 31 percent claimed in all cases.

3.5.3 Barriers to Promotion of Energy Efficiency

Insufficient Energy/Cost Savings

Sampled contractors were asked to identify the largest obstacle to success in promoting high-efficiency central air conditioners, gas furnaces and boilers in existing homes. As indicated in Table 3-19, the obstacle cited most often for both technology groups was insufficient energy/cost savings to stimulate significant consumer interest (49 percent for central air conditioners and 55 percent for gas furnaces and boilers). A much smaller percentage of the sampled contractors noted rebate hassles and lack of customer interest in high-efficiency equipment

Table 3-19
Biggest Problem Promoting High-Efficiency Central AC and Gas Furnaces/Boilers

	Problem/Totals for Central AC	Problem/Totals for Gas Furnaces/Boilers
Not important to Business	0%	1%
Customer not interested	7%	7%
Savings not enough	49%	55%
Rebate hassles	17%	6%
Other	28%	31%

Emergency Replacement

Emergency replacement of failed heating and cooling equipment is another frequently cited barrier to the greater adoption of energy efficient heating and cooling equipment. In these situations, supposedly, the first priority of the consumer is to resume normal operations as quickly as possible. Due to this fact there is not the time taken to review energy-efficient alternatives or special order a high-efficiency replacement model that may not be readily obtainable from the warehouse. This barrier may seem intuitive but is not consistent with the fact that most manufacturers have extensive distributor networks and that parts availability should be no different than with traditional alternatives. In any case, emergency installs account for only 12 –26 percent (12 percent ±7, 26 percent ±11) percent or so of installations, depending on type of equipment. So, we would not characterize this barrier as being particularly decisive.

Reliability/Callbacks

Finally, many industry spokesmen cite the added complexity of energy-efficient heating cooling equipment and speculate that this leads to greater unreliability in the field and more frequent contractor callbacks to perform maintenance and repairs. We asked the sampled contractors whether the energy efficient central air conditioners and gas furnaces and boilers required more frequent maintenance calls than the standard models. Almost all respondents reported no difference in the frequency of callbacks for central air conditioners, but 36 percent reported more callbacks for efficient gas furnaces and boilers. This is consistent with the nature of condensing boiler technologies, which are more complicated and that give rise to different exhaust requirements. (See Table 3-20 and 3-21.)

Table 3-20
Energy Efficient vs. Standard Central Air Conditioner Callbacks

	Market Activity (number of homes served / year, 1999-2000)				Total
	Smallest (max 38)	Small (max 200)	Medium (max 550)	Large (max 2250)	
More Frequent	0%	3%	0%	0%	1%
Less Frequent	1%	0%	0%	0%	<1%
About the same	99%	97%	100%	100%	99%

Table 3-21
Energy Efficient vs. Standard Gas Furnaces and Gas Boilers

	Market Activity (number of homes served / year, 1999-2000)				Total
	Smallest (max 38)	Small (max 200)	Medium (max 550)	Large (max 2250)	
More Frequent	19%	27%	8%	80%	36%
Less Frequent	0%	2%	0%	0%	1%
About the same	81%	71%	92%	20%	63%

3.6 PROGRAM AWARENESS AND PARTICIPATION

To better understand the market acceptance of energy-efficient products in New Jersey it is necessary to estimate the effectiveness of the various high-efficiency HVAC programs operated by New Jersey's electric and gas utilities as well as Federal government programs such as Energy Star. Sample contractors were asked whether they had or intend to participate in these programs and to rate their level of effectiveness to generate greater market acceptance of these products.

3.6.1 NJ High Efficiency Electric HVAC Program

Fifty-two percent of the sampled contractors had heard of the NJ high-efficiency electric HVAC program, and 79 percent of this group said they had participated in the program. All contractors that comprised the large tier participated in the program. Participation was also strong among the small group of firms. Those contractors in the smallest and medium categories claimed the fewest participants.

Those contractors that chose not to participate in the program were asked what their rationale was for doing so. Just over one-third of the contractors cited rebate paperwork hassles with energy-efficient products, 16 percent of firms saw energy efficient HVAC as a non-profitable enterprise, and 14 percent of the firms saw insufficient energy savings in high-efficiency HVAC. The remainder of the contractors claimed that they did not have sufficient information about the program.

Secondary reasons for non-participation included 38 percent that cited insufficient energy savings associated with the equipment, 22 percent that noted rebate hassles, 9 percent that believed the products were not important to their business, and 7 percent that identified performance problems with the technology.

Table 3-22
Participation in the NJ High-Efficiency Electric HVAC Program

	Market Activity (number of homes served / year, 1999-2000)				Total
	Smallest (max 38)	Small (max 200)	Medium (max 550)	Large (max 2250)	
Yes	28%	82%	45%	100%	79%(±1%)
No	72%	18%	55%	0%	21%(±1%)

Table 3-23
Participation in the NJ High-Efficiency Gas HVAC Program

	Market Activity (number of homes served / year, 1999-2000)				Total
	Smallest (max 38)	Small (max 200)	Medium (max 550)	Large (max 2250)	
Yes	46%	100%	67%	100%	88%(±1%)
No	54%	0%	33%	0%	12%(±1%)

3.6.2 NJ High-Efficiency Gas HVAC Program

We followed a similar strategy with the NJ High-Efficiency Gas HVAC Program. Of the sampled contractors, 40 percent had heard of the NJ high-efficiency gas HVAC program and, of these, 88 percent claimed that they had participated in the program. Participation was strongest among the three largest tiers of contractors with complete participation among the large tier firms. The primary reasons given for non-participation by the remaining 12 percent of contractors included rebate hassles (75 percent) and the belief that energy-efficient HVAC is not sufficiently profitable (25 percent). A couple of respondents noted the insufficient savings associated with these products and felt that they are not vital enough to their business strategy.

3.6.3 Energy Star/Good Cents Home/ EEH 5 Star Builders Program-New Construction

Of the sampled contractors, 89 percent had heard of the Energy Star/Good Cents Home/EEH 5 Star Builders program offered by their participating NJ utility. About half of the respondents (49 percent) were very familiar and 8 percent were somewhat familiar with the services and marketing support that this program offers to builders.

Contractors were asked to name the services offered by the program that they were most familiar with. The list of services included: guidelines for energy-efficient new construction; certification of energy-efficient construction by trained third-party inspectors; use of the Energy Star (Good Cents) label on the home and marketing materials; co-advertising and other types of marketing support; access to mortgage plans that reflect lower operating costs by providing higher levels of funding; and financial incentives for including energy efficient features in new homes. The contractors were most cognizant of the financial incentives offered by the program (69 percent) and nearly half (49 percent) were aware of the EE guidelines under the program.

Survey recipients were also asked to gauge the effectiveness of the program in encouraging homebuilders to include high-efficiency HVAC equipment in their houses. Nearly three-quarters of the respondents felt that this program *would not* be effective.

Contractors that felt the program would not be successful in its goals felt this way because:

- There is too much paperwork involved, it is very complicated and not worth all the forms that have to be filled out.
- Too many people are already dissatisfied with their Energy Star homes. They impose too many restrictions and impede the enjoyment of the homes
- Haven't seen any builder advertising 5 Star Builders—builders know that they have to satisfy certain levels anyway.
- Tough for builders
- Does not help because the financial incentive to builders is insufficient

Less than 20 percent of the contractors claimed they had actually installed equipment in Energy Star homes. This suggests that their negative opinions regarding the effectiveness of the program as well as consumer satisfaction with Energy Star homes is based on limited experience.

3.6.4 NJ Gas Utility HVAC Program

Since New Jersey's investor-owned gas utilities are planning to enhance their gas furnace and boiler programs to better promote high efficiency units next year we asked the sample contractors what program features would make the program most attractive to them (Table 3-24). The most important feature to 84 percent of the contractors was the provision of rebates, and 28 percent cited financing support. The contractors were much less interested in other, non-monetary features such as consumer education (15 percent), training (12 percent) and co-op marketing (10 percent). There was some variation among the four size tiers of the firms. The smallest firms were much more interested (73 percent) in co-op marketing than either rebates (33 percent) or financing (37 percent).

Table 3-24
Features Most Attractive in the NJ Gas Utility HVAC Program

	Market Activity (number of homes served / year, 1999-2000)				Total
	Smallest (max 38)	Small (max 200)	Medium (max 550)	Large (max 2250)	
Rebates	33%	94%	72%	100%	84%
Financing	37%	14%	65%	0%	28%
Co-op marketing	73%	0%	15%	0%	10%
Training	3%	14%	23%	0%	12%
Consumer/end-user education	5%	8%	22%	20%	15%
Other	0%	27%	16%	74%	34%

Table 3-25
Aware of Energy Star Residential Gas Heating Standards Before Interview?

	Market Activity (number of homes served / year, 1999-2000)				Total
	Smallest (max 38)	Small (max 200)	Medium (max 550)	Large (max 2250)	
Yes	14	30	78	80	55
For some types of equipment	0	4	0	20	7
Somewhat	67	64	11	0	32
No	20	2	11	0	5

3.6.5 Energy Star Label

Recent studies have shown that 40 to 50 percent of consumers nationwide recognize the ENERGY STAR label and that 30 percent have a good idea of the concepts it represents. Contractors were asked what the EPA Energy Star label means to them with regard to the selling and installation of residential gas boilers and furnaces. The contractors generally knew that the label meant that the products met energy efficiency guidelines (38 percent) and that they save energy (30 percent). Interestingly enough, nearly one-third of the contractors claimed that they were not familiar with Energy Star and only a few firms in the smallest tier made the connection between saving energy and protecting the environment. See Table 3-26.

Table 3-26
Meaning of Energy Star Label for Residential Gas Furnace/Boilers Contractors

	Market Activity (number of homes served / year, 1999-2000)				Total
	Smallest (max 38)	Small (max 200)	Medium (max 550)	Large (max 2250)	
Meets EE Specs	14%	18%	33%	76%	38%
Specs worked out with industry	0%	0%	0%	0%	0%
Saves energy	3%	8%	21%	76%	30%
Saves customer money	0%	15%	0%	0%	5%
Reliable	0%	7%	0%	0%	2%
More expensive	0%	0%	0%	0%	0%
Helps environment	62%	1%	0%	0%	5%
Other	62%	25%	56%	5%	32%
Not familiar with Energy Star	24%	61%	7%	20%	30%

The contractors were also able to add their own suggestions to the list of items. Their responses cited the additional selling point represented by the Energy Star seal, and that (higher) quality contractors tend to install these products. Negative responses concerned the added hassle and paperwork associated with the products, and their value for the money. One respondent felt the label did not mean anything at all.

Table 3-27
Do you Use Energy Star Label as a Selling Point for High-Efficiency Equipment?

	Market Activity (number of homes served / year, 1999-2000)				Total
	Smallest (max 38)	Small (max 200)	Medium (max 550)	Large (max 2250)	
Yes	0	22	0	0	9
No	100	78	100	100	91

Finally, contractors were asked if they had used the Energy Star label as a selling point to consumers. Nearly all the respondents, some 91 percent, said that they had not used it in this fashion. The contractors in the small tier claimed it was used in 22 percent of cases, which translated into less than 10 percent of all contractors surveyed overall. See Table 3-27.

3.7 PROGRAM COMMUNICATIONS CHANNELS

To understand the best promotional mechanisms in the HVAC industry, it is necessary to determine where its members seek information about new product, technology and industry trends, receive training and certifications and where they go to recruit new employees. These outlets may include industry journals and trade publications, membership in professional organizations, outreach from local utilities, and through the Internet. One of the best sources of information about new industry techniques and products comes through the training offered by a host of entities that may include professional organizations, distributors, US DOE, manufacturers and local utilities.

Trade Publications

Among the publications that the contractors read on a regular basis, the most popular was *HVAC News* at 28 percent followed by *Contractor Magazine* and *Contracting Business*, each with a little less than 20 percent. Additional results are contained in Table 3-38. Nearly 50 percent of the contractors surveyed listed a myriad group of other publications. These included:

- *Oil Heat Magazine*
- *Fuel Oil News*
- *United Association Journal*
- *Professional Remodeler*
- *ASHRAE Journal*
- *Oilheating*
- *ACCA Publications*
- *HVAC Insider*
- *HVAC Contractor*
- *RSES Journal*

Table 3-28
Trade Publications Read

	Market Activity (number of homes served / year, 1999-2000)				Total
	Smallest (max 38)	Small (max 200)	Medium (max 550)	Large (max 2250)	
HVAC News	0%	28%	42%	21%	28%
Contractor's News	15%	8%	12%	0%	8%
Contracting Business	50%	6%	7%	21%	14%
Refrigeration News	0%	2%	16%	0%	6%
Contractor Magazine	0%	4%	7%	59%	19%
Plumbing and Mechanical	50%	5%	0%	0%	6%
Other	15%	27%	70%	59%	48%

Professional Trade Organizations

Just over half the contractors said that their firms were members of a professional or trade association, and just under a third of this group (28 percent) were members of the Air Conditioning Contractors of America (ACCA). Only 11 percent of those surveyed were members of American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE). In addition, just under a third of the NJ contractors belonged to other organizations that included:

- *State of NJ Master Plumbers Association*
- *Fuel Merchants Association of NJ*
- *East Coast Heating & Cooling Council*
- *PHCC*
- *New Jersey Better Business Bureau*
- *Chamber of Commerce*
- *Refrigeration Service Engineers Society (RSES)*
- *South Jersey Business League (SJBL)*
- *ABC*
- *Oil Heat Association of NJ*
- *The Old Heat Pump Council*

Table 3-29
Trade Organization Memberships

	Market Activity (number of homes served / year, 1999-2000)				Total
	Smallest (max 38)	Small (max 200)	Medium (max 550)	Large (max 2250)	
ACCA	31%	23%	17%	45%	28%
SMACNA	9%	0%	0%	5%	2%
ASHRAE	9%	2%	9%	26%	11%
Other	65%	23%	35%	5%	26%
None	6%	70%	58%	55%	56%

Utilities frequently provide technical outreach and training to energy service companies and building contractors. We wanted to know whether the sampled contractors felt that their local utilities were credible sources of information for the more technical aspects of residential HVAC. About three-quarters of the respondents believed that they were not a credible source of information.

Table 3-30
Local Utility as Source of Technical Information on Residential HVAC

	Market Activity (number of homes served / year, 1999-2000)				Total
	Smallest (max 38)	Small (max 200)	Medium (max 550)	Large (max 2250)	
Yes	11%	34%	41%	0%	26%
No	89%	66%	59%	100%	74%

Use of Internet

With the Internet fast becoming a staple of business for information sharing, selling and marketing, we asked the sample contractors whether it was utilized in the course of their normal business operations. Slightly more than three-quarters of the medium- and large-tier contractors used the Internet, but only 15 percent of the smallest and 28 percent of the small firms did. Thus, as the size of the firm increased so did the likelihood that the Internet was used.

Table 3-31
Internet Use In Normal Business Operations

	Market Activity (number of homes served / year, 1999-2000)				Total
	Smallest (max 38)	Small (max 200)	Medium (max 550)	Large (max 2250)	
Yes	15%	28%	76%	76%	55%
No	85%	72%	24%	24%	45%

Contractor Training.

Contractors were asked what percentage of their installation staff received training in a variety of areas related to system sizing, design, and maintenance. The results are shown in Table 3-32. The installers received the most instruction in system charging, airflow measurement and high-efficiency gas furnace and gas boiler installation issues. There appears to have been little instruction in Manual J for system sizing and Manual D for duct design. The survey questionnaire did find out whether sales staff or other employees might attend such training or perform these procedures.

Table 3-32
Number of Residential Installers that Attended Training

	Market Activity (number of homes served / year, 1999-2000)				Total
	Smallest (max 38)	Small (max 200)	Medium (max 550)	Large (max 2250)	
Manual J (system sizing)	0	1	2	2	1
Manual D (duct design)	0	1	0	0	0
System charging	5	2	4	26	9 (±7)
System airflow measurement	5	2	4	10	5 (±3)
High efficiency GF and GB installation issues	5	2	4	20	7 (±7)
Other	0	1	2	2	1 (±1)
+-Other	0	0	0	0	0

The installers tended to receive training sponsored by the equipment manufacturers and distributors or received it in-house. Less than 10 percent of the contractors received training from ACCA, SMACNA, DOE Energy Star or their utilities. Although distributor staff rather than utility personnel may host utility-sponsored training, the survey response was worded to discover training sponsorship only. The size of the firm does not appear to be very important in this case—the results are sufficiently random that it is difficult to see a trend. More than 20 percent of contractors received training from "other" sources that typically include vocational and trade schools. See Table 3-33.

Table 3-33
Where Did Installers Receive Training?

	Market Activity (number of homes served / year, 1999-2000)				Total
	Smallest (max 38)	Small (max 200)	Medium (max 550)	Large (max 2250)	
Provided in-house	23%	24%	32%	100%	73%
ACCA-sponsored	9%	6%	9%	0%	6%
SMACNA-sponsored	9%	0%	9%	0%	5%
Distributor-sponsored	13%	64%	42%	0%	31%
DOE-Energy Star	0%	0%	9%	0%	4%
Manufacturer-Sponsored	26%	83%	65%	26%	53%
Utility-sponsored	3%	14%	8%	0%	6%
Other	55%	3%	31%	6%	22%

Nearly half (48 percent) of service technicians received training in-house and 36 percent received instruction provided by the equipment manufacturers. Over half the contractors cited "other" sources that included vocational and trade schools. About 10 percent or fewer contractors received training from ACCA (10 percent), SMACNA (8 percent), distributors (8 percent), DOE Energy Star (6 percent), and utilities (7 percent). The service technicians from the smallest-tier firms appeared to have the most training and the large-tier firms had the least overall training. See Table 3-34.

Table 3-34
Where Did Service Technicians Receive Training?

	Market Activity (number of homes served / year, 1999-2000)				Total
	Smallest (max 38)	Small (max 200)	Medium (max 550)	Large (max 2250)	
Provided in-house	82%	50%	68%	32%	48%
ACCA-sponsored	59%	14%	19%	0%	10%
SMACNA-sponsored	59%	0%	19%	0%	8%
Distributor-sponsored	0%	50%	0%	0%	8%
DOE-Energy Star	0%	0%	19%	0%	6%
Manufacturer-Sponsored	87%	64%	34%	26%	36%
Utility-sponsored	23%	4%	16%	0%	7%
Other	36%	6%	51%	74%	55%

Nearly all (86 percent) of the contractors' sales staff received manufacturer-sponsored training by these organizations. The large tier firms reported that all of their staff received this training. Nearly one-third (31 percent) of the contractors received training from distributors and almost one-quarter (24 percent) reported receiving training in-house. None of the sales staff received training from ACCA, SMACNA, or DOE Energy Star.

Table 3-35
How Many Sales Staff Received Training and from Where?

	Market Activity (number of homes served / year, 1999-2000)				Total
	Smallest (max 38)	Small (max 200)	Medium (max 550)	Large (max 2250)	
Average number of staff that received training	1	1	2	2	2
Provided in-house	13	47	16	28	24
ACCA-sponsored	0	0	0	0	0
SMACNA-sponsored	0	0	0	0	0
Distributor-sponsored	50	13	53	0	31
DOE-Energy Star	0	0	0	0	0
Manufacturer-Sponsored	97	71	79	100	86
Utility-sponsored	0	0	0	0	0
Other	0	5	8	72	28

Distributor Services and Training.

The distributors provided three key services to a large portion of the contractors: technical updates (46 percent), various technical support (52 percent), and marketing materials (46 percent). Coop advertising (9 percent) and other marketing support (3 percent) were in distant third- and fourth-place.

Table 3-36
Services Provided to Contractors by Distributors

	Market Activity (number of homes served / year, 1999-2000)				Total
	Smallest (max 38)	Small (max 200)	Medium (max 550)	Large (max 2250)	
Sizing calculations	0%	0%	0%	0%	0%
Tech updates	35%	6%	67%	74%	46%
Other tech support	12%	91%	34%	41%	52%
Marketing materials	23%	57%	0%	95%	46%
Coop advertising	0%	0%	7%	26%	9%
Other marketing support	13%	7%	0%	0%	3%
Customer leads	0%	0%	0%	0%	0%
No Services	2%	7%	0%	0%	3%
Other	63%	15%	19%	0%	17%

The majority (56 percent) of contractors said that they were not interested in receiving training from their local utility on HVAC design and installation.

NATE Certification.

North American Technical Excellence (NATE) is the predominant certification program for technicians in the HVAC and refrigeration industry. The survey asked the sampled contractors if they had heard of NATE and, if so, the number of their staff received the certification. About two-thirds of the contractors had not heard of NATE and only two firms reported having certified staff.

Table 3-37
Aware of NATE Certification Program

	Market Activity (number of homes served / year, 1999-2000)				Total
	Smallest (max 38)	Small (max 200)	Medium (max 550)	Large (max 2250)	
Yes	14%	23%	65%	21%	35%
No	86%	77%	35%	79%	65%

Table 3-38
Number of Staff (Average) that Received NATE Certification Training

	Market Activity (number of homes served / year, 1999-2000)				Total
	Smallest (max 38)	Small (max 200)	Medium (max 550)	Large (max 2250)	
Average	0	1	0	0	0

Recruiting Technicians and Installers

Popular sources to recruit new technicians and installers included newspapers (39 percent), vo-tech schools (36 percent), and trade schools (22 percent). Other responses included job fairs, word of mouth, radio ads, high schools, and signs on their buildings. These various sources would represent another area to target the message of the importance of energy efficiency.

Table 3-39
Recruitment of Technicians and Installers

Recruitment of Technicians and Installers	Market Activity (number of homes served / year, 1999-2000)				Total
	Smallest (max 38)	Small (max 200)	Medium (max 550)	Large (max 2250)	
Vo-tech Schools	64%	8%	7%	95%	36%
Community Colleges	0%	0%	0%	0%	0%
Trade Schools	0%	15%	0%	63%	22%
Other Firms	0%	5%	0%	0%	2%
Trade Journals	0%	0%	0%	21%	6%
Newspaper	67%	23%	42%	45%	39%
Other	87%	75%	74%	76%	76%

4 INTERVIEW ANALYSIS-HVAC EQUIPMENT DISTRIBUTORS

4.1 OBJECTIVES

The primary objectives of the HVAC equipment distributor interviews were to:

- Gather information on market share of energy efficient HVAC equipment;
- Determine distributor impressions of manufacturer and dealer effort to market high efficiency equipment; and
- Identify potential availability problems for high efficiency equipment.

4.2 SURVEY METHODS

Distributor perceptions of the market for high efficiency HVAC equipment were examined using a set of detailed telephone surveys. A total of 16 in-depth interviews were completed with representatives from distribution firms supplying a range of heating and cooling equipment including air conditioners, heat pumps, gas furnaces, gas boilers, and programmable thermostats. The firms do not represent a random sample of distributors. However, the distributors contacted are representative of the national HVAC market in terms of manufacturer share. They also roughly align with high-efficiency equipment rebate ranking data from GPU[1].

Most respondents were owners and operations managers, although some firms were represented by other positions. In all cases, the survey respondents were knowledgeable about marketing and sales for high efficiency equipment. Details are provided in Table 4-1.

[1] This rebate ranking is based on data covering GPU rebates for the time period Jan 1, 2000 – Aug 7, 2000. Firms shown in the table without ranking results were not involved in rebates. Other firms in the rebate ranking were: Superior Coils (2), Advanced Coils (4), Benchmark Coils (5), Airmax Coils (6) and Heil (7).

Table 4-1
Number of Distributors and Market Share for Manufacturer Brands Carried

Manufacturer	Number of Distributors	Percent of Surveyed	National Market Share (Ranking)	GPU Rebate Ranking
United Technologies (Airquest, Arcoaire, Bryant, Carrier, Comfortmaker, Heil Tempstar, Payne)	9	56%	19% (1)	3
Goodman Manufacturing (Amana (10), GMC, Goodman (9), Janitrol)	6	38%	15% (2)	9, 10
Weil-McLain	3	19%		
American Standard (Trane)	2	13%	9% (3)	8
Burnham	2	13%		
Crown	2	13%		
Peerless	2	13%		
Bradford-White	1	6%		
Lennox (Armstrong, Ducane, Lennox)	1	6%	8% (5)	1
Luxair	1	6%		
Rheem / Paloma Industries (Rheem, Ruud)	1	6%	7% (7)	
Utica	1	6%		
York	1	6%	3% (10)	

4.3 DISTRIBUTOR PROFILE

The interviews yielded the following information about distributors included in the survey:

- **Self-characterization.** All of the distributors included in the survey claim to be "full service" operations offering a number of services including site delivery, technical support, and training of contractor personnel. In addition, 63 percent of distributors included in the survey indicated that they also carry energy analysis software.
- **Business size.** Number of locations for distributors in the survey ranges from 1 to 11 but averages 4 locations in the state of New Jersey.
- **Customer base.** Each distributor serves an average of 720 contractors. It is important to note that not all contractors are regular customers of specific distributors and there may be significant overlap among the distributors' customer lists. The distributors contacted

serve large and small contractors, ranging from operations with 20 trucks and more than $1 million in annual sales to 1-truck operations with less than $100,000 in sales. Three of the distributors serve a large national retailer (Sears).

- **Distribution.** Sixty-nine percent of the distributors contacted derive all of or the vast majority (more than 95 percent) of their business from contractors in the state of New Jersey.

Distributor profile information is summarized in Table 4-2.

Table 4-2
Distributor Characteristics

Distributor	Number of NJ Locations	Number of Contractors Served	Percent of Business in State of New Jersey
A	5	200	98%
B	6	2,000	15 – 20%
C	2	160	100%
D	6	2,500	95%
E	6	NR	100%
F	3	400	60%
G	6	450	100%
H	3	900	100%
I	2	525	95%
J	6	990	20%
K	1	600	80%
L	11	400	20%
M	1	NR	100%
N	1	300	100%
O	1	200	100%
P	1	450	100%
Average	4	720	80%
			NR = No response

4.4 MARKETING STRATEGY

4.4.1 Product Focus

The extent of high-efficiency product focus for distributors may be characterized in one of the three following ways:

- **High efficiency**. Distributors who focus on high efficiency market middle-to-high-end equipment. Eighty-eight percent of respondents indicated that high efficiency is generally positioned as one of several high-end features including noise reduction, longer

warranty, and improved controls in the equipment they carry. Distributors in this category tend to actively promote efficiency and prominently include this feature in their marketing materials. Twenty-eight percent of the distributors contacted fall in this category.

- **Middle of the road**. Distributors in this category place their greatest emphasis on mid-range equipment and do not specifically focus on highest efficiency or lowest price. These distributors use efficiency simply as one of many selling points. Efficiency plays a moderate role in marketing strategy and figures less prominently in marketing materials. Forty-three percent of survey respondents fit into this category.
- **Price**. Distributors in this category compete primarily based upon price alone, and efficiency has a very minor role (if any) in marketing strategy and rarely figures into promotional materials. Twenty-eight percent of survey respondents can be categorized as primarily price-driven in their product focus.

One hundred percent of distributors surveyed indicated that they generally use sales histories and contractor demand to determine their product mix. Approximately 20 percent of survey respondents indicated that both utility rebate programs and manufacturers play a role in determining which products the distributors will carry.

4.4.2 Market Focus

The distributor survey respondents indicated that single-family homes in the replacement market constitute their primary focal points within the residential market. Some distributors pursue secondary segments (including the residential new construction market) but to a lesser degree. Market focus is detailed in Table 4-3.

Table 4-3
Concentration of Market Focus for NJ HVAC Equipment Distributors

Market Segment	Percent of Distributors	Number of Responses
Replacement	83%	16
New construction	17%	16
Single-family	96%	13
Multi-family	4%	13

4.4.3 Competitive Advantage

The distributors contacted cite size and diversity of inventory as the key source of competitive advantage in their industry. This is followed by quality product, price, customer service, and efficiency (see Table 4-4). All of the distributors maintain large inventories, several in excess of

$1 million. According to the distributors contacted, inventories are kept inflated because manufacturers cannot fill orders fast enough to satisfy contractors' demands. The distributors are a crucial link in the supply chain, keeping equipment readily available for contractors.

Table 4-4
Sources of Competitive Advantage for HVAC Equipment Distributors

Advantage	Percent of Distributors Citing Advantage
Large, diverse inventory	100%
Quality product	56%
Price	38%
Customer service	25%
Efficiency	25%

4.4.4 Importance of High Efficiency in Overall Marketing Strategy

High efficiency appears to play a role in every distributor's overall market strategy, although the relative importance varies. Overall, 44 percent of distributors indicated that high efficiency was one of many components of their market strategy, while 31 percent indicated that high efficiency is a major component of marketing strategy. Numerical results are shown in Table 4-5.

Table 4-5
Importance of High Efficiency in Overall Market Strategy

Importance	Frequency	Percent of Total
One of many components	7	44%
A major component	5	31%
A minor component	4	25%
Total	16	100%

Some distributors push high-efficiency in their promotional literature, generally in the form of efficiency ratings and lifetime costing analysis. Only one distributor linked high efficiency to cash incentives (a manufacturer rebate). All of the distributors' representatives interviewed indicated that their firms conduct cooperative advertising with manufacturers. Approximately 33 percent also conduct cooperative advertising with contractors.

4.4.5 Profit Margin and Unit Cost

All of the distributors' representatives reported that high efficiency units yield higher profit margins than their standard efficiency counterparts. Likewise, mid-range efficiency units yield higher profit margins than low-efficiency units. The average difference in profit margin between high and low efficiency equipment is approximately 13 percent. Cost difference is also greater between high and low efficiency equipment with high efficiency equipment averaging about 22% higher in cost than low efficiency equipment. Profit margins and cost information for both gas and electric HVAC equipment are detailed in Table 4-6. Because profit margins are higher on high-efficiency equipment, this should encourage distributors to push sales of high efficiency units to contractors, who can also earn a greater profit on high efficiency units.

Table 4-6
Range of Profit and Cost Differences
Among Different HVAC Equipment Types and Efficiencies

Equipment Type and Profit / Cost Comparison	Range and Average of Profit / Cost Comparison	
	Range	Average
Profit Margin		
Air Conditioner and Heat Pump		
Mid-range efficiency vs. low-efficiency	4 – 25%	11%
High-efficiency vs mid-range efficiency	8 – 20%	16%
Gas Furnace		
High efficiency vs low efficiency	10 – 15%	13%
Gas Boiler		
High efficiency vs low efficiency	8 – 15%	13%
Average Profit Margin		13%
Cost Difference		
Air Conditioner and Heat Pump		
SEER 12 vs SEER 10	15 – 50%	22%
SEER 14 vs SEER 12	10 – 25%	18%
Gas Furnace		
High efficiency vs low efficiency	20 – 40%	26%
Gas Boiler		
High efficiency vs low efficiency	15 – 35%	23%
Average Cost Difference		22%

4.5 MARKET MEASUREMENT

4.5.1 Defining High Efficiency

Definitions of high efficiency varied greatly among distributors in the survey. Fifty percent of distributors defined high efficiency for air conditioners and heat pumps as 13 SEER or greater, which meets the New Jersey rebate threshold. Only 6% defined high efficiency in the same way as the ENERGY STAR program, which requires SEER 12 or higher for program qualification.

The ENERGY STAR program requires annual fuel utilization efficiencies (AFUE) of 90% or greater for gas furnaces and 85% or greater for gas boilers (These levels are the same as the new New Jersey utility rebate standard, effective on August 1, 2001. This standard was used historically by some utilities, although other utilities provided rebates for anything over 80%). Distributors did not distinguish between furnaces and boilers when defining efficiency, and 54 percent defined high efficiency for gas heating equipment as AFUE 90% or greater. Additional details of program and distributor definitions of high efficiency for heating and cooling equipment are provided in Table 4-7.

Table 4-7
Program and Distributor Definitions of High Efficiency for HVAC Equipment

Air Conditioners and Heat Pumps		Gas Furnaces and Gas Boilers	
SEER Rating	Program / Percent of Distributors	AFUE Rating	Program / Percent of Distributors
Program Definitions			
13	NJ Utility	90%+	ENERGY STAR Furnace, NJ Utility*
12	ENERGY STAR	85%+	ENERGY STAR Boiler NJ Utility*
Distributor Definitions			
14+	38%	90%+	54%
13+	50%	78 – 84%	23%
12+	6%	85 – 89%	23%
10 – 11	6%		
* NJ Utility rebate requirements as of Aug 1, 2001. Prior to Aug 1, the requirements varied among utilities.			

4.5.2 Market Penetration

Distributors in the survey indicated that the average market penetration of high-efficiency electric HVAC equipment (based on equipment sales) is greater than for gas equipment. This is consistent with data from the Manufacturer Survey included in Section 5 of this report. Detail of the range and average percentage of high efficiency sales is included in Table 4-8. The table also

contains figures relating the percentage of distributor inventory accounted for by ENERGY STAR qualifying gas and electric heating and cooling equipment. The high efficiency equipment share in inventory averaged approximately 32 percent across distributors included in this survey.

Table 4-8
Range and Average Percentage of High Efficiency Sales and Inventory Across Distributors

Sales / Inventory Characteristic	Range Across Distributors	Average Across Distributors	Number of Responses
Percentage of Sales			
AC / heat pump 13+ SEER	5 – 70%	34%	14
AC / heat pump 10 – 12 SEER	30 – 95%	66%	14
Furnace AFUE 90%+	10 – 60%	26%	11
Boiler AFUE 85%+	1 – 10%	6%	10
Percentage of Inventory			
AC / heat pump 13+ SEER	10 – 60%	32%	14
ENERGY STAR qualifying gas equipment	15 – 60%	32%	11

4.6 CUSTOMER PURCHASE DECISION-MAKING

4.6.1 Factors Influencing Customer Decisions

Distribution firms indicated that several factors may influence a homeowner's decision about whether or not to purchase a high efficiency unit. Of these factors, 82 percent of distributors indicated that they thought price exerted the greatest influence on a homeowner's decision. This is fairly consistent with the Manufacturer Survey (Section 5 of this report), which indicates that 77 percent of manufacturers felt price was the greatest influence on homeowner decisions. After price concerns, both comfort and warranty were mentioned as principal influences on homeowner decisions by 56 percent of distributors

In one area of important difference with the Manufacturer Survey, only 44 percent of distributors indicated that dealer advice was a primary influence on homeowner decisions. For manufacturers, advice from dealers (i.e. contractors) was cited by 85 percent of respondents as the factor having the greatest influence on customer purchase decisions. One possible explanation for this discrepancy is possibly large differences between manufacturers and distributors in their impressions of consumer purchase decision-making strategies.

Further detail of distributor impressions of principal influences on homeowner decisions is provided in Table 4-9.

Table 4-9
Distributor Impressions of Principal Influences on Homeowners' Decision to Purchase Equipment

Influence	Percent of Distributors
Price	82%
Comfort	56%
Warranty	56%
Trustworthy dealer / quality installation	50%
Dealer advice	44%
Low maintenance / reliable product	38%
Brand recognition	31%
Efficiency	25%
Rebate	19%
Lifetime costing	13%
Financing	6%
Number of Respondents	16

4.6.2 Barriers to Purchase of High Efficiency Equipment

Distributors' representatives were asked for their impressions of barriers to increasing the market share of high efficiency heating and cooling equipment. Fifty percent of survey respondents felt that a lack of contractor education is the greatest barrier to increasing the market share of high efficiency equipment.[2] This percentage is consistent with Section 5 of this report in which 46 percent of manufacturers' representatives indicated that poor contractor training is the main barrier to homeowner purchase of efficient equipment.

The barrier cited next in frequency by distributors was the amount and complexity of rebate paperwork and high requirements for documentation, mentioned by 44 percent of survey respondents. Similarly, 54 percent of manufacturers indicated that simplification of the customer rebate process would be necessary to ensure greater market penetration of efficient equipment. Distributors' impressions of the relative influence of these factors as barriers to increasing market share are included in Table 4-10.

[2] While all of the distributors interviewed provide some type of training to contractors, only two of them provide training specifically in high efficiency.

Table 4-10
Distributors' Impressions of Barriers to Increasing Market Share of High Efficiency HVAC Equipment

Barrier	Percent of Distributors
Lack of dealer education	50%
Amount / complexity of paperwork	44%
Lack of contractor demand	38%
Price competition among contractors	31%
Poor dealer sales and marketing skills	31%
Homeowner education	25%
Number of Respondents	16

4.6.3 Utility-Sponsored High-Efficiency HVAC Programs

Distributors indicated that utility-sponsored programs for high efficiency heating and cooling equipment have the potential to influence customer decisions to purchase efficient equipment, but all indicated that improvements are necessary. All but one of the distributors encourage their contractors to participate in utility rebate programs.

Four of the distributors (25 percent) indicated that some of their contractors no longer mention the rebate program to homeowners to avoid the "hassle" involved with paperwork for the rebate process. These same distributors indicated that the smallest contractors (those with annual sales of less than $100,000 and only 1 or 2 trucks) have the greatest difficulty with the rebate program because they have the least time and staff to handle the necessary paperwork. Fifty percent of distributors indicated that the best way to improve the rebate program would be to reduce the amount and complexity of the paperwork. Approximately 20 percent of distributors also mentioned the following possible improvements:

- Contractor incentives should be increased;
- Contractor education should be increased; and
- Utilities companies should exit the equipment market and create a more cooperative environment.

4.7 PROGRAM COMMUNICATIONS CHANNELS

In order to more effectively promote the message of energy-efficiency in the HVAC community it is necessary to determine where its members seek information about new product, technology and industry trends. To this end, we asked distributors to name the professional and trade

organizations they belonged as well as the trade and industry publications they read on a regular basis.

One hundred percent of distributors in the survey indicated that they belong to the Eastern Heating and Cooling Council (EHCC). Membership in the Air Conditioning Contractors of America (ACCA) was second highest, with 50 percent of distributors indicating membership. Only one distributor mentioned membership to any other trade association.

The publication most frequently read by distributors in the survey was *HVAC News*, with a distributor readership of 56 percent. The publication with the second highest readership was *Wholesaler*, which was indicated by 21 percent of distributors. Other publications read by distributors on a regular basis include the following:

- *Air Conditioning Today;*
- *Contracting Business;*
- *Oil Heat Magazine*;
- *Refrigeration News;*
- *Transportation and Distribution;* and
- *Upside.*

Parties interested in communicating information to distributors in New Jersey would be well advised to pursue these associations and publications as communication channels.

4.8 POOLING SALES INFORMATION

Fifty-seven percent of distributors contacted said they were not interested in pooling high efficiency sales information with the utilities, even with confidentiality maintained. Thirty-eight percent of the respondents indicated that their primary reason for the lack of interest is that they would not release sales data. The same percentage indicated that they would not offer their sales information because competing distributors would not cooperate. One-fourth of the survey respondents indicated that they would not release this information to utilities because they do not trust the utility companies.

Twenty-nine percent of the distributors in the survey said they would consider the proposal with more information. Only 14 percent said they would be interested in providing the data. This information is provided in Table 4-11.

Table 4-11
Distributor Opinions on Pooling Sales Information with Utilities Companies

Response	Percent of Distributors	Number of Responses
Would not pool sales information	57	8
Would consider pooling sales information	29	4
Would pool sales information	14	2
Not in the position to comment	14	2

4.9 FUTURE TRENDS

Distributors perceive the following trends in the future of the heating and cooling equipment market:

- Market share of high-efficiency equipment will remain the same in the short-term, but will increase in the long-term.
- The market share of high efficiency heating and cooling equipment will likely grow, albeit slowly, as a result of two primary factors including government mandates and manufacturer initiatives.
- Eighty-eight percent of distributors felt that contractor consolidation will continue. They further believe that consolidation will bring about more marketing-savvy contractors who will be better able to sell high-efficiency equipment.

5 INTERVIEW ANALYSIS - HVAC EQUIPMENT MANUFACTURERS

5.1 OBJECTIVES

The primary objectives of the HVAC equipment manufacturer interviews were to:

- Gather information on market share and regional variations in shipment of energy efficient HVAC equipment;
- Examine motivations and practices for promoting high-efficiency equipment;
- Characterize perceptions of barriers to sale of high-efficiency equipment to both contractors and customers and determine activities that utilities companies could pursue to mitigate such barriers;
- Investigate awareness and participation in the ENERGY STAR and utility-sponsored high efficiency programs and the roles of these programs in marketing strategies for high efficiency equipment; and
- Determine the position of energy efficiency in priorities for new product development and manufacturers' perceptions of future trends in the HVAC equipment market.

5.2 SURVEY METHODS

The manufacturer research was organized around a set of detailed telephone surveys designed to investigate manufacturer perceptions of the high efficiency equipment market. The survey consisted of 13 in-depth interviews with manufacturers' representatives that were not randomly selected and that did not refer to written records for information. Ten interviews were completed with representatives from central air conditioner (CAC)/heat pump/furnace manufacturers and three with gas boiler manufacturers[1]. The participating firms account for more than 85 percent of all central air conditioning units shipped and more than 60 percent of residential-sized gas boilers.

The individuals interviewed held various positions at their firms but all had technical knowledge regarding high efficiency equipment marketing and sales. Table 5-1 provides details on the sample respondent's role.

[1] Interviews included 3 central air conditioning (CAC)-only manufacturers, 3 gas boiler-only manufacturers and 7 manufacturers with multi-line, multi-brand (MLMB) products. The MLMB firms produce CACs, heat pumps and furnaces, although sufficient data was not available to break out most results for these product lines separately. These firms are labeled in this report as MLMB (or CAC) manufacturers for convenience.

Table 5-1
Interview Characterization

Respondent's Role	Equipment Type		Total
	MLMB*	Gas Boiler	
VP (Sales, Marketing)	1	2	3
Managerial (Distribution, Product Management)	5	1	6
Marketing	4	0	4
Total Completed Interviews	10	3	13

* MLMB – Multi-line, multi-brand product manufacturers. These firms typically produce central air conditioning, furnace and heat pump products.

5.3 MANUFACTURER PROFILES

The interviews yielded the following information about manufacturers included in the survey:

- **Geographic coverage.** All of the manufacturers included in the survey claim to have national coverage with presence in the New Jersey market. None of the manufacturers supplies to local or regional markets exclusively.
- **Customer base.** More than 90 percent of manufacturers' sales or residential-sized air conditioners and gas boilers are in the residential market. The remaining percentage is split between the small Commercial and Industrial markets.
- **Distribution.** All of the firms included indicated that they sell their products through distributors, with the majority of sales coming through private distributors. The one exception to this is an air conditioner manufacturer that owns its distribution network that operates in a fashion similar to private distributors. Consolidation continues among distributors.

5.4 MARKETING STRATEGY

5.4.1 Product Focus

Manufacturers' representatives indicated that their firms' principle product focus is generally one of the three following options:

- **Broad product lines.** Some manufacturers focus on establishing and maintaining product broad product families along quality and size lines, with many products at different price points and efficiencies.
- **High-end, high efficiency products.** Some manufacturers focus solely on high quality products with high efficiency ratings.

- **Low cost products.** The remaining manufacturers included in the survey offer low cost, low efficiency products. These manufacturers do not accentuate high quality or high efficiency.

All of the gas boiler manufacturers included in the survey focus on offering full product lines, with no emphasis purely on price or efficiency. Air conditioner manufacturers (i.e. the multi-line, multi-brad (MLMB) firms) tend to focus slightly more often on high-end equipment, with full product lines following as a second product focus. These results are illustrated in Table 5-2.

Table 5-2
Stated Manufacturer Marketing Strategies

Strategy	Equipment Type		Total
	MLMB	Gas Boiler	
Full product line	4	3	7
High end, high efficiency	5	0	5
Low cost	1	0	1
Total	10	3	13

5.4.2 Market Focus

Representatives interviewed in the manufacturer survey indicated that single-family homes in the replacement market constitute the primary focal points within the residential market. Some manufacturers pursue secondary market segments as well and target high-end sales. Most air conditioner manufacturers, for example, offer 12, 13, and 14 SEER models, but Carrier offers a super-premium efficiency 17 SEER model specifically targeting high-end customers. Manufacturers may also focus on residential new construction markets in some regions.

5.4.3 Distributor Networks

All of the manufacturers' representatives interviewed indicate that their firms attempt to gain an advantage in the market by developing a large network of distributors. The main reason for this is to provide superior support for contractors with the hope of gaining their business.

5.4.4 Importance of High Efficiency in Overall Market Strategy

High efficiency is part of every manufacturer's overall market strategy though the relative importance varies among manufacturers. Overall, 46 percent of manufacturers indicated that high efficiency was one of many components of their market strategies, while 39 percent indicated that high efficiency is a very important component of their marketing strategies. Further detail is provided in Table 5-3.

Table 5-3
Importance of High Efficiency in Overall Market Strategy

Importance	Frequency	Percent of Total
One of many components	6	46%
A very important component	5	39%
An important component	2	15%
Total	13	100%

Several different manufacturers each claimed leadership in the realm of high efficiency, but only Carrier has achieved peer recognition as the High Efficiency Leader.

5.4.5 Bundling High Efficiency with Other Premium Features

High efficiency is considered one of many high-end features, and manufacturers often bundle several of these features into high-end models. Manufacturers indicated that if a high-cost, premium-efficiency unit is sold, features other than efficiency will likely play a greater role in the sale of the unit than its efficiency. System features commonly bundled with high efficiency for both air conditioners and gas boilers include:

- Quiet operation (most commonly mentioned bundled feature);
- Longer warranties; and
- Ease of installation.

Features commonly bundled with high efficiency in air conditioners also include:

- Additional or better controls, often including a humidity control; and;
- Improved aesthetics of outdoor condenser unit.

None of the manufacturers included in the survey offers a high efficiency model that is standard in all other respects.

5.4.6 Profit Margin

All of the manufacturers representatives reported that their companies' high efficiency units offer higher profit margins than their standard efficiency counterparts. Manufacturers understand that their high efficiency equipment is also a high margin sale for equipment distributors and contractors as well, which should move both of these groups to encourage customers to purchase high efficiency equipment.

5.5 MARKET MEASUREMENT

5.5.1 Defining High Efficiency

Definitions of high efficiency used by manufacturers tended to vary. For cooling systems, high efficiency is generally considered to be at and above 12 SEER. Only one manufacturer reported a level at or above 13 SEER. Gas boiler high efficiency definitions tended to vary from 80% to 90% AFUE, but 63 percent of respondents reported that at or above 90% AFUE was their definition. Details are shown in Table 5-4

Table 5-4
Program and Manufacturer Definitions of High Efficiency for HVAC Equipment

Air Conditioners and Heat Pumps		Gas Furnaces and Gas Boilers	
SEER Rating	Program / Percent of Distributors	AFUE Rating	Program / Percent of Distributors
Program Definitions			
13	NJ Utility	90%+	ENERGY STAR Furnace, NJ Utility*
12	ENERGY STAR	85%+	ENERGY STAR Boiler NJ Utility*
Manufacturer Definitions			
14+	0%	>90%	0%
13+	11%	90%+	63%
12+	78%	78 – 84%	13%
10 – 11	11%	85 – 89%	25%
* NJ Utility rebate requirements as of Aug 1, 2001. Prior to Aug 1, the requirements varied among utilities.			

5.5.2 Market Penetration

Manufacturers representatives indicated that the average penetration of high efficiency air conditioning units is higher than for gas boilers or furnaces. In addition, one respondent stated that furnace sales were substantially higher than sales for boilers nationally. High efficiency penetration figures for air conditioners (at or above 12 SEER) ranged from 10 to 45 percent of overall sales, but cluster around an average of approximately 20 percent (the two results reported for heat pumps were nearly identical to CACs). High efficiency gas furnace sales were reported by two respondents at an average of about 30% of overall sales.

Market penetration of high efficiency gas boilers was reported to be well below 10 percent by three respondents. Manufacturers indicated that this is likely a result of the high costs associated with retrofitting existing flues to handle corrosive condensation, a problem with high efficiency boiler systems.

5.5.3 Regional Differences

The manufacturers representatives interviewed all indicated that the market for high efficiency equipment varies across the United States. These differences arise from variations in:

- **Climate.** Air conditioners and gas boilers are likely to have greater market penetration in areas with seasonal temperature variations. Areas in which temperature extremes are greatest are those in which heating and cooling equipment sales are likely to be highest.
- **Housing markets.** Regions in which the replacement market is stronger than the new construction market are likely to account for a large volume of high efficiency equipment sales. High efficiency sales are lower in regions in which the new construction market is dominant because builders are unlikely to undertake the higher initial purchase costs of high efficiency equipment.
- **Energy cost.** Sales of high efficiency equipment are likely to be greater in regions of the country in which energy costs are rising or turbulent than in regions with lower, more stable energy costs. High electricity prices, for example, will decrease the payback time on high efficiency unit, and this is a useful selling point for high efficiency equipment.
- **Rebates.** High efficiency equipment sales are likely to be greater in areas that offer rebates to retailers and customers upon purchase of a high efficiency model. There is a great deal of regional variation in rebates offered by manufacturers, utilities companies, and retailers.

Relative to other parts of the country, the state of New Jersey has above-average sales of high efficiency air conditioning units. Gas boiler manufacturers indicated that sales in New Jersey are lower than the national average and cited "cost pressures" as the primary reason for this difference in market penetration.

5.6 CUSTOMER PURCHASE DECISION-MAKING

5.6.1 Factors Influencing Customer Decisions

Manufacturers representatives indicated that several factors may influence a customer's decision about whether or not to purchase a high efficiency model. Of these factors, 85 percent of respondents indicated that they thought contractor advice exerted the greatest influence on a customers HVAC equipment purchase decision. The customer survey (Section 2 of this report) indicates that 91 percent (of 117 total) of survey respondents installed a unit recommended by their contractor, providing further evidence of contractor influence on customers' purchase decisions. The customer survey section also indicates that contractors recommended high efficiency units to more than two-thirds of the survey respondents.

Manufacturers representatives indicated that they thought price would be the second most important factor influencing a customer's choice of heating and cooling equipment. Other influences mentioned by manufacturers' representatives include equipment quality, features, reliability, brand, efficiency, available warrantee, lifetime costing, comfort, and the availability of rebates for high efficiency equipment. Manufacturers' impressions of the relative weights of each of these factors on customer purchase decisions are detailed in Table 5-5.

Table 5-5
Manufacturers Impressions of the Importance of Factors Influencing Customer Decisions to Purchase High Efficiency HVAC Equipment

Factor	Percentage of Survey Respondents		
	Equipment Type		Overall
	MLMB	Gas Boiler	
Contractor advice	80%	100%	85%
Price	80%	67%	77%
Efficiency	40%	33%	38%
Brand	20%	33%	23%
Features	20%	33%	23%
Rebate	20%	33%	23%
Comfort	10%	0%	8%
Lifetime costing	10%	0%	8%
Quality	0%	33%	8%
Reliability	10%	0%	8%
Warrantee	10%	0%	8%

5.6.2 Barriers to Purchase of High Efficiency Equipment

Manufacturers' representatives were asked for their impressions of barriers to increasing the market share of high efficiency heating and cooling equipment. Ninety-two percent of survey respondents felt that price competition with low cost units – the difference in price between a high efficiency unit and a standard efficiency unit of comparable size or capacity - is the greatest barrier to increasing the market share of high efficiency equipment. Similarly, the second most frequently cited barrier is the high initial cost to the customer. Other factors mentioned by manufacturers included the following:

- Poor contractor training;
- Lack of homeowner understanding;
- Low contractor interest in high efficiency sales:
- Cosmetics of high efficiency units; and
- Lack of homeowner trust of contractors.

Manufacturers' impressions of the relative influence of these factors as barriers to increasing market share are included in Table 5-6.

Table 5-6
Manufacturers' Impressions of Barriers to Increasing Market Share of High Efficiency HVAC Equipment

Barrier	Percentage of Survey Respondents		
	Equipment Type		Overall
	MLMB	Gas Boiler	
Price competition with low-cost units	90%	100%	92%
High initial cost to customer	80%	67%	77%
Poor contractor Training	60%	0%	46%
Lack of homeowner understanding	40%	33%	38%
Low contractor interest in high efficiency sales	20%	67%	31%
Cosmetics	30%	0%	23%
Low homeowner trust of contractor	20%	0%	15%

5.6.3 Steps to Mitigate Barriers to Customer Purchase of High Efficiency Equipment

Manufacturers' representatives were asked to identify potential steps toward reducing the previously mentioned barriers to customer purchase of high efficiency heating and cooling equipment. Responses differed between gas boiler and air conditioner manufacturers as follows:

- **Gas boiler manufacturers** unanimously indicated feelings that financing programs would be the most effective means by which to address customer concerns about the high initial cost of high efficiency heating and cooling equipment. To a lesser extent, gas boiler manufacturers indicated that dealer training and simplification of the customer rebate process (specifically by lessening paperwork) would also be beneficial.
- **Air conditioning (MLMB) manufacturers** exhibited less uniform opinions but identified several possible steps, the most frequently mentioned of which was simplification of the customer rebate process. Approximately half of the air conditioning manufacturers interviewed indicated that financing programs would also be beneficial.

Overall, support was greatest for financing programs and a simplified rebate process. Additional steps to reduce customer purchase of high efficiency heating and cooling equipment are detailed in Table 5-7.

Table 5-7
Steps to Reduce Barriers to Customer Purchase of High Efficiency HVAC Equipment

Step	Percentage of Survey Respondents		
	Equipment Type		Overall
	MLMB	Gas Boiler	
Financing program	50%	100%	62%
Simplification of customer rebate process	60%	33%	54%
Dealer training	30%	33%	31%
Increased consumer rebates	30%	0%	23%
Consumer education	20%	0%	15%
Increase availability of high efficiency equipment	20%	0%	15%
Contractor rebate	10%	0%	8%
Legislation	10%	0%	8%

5.6.4 Utility-Sponsored High Efficiency HVAC Programs

Manufacturers' representatives indicated that utility-sponsored high efficiency programs have the potential to influence customer decisions to purchase efficient equipment, but all indicated that improvements in the programs are necessary. Respondents expressed nearly unanimous support of further promotional programs to increase consumer awareness of high efficiency heating and cooling equipment. They also indicated that improvements in customer rebate programs are necessary. Contractor training in sales of high efficiency equipment was a distant third in the percentage of respondents mentioning it. Manufacturers lowest response percentages were for contractor rewards and financing as potential ways to influence customer purchase decisions.

5.6.5 The Role of the ENERGY STAR Program

The manufacturer interviews yielded the following information with regard to the ENERGY STAR program:

- All surveyed manufacturers participate in the program, and most have participated since the program first began. All feature the ENERGY STAR logo throughout their literature and product labeling.
- Most manufacturers indicated that program participation is *expected* within the heating and cooling equipment market as a qualifier but does not provide a means by which to differentiate one manufacturer's products from another.
- Manufacturers recognize the good will generated by the program but concede no other real benefits other than an increased consumer awareness of energy efficiency and the potential benefits of high efficiency equipment to homeowners.

- Manufacturers feel that contractors and consumers sufficiently understand the message of the ENERGY STAR program.

From this we can conclude that although manufacturer participation in the ENERGY STAR program is high, manufacturers see little benefit in program participation for the sake of efficiency or to set their products apart from others available in the HVAC equipment market. In addition, manufacturers' impressions of consumer understanding are inconsistent with those indicated by the Section 2 of this report, the Customer Survey in which only 19 percent of 170 total respondents indicated that they had even heard of the ENERGY STAR program. Only approximately 1 percent of the total survey respondents were able to correctly identify two or more characteristics of the program, indicated a far lower understanding than manufacturers perceive.

5.7 NEW PRODUCT DEVELOPMENT

Manufacturers' representatives were questioned with regard to their plans for new product development. All of the manufacturers indicated that there had been little change in recent years in terms of the direction of development, and quality and efficiency were ranked as the highest priorities among manufacturers in new product development. These were closely followed by a focus on low manufacturing costs as a priority. The only technology mentioned to be on the horizon is a new refrigerant, R410A, mandated by the United States government. One air conditioner manufacturer mentioned that the switch to this new refrigerant will force product and production line changeover for most air conditioner manufacturing firms.

Further detail of manufacturer focus for new product development is detailed in Table 5-8.

Table 5-8
Manufacturer Focus in New Product Development

Step	Percentage of Survey Respondents		
	Equipment Type		Overall
	MLMB	Gas Boiler	
Efficiency	50%	33%	46%
Quality	50%	33%	46%
Low manufacturing cost	50%	0%	38%
Refrigerant	20%	n / a	20%
Breadth of product line	10%	0%	8%
Comfort	10%	0%	8%
Compliance with regulations	10%	0%	8%
Ease of installation	0%	33%	8%
Quiet operation	10%	0%	8%

5.8 FUTURE TRENDS

Manufacturers perceive the following trends in the future of heating and cooling equipment manufacturing:

- Consolidation will continue across all levels of distribution, on the manufacturer, distributor, and contractor levels.
- The market share of high efficiency heating and cooling equipment is generally expected to grow at a slow rate. Two primary factors driving this growth are government mandates and rising energy costs.

6 TECHNICAL ASSESSMENT: ON-SITE SURVEYS

6.1 OBJECTIVES

The purpose of the on-site surveys is to produce data for the Technical Assessment of recently installed HVAC equipment. The two technical objectives of the on-site house visits were:

- To assess the physical and measured performance characteristics of HVAC equipment, and
- To document house characteristics that can increase energy consumption and occupant discomfort.

In addition to supporting the Technical Assessment, the on-site data was also used to identify areas of difference in HVAC characteristics between measured results and the perceptions of respondents in survey interviews.

The roles and responsibilities of organizations participating in this task are shown below:

Organization	Roles and Responsibilities
XENERGY, Inc	Overall project and task management, final data analysis, final report documentation and payment of participating house occupants.
Atlantic Market Research	Identifying sample homes, telemarketing to develop a list of eligible customers.
Advanced Energy Corporation	Survey instrument design, on-site inspector training, on-site procedures, and preliminary tabulation of survey data from Honeywell.
Honeywell DMC	Planning and scheduling each visit, conducing the on-site data collection, organizing and transmitting data to Advanced Energy.

6.2 SURVEY METHODS

The survey methods for the on-site visits included a random sample of houses meeting the study selection criteria. Visual inspections and physical measurements by trained energy auditors were made to gather and record the required data at each house in the sample.

6.2.1 Sample Characteristics

The total sample size for the on-site inspection visits was 70 houses. The population from which the random sample was selected is the set of houses that had a new installation of HVAC

equipment in the past 3 years (after July 1997). Atlantic Market Research chose the sample from a list of customer houses that had recent construction or renovation, including HVAC installations (The same sample frame as that generated for the customer survey in Chapter 2). To qualify sites, telemarketing calls were made to candidate homes to ensure they met the study criteria.

Although data were obtained on 70 homes, two homes had two separate HVAC systems in different zones or floors of the house (a 2-zone HVAC system). In these cases, each of the two zones was simply considered to be a separate house. Thus, these two houses actually produced 2 extra data points, making 72 the total number of "houses" where data was obtained.

6.2.2 General Data Collection Approach

Site visits were made by two trained field auditor staff from Honeywell DMC. Data in the sample homes was documented using a customized version of a Residential Survey document designed by Advanced Energy. Each participating homeowner (where useable site visit data could be obtained) was paid $ 50 for allowing the data to be collected from their property.

Site Visit Agenda

Visits were scheduled to last about four hours, and for a typical house, the agenda was broken down into the following activities and approximate schedule:

On-Site Activity	Approximate Duration (hrs)
Greeting to occupant	0.2
General walk through inspection (Collect data for Manual J)	1.0
Visual inspection and recording of HVAC equipment characteristics	0.2
Visual inspection and recording of HVAC ductwork characteristics	0.1
Tests: Dust blaster test	1.0
Tests: Refrigerant charge	0.5
Photographs of key locations	0.2
Final review of survey with occupant	0.1
Clean-up and Depart	0.7
Total	4.0

Auditor Training

Each of the on-site auditors was trained to make the visit effective for the study and as pleasant as possible for the home occupants. Senior Advanced Energy technical staff conducted training for the Honeywell data collectors. The training session consisted of two phases:

In-class sessions: Lectures and discussion of the technical aspects of the visit, proper test procedures. The training covered the following topics: HVAC testing, duct pressurization techniques and thermal envelope analysis. An examination was not given at the end of the training.

On-site visit practice: Each inspector was accompanied on one site visit by an instructor, who provided assistance where appropriate and identified practices that needed improvement.

The classroom work was two days in length and the field training covered one day.

6.2.3 Site Data Collection Protocols

The site data collection protocols had two main components: equipment data collection and house characterization data collection. The equipment data was obtained on the current condition and operating parameters of central air conditioners (recently purchased) and heating equipment (gas furnaces, boilers or heat pumps of all ages). This included collection of information on the equipment characteristics and operating parameters called out in the RFP such as:

- Distribution of systems by SEER, and AFUE (for gas furnaces);
- Distribution of rates of air flow over the indoor coil compared to manufacturer-recommended levels;
- Equipment capacity compared to Manual J estimated loads: evaluate average oversizing and percent of units exceeding Manual J size by 15 percent or ½ ton,
- Duct leakage to the outdoors, and
- Envelope data for calculating Manual J heating and cooling loads.

House characterization data was collected by visual inspection of the physical building and review of building photographs. The data collected were general house features as well as special house characteristics designated by Advanced Energy as being important determinants of energy consumption and occupant comfort. Data was recorded on the survey instrument.

Data were recorded in three ways: visual inspection, test measurements and photographs. The test measurements were conducted as follows:

- *Dust blaster test*: This test was done in accordance with procedures specified by The Energy Conservatory for the Minneapolis Duct Blaster Series B.

- *Refrigerant charge measurements*: Charging was determined to be in one of three states, under charged, over charged, or charged OK, but quantification of the amount of over or

undercharging was not possible with the measurement method used[1]. Determination of charging state was assessed by measuring the degrees of superheat or subcooling, depending on which refrigerant metering device was used, fixed orifice or thermal expansion valve (TXV), respectively. The technician measured the temperatures on the suction (large) line and the liquid (small) line. They also listed what type of metering device the system was using. Because the on-site visits were made during late fall and winter months instead of the planned summer month visits, it was not possible to take the planned coolant charge measurements on the majority of the systems.

Photographs were taken from each of the cardinal compass points to document orientation. Also, any unusual features that might affect the thermal envelope or HVAC functioning or installation were photographed to document site conditions.

The equipment used for the tests and measurements is summarized below:

Equipment	Manufacturer	Model
Temperature Probe	UEI	DT – 40
Temperature gauge	Manix	SAM 990 DW
Refrigerant gauge	Yellow Jacket	Fludderleg (no model number)
Duct test rig	The Energy Conservatory	Minneapolis Duct Blaster Series B
Digital manometer	The Energy Conservatory	DG – 3
Camera	Polaroid	1 Step, 600 film
Computer	Del	Latitude CP
Ruler	Stanley	100 ft ruler; Model 34-106

All equipment was supplied and is owned by Advanced Energy Corporation.

6.2.4 House and Equipment Characteristics

Characteristics for the sample houses are summarized in two ways. First, using quantitative measures recorded during the visits, a typical or average house and its equipment can be described. Second, using an Advanced Energy House Characterization™ methodology, data were also recorded to describe the structural and framing features of each sampled house. These are important building features that help determine energy consumption and occupant comfort.

[1] Without the opportunity of testing the actual weight of the refrigerant charge it is impossible to determine the exact percentages of over or under charge with the systems tested. Weight measurement was not considered feasible within the scope of this study.

Average House and Equipment Profile

Table 6-1 lists several average results to profile a typical house and its equipment from the population sampled. Several characteristics shown in this table are illustrated with further detail by using frequency distribution plots, as shown Figure 6-1 through Figure 6-5. For some of the characteristics, it was not possible to obtain all data desired at each house. For instance, because of excessively low exterior ambient air temperatures, it was not possible to collect a full set of refrigerant charging data with the methods used. Moreover, duct blaster data could not be obtained for all systems because of equipment access and interface issues. In addition, some data points were not usable. As a result, the actual sample size of usable data for each major survey topic is shown along with the sample data characteristics.

In Table 6-1, the age of the HVAC units was determined from serial number data, homeowner paperwork, or dates stamped or written on equipment. The manufactured date is considered to be close to the installed date since most HVAC dealer inventories are approximately 6 months old or less (Norris, 2001a). The Table 6-1 the data shows an interesting multiple purchase result – 60 percent of homes with furnaces had the AC unit and furnace replaced at the same time. This result suggests a good marketing opportunity to promote both gas and electric efficiency programs together.

Table 6-1
House and Equipment Profile

House Characteristics	Average	±CI 90%	n	SE
Number of Stories	1.5	0.09	72	0.05
Conditioned Area (sq ft.)	1,780	140	72	84.20
Age of Home (years)	31	2.9	72	1.75
Number of Residents	3.1	0.28	72	0.17
Age of Cooling System (years)	2.3	0.83	27	0.49
AC and Furnace Replacement	60% of homes with furnaces replaced the AC and furnace at the same time (n=21/35)			
AC and Boiler Replacement	7 % of homes with boilers replaced the AC and boiler at the same time (n=1/14)			
Cooling System Type	Split System			
Cooling SEER	11	0.32	71	0.19
Cooling SEER of 13 or higher	28 % of AC systems had a SEER of 13 or higher			
Cooling Unit Size (tons)	2.8	0.14	72	0.09
Age of Heating System (years)	7.5	2.5	27	1.45
Gas Boiler	17 % of heating systems were gas fired boilers			
Gas Furnace	52 % of heating systems were gas furnaces			
Gas Boiler AFUE	75.8	3.5	9	1.9
Gas Furnace AFUE	81	2.3	33	1.35
Gas Furnace AFUE 90%	27 % of gas furnaces had an AFUE of 90% or greater			
Heating Unit Size (Btuh)	91,000	5,510	59	3,296
Number of Electric Appliances	4.4	0.41	72	0.25
Number of Gas Appliances	2.2	0.33	71	0.20
Number of Oil Appliances	0.11	0.06	72	0.04

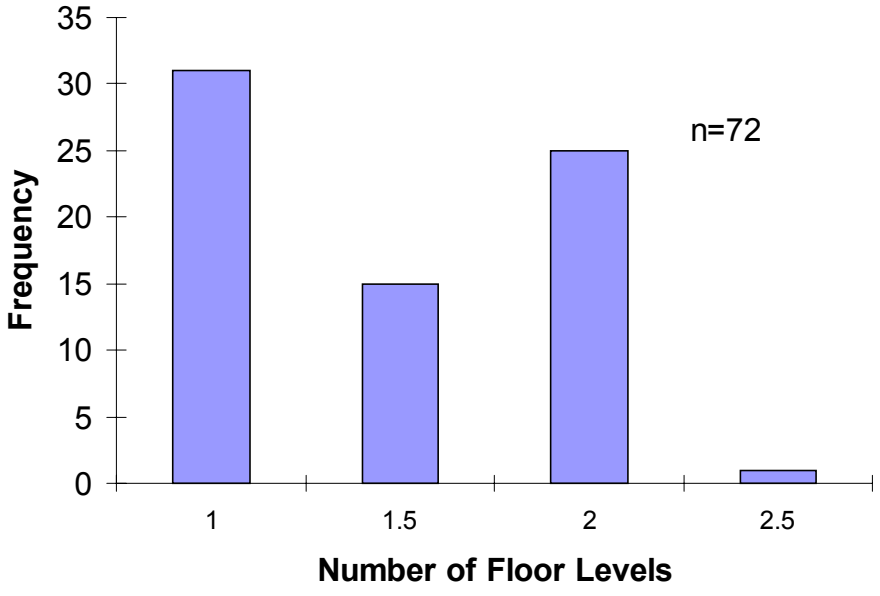
Notes: CI = Confidence Interval, SE = Standard Error, n = Sample Size

Advanced Energy House Characterization Results

Houses were also characterized using Advanced Energy's House Characterization™ process to document features that could affect energy consumption and / or occupant comfort. In previous work, Advanced Energy has identified several building characteristics that can be associated with increased energy use and degraded occupant comfort[2]. These "indicators" serve as warning signals of possible problems that can then be further assessed if warranted. The Advanced Energy characteristics in this study are a set of framing and geometric building styles that create potentially problematic air paths and thermal breaks for energy consumption and occupant comfort. Visual inspection of the 70 houses or their photographs to identify characteristics was completed. Figure 6-5 presents a histogram of the results. The data are displayed as the frequency and percent of homes in the sample that had each of the twelve characteristics shown.

These results shown that the most prevalent characteristics are cantilevers / bay windows / roof-to-room (# 5) and broken ceiling planes (# 10). Although not shown, the on-site visit data also indicated that a substantial number of homes have multiple characteristics (e.g., 34% of the homes had 3-5 of the listed characteristics and 56% of them had from 0 – 2 characteristics).

Figure 6-1: Home Floor Level Distribution



[2] For example, sidewall attics typically have lower insulation level requirements than attic floors, yet both are exposed to often-hostile environments, especially in the summer. If the attic floor over a conditioned space is required to have R-30 insulation, what are the implications of having the attic-knee-wall insulated with just R-11 or R-13? Additionally, homes with sidewall attics are often framed so that the floor volume below the conditioned room is open to the attic area on either side of the room. As a result, hot (or cold) attic air flows freely below the floor (and above the un-insulated ceiling below), creating significant impact on occupant comfort and energy use.

Figure 6-2: Cooling SEER Distribution

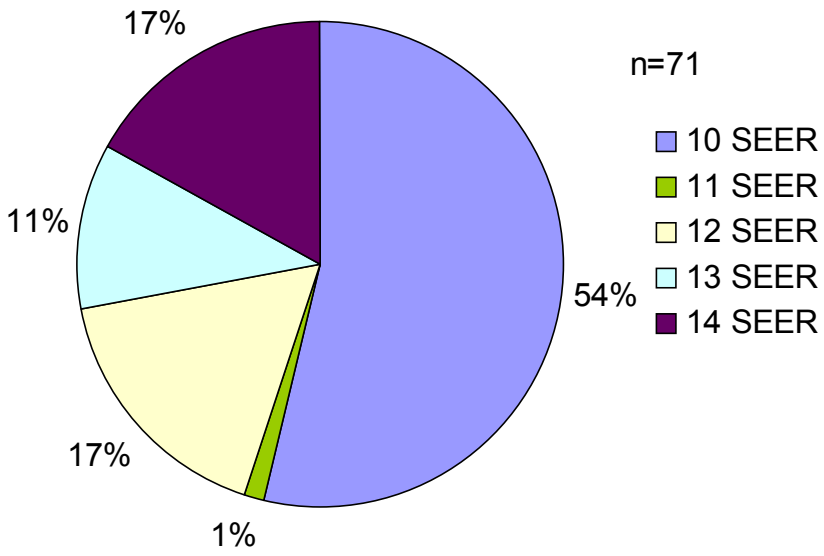


Figure 6-3: Gas Boiler AFUE Distribution

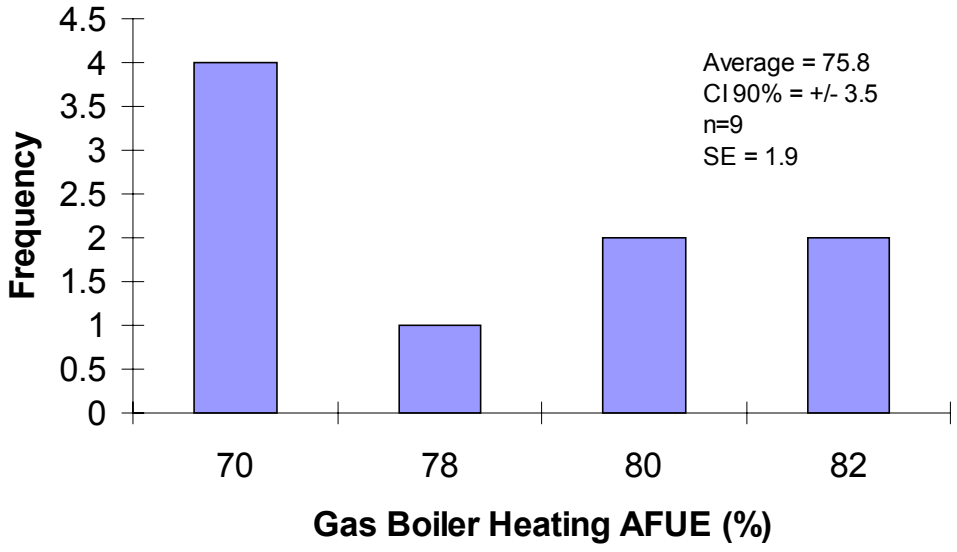


Figure 6-4: Gas Furnace AFUE Distribution

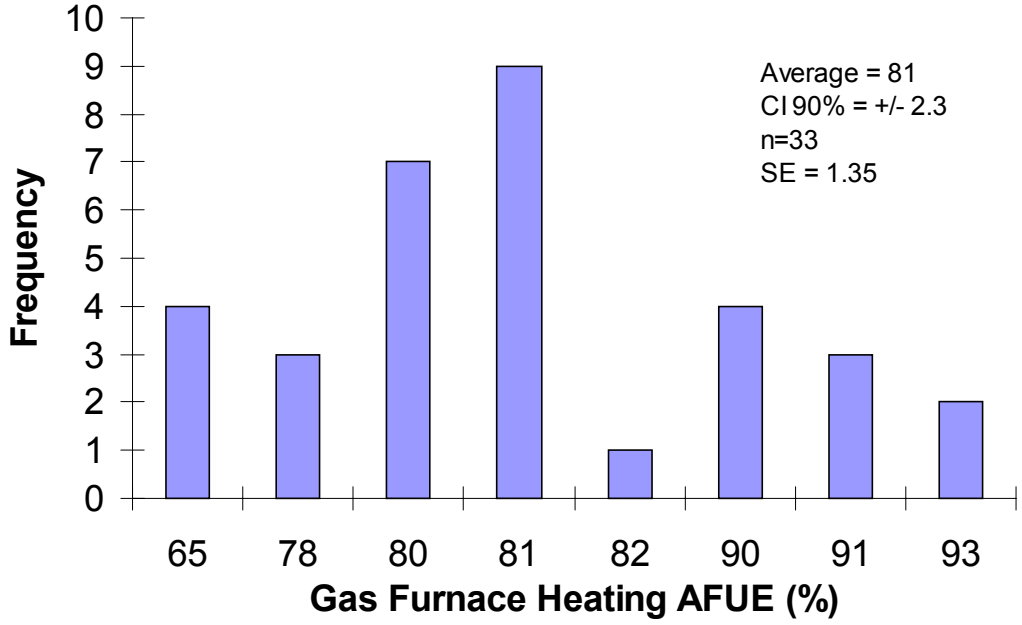


Figure 6-5: Heating Type Distribution

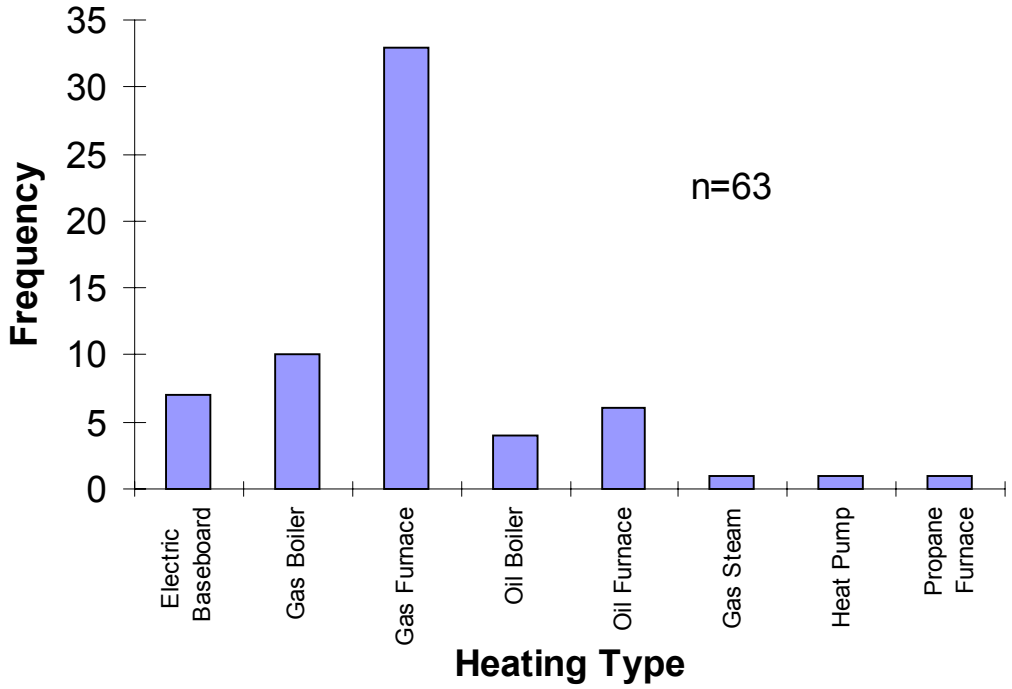
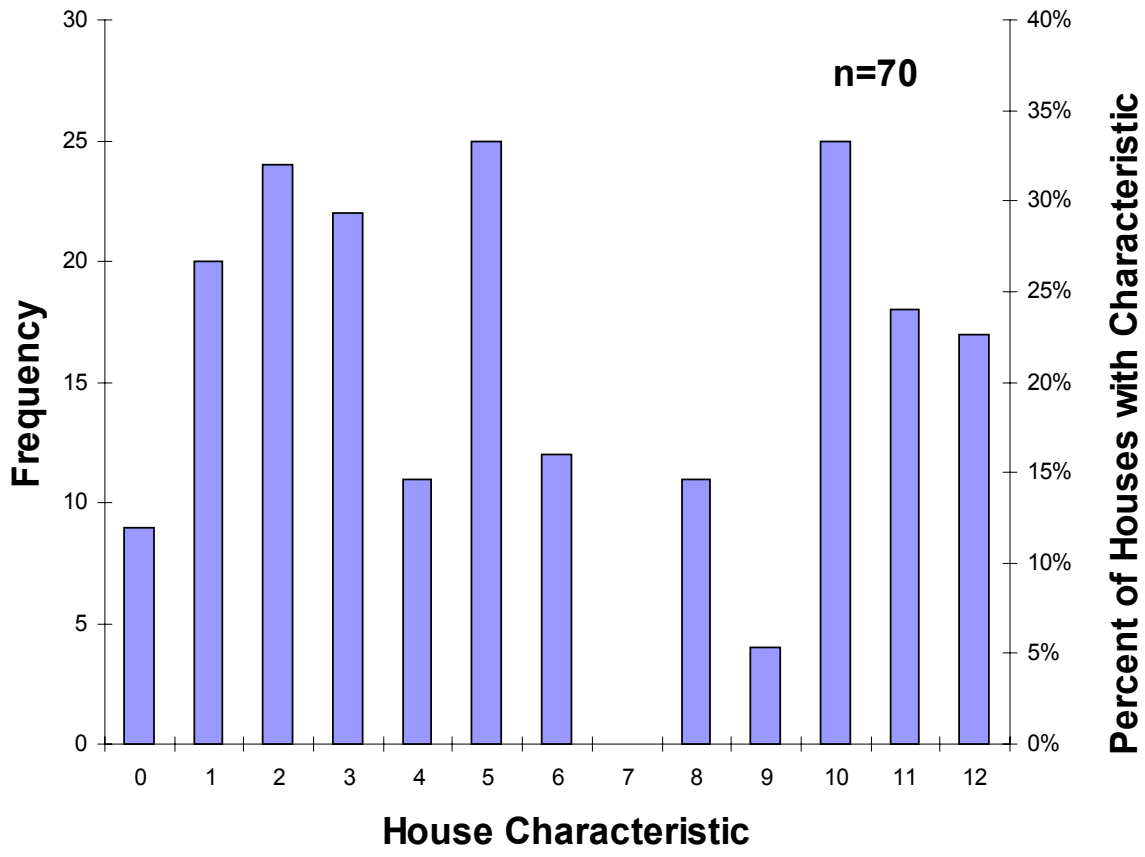


Figure 6-6: Building Style Characteristics for NJ Sample



Characterization Definitions:

0 - Characteristic(s) not present.

1 - Knee Wall & fireplace.

2 - Floor system, porth-to-floor & fireplace.

3 - Side wall attic, roof-to-room & fireplace.

4 - Dormers, roof-to-rom & fireplace.

5 - Cantilevers, bay windows & roof-to-room.

6 - Crawl space, splt level connection & roof-to-room.

7 - The house that has everything.

8 - Porch-to-floor, floor system & fireplace.

9 - Uneven & broken building planes

10 - Broken ceilling planes.

11 - Broken wall planes.

12 - Broken floor planes.

6.3 DATA ANALYSIS

This section presents analysis and findings to address the objectives of the on-site interviews. The material is organized into the following five main areas:

- HVAC equipment sizing
- Supply fan flow and return duct sizing
- Duct leakage
- Duct insulation
- Refrigerant charging

Discussions of these areas include three topics: the findings of the on-site surveys, the effects of the findings on comfort and energy usage and comparison of the current results to past work in this area.

6.3.1 HVAC Equipment Sizing

Actual cooling and heating nameplate equipment sizes were collected during site surveys and subsequent Manual J cooling and heating total loads were calculated for comparison. Manual J calculations used actual building data collected including, but not limited to, insulation and geometry characteristics. For heating oversizing comparisons, total load was represented only by sensible load due to the lack of dehumidification requirements in winter.

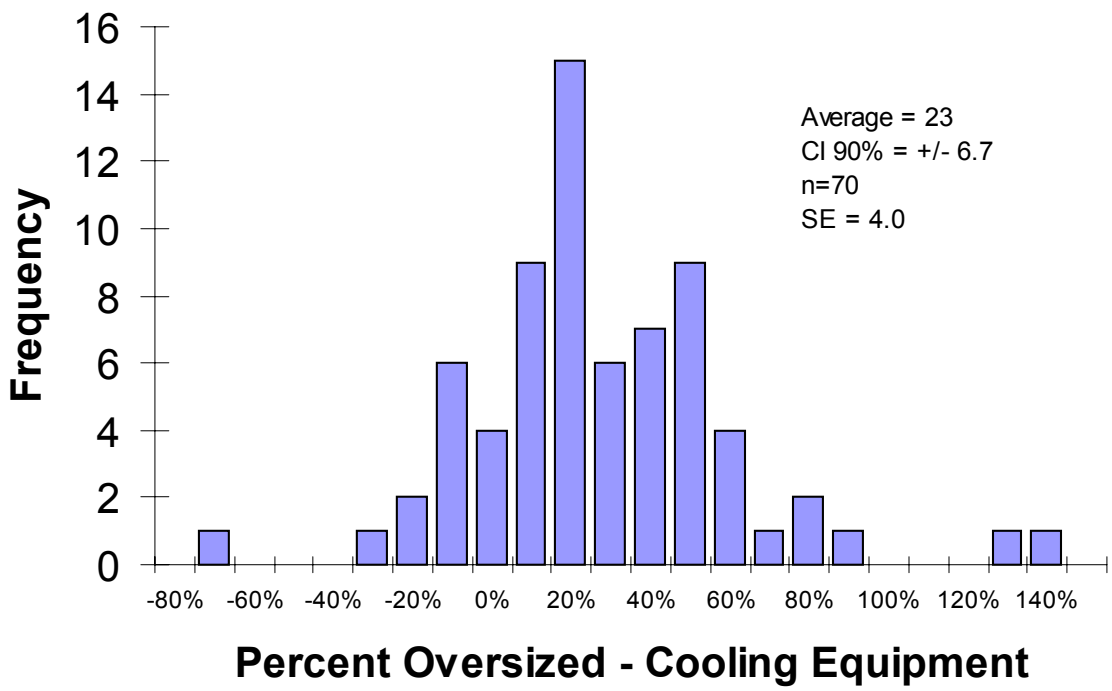
Obtaining sensible heat ratio (sensible load to total load ratio) performance data for the AC units was not possible during the 70 on-site visits made for this study. Also, the sensible heat ratio (SHR) of the architectural interior space depends greatly on infiltration and duct leakage, which are very difficult to predict accurately. Considering these two factors, an adjusted methodology was utilized to compensate.

To compensate for the equipment and space SHR challenges, the methodology used a "typical" SHR of 0.75 for both the equipment and the space load. The methodology was implemented by first calculating the sensible[3] cooling load for the space with the Manual J method and then dividing by 0.75 to obtain the total load. The total load was then compared to the nameplate rating to determine oversizing. Both space and equipment SHR can vary considerably with a typical range of 0.7-0.82, and 0.68-0.78, respectively. The use of a typical SHR of 0.75 is a compromise falling within range and should produce oversizing estimates close to the real situation. This methodology may also facilitate uniform and efficient comparisons to future studies.

[3] Manual J construction quality of “Average” was used for sensible load calculations. Average construction assumes 0.5 air changes per hour for homes less than or equal to 1,500 sqft. and 0.4 ACH for homes larger. Manual J assumes no duct leakage.

The actual cooling equipment nameplate size is compared to the Manual J total cooling load calculations in Figure 6-7. This data approximates normal distribution with the average oversizing being 23 percent when compared to Manual J calculations[4]. The data shows that the tendency is for HVAC contractors to oversize systems. While only 6 percent of cooling systems were more than 10 percent undersized, 80 percent of systems were oversized more than 10 percent. Systems oversized more than 20 and 30 percent equal 68 and 46 percent of the population, respectively.

Figure 6-7: Cooling Equipment Sizing Versus Manual J

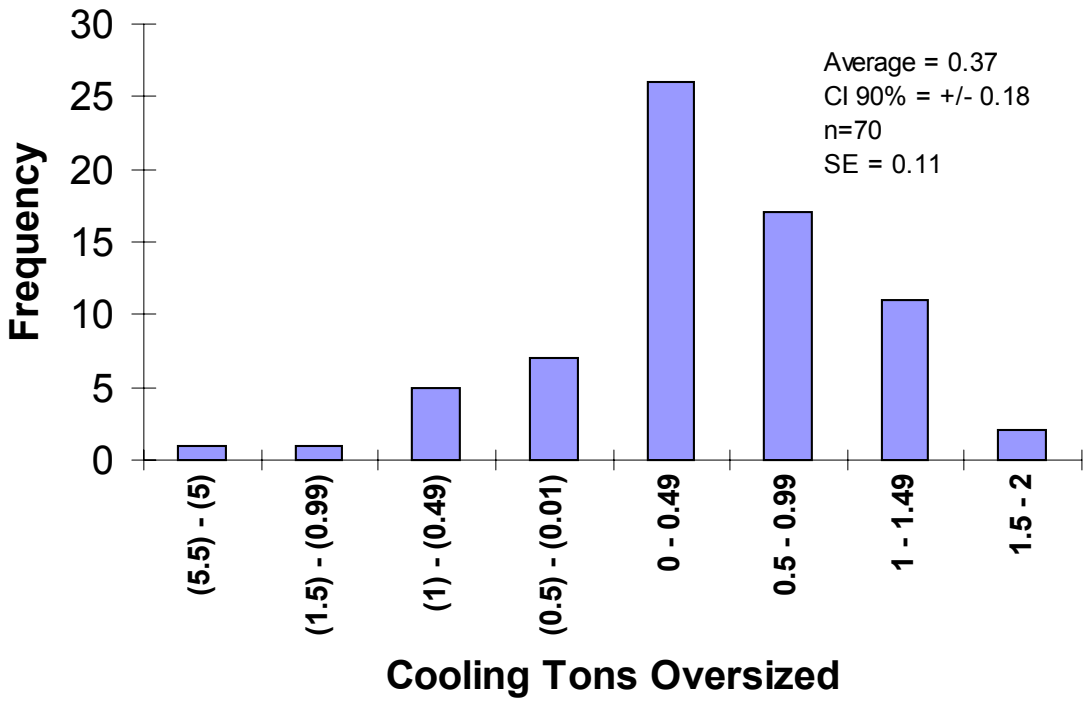


Air conditioning units are typically available in increments of 6,000 Btuh, or one half ton of cooling. Thus, the percent oversized data shown in Figure 6-7 does not show the entire picture of how well the installed systems were sized. A better indicator to determine if the units were sized properly is the difference in size between the actual installed unit capacity and the Manual J load calculated. A difference of one half ton or greater would indicate that the system is oversized. This data is illustrated in Figure 6-8. The average size difference between the actual equipment and Manual J is 0.37 tons. Oversized cooling units sized 0.5 ton or greater account

[4] Manual J is believed to be conservative by itself, over sizing equipment by approximately 24 percent as reported in Iris Communications April 1997, Energy Source Builder #50, web address used 2/21/2001, http://oikos.com/esb/50/manualj.html

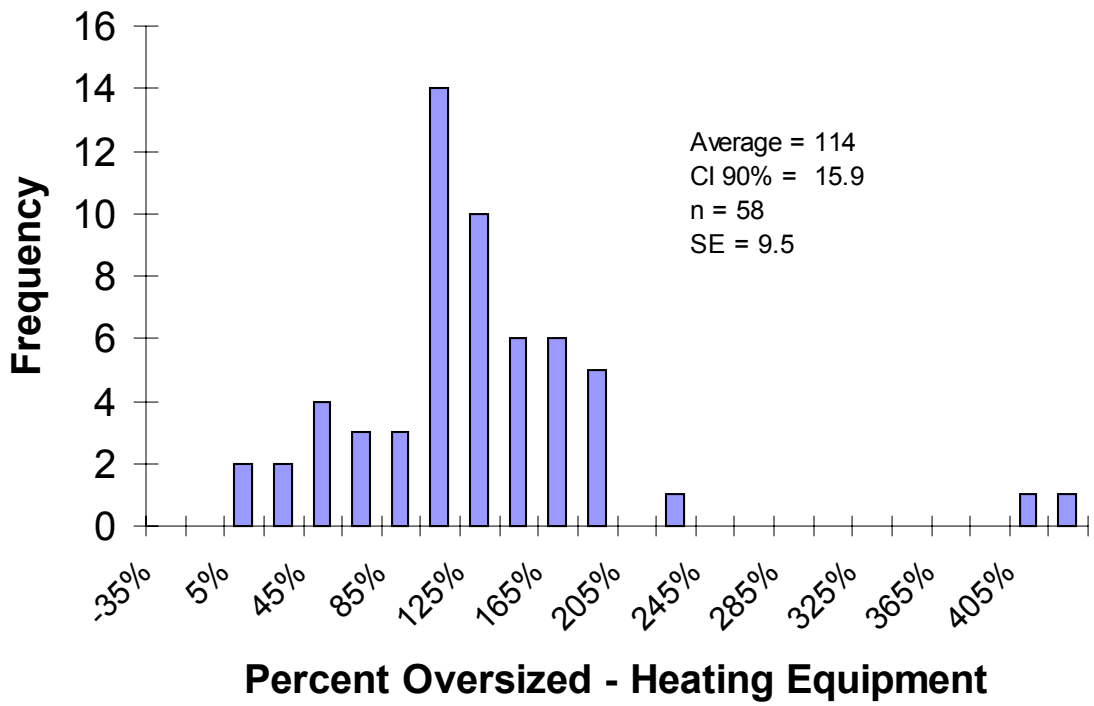
for 43 percent of the population. Units that were oversized correctly, between 0 and 0.49 tons equal 37 percent of the population.

Figure 6-8: Cooling Equipment Size Difference From Manual J



A comparison heating equipment nameplate capacity with Manual J space load calculations is presented in Figure 6-8. Heating systems were on average 114 percent oversized when compared to Manual J, with the extremes at –13 percent and 405 percent. A total of 54 units, or 93 percent were oversized 25 percent or more compared to the Manual J heating load calculated.

Figure 6-9: Heating Equipment Sizing Versus Manual J



Effects of Oversizing On Comfort and Energy Usage

Oversized cooling systems ensure high sensible heat load removal and low space temperatures; this alone will not ensure comfort. Oversized equipment operate less time to achieve the same indoor air temperature setting. This leads to short cycling, which can have three effects: 1) indoor air humidity levels may increase if cycle times approach 7 minutes or less, which is the approximate time for a coil to reach the dew point temperature of the entering air, 2) an increase in energy usage due to high humidity comfort problems. This may occur if the occupant lowers the temperature setting to obtain the same comfort at a lower temperature and higher humidity level as opposed to a correctly sized unit that could provide the same comfort at a higher temperature and lower humidity level, and 3) a decrease in the efficiency due to the mechanical/thermal inefficiency of cycling the cooling equipment.

Very few studies have been performed to determine the energy savings that can be achieved by correctly sizing an air conditioning unit. According to the American Council for an Energy-Efficient Economy (ACEEE), who has reviewed more than a decade of research, reports an energy increase of between 0.6 to 2 percent for every 10 percent oversizing (Neme et. al. 1999).

The savings were estimated for this study used an average of the 1.3 percent power increase for every 10 percent of oversizing. Analysis of the data in Figure 6-8 results in a potential savings of 6.7 percent of the cooling energy for all units oversized by more than 0.5 tons (43 percent, n=30). When considering the potential savings over the entire population of 70 cooling systems in Figure 6-8, the savings decreases to 2.9 percent. Confidence intervals are provided for this result in Section 6.4.

Oversized heating systems do not have the same comfort problems as cooling systems because of the lack of latent load removal, however, excessively oversized systems may have a tendency to overheat a space and lower the relative humidity which occupants could perceive as affecting comfort negatively.

Energy savings from correctly sizing heating systems has not been evaluated as fully as cooling systems. This is probably due to the fact that the efficiency is almost constant for furnaces and boilers until relatively small part loads are encountered. With heating, an appreciable loss of efficiency does not occur until the heating unit is oversized by more than 100 percent. An estimate of heating efficiency loss is presented in Table 6-2. This table was derived based on heating equipment oversized by 100 percent above the peak load (Bortone 1993). The heating efficiency decreases non-linearly from 2 to 15 percent over the range of heating loads analyzed. An annual efficiency loss was estimated to be 8 percent for a 100 percent oversized unit. This was calculated by weighting the efficiency loss based on the fraction of the time at various loads, as shown in Table 6-2. As a unit's size is increased above 100 percent over sizing, the annual efficiency loss will increase because of the non-linear relationship.

Table 6-2
Annual Heating Efficiency Loss for 100 Percent Oversized Unit

Heating Load Fraction	Heating Efficiency Decrease	Fraction of Time at Heating Load	Efficiency Loss
100 %	2 %	0.05	0.1 %
75 %	3 %	0.11	0.3 %
50 %	4 %	0.28	1.1 %
25 %	8 %	0.28	2.2 %
12.5 %	15 %	0.28	4.2 %
Total		**1.00**	**7.99 %**

Source: Derived from heating efficiency curves (Bortone, 1993)

Savings are calculated for the data set analyzed for this project. For calculations a base efficiency loss of efficiency loss of 8 percent was used if a unit was oversized by 100 percent. An additional 0.8 percent efficiency loss was calculated for every 10 percent of oversizing above 100 percent oversized. The results yielded an average of 6.8 percent savings over the entire

population (n=58) with a high of 32 percent for one unit that was oversized by 400 percent. Fifty five percent of the population had savings of greater than 8 percent. Confidence intervals are provided for the average result in Section 6.4.

Comparison of Results to Past Work

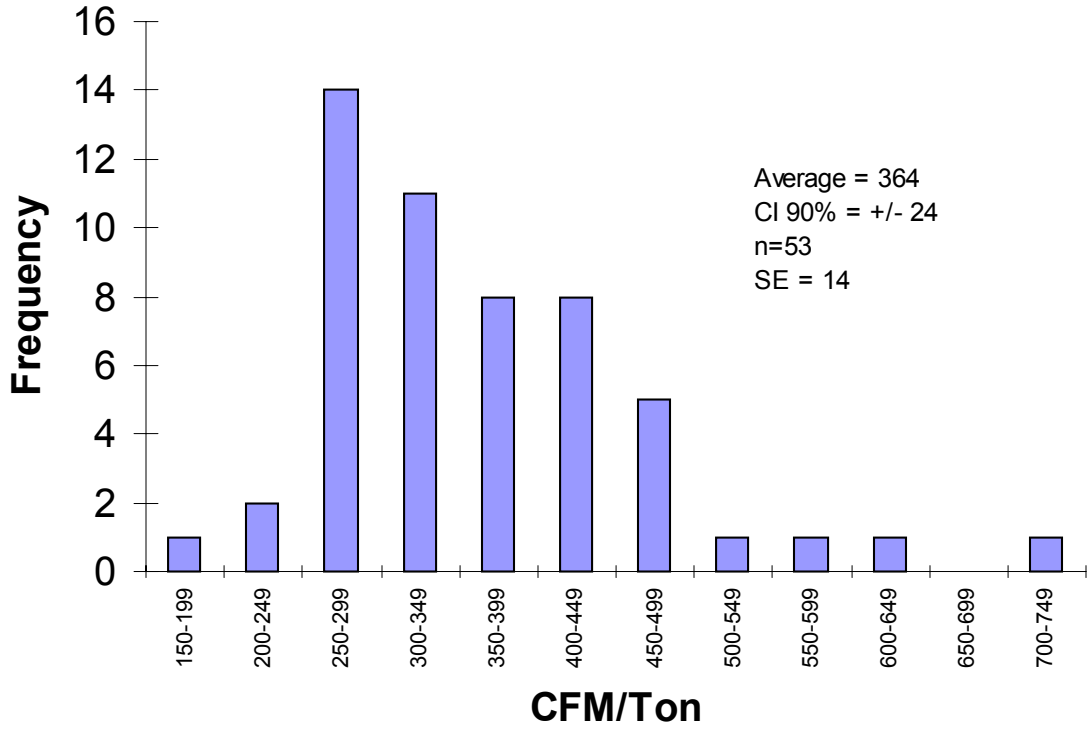
The results of the survey showed an average oversizing of 23 percent and 0.37 tons for cooling equipment when compared to Manual J. This is less than what was expected when considering previous studies performed in New Jersey. An ACEEE paper reviewed more than a decade of relevant research papers and found that systems in New Jersey were typically oversized 60 to 70 percent on average with an oversizing of 1.58 tons (Neme et. al. 1999). This discrepancy may be due to the selection of the population. Sites were visited that had cooling systems with an age of 1 to 3 years. This sample may reflect the more recent improvements contractors have made in sizing new equipment. Difference in oversizing could also be at least partly attributed to difference between the existing homes in this study that were retrofitted versus new construction which is what the older NJ study was based on (Neme 2001).

6.3.2 Supply Fan Flow and Return Duct Sizing

Proper duct sizing and equipment selection is key for providing adequate airflow for the cooling system. Air conditioners are designed to operate at a flow of 400 cfm per ton, which is considered the industry standard. This is the airflow that is necessary to achieve the balance between sensible heat transfer and moisture removal. It is accepted practice that an airflow volume of 350 cfm per ton is the lowest acceptable limit before efficiency is affected appreciably. Higher flow rates of greater than 400 cfm per ton have the opposite effect of increasing the efficiency of the equipment slightly, however, moisture removal is decreased as the air flows quicker over the coil, which can lead to greater discomfort by occupants.

The supply flow data collected for the GPU analysis is normalized with the installed cooling capacity as shown in Figure 6-10. For the population analyzed, the average flow rate of cooling systems is 364 cfm per ton. The flows observed are skewed towards being lower than the design criteria; a total of 68 percent of all systems tested had a flow less than 400 cfm per ton. Inadequate flows of less than 350 cfm per ton were present for 53 percent of the systems inspected. Flows of less than 325 cfm per ton were observed for 49 percent of the population.

Figure 6-10: Supply Flow for Cooling System

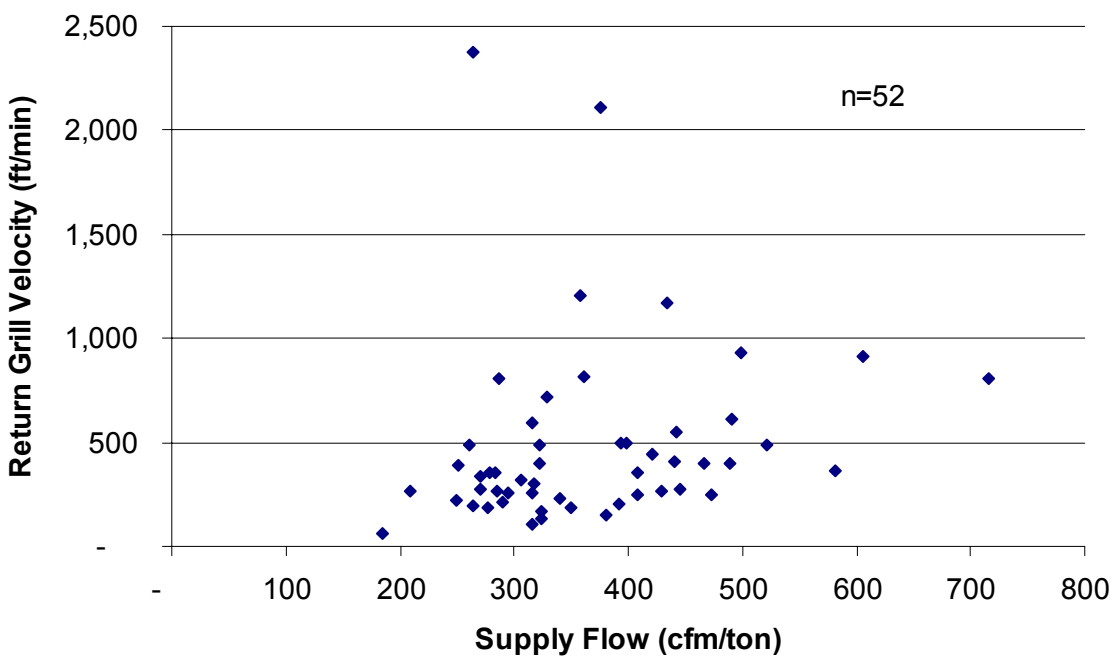


The majority of all the heating and cooling systems in this study shared the same supply fan, as part of a forced air furnace. The efficiency and performance of the cooling equipment is more dependent on a narrow range of acceptable flow rates than the heating system. Thus only flow data relative to cooling systems has been presented. From inspection of manufacturers data, heating flow rates for furnaces are capable of extending over a much greater range. Data for one manufacturer allowed flow rates of 23 cfm per Kbtuh heating capacity with a flow variation of ± 50 percent. The variation of flow for cooling is much less at 400 cfm per ton ± 12 percent.

During the site visits the auditors recorded return grill size and quantity, so that return grill velocity could be checked for adequate sizing. The ACCA Manual D recommends return grill velocities of 400 feet per minute or less to maintain a reasonable pressure drop and sound level. Analysis of the data showed that the majority of return grills were sized properly to provide less than 400 feet per minute of flow and that there was no clear relationship between return grill velocity and supply flow rates. This data is presented in Figure 6-11. This analysis eliminates return grill size as one of the major causes of inadequate supply flow. Experience has also shown that if the return grilles are sized properly, then the associated return ducts and trunks are typically sized properly (Norris, 2001b). Figure 6-11 shows that only 5 sites could have return grill velocities that are high enough to warrant further inspection of the return grill and ducts.

The exact cause of the reduced flow was not determined for each home. However, it is likely that the actual cause of the supply flow reduction for the majority of systems is a combination of fan speed, and/or high supply static pressure drop from the supply fan to the diffuser grills. If the problem is only fan speed, the flow can typically be corrected. The supply fan motors are usually equipped with multiple speed tabs, capable of up to 4 speed adjustments. Some systems may not be set at the highest speed, which allows for an adjustment to increase flow. Increasing fan speed will increase energy usage, which may offset the cooling energy savings. These fan interactions were not analyzed in the data set. Supply fan speeds were not determined as part of the on-site inspections. If lowering of supply ducts to pressure loss is needed for correcting flow, this can be remedied, although typically not as easily. The remedy for this situation is replacement of restrictive duct portions or entire duct systems. The ACCA Manual D is one resource that can be used to determine appropriate duct sizing, however, residential ducts are rarely designed with the help of such resources.

Figure 6-11
Return Velocity Versus Supply Flow



Effects of Supply Fan Flow On Comfort and Energy Usage

Undersizing supply fan flow rate will compromise a cooling system's ability to maintain the temperature in the space. Oversizing the supply fan will compromise a system's ability to reduce moisture. Adequate supply fan flow strikes a balance between adequate temperature reduction and moisture removal.

Over the last decade studies have shown that when flow rates fall 20 percent below manufacturers design rates, energy consumption increases. It has been determined that at flow rates of 320 cfm per ton or less, consumption is increased by 10 percent for systems with fixed orifice refrigerant metering devices, such as capillary tubes and orifices. Refrigerant devices that use thermal expansion devices, only have a 2 percent increase in energy consumption (Neme et. al. 1999). Of the 47 cooling system refrigerant expansion devices inspected for this study, 58 percent used fixed orifice technology and 42 percent used thermal expansion valves. Applying the savings percentages to the population that has flow rates of 320 cfm per ton or less yields an average savings of 5.5 percent cooling energy savings for the population of deficient systems. When considering the potential savings over the entire population of cooling systems in Figure 6-10 (n=53), the average savings decreases to 2.3 percent. Confidence intervals are provided for this result in Section 6.4.

Comparison of Results to Past Work

Fifty eight percent of systems tested had flow rates of less than 350 cfm per ton. This is not surprising considering 7 different studies over the last 9 years yielded an average of 70 percent of all systems tested less than 350 cfm per ton (Neme et. al. 1999).

6.3.3 Duct Leakage and Insulation

A high efficiency, properly sized, central air conditioner or heating furnace will not operate efficiently as a system if the ducts are poorly sealed and insulated. Duct leakage can increase outside air infiltration and impose a host of other problems including improper drafting of combustion appliances, moisture and mold introduction among others. Duct insulation has a major impact on the energy usage and consequently, the sizing of the heating and cooling equipment. Supply and return ducts located in unconditioned spaces have the greatest impact for both leakage and insulation.

Duct Leakage

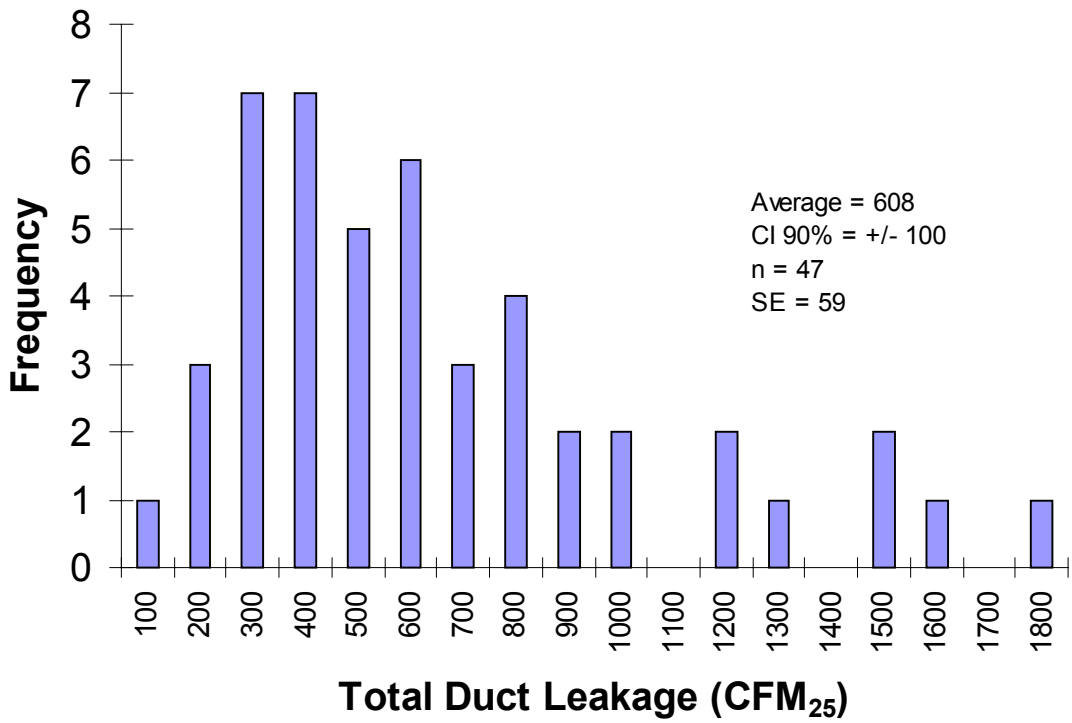
Leakage tests were conducted using a Minneapolis Duct Blaster. The procedure collected leakage flow data for both the supply and total leakage in units of cubic feet per minute at a pressure of 25 Pascals (CFM_{25}). The return duct leakage was then calculated by subtracting the supply leakage from the total duct leakage. A pressure of 25 Pascals is used because it is considered an industry standard that approximates the pressure when the air handler is operating.

The total leakage data for this study is presented in Figure 6-12. The data analyzed shows an average leakage of 608[5] CFM_{25} with 38 percent of all leaks being greater. The data does not

[5] multiple data points have been removed from the data set due to problems with collecting data.

approximate a normal distribution. The peak frequency of observations actually occurs in the 200 to 400 CFM_{25} range. This data is not surprising and could be expected since installing ducts with high leakage is significantly easier than installing ducts with very low leakage.

Figure 6-12: Total Duct Leakage



The main goal of the leakage tests is to estimate outside air leakage, using the total leakage data[6]. The worst-case scenario, which would overstate the leakage of the outside air, is to assume that the total leakage is the outdoor air leakage. This would assume that all supply and return ducts are in an unconditioned space outside and all leaks cause outside air to enter either the house or the return duct system. This is very unlikely, even for homes that have the majority of ducts in an attic or crawl space; this is because there is typically some leakage to the conditioned space.

For this study, outside air leakage is estimated using total duct leakage data in combination with the results of previous work. Outside air leakage can be correlated to total duct leakage by considering the house and duct characteristics, as shown in Table 6-3 (Procter 2001). Outdoor air leakage rates approach total duct leakage when houses have the majority of ducts in unconditioned spaces and there are a small number of returns. Houses that have most of the

[6] Outside airflow can be estimated directly from measurements using a duct blaster in combination with a blower door. This technique was not utilized for this study. Instead, total duct leakage has been used in combination with past studies that allow for correlation of outdoor air leakage to total leakage.

ductwork within a conditioned space and have multiple returns will have significantly less leakage to the outdoors.

For this study the house and duct characterization that matches the closest to Table 6-3 is the data from the New York study. In the New York study, 54 percent of the total duct leakage ends up being outdoor leakage. Applying the 54 percent factor to the data from this study may be a conservative estimate of outdoor air leakage. It is believed to be conservative because half the houses had a majority of ducts in attic spaces, which would tend to give higher results when compared to a basement duct system. Basements tend to reduce outside air leakage because they are integral to the house with doors connecting the space to the conditioned space above and there is typically no insulation between spaces, thus leaks are more prone to pass through the basement to the conditioned space instead of outside.

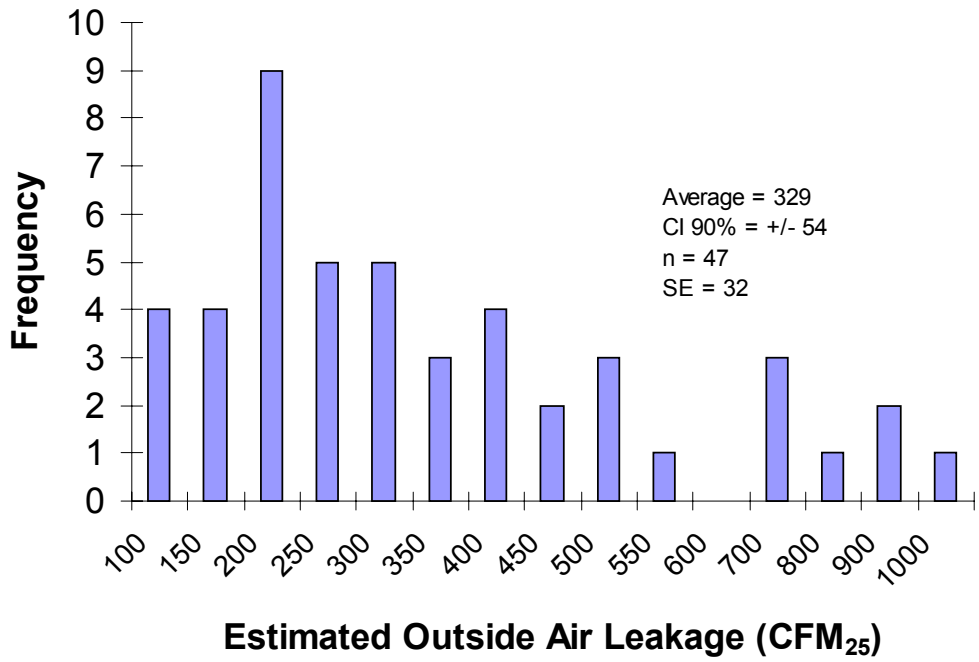
Outdoor air leakage estimates are presented in Figure 6-13. The data was calculated by applying a fraction of 0.54 from the New York Study to the total leakage. Analysis of the data determined an average outdoor air leakage of 329 CFM_{25}, with 38 percent of all systems having an outdoor leakage rate higher. The data does not approximate a normal distribution curve for the same reasons discussed for the total leakage data.

Table 6-3
Studies in Outdoor Air Leakage

Typical House Characteristics	Sample Size	State	Total Leak CFM_{25}	Outdoor Air CFM_{25}	Ratio OA/Total
Two story homes with basement. Majority of ducts are in basement and interior, multiple returns, joist pan ducts.	66	NY	450	245	0.54
Majority of Ducts in attic space with a single return	30	NV	369	253	0.69
Majority of Ducts in attic space with a single return	10	CA	379	292	0.77

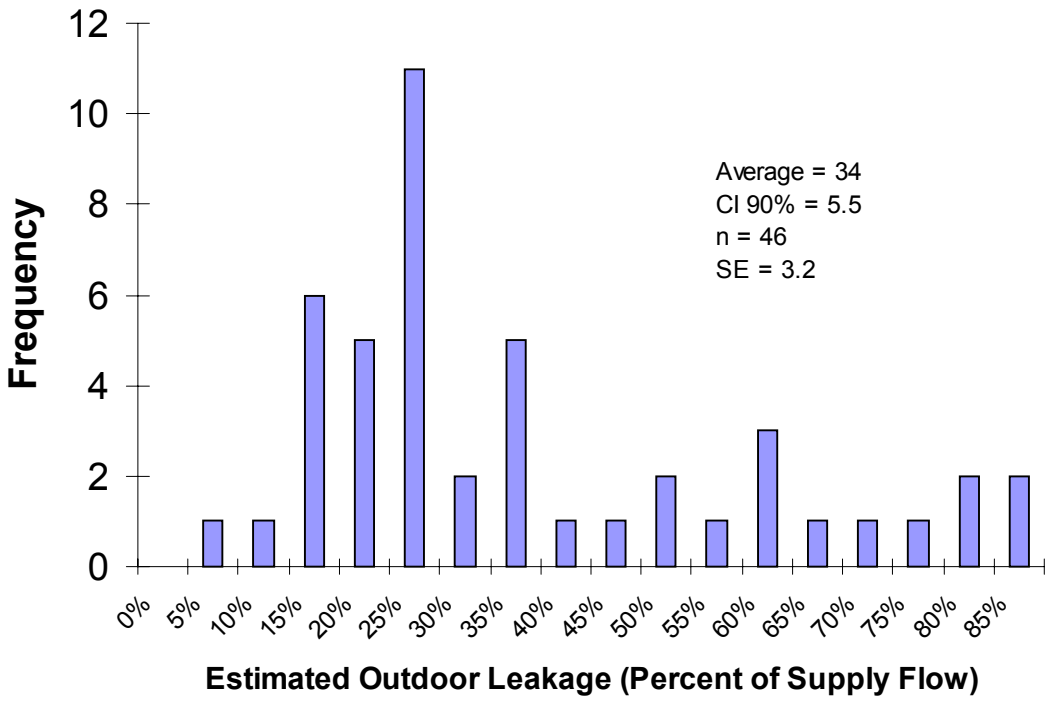
Source: Data provided by John Proctor, Proctor Engineering Group by phone communications April 18, 2001

Figure 6-13: Outdoor Air Leakage Results



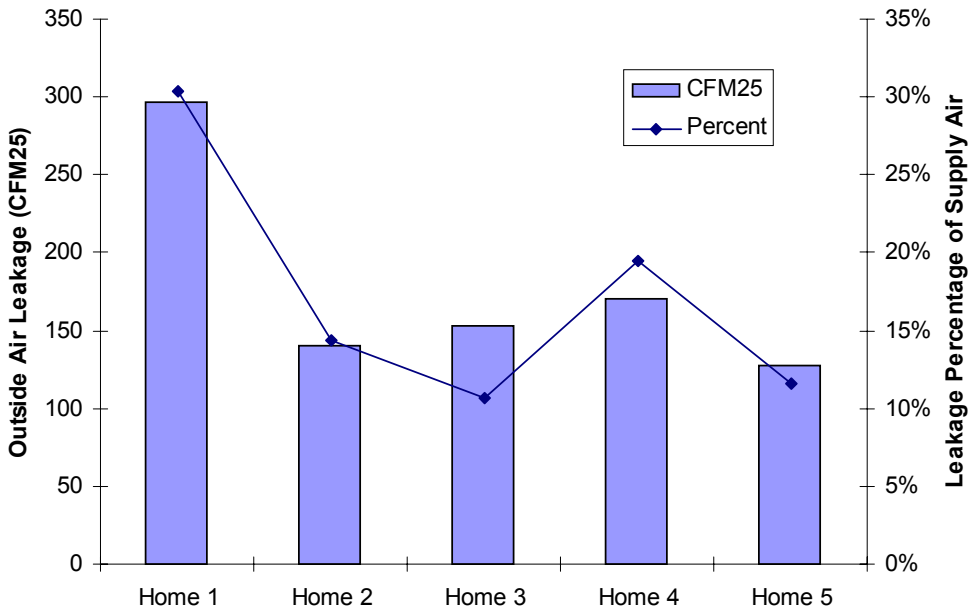
The magnitude of the leaks is put into perspective by comparing the outdoor air leakage rate to the supply airflow rate. The distribution of leakage percentages is presented in Figure 6-13. Analysis of the data determined that the average outdoor air leakage rate is 34 percent of the supply airflow. Thirty five percent of the systems analyzed had a leakage greater than 34 percent of supply airflow.

Figure 6-14: Leakage Percentage of Supply Flow



The practice of sealing ducts to prevent leaks is virtually nonexistent in the sample studied. A deliberate attempt to seal ducts was found for only 8 percent (n=4) of the ducts systems inspected. The majority used duct-sealing tape. All of the systems that had duct sealing performed better than the average results, as shown in, Figure 6-15. Not including the first home in the data, the average outdoor air leakage is 148 CFM_{25}, 55 percent lower than the population average. Additionally, the average percent of supply flow is 14 percent, which is 40 percent lower than the population average.

Figure 6-15: Homes With Sealed Ducts

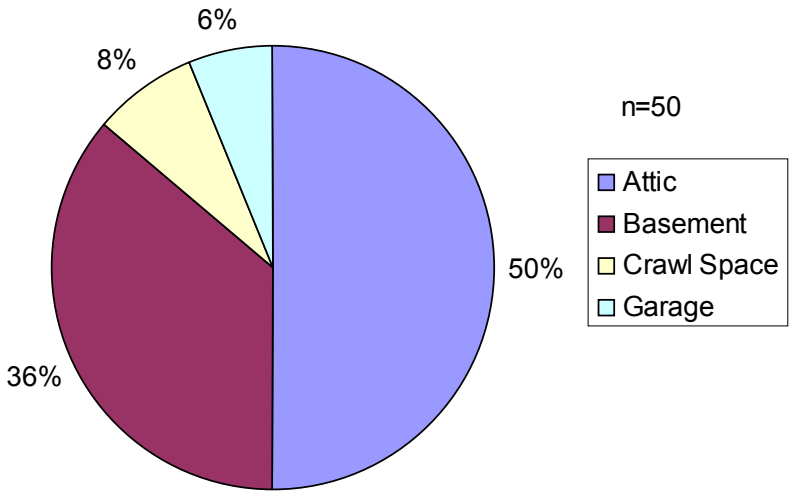


Duct Insulation

Duct insulation has a major impact on the energy usage and consequently, the sizing of the heating and cooling equipment. Supply and return ducts located in unconditioned spaces have the greatest impact. For this study homes were inspected and ducts that were located in unconditioned spaces were noted. Unconditioned spaces included: attics, crawl spaces, basements, and garages. Basements and garages were considered unconditioned if there were no supply registers serving these areas. Ducts located in the exterior walls of homes were not included for this study.

Analysis of the data shows that 89 percent (n=50) of the population analyzed (n=56) had a significant portion of the duct distribution in an unconditioned space. The distribution of unconditioned space type encountered during the site surveys is summarized in Figure 6-16. From analysis of the data, 86 percent of all ducts in unconditioned spaces can be found in either a basement or an attic space, with the majority found in attics.

Figure 6-16: Distribution of Unconditioned Spaces



Of the homes that had ducts in unconditioned spaces, 54 percent had insulation on ducts. The majority of uninsulated ducts were located in unconditioned basements as shown in Figure 6-17. When comparing this graph to Figure 6-16, there is a major shift in distribution between the attic and basement spaces. This trend may be occurring because occupants and their contractors understand the importance of insulating the ducts in the attic because they are likely to be exposed to outside air conditions. Basements on the other hand may be used frequently and the duct losses condition these spaces to some degree, therefore, the tendency to insulate basement ducts is reduced. The analysis shows that the areas that could probably benefit the most from insulation, attics and crawl spaces, had the highest occurrence of insulation on ducts, 83 and 100 percent, respectively. Other areas such as unconditioned basements and garages had the lowest incidence of insulated ducts, 6 and 33 percent, respectively.

The homes that did have insulation typically used either a foam duct board or a fiberglass batt type of insulation. Insulation values of R-6 were used for ducts in one garage out of the three encountered. Ducts in crawl spaces used R-6 for three homes and a fourth used R-4 insulation. Only one basement analyzed had insulated ducts with a value of R-4, the other 18 had none. Attics had the widest distribution of insulation values, which are summarized in Figure 6-18.

Figure 6-17: Uninsulated Duct Location

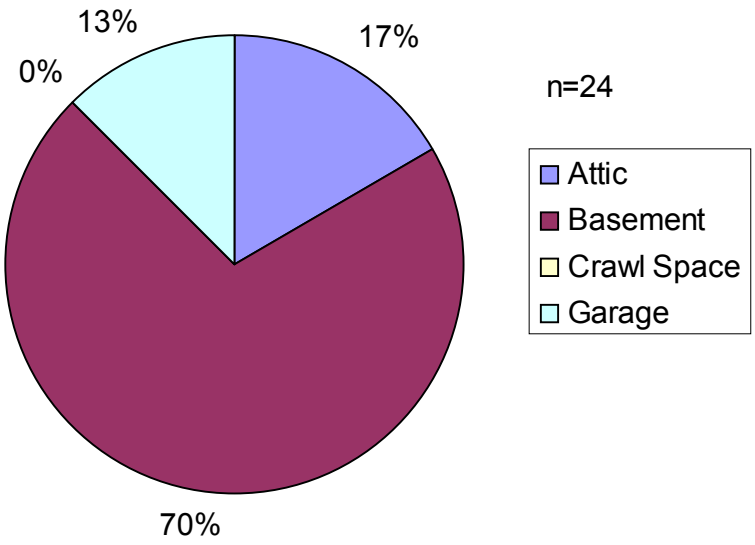
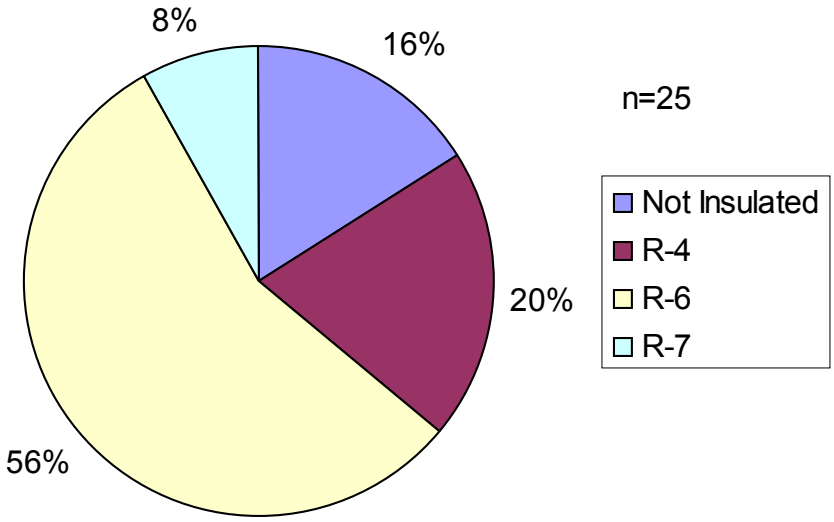


Figure 6-18: Attic Duct Insulation Distribution



Effects of Duct Leakage and Insulation On Comfort and Energy Usage

Duct Leakage

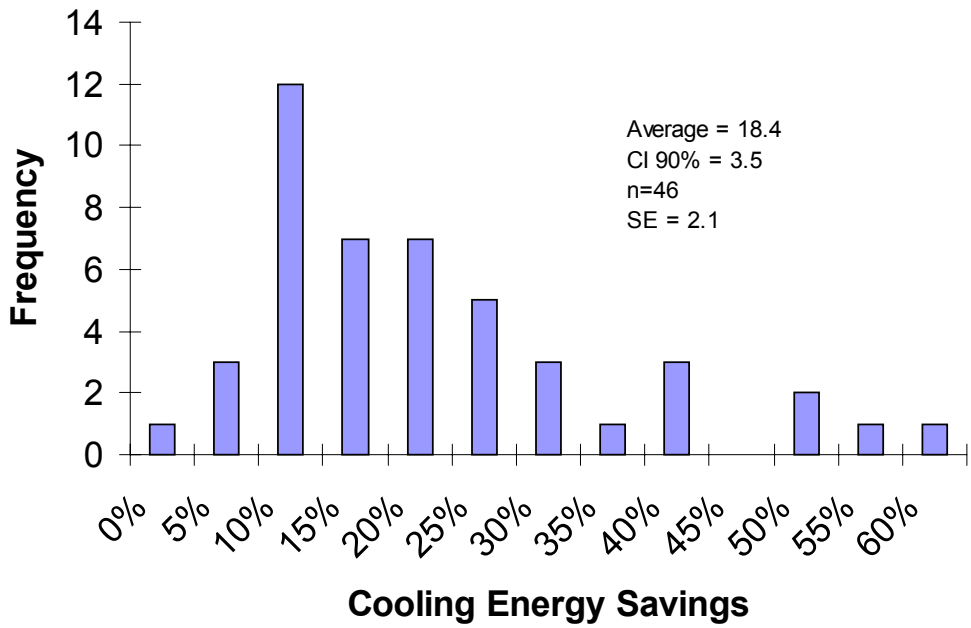
Duct leakage can cause both comfort and safety problems in a home. Leaks affect comfort by creating drafts if outside air is drawn through the conditioned space. Humidity levels can also be affected. Leaks in the winter will have the affect of lowering the indoor air humidity and summer leaks will have the opposite affect by increasing humidity levels. Safety can be compromised by the imbalance of pressure the leakages can cause, which can lead to improper drafting of fireplaces and fuel burning appliances such as water heaters and gas dryers. Of particular concern are leaky returns located in basements were fuel combustion appliances are operated. Carbon monoxide levels could increase as a result of improper drafting. Other pollutants from the crawlspace, attic, and basement can be introduced into the house including: radon, mold spores, and mildew.

According to the American Council for an Energy-Efficient Economy (ACEEE), who has reviewed more than a decade of research, reports an average heating and cooling energy savings of approximately 6.5 percent for every 100 CFM_{25} saved. This number is an average for heating and cooling savings over a wide geographical sampling (Neme et. al. 1999). XENERGY checked savings data for reasonableness by calculating the savings with engineering calculations. The estimate for heating and cooling energy savings was determined to be 7.9 and 6.4 % per 100 CFM_{25}[7], respectively.

Annual energy savings for the population was estimated by assuming that the leakage in Figure 6-13 could be reduced to 5 percent of the supply flow. The 6.5 percent savings factor was then applied to each 100 CFM of leakage that is saved. A distribution of cooling energy savings estimated is shown in Figure 6-19. The average cooling energy savings is 18.4 percent. Savings of greater than 18 percent are estimated for 37 percent of the population. The heating energy savings potential is 16.5 percent across the same population. This is smaller than the cooling results because some of the homes evaluated used hot water boiler systems with baseboard heating distribution systems, thus duct leakage was not applicable for these homes. If baseboard heating systems are removed from the population, then heating savings are estimated to be 22.3 percent (n=34). Confidence intervals are provided for savings results in Section 6.4.

[7] . XENERGY's method of estimation used degree-day calculations to estimate both the total energy usage and the savings. It was necessary to calculate total cooling and heating energy usage because utility bills were not available for the houses inspected. XENERGY's analysis has a higher degree of uncertainty since both total energy and savings was estimated, thus, the results are only used as a benchmark to compare for reasonableness to the data from Neme's 1999 ACEEE paper.

Figure 6-19: Cooling Energy Savings (leakage reduction to 5% supply)



Duct Insulation

Insulating ducts in unconditioned spaces helps keep the supply temperature colder in the summer and warmer in the winter, which may improve comfort for the occupants of a home. During the summer when cooling is used, condensation could occur on uninsulated ducts in basements, crawl spaces, and attics ducts. The condensation could cause wood decay and mold and fungus growth.

The ACCA Manual J load calculations account for duct insulation in the calculations. If insulation is added to a duct, then the heating and cooling load can be reduced by the amounts in Table 6-4. These values are meant to capture the worst-case design conditions so that they can be applied to all homes and geographic conditions encountered. For the majority of homes, actual heating and cooling energy savings from installing duct insulation will be smaller than the values in Table 6-4. Savings from insulating ducts are typically reported in combination with sealing ducts since it makes sense to seal the ducts before covering them. Because of this, it is rare to find actual field data that analyzes achieved savings. A study by ACEEE appears to show that insulating ducts may reduce heating and cooling energy, incrementally, by approximately 3 to 10 percent (Neme et. al. 1999), this is anecdotal because an apples-to-apples comparison could not be achieved with the data presented. Applying reasonable judgment, it is estimated that the

average cooling and heating savings achievable will be approximately 50 percent of the values listed in Table 6-4.

Applying insulation to the population yields small savings because most of the attic and crawl space ducts were insulated. The vast majority of uninsulated ducts was in basements which occupants may not allow to be insulated if they receive some conditioning from the ducts and they use the space. If only attics, garages, and crawls spaces are to be insulated with R-8, then the cooling energy savings achievable is 1.5 percent on average for the entire population (n=56) of houses with and without ducts in unconditioned space. This is small because only 7 houses would receive insulation. If basements were also to receive insulation then the cooling savings would increase to 4.7 percent energy savings for the entire population of houses with and without ducts in unconditioned space. The potential heating savings are estimated at 2.0 and 6.9 percent, , respectively. The heating savings are different from the cooling savings because some of the homes used hot water boiler systems with baseboard distribution systems, thus duct insulation savings were applied to a smaller population (n=35). Confidence intervals are provided for the savings results in Section 6.4.

Table 6-4
Duct Insulation

Space	Insulation	Manual J Load Credit
Basement/Crawl Space	R-8	20 %
Basement/Crawl Space	R-6	15 %
Basement/Crawl Space	R-4	10 %
Basement/Crawl Space	R-2	5 %
Attics	R-8	25 %
Attics	R-6	20 %
Attics	R-4	15 %
Attics	R-2	10 %

Comparison of Results to Past Work

The outdoor air leakage average of 329 CFM_{25} is close to other studies conducted. An ACEEE paper investigated the results of 12 different studies that were conducted over the last 9 years. The average yielded 270 CFM_{25} and with a range of data from 193 to 397 CFM_{25} (Neme et. al. 1999).

6.3.4 Refrigerant Charging

Proper charging is essential for proper operation of cooling equipment. Manufacturers are very specific about the amount of refrigerant cooling systems need. Too much refrigerant can cause flooding, slugging, capacity loss, higher energy usages and shorten the life of a compressor. Too little refrigerant will starve the evaporator coil and compressor. Overheating of the compressor will result, shortening the compressor life. A starved evaporator will also prevent sufficient cooling of the air passing through. Both conditions, over and under charging have the potential to lower the efficiency and capacity, and shorten the life of the cooling equipment.

For this study refrigerant charging was determined to be in one of three states, under charged, over charged, or charged OK. The determination of state was accomplished by measuring the degrees of superheat or subcooling, depending on which refrigerant metering device was used, fixed orifice or thermal expansion valve (TXV), respectively. The data collected allows the qualitative determination the refrigerants state, but does not allow the quantification of over and under charging. Without the opportunity of testing the actual weight of the refrigerant charge it is impossible to determine the exact percentages of over or under charge with the systems tested. Accuracy of the charged OK condition is estimated to be within ± 10 percent of the manufacturers charge specification. The technician measured the temperatures on the suction (large) line and the liquid (small) line. They also listed what type of metering device the system was using. This information was then used determine the charge state of system using standard industry charging calculators that utilized superheat for fixed orifice metering devices and subcooling for thermal expansion devices.

The data analyzed is shown in the pie chart of Figure 6-20. The data shows that 47 percent of systems were under charged and 21 percent were overcharged. Of the 19 systems tested only 3 used TXV for metering the refrigerant and all of them were charged correctly. It would be expected that if the sample were larger there would be little or no difference in the results of TXV or fixed orifice refrigerant metering devices. The sample size for this study was low because outdoor air temperatures dropped below acceptable levels to perform the test for the majority of the systems. We believe the sample size is still valid because the data taken was collected in a random and unbiased manner. Thus, we have no reason to believe that the data collected from the homes was different than the data missed in other homes.

Data was collected on the type of refrigerant metering device because it impacts the performance of the system significantly by allowing the system to be more tolerant of over or under charging. The data shows the breakdown between refrigerant metering devices is 43 percent TXV and 57 percent fixed orifice, Figure 6-21 illustrates the results.

Figure 6-20: Refrigerant Charging Results

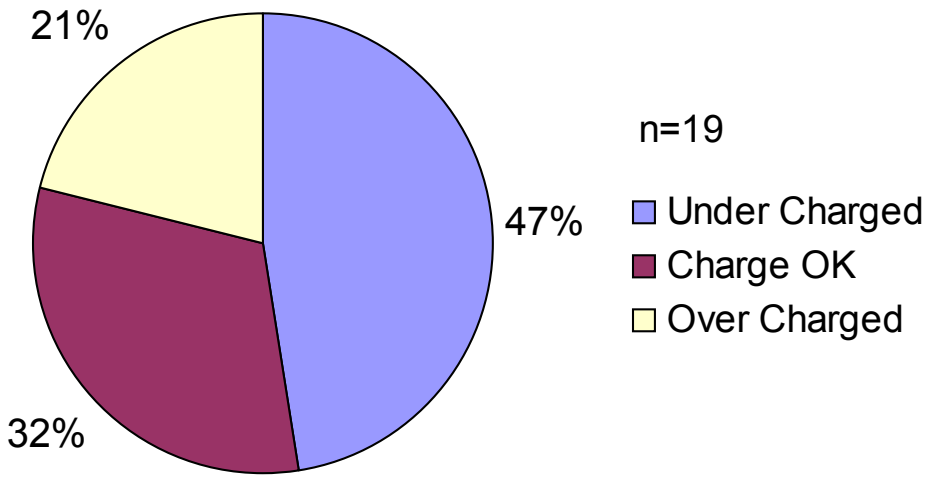
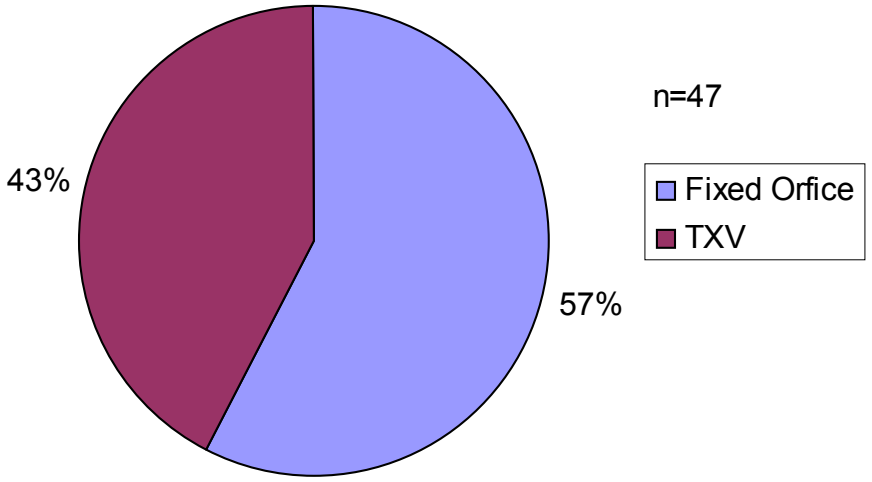


Figure 6-21: Refrigerant Metering Device



Effects of Refrigerant Charging On Comfort and Energy Usage

Both over and under charging will decrease the efficiency of the cooling system and result in higher air temperatures leaving the evaporator. With over charging the indoor coil becomes flooded increasing the system pressures, thus increasing the refrigerant temperatures. Because of higher refrigerant temperatures, the dew point of the air may be above the temperature of the refrigerant. With the dew point above the refrigerant temperature the system will not remove moisture from the air increasing the humidity in the conditioned space. If significant enough, this will decrease comfort by increasing the space temperature and humidity levels. With under charging, the amount of refrigerant at saturation is reduced inside the evaporator (indoor) coil. This will cause capacity loss, higher energy usage, and higher leaving temperatures. Under charging may freeze the evaporator coil, which decreases the heat transfer of the coil and reduce airflow. This is caused by refrigerant pressures/ temperature dropping below the freezing temperature of water. Any moisture coming in contact with the coil at this temperature will freeze, restricting the airflow of the system. This condition will lead to an increase air temperature and thus, similar comfort issues may arise as compared with over charging.

Efficiency loss due to incorrect charging is significant for systems with fixed orifice metering devices. A 20 percent over charge results in a 10 percent loss of efficiency, and a 20 percent under charge will decrease efficiency by 20 percent. It is clear that undercharging bears double the penalty than overcharging. Cooling systems that use TXV metering devices will lose 8 percent of efficiency at 20 percent over charge, but only 2 percent at 20 percent under charged (Neme et. al. 1999). The effect of the TXV on efficiency loses is much less for undercharging compared to fixed orifice.

An estimate of potential savings for correcting charges was determined using the data collected during the site surveys. It was assumed that systems not charged correctly are either 20 percent over or under charged. Previous experience by Advanced Energy has found that systems are typically over/under charged 10 to 50 percent (Norris, 2001b), thus 20 percent is a reasonable assumption. The savings estimates discussed above were assigned to the data set and no savings were assigned to systems that had an OK charge. The analysis determined that the savings potential is an average of 11 percent for the 19 systems tested.

Comparison of Results to Past Work

The results of the survey showed that 47 percent of systems were under charged and 21 percent of systems were over charged. Six other studies performed over the last nine years have an average of 41 and 33 percent, respectively, for under charging and overcharging (Neme et. al. 1999). Some of the six studies found a trend towards over charging and others under charging. It will take further data collection to determine if the trend found in this study is prevalent over the larger population.

The energy savings estimate for correcting the charges is 11 percent. This correlates well with reference above the same six studies mentioned above (Neme et. al. 1999); the average for two relevant studies showed an average of 12 percent savings for a sample of 78 systems.

6.4 DATA ANALYSIS SUMMARY

On-site surveys of 70 homes were conducted to assess the characteristics and performance of HVAC equipment. Homes were selected randomly from a population of homes that were identified to have cooling systems aged 3 years or less. The home and the duct system age was typically much older, thus the majority of cooling systems were replacements. Data at each site were taken in order to characterize the cooling and heating design load, equipment efficiencies, supply airflow, duct leakage, duct insulation values, and refrigerant charge. The potential savings achievable by correcting HVAC deficiencies were then estimated in order to provide insight to which deficiencies are the most significant. It is hoped that this study will provide a road map that will aid in the development of future programs to address these HVAC deficiencies.

A summary of the key findings is presented in Table 6-5. The categories shown in the table follow the order in which they are presented in the body of the report. Overall, the analysis showed that the conditions of the HVAC equipment are well within the ranges found in other similar studies, with the exception of equipment sizing for cooling. The data shows that cooling oversizing is considerably less than other similar studies. Systems were on average, oversized by 23 percent and 0.37 tons. Other similar studies showed an oversizing of approximately 65 percent, or 1.6 tons. This finding may be directly related to the age of the cooling systems studied, which were less than 3 years old. This result implies that the industry is sizing cooling systems more accurately now, than in the past.

Table 6-5
Summary of HVAC System Data Analysis

Category	Analysis
Sizing	
Cooling	43 % of systems are oversized 0.5 ton or more
Heating	93 % of systems are oversized by more than 25 %
Air Flow	
Supply	30 % of supply air flows are between 350-450 CFM per cooling ton
Supply	53 % of supply air flows are less than 350 CFM per cooling ton
Duct Leakage	
Outdoor	34 % of supply air flow is estimated to be outdoor air leakage
Outdoor	329 CFM_{25} is the estimated outdoor air leakage flow rate
Total	608 CFM_{25} is the average leakage for the supply and returns
Sealing	8 % of ducts inspected were partially sealed with duct tape
Duct Insulation in Unconditioned Areas	
Attic	83 % of ducts were insulated (n=25)
Crawl Space	100 % of ducts were insulated (n=4)
Basement	6 % of ducts were insulated (n=18)
Garage	33 % of ducts were insulated (n=3)
Refrigerant System	
Under Charged	47 % of systems
Over Charged	21 % of systems
Fixed Orifice	57 % of systems
TXV	43 % of systems

Cooling Energy Savings

The results of the data analysis for cooling energy are presented in Table 6-6. This table summarizes each individual savings analysis presented in 6.3.1 through 6.3.4. The savings are presented as a percentage of the cooling energy utilized and are the average results for the entire population analyzed. Thus, systems with no deficiencies were tallied along with systems with deficiencies. Each of the efficiency improvements is listed in order of magnitude with the outdoor air leakage reduction having the largest potential for savings at 18.4 percent, and duct insulation having the lowest potential savings at 1.5 percent savings.

Table 6-6
Cooling Energy Data Analysis Set

Measure	Energy Savings Potential	± CI 90%	n	SE
OA Leakage Reduction	18.4 %	3.5 %	46	2.1 %
Refrigerant Charge Correction	11.4 %	3.6 %	19	2.1 %
Sizing Correction	2.9 %	0.8 %	69	0.5 %
Air Flow Correction	2.3 %	1.0 %	38	0.6 %
Additional Duct Insulation	1.5 %	0.9 %	56	0.5 %
Total[2]	36.4 %			

Notes:
1. Insulation measure does not include insulation of ducts in unconditioned basements
2. Actual total savings are not additive
3. Savings are relevant for homes with central AC split systems

The savings were developed using the following assumptions:

- Outdoor air leakage can be reduced to 5 percent of the supply air flow rate
- Refrigerant charges are corrected from an under/over charge of 20 to 0 percent
- Size correction savings calculations were based on sizing units to within ½ ton of Manual J calculations.
- Airflow savings applied to correcting flow rates of 320 cfm/ton or lower to 400 cfm/ton. Fan energy usage changes as a result of this measure were not considered.
- Duct insulation of R-8 was added to ducts with no insulation located in attics, garages, and crawl spaces.

The estimated energy savings of implementing all the measures in Table 6-6 is not cumulative as would be suggested by the sum of 36 percent at the bottom of the table. Interactive effects of the measures reduce savings when all are combined. There are two types of interactions possible, the first is mathematical for measures that do not physically interact with each other. For example, if four measures each saved 25 percent, then the total would not equal 100 percent. The energy usage would be reduced by 25 percent after each measure was implemented and thus the energy savings would approach, but never reach 100 percent. Applying this interaction to the cooling savings yields the results of Table 6-7. The results can be interpreted that the average house in the study has a potential to save approximately 32 percent of the cooling energy used. Note that only the sum is relevant in Table 6-7. This estimate should be considered as an upper limit since it may not be practical to implement all the measures to the degree assumed in the analysis.

Table 6-7
Mathematical Interactive Cooling Energy Savings

Measure	Potential
OA Leakage Reduction	18.4 %
Refrigerant Charge Correction	9.3 %
Sizing Correction	2.1 %
Air Flow Correction	1.6 %
Additional Duct Insulation	1.0 %
	32.4 %

The second type of interaction occurs when the implementation of one measure physically affects the savings outcome of another measure. This interaction type occurs when duct leakage, airflow, refrigerant charge, and sizing are combined together. Estimates of these interaction effects were considered for this study to be relatively small. Previous studies have shown that even with interactions of the mathematical and physical, potential savings are in the order 24 to 35 percent, as opposed to the summation of independent savings estimates, which ranged from 32 to 45 percent (Neme et. al., 1999). Thus, we would expect a 22 to 25 percent drop in savings for mathematical and physical interactions. Using the data in Table 6-7, an eleven percent drop was already calculated with the first interaction reduction of 36 to 32 percent. If we are conservative and assume a 25 percent total drop in savings due to both types of interactions, then the interactive savings potential is estimated to be 27 percent for the average home in the study.

Table 6-8 provides estimates of the confidence intervals for the cooling savings. In order to provide confidence intervals, each home needed the total savings calculated and then statistics were performed on the total for each home in the sample population. There are approximately 12 homes that had complete data collected; the majority of missing data is for refrigerant charge because low outdoor temperatures did not allow accurate testing. In order to include the volumes of data colleted on all homes, missing data were handled in the following manner: the average result of a measure listed in Table 6-6 was used to replace missing data. This technique allowed data for all 72 homes to be included in the analysis. As expected, this methodology produced negligible differences in the energy savings potential when compared to results in Table 6-6 and Table 6-7.

Table 6-8
Sample Population Cooling Savings

Measure	Energy Savings Potential	± CI 90 %	n	SE
Cooling Savings Potential[1] (non-interactive)	36.2 %	2.8 %	72	1.7 %
Mathematical Interaction Cooling Savings Potential[1,2]	32.2 %	2.3 %	72	1.4 %
Total Interactive Cooling Savings Potential[1,3,4]	27.2 %	2.3 %	72	1.4 %

Notes:
1. Savings are relevant for homes with central AC split systems.
2. Savings take into account mathematical interactions between measures.
3. Savings s take into account mathematical and Physical interactions between measures.
4. Confidence interval was not calculated due to unknown covariance between physical interactions, thus the confidence interval for mathematical interactions was used as a best estimate.

Heating Energy Savings

The results of the data analysis for heating energy savings potential are presented in Table 6-9. This table summarizes each individual savings analysis presented in 6.3.1 through 6.3.4. The energy savings are a percent of heating energy usage. The savings are listed in same order of the cooling savings to facilitate comparison. The savings potential follows the same trend as the cooling analysis; outdoor air leakage reduction has the largest potential for savings at 22 percent, and duct insulation having the lowest potential savings at 2 percent savings. Only one heat pump was encountered in the data set, however, no savings were attributed to this unit, thus charge and air flow savings are not realized.

Table 6-9
Heating Energy Data Analysis Set

Measure	Energy Savings Potential	± CI 90 %	n	SE
OA Leakage Reduction[5]	22.3 %	4.1 %	34	2.4 %
Refrigerant Charge Correction[3,5]	0.0 %	0.0 %	19	0.0 %
Sizing Correction[4]	6.8 %	1.6 %	58	1.0 %
Air Flow Correction[3,5]	0.0 %	0.0 %	38	0.0 %
Additional Duct Insulation[1,5]	2.0 %	1.3 %	35	0.8 %
Total[2]	31.1 %			

Notes:
1. Insulation measure does not include insulation of ducts in unconditioned basements
2. Actual total savings are not additive
3. One unit was a heat pump which had no savings potential due to correct sizing
4. Savings are relevant for heating systems with and without ducts for distribution
5. Savings are based on the heating system population that utilized ducts for distribution

The savings were developed using the following assumptions:

- Outdoor air leakage can be reduced to 5 percent of the supply air flow rate
- For fuel furnaces and boilers, size correction savings calculations were determined for systems oversized 100 percent or more.
- Airflow correction savings are negligible for furnaces when airflow rates are corrected to optimize cooling efficiency.
- Duct insulation of R-8 was added to ducts with no insulation located in attics, garages, and crawl spaces.

The interactive savings achievable when implementing all measures are of the mathematical type as described above for cooling. The physical type of interaction is negligible because the measures combined effects on efficiency are negligible when compared to cooling equipment interactions. Thus the interactive savings potential for the average heating system in Table 6-9 is approximately 29 percent as shown in Table 6-11.

Table 6-10
Total Interactive Heating Energy Savings

Measure	Savings Potential
OA Leakage Reduction	22.3 %
Refrigerant Charge Correction	0.0 %
Sizing Correction	5.3 %
Air Flow Correction	0.0 %
Additional Duct Insulation	1.4 %
Total	29.0 %

The savings presented in Table 6-9 and Table 6-10 are valid for homes that have the potential to save energy for the measure listed. Thus, OA leakage reduction savings were calculated only for homes that used ducts for the heating system, and baseboard systems were ignored. Many homes had boilers with baseboard distribution, which had no potential for savings except for equipment sizing correction. If the savings results for all measures are considered for the entire sample population of the study (n=72), then the total heating savings potential is reduced to 23.6 percent as shown in Table 6-11. The heating savings potential was calculated by taking the average of the total savings for each home[8]. Calculating the same interactions as described above for Table 6-10, the interactive savings potential for the average heating system for the entire sample population is approximately 22.3 percent as shown in Table 6-11.

Table 6-11
Sample Population Heating Energy Savings

Measure	Energy Savings Potential	± CI 90 %	n	SE
Heating Savings Potential[1]	23.6 %	3.1 %	72	1.9 %
Total Interactive Heating Savings Potential[1,2]	22.3 %	2.8 %	72	1.7 %

Notes:
1. Savings are relevant for heating systems with and without ducts for distribution
2. Savings s take into account mathematical and Physical interactions between measures.

[8] As in the case of cooling analysis, missing data points were treated as follows: the measure average from Table 6-9 was used if the savings measure was applicable. Additionally, a zero was used if the measure was not applicable; such is the case for air leakage reduction savings for all homes that utilized baseboard heating systems.

Implementation Considerations

The study has shown the potential for significant cooling and heating savings. The savings that can actually be achieved by implementing these measures may be significantly smaller than estimated. For example, HVAC contractors will be very cautious about installing smaller systems than what they are used to. This is probably the case because Manual J does not take into account all of the characteristics of a home that can lead to higher infiltration and poor insulation. Homes with complex geometry have a greater potential for increased infiltration and uninsulated voids such as non-flat, non-contiguous surfaces, trayed-ceilings, cantilevers, bay windows, dropped-soffits, dormers, non-sealed or missing band joists, fireplace chases, split-level connections, plumbing and HVAC chases, and cathedral ceilings. It would be very difficult to convince a contractor to install smaller sized unit when a larger unit may reduce or even eliminate the number of comfort callbacks that are attributable to the above housing characteristics not accounted for with Manual J calculations.

Airflow corrections could be achieved by numerous methods such as: improving the return and/ supply ducting, installing a smaller air conditioner, or increasing the fan speed. The first two changes are the most expensive but may save some additional fan and cooling energy. Increasing the fan speed is usually the easiest method since fan motors typically have multiple speed tabs for such a purpose. However, fan energy will increase, which may offset the cooling energy savings. These fan interactions were not analyzed in the data set.

The most significant potential for saving energy in the population analyzed is from implementing the first two measures, duct leakage reduction, and refrigerant charge correction. These measures may also have a high degree of probability of being implemented. Duct leakage reduction is a simple procedure; typically duct mastic (a gluey substance) is applied to the ducts to reduce leakage. Ducts that are hidden in exterior walls can also be treated with products that are blown into a cavity which plug leaks. Correct refrigerant charge can be achieved through extraction of refrigerant and direct weighing, or superheat or subcooled methods can be used. Either method can be employed for new or existing systems. Even though refrigerant charging methods are quite methodical, they are sometimes used incorrectly and the importance of accuracy is not fully understood. Advanced Energy Corporation has been re-training refrigerant technicians throughout the United States and has concluded that the majority of technicians does not understand the basic refrigerant cycle and cannot properly charge a system (Norris, 2001b). With this in mind, there is a great need for workshops explaining the refrigerant cycle as well as proper charging techniques.

Duct insulation in unconditioned areas is an excellent that cost effectively saves energy; it is both easy to install and offers significant savings benefits. However, the population of homes that were visited typically had insulation on ducts already, which is why the savings potential was low. If homes are lacking duct insulation, especially in attics and crawlspaces, then insulation would have significant energy savings benefits as described in 6.3.3.

Recommendations:

1. Results of the study clearly show that the greatest potential to save energy is through duct leakage reduction and refrigerant charge correction. These two measures should be the cornerstone of any efficiency programs in the future.

2. System sizing, airflow correction, and duct insulation did not show significant savings over the population. However, they should not be forgotten, they can still yield significant savings on a home-by-home basis if they can be identified and corrected effectively. These measures should be appropriately addressed in an efficiency program along with recommendation 1.

3. Maximize marketing efforts by combining high efficiency gas and electric programs. The data analyzed showed that 60% of homes with furnaces had both a new AC and furnace installed at the same time.

4. Implementation of the energy savings measures discussed in this report will be improved if a whole building approach is considered. This approach would combine envelope infiltration and insulation measures, not discussed in this report, with system sizing, duct design and leakage sealing, and airflow correction. This approach would result in a maximization of comfort, health, and energy savings for the homeowner. The whole building approach is recommended because of the airflow interactions that occur between the envelope and the duct system. Also, a home with properly installed insulation and low infiltration can have a properly sized AC or heating unit specified with more confidence, thus over sizing can be reduced.

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Appendix A
Customer Survey

NJ Residential HVAC Baseline Study
Customer Survey

Introduction

RESPNUM: Unique respondent number (XENERGY) _____
TOWN: _____
ZIPCODE: _____
PHONE: _____

"Hello, my name is _____, calling on behalf of GPU Energy, New Jersey Natural Gas, PSE&G, Elizabethtown Gas, Conectiv Power Delivery, South Jersey Gas, and Rockland Electric. We're conducting a study among households

May I please speak to the person who makes the decisions in your household regarding heating and cooling?
REASSURE: I want to assure you that this is not a sales call and that the information that you provide will be kept strictly confidential. This will only take about 10 to 15 minutes of your time.

[CONTINUE OR ARRANGE FOR CALLBACK]

Screener

SC1. What type of home do you live in – single family or multi-family (i.e., apartment or condo)?

Single family	1
Multi-family	2
Other (Specify)	3
Don't Know	97

SC2. Do you pay your own utility bills?

Yes	1
No	2
Don't Know	97

[IF SC2=1 THEN ASK SC3 ELSE END.]

SC3. Do you own the unit's central heating or cooling equipment? (We are not examining room air conditioners as part of this study.)

Yes	1
No	2
Don't Know	97

[IF SC3=1 THEN ASK SC5 ELSE END.]

SC5. In what year was your house or building constructed?
Enter year _____

Don't Know 97

[IF SC5 = (1998, 1999, 2000) THEN END. ELSE SKIP TO SC10.]

SC10. Did you have a new central air conditioner or new heat pump installed in 1998, 1999, or 2000?
(prompt if necessary – a heat pump provides both heating and cooling)

Yes 1
No 2
Don't Know 97

[IF SC10=1 THEN ASK SC11. ELSE SKIP TO SC12.]

SC11. Was it a central air conditioner or heat pump?
(prompt if necessary – a heat pump provides both heating and cooling)

Central air conditioner 1
Heat Pump 2
Don't Know 97

SC12. Did you have a new gas furnace or new gas boiler installed in 1998, 1999, or 2000?

Yes 1
No 2
Don't Know 97

[IF SC12=1 THEN ASK SC13.
ELSE IF SC10=2 AND SC12=2 THEN END
ELSE SKIP TO SKIP RULE BEFORE SC20.]

SC13. Was it a gas furnace or gas boiler? (prompt if necessary – a furnace provides warm air through registers and a boiler circulates hot water through radiators)

Gas Furnace 1
Gas boiler 2
Don't Know 97

[*SKIP RULE STATEMENTS TO BE RANDOMLY ROTATED*
IF SC11 = 1 THEN UNIT TYPE= 'Central Air Conditioner' & UT=1
ELSE IF SC11=2 THEN UNIT TYPE= 'Heat Pump' & UT=2
ELSE IF SC13=1 THEN UNIT TYPE= 'Gas Furnace' & UT=3
ELSE IF SC13=2 THEN UNIT TYPE= 'Gas Boiler' & UT=4
ELSE END.]

*SC20. Did the new (UNIT TYPE) replace an existing (UNIT TYPE)?

Yes 1
No 2
Don't Know 97

[IF SC20= 1 THEN ASK SC21. ELSE SKIP TO CS1]

*SC21 Was the (UNIT TYPE) that was replaced operating at the time of replacement or had it failed?

Operating	1
Failed	2
Don't Know	97

[IF SC21=1 THEN ASK SC22. ELSE SKIP TO CS1]

*SC22. Why did you replace the existing (UNIT TYPE) with a new one? (DO NOT PROMPT) (ALLOW MULTIPLE RESPONSES)

Unit was old	1
Better performance	2
Higher efficiency	3
Lower operating costs	4
Greater comfort	5
Contractor suggested change	6
Other (Specify)	7
Don't Know	97

Contractor Selection Process

*CS1. How did you select the contractor that installed your new (UNIT TYPE)? (DO NOT PROMPT) (ALLOW MULTIPLE RESPONSES)

Recommended by friend or family member	1
Saw newspaper ad	2
Saw TV ad	3
Direct mail	4
Heard radio ad	5
Saw Internet ad	6
Yellow page listing	7
Contractor previously serviced the unit	8
Contractor's name was on the indoor unit	9
Other (Specify)	10
Don't Know	97

[IF SC10=1 AND SC12=1 THEN ASK CS1a. ELSE SKIP TO CS2]

CS1a. Did the same contractor install both of your new units?

Yes	1
No	2
Don't Know	97

[IF CS1a=2 THEN ASK CS1b. ELSE SKIP TO CS2]

CS1b. How did you select the contractor that installed your new (NON-SURVEYED UNIT TYPE)?

(DO NOT PROMPT) (ALLOW MULTIPLE RESPONSES)

Recommended by friend or family member	1
Saw newspaper ad	2
Saw TV ad	3
Direct mail	4
Heard radio ad	5
Saw Internet ad	6
Yellow page listing	7
Contractor previously serviced the unit	8
Contractor's name was on the indoor unit	9
Other (Specify)	10
Don't Know	97

*CS2. When you chose your contractor, were you looking for a specific brand of (UNIT TYPE) equipment?

Yes	1
No	2
Don't Know	97

*CS3. Did you get quotes from more than one contractor?

Yes	1
No	2
Don't Know	97

[IF CS3=1 THEN ASK CS4. ELSE SKIP TO CS8.]

*CS4. How many?

Enter # _____

Don't Know 97

*CS5. How many of the quotes were based on an on-site inspection of your home?

Enter # _____

Don't Know 97

*CS6. How many of the quotes were provided in writing?

Enter # _____

Don't Know 97

*CS8a. What was your primary reason for selecting the firm who installed your (UNIT TYPE)? (DO NOT PROMPT)

*CS8b. What were your additional reasons for selecting the firm who installed your (UNIT TYPE)? (DO NOT PROMPT) (ALLOW MULTICPLE RESPONSES)

	CS8a	CS8b
Reputation	1	1
Qualifications	2	2
Installed cost of unit	3	3
Warranty length and/or features	4	4

Operating cost of unit	5	5
Unit efficiency	6	6
Ability to install within required timeframe	7	7
Availability of a maintenance contract	8	8
Don't Know	97	97

*CS9. Did your selected contractor offer to provide you with…[READ LIST]

Certification to handle refrigerants?	1
Evidence of liability insurance?	2
Both	3
Don't Know	97

*CS10. Were you satisfied with the HVAC equipment and its installation performed by your contractor?

Yes	1
No	2
Don't Know	97

[IF CS10=2 THEN ASK CS11. ELSE SKIP TO HE1.]

*CS11. Why weren't you satisfied with the HVAC equipment and its installation performed by your contractor? (DO NOT PROMPT) (ALLOW MULTIPLE RESPONSES)

Installation took too long	1
Installation cost too much	2
Too expensive to operate	3
Too noisy	4
Comfort problem	5
Other (Specify)	6
Don't Know	97

Awareness of High Efficiency

*HE1. Prior to purchasing your new (UNIT TYPE), did you know that high efficiency (UNIT TYPE) were available?

Yes	1
No	2
Don't Know	97

[IF HE1=1 THEN ASK HE2. ELSE SKIP TO ES1.]

*HE2. Did you request information on high efficiency (UNIT TYPE) from your contractor?

Yes	1
No	2
Don't Know	97

[IF HE2=2 THEN ASK HE3. ELSE SKIP TO HE4.]

*HE3. Why didn't you request information on high efficiency (UNIT TYPE) from your contractor? (DO NOT PROMPT) (ALLOW MULTIPLE RESPONSES)

Cost too much	1
Not convinced operating costs would be lower/no significant savings	2
Reliability concerns	3
Not readily available	4
Other (Specify)	5
Don't Know	97

*HE4. What are the benefits of installing a high efficiency (UNIT TYPE)? (DO NOT PROMPT) (ALLOW MULTIPLE RESPONSES)

Lower operating costs	1
Less energy use	2
Improved performance	3
Greater comfort	4
Increased reliability	5
Less pollution/environmental impacts	6
Received utility rebate	7
Other (Specify)	8
Don't Know	97

*HE5a How is the efficiency of (UNIT TYPE) measured? (DO NOT PROMPT)

SEER	1
Seasonal energy efficiency ratio	2
AFUE	3
Annual fuel utilization efficiency	4
% Efficiency	5
Don't Know	97

[IF UT=1 OR UT=2 AND HE5a=1 AND/OR HE5a=2 THEN ASK HE5b.
ELSE IF UT=3 OR UT=4 AND HE5a=3 AND/OR HE5a=4 AND/OR HE5a=5 THEN ASK HE5b.
ELSE SKIP TO HE6]

*HE5b. For (UNIT TYPE) what (INSERT RESPONSE FROM HE5a) defines a high efficiency unit?

Enter value _____

Don't Know 97

*HE6. In addition to installing high efficiency (UNIT TYPE), what other factors affect the performance of your heating and cooling system? (DO NOT PROMPT) (ALLOW MULTIPLE RESPONSES)

Duct leakage	1
Duct insulation	2
Proper refrigerant charge	3
Proper equipment sizing	4

Adequate airflow over the indoor coils 5
Other (Specify) 6
Don't Know 97

Equipment Selection

*ES1. Did the contractor who installed your (UNIT TYPE) recommend more than one unit for you to consider installing?

Yes 1
No 2
Don't Know 97

[IF ES1=1 THEN ASK ES2. ELSE SKIP TO ES9]

*ES2. Did the contractor discuss with you that some units are more efficient than others?

Yes 1
No 2
Don't Know 97

[IF ES2=1 THEN ASK ES3. ELSE SKIP TO ES10]

*ES3. Did the contractor define any specific efficiency level as being high efficiency?

Yes 1
No 2
Don't Know 97

[IF ES3=1 THEN ASK ES4. ELSE SKIP TO ES5]

*ES4. What level did the contractor define as high efficiency? (Prompt if necessary - Air conditioner and heat pump efficiencies are measured in SEER. Furnace and boiler efficiencies are measured as a percentage or in AFUE).

Enter value _____
Don't Know 97

*ES5. Did the contractor discuss the operating costs of different units?

Yes 1
No 2
Don't Know 97

[IF ES5=1 THEN ASK ES6. ELSE SKIP TO ES7]

*ES6. Did the contractor provide any type of operating cost comparison between units of different efficiencies?

Yes 1
No 2
Don't Know 97

*ES7. Did the contractor provide prices for both standard and high efficiency units?

Yes	1
No	2
Don't Know	97

[IF ES7=1 THEN ASK ES8. ELSE SKIP TO ES9]

*ES8. How much more was the high efficiency unit? (ALLOW EITHER A Incremental $ OR % Difference RESPONSE)

ENTER $ Amount	$_____
ENTER % Difference	_____%
Don't Know	97

*ES9. Did the contractor recommend that you install a high efficiency (UNIT TYPE)?

Yes	1
No	2
Don't Know	97

[IF ES9=1 THEN ASK ES10. ELSE SKIP TO ES12]

*ES10. Did you install a high efficiency unit?

Yes	1
No	2
Don't Know	97

[IF ES10=2 THEN ASK ES11. ELSE SKIP TO ES12]

*ES11. Why didn't you install a high efficiency (UNIT TYPE)? (DO NOT PROMPT) (ALLOW MULTIPLE RESPONSES)

Cost too much	1
Not convinced operating costs would be lower/no significant savings	2
Reliability concerns	3
Not readily available	4
Comfort concerns	5
Other (Specify)	6
Don't Know	97

*ES12. Besides your contractor, did you rely on any other sources of information to help you choose your (UNIT TYPE)?

Yes	1
No	2
Don't Know	97

[IF ES12=1 THEN ASK ES13. ELSE SKIP TO SKIP RULE BEFORE SI1]

*ES13. What other sources of information did you use? (DO NOT PROMPT) (ALLOW MULTIPLE RESPONSES)

Utility program information	1
Energy Star	2
Manufacturer advertisements	3
Family/friend recommendation	4
Past experience with brand	5
Other (specify)	6
Don't Know	97

*ES14. How did you pay for your new unit?

Cash or check	1
Credit card	2
Financed (including home equity loan)	3
Other (specify)	4
Don't Know	97
Refused	98

[IF ES14=3 THEN ASK ES15. ELSE SKIP TO SKIP RULE BEFORE SI1]

*ES15. What type of financing did you use to purchase your new unit?

Home equity line	1
Contractor provided financing	2
Manufacturer provided financing	3
Other (specify)	4
Don't Know	97
Refused	98

System Installation [SI1, SI4-SI11b only CAC & HP]

[IF (UT=1 OR UT=2) AND SC20=1 THEN ASK SI1. ELSE SKIP TO SI2]

SI1. Did the contractor replace the outdoor compressor unit only, or both the outdoor compressor unit and the indoor fan coil unit?

Outdoor compressor unit only	1
Both	2
Don't Know	97

*SI2. Did the contractor discuss with you the size or cooling (heating) capacity of the (UNIT TYPE)?

Yes	1
No	2
Don't Know	97

[IF SI2=1 THEN ASK SI3. ELSE SKIP TO SKIP RULE BEFORE SI4]

*SI3. Did the contractor provide you with any documentation supporting the size of the unit installed in your home?

Yes	1
No	2
Don't Know	97

[IF UT=1 OR UT=2 THEN ASK SI4.
ELSE IF UT=3 SKIP TO SI6. ELSE SKIP TO SI12.]

SI4. Did the contractor discuss with you the need to ensure a proper refrigerant charge in the unit?

Yes	1
No	2
Don't Know	97

SI5. Did the contractor discuss with you the need to ensure proper airflow in the indoor part of the system?

Yes	1
No	2
Don't Know	97

SI6. Did the contractor check to see that your ductwork was adequately insulated?

Yes	1
No	2
Don't Know	97

[IF SI6=1 THEN ASK SI7. ELSE SKIP TO SI8]

SI7. Did the contractor recommend that insulation be added?

Yes	1
No	2
Don't Know	97

SI8. Did the contractor discuss the impact of leakage in your ductwork on the efficiency of your cooling and/or heating system?

Yes	1
No	2
Don't Know	97

[IF SI8=1 THEN ASK SI9. ELSE SKIP TO SI11b]

SI9. Did the contractor offer to measure the leakage in your ductwork?

Yes	1
No	2
Don't Know	97

[IF SI9=1 THEN ASK SI10. ELSE SKIP TO SI11b]

SI10. Did you accept the contractor's offer to measure the leakage in your ductwork?

Yes	1
No	2
Don't Know	97

[IF SI10=2 THEN ASK SI11a. ELSE SKIP TO SI11b]

SI11a. Why didn't you accept the contractor's offer to measure the leakage in your ductwork?

Too expensive	1
Ducts already tight	2
Not enough savings	3
Benefits unclear	4
Other (specify)	5
Don't Know	97

SI11b. Did you have additional ductwork added as part of your installation?

Yes	1
No	2
Don't Know	97

SI12. Prior to the installation of the new (UNIT TYPE), were all of the thermostats in your home programmable thermostats?

Yes	1
No	2
Don't Know	97

[IF SI12=2 THEN ASK SI13. ELSE SKIP TO SI15]

SI13. Did the contractor recommend that new programmable thermostats be installed?

Yes	1
No	2
Don't Know	97

[IF SI13=1 THEN ASK SI14. ELSE SKIP TO SI15]

SI14. Did you install them?

Yes	1
No	2
Don't Know	97

*SI15. Do you know the (efficiency) of your new (UNIT TYPE)? (Define "efficiency as "SEER" if a CAC or HP, or as "AFUE or % efficiency" if a furnace or boiler)

Yes	1
No	2
Don't Know	97

*SI16. And what is the (efficiency) of your new (UNIT TYPE)?

Record value _____
Don't Know 97

Utility Program Awareness and Participation [All CAC & HP]

[IF UT=1 OR UT=2 THEN ASK UP1a. ELSE SKIP TO SA1.]

UP1a. Are you aware that your electric utility offers rebates to promote the proper installation of high efficiency central air conditioners and heat pumps?

Yes	1
No	2
Don't Know	97

[IF UP1a=1 THEN ASK UP1b. ELSE SKIP TO SA1.]

UP1b. How did you find out about the rebate program? (DO NOT PROMPT) (ALLOW MULTIPLE RESPONSES)

Contractor suggestion	1
Recommended by friend or family member	2
Program brochure/direct mail	3
Saw newspaper ad	4
Saw TV ad	5
Heard radio ad	6
Saw internet ad	7
Discussion with utility staff	8
Bill insert	9
Other (Specify)	10
Don't know	97

UP2. Did you participate in the program?

Yes	1
No	2
Don't Know	97

[IF UP2=1 THEN SKIP TO UP4. ELSE ASK UP3.]

UP3. Why didn't you participate in the program? (DO NOT PROMPT) (ALLOW MULTIPLE RESPONSES)

Too much bother	1
Not enough time	2
Contractor didn't recommend it	3
Contractor recommended against it	4
Rebate too small	5
Didn't understand the benefits	6
Savings not worth it	7

H.E. units too expensive	8
Other (Specify)	9
Don't Know	97

[SKIP TO SA1.]

UP4. On a scale of 1 to 5, where 1 means you are "not at all satisfied" and 5 means you are "very satisfied", how satisfied are you with the utility program?

Not at all satisfied				Very satisfied
1	2	3	4	5
[ASK UP5]	[ASK UP5]	[ASK UP5]	[SKIP TO UP7]	[SKIP TO UP7]

UP5. Were there specific problems with the program?

Yes	1
No	2
Don't Know	97

[IF UP5=1 THEN ASK UP6. ELSE SKIP TO UP7.]

UP6. What were those problems?

Record response _____

UP7. Can you tell me what benefits you received from participating in the program?
(DO NOT PROMPT) (ALLOW MULTIPLE RESPONSES)

Correct equipment sizing	1
Proper airflow over the indoor coils	2
Duct leakage measurement	3
Proper refrigerant charge	4
Purchase/installation of efficient equipment	5
Other (Specify)	6
Don't know	97

UP9. Do you remember receiving a program brochure titled "Buying An Energy-Efficient Cooling and Heating System"?

Yes	1
No	2
Don't Know	97

[IF UP9=1 THEN ASK UP10. ELSE SKIP TO UP12.]

UP10. Did you read this brochure?

Yes	1
No	2

Don't Know 97

[IF UP10=1 THEN ASK UP11. ELSE SKIP TO UP12.]

UP11. On a scale of 1 to 5, where 1 means "not at all helpful" and 5 means "very helpful", how helpful was the brochure in dealing with your contractor's installation of your high efficiency (UNIT TYPE)?

Not at all helpful				Very helpful
1	2	3	4	5

UP12. If you hadn't participated in the program, would you have still installed a high efficiency (UNIT TYPE)?

Yes 1
No 2
Don't Know 97

[IF UP12=2 THEN ASK UP13. ELSE SKIP TO SKIP RULE BEFORE UP14.]

UP13. Why wouldn't you have installed a high efficiency (UNIT TYPE)? (DO NOT PROMPT) (ALLOW MULTIPLE RESPONSES)

Not aware of high efficiency option 1
Didn't know where to get H.E. equipment 2
Not aware of cost savings 3
Cost of EE units too high 4
Other (Specify) 5
Don't know 97

[IF SC20=1 THEN ASK UP14. ELSE SKIP SA1.]

UP14. Have you noticed any changes since your new (UNIT TYPE) was installed?

Yes 1
No 2
Don't Know 97

[IF UP14=1 THEN ASK UP15. ELSE SKIP TO SA1.]

UP15. What type of changes have you noticed? (DO NOT PROMPT) (ALLOW MULTIPLE RESPONSES)

Lower utility bills 1
Higher utility bills 2
Improved comfort 3
Less comfort 4
Quieter operation 5
Other (Specify) 6
Don't know 97

ENERGY STAR® Awareness

SA1. Have you heard of the ENERGY STAR® Program for air conditioners, gas furnaces or gas boilers?

Yes	1
No	2
Don't Know	97

[IF SA1=1 THEN ASK SA2. ELSE SKIP TO DE1.]

SA2. In your words, what does the ENERGY STAR® Program do? (DO NOT PROMPT) (Allow multiple responses) (Note to Working Group: will score as 'yes' if two of the four are mentioned)

Federal Gov't/ Dept. of Energy/ EPA program	1
Promote high efficiency HVAC equipment	2
Work with manufacturers	3
Marketing/ labeling program	4
Don't Know	97

Customer Demographics

Before we finish, I have just a few more questions about your household.

DE1. Do you own or rent your home?

Own	1
Rent	2
Don't Know	97

DE2. About how large is your home?

Square Feet	_____
Don't know	97
Refused	98

DE3. And how many rooms does your home have? Please exclude closets, bathrooms, hallways, garages, and unfinished basements?

Number of rooms	_____
Don't know	97
Refused	98

[IF SC1=2 THEN ASK DE4a. ELSE ASK DE4b.]

DE4a. How many housing units are in your building?

2 to 4	1
5 or more	2
Don't Know	97

[SKIP TO DE5a]

DE4b. What type of single family home do you live in? (READ LIST)

Detached	1
Mobile Home	2
Other (Specify)	3
Don't know	97

DE5a. In each of the following age groups, how many people live in your home year-round?

For DE5aa – DE5ad:

Don't know	97
Refused	98

		DE5a
D5aa	Less than 18 years old	
D5ab	19 - 34	
D5ac	35 - 59	
D5ad	60 years old or older	

DE5b. And which of those categories contains your age?

	DE5b
Less than 18 years old	
19 - 34	
35 - 59	
60 years old or older	

DE6. Which of the following describes your educational background?

	D6
Some high school	1
High school graduate	2
Trade or technical school	3
Some college	4
College graduate	5
Some graduate school	6
Graduate degree	7
Don't know	97
Refused	98

DE7. Which of the following best represents your annual household income *(from all sources in 1999, before taxes)*?

	D7
Less than $35,000 per year	1
$35,000-49,999	2
$50,000-74,999	3
$75,000-99,999	4

$100,000 or more	5
Don't know	97
Refused	98

DE9. We'd like to send one or two trained inspectors to your home to evaluate your heating & cooling systems. In exchange for you assistance, we will pay you $50. Are you interested in participating?

Yes	1
No	2
Don't Know	97

[IF DE9 =1 THEN ASK DE10. ELSE SKIP TO GOODBYE.]

DE10. Someone will call back in the next few weeks to schedule an appointment. Who should we ask for when we call back?

Record name _____

DE11. When is the best time to call?

Record response _____

DE12. Are weekends ok?

Yes	1
No	2

Thank you for your time. Good Bye.

Note to interviewer
Record Gender: Male of Female?

Appendix B
Contractor Survey

NEW JERSEY RESIDENTIAL NEW CONSTRUCTION BASELINE STUDY
HVAC CONTRACTOR QUESTIONNAIRE – JOINT SURVEY REVISED

Contact Name: [from sample]_____
Company Name: [from sample]_____
Address: [from sample] _____
City, State, Zip [from sample] _____
Telephone: [from sample]_____
Employment Category: [from sample] _____
Survey ID Number: _____

LEAD-IN: Hello, my name is _____ and I am calling from XENERGY Inc. We are conducting a study of residential HVAC specification and installation practices for a group of New Jersey's electric and gas utilities. May I speak with [NAME OF CONTACT].

IF CONTACT IS NOT AVAILABLE ASK TO SPEAK WITH THE GENERAL MANAGER FOR THE LOCATION. REPEAT FIRST PART OF LEAD IN AS NECESSARY.

We are interviewing a sample of HVAC contractors to better understand current HVAC specification and installation practices. The information will be used to help design ratepayer funded energy efficiency programs. Any information provided by you will be used solely for this purpose and will be considered confidential.

E.1 First, before continuing, in roughly how many homes has your company installed heating and cooling equipment in 1999? How many in 2000?

ENTER NUMBER OF 1999 HOMES....._____
ENTER NUMBER OF 2000 HOMES....._____

IF E.1 < 5 FOR EITHER YEAR, THANK AND TERMINATE.

The interview will take about 20 minutes. In appreciation for your time, we will pay you $50 or make a contribution of that amount in your name to the charity of your choice. All responses you provide will be confidential.

Establishment Data

We'd like to begin by asking you a few general questions about your company.

E.2 In how many newly constructed houses, as opposed to existing homes, did you install heating and/or cooling systems in the year 2000?

ENTER NUMBER IN NEW HOMES....._____

SKIP E.2.a IF RESPONSE TO E.2 is "0"

E.2.a In what percentage of the new homes did you install the ductwork as well as heating and cooling equipment itself?

ENTER PERCENT..... _____%

E.3 Roughly how many units of residential [type of equipment] did you sell in 2000?

a. Gas furnaces ....____
b. Gas boilers....____
c. Central air conditioners....____
d. Air source heat pumps....____
e. Oil and propane heating equipment....____
f. Programmable thermostats....____

E.3.a What percent of your [type of equipment] installations in existing homes were emergency installations of failed units?

1. Gas furnaces .... ____%
2. Gas boiler .... ____%
3. Central air conditioners.... ____%
4. Heat pumps .... ____%

E.4 What manufacturers' product lines do you carry?

Air Comfort 1
Amana 2
American Standard....3
Armstrong....4
Bard 5
Bryant....6
Burnham....7
Carrier 8
Coleman....9
General Electric 10
Goodman.... 11
Heil.... 12
Honeywell.... 13
Hydrotherm.... 14
Janitrol.... 15
Lennox.... 16
Luxaire 17
Rheem.... 18
Ruud.... 19
Sears(Kenmore) 20
Slant/Fin 21
Smith 22
Teledyne Laars.... 23
Tempstar.... 24
Trane 25
Utica.... 26
Weatherking.... 27
Weil-McLain 28
Whirlpool.... 29
York.... 30
Other (Specify) _____.... 31

E.5 Which of the following best describes the geographic area your company is active in?

Your local city or town.....1
A metropolitan area 2
A significant portion of New Jersey 3
All of New Jersey.....4
A multi-state region.....5
Other (Specify)_____.....6

E.6 How many employees work at this location?

ENTER NUMBER OF EMPLOYEES....._____

E.7.a How many of these employees work in the field as residential installers?

ENTER NUMBER OF EMPLOYEES IN FIELD ....._____

E.7.b Does the same field staff typically handle both residential HVAC installations and service calls?

Handle both 1
Separate installer and service technician staff 2
Don't' know 97

IF E.7.b RESPONSE is "2", THEN ASK E.7.c, OTHERWISE SKIP TO E.7.d

E.7.c How many of these employees work primarily as residential service technicians?

ENTER NUMBER OF SALES STAFF....._____

E.7.d How many of these employees work primarily as residential sales staff?

ENTER NUMBER OF SALES STAFF....._____

E. 8 Where do you recruit new technicians and installers from? [CIRCLE ALL THAT APPLY]

Vo-tech schools 1
Community colleges 2
Trade schools 3
Other firms.....4
Trade journals.....5
General newspaper help wanted 6
Other (Specify)_____.....7
Don't know 97

E.9a Which electric utility provides service to most of the homes you worked on this year?

ENTER NAME ..._____

E.9b Which gas utility provides service to most of the homes you worked on this year?

ENTER NAME ..._____

IF RESPONDENT INSTALLED MORE THAN 5 SYSTEMS (SEE Q. E.2) IN NEW CONSTRUCTION, ASK M.1, OTHERWISE SKIP TO M.3.

Market Share and Marketing To Builders And General Contractors

Now I'd like to ask you a few questions about your experience in selling energy efficient equipment in new construction.

M.1 **CODE ANSWERS IN GRID BELOW.** What percentage of the [TYPE OF EQUIPMENT] you installed in new homes in 2000 were (or had) [EFFICIENCY CRITERIA FROM ANSWER GRID] or above?

ENTER 997 FOR DON'T KNOW, 998 FOR DON'T INSTALL THAT KIND OF EQUIPMENT, 999 FOR REFUSED.

M.2 What percentage of the thermostats that you installed in *new* homes were ENERGY STAR thermostats?

ENTER PERCENTAGE ..... _____%
Don't Know 97

IF RESPONDENT INSTALLED MORE THAN 5 SYSTEMS (SEE Q. E.2) IN EXISTING CONSTRUCTION, ASK M3, OTHERWISE SKIP TO B1.

M.3 **CODE ANSWERS IN GRID BELOW.** What percentage of the [TYPE OF EQUIPMENT] you installed in existing homes in 2000 were (or had) [EFFICIENCY CRITERIA FROM ANSWER GRID] or above?

ENTER 997 FOR DON'T KNOW, 998 FOR DON'T INSTALL THAT KIND OF EQUIPMENT, 999 FOR REFUSED.

M.4 What percentage of the thermostats that you installed in *existing* homes were ENERGY STAR thermostats?

ENTER PERCENTAGE ..... _____%
Don't Know 97

3. Market Measurement

a. What portion of your sales is in high efficiency categories? (Where the manufacturer has several levels of high efficiency, try to distinguish between them)
   i. Air conditioning
   ii. Gas furnaces
   iii. Gas boilers
   iv. Heat pumps

b. How does this differ among regions?

c. How does the percentage of high efficiency sales in New Jersey compare with other regions?

d. Do you think that your share is different from the total market? How and why?

4. Purchase Decision Making.

a. What do you believe are the principal factors in the homeowner's purchase decision?
   i. Price
   ii. Lifetime costing
   iii. Contractor advice
   iv. Past experience
   v. Brand of equipment
   vi. Efficiency
   vii. Other quality features (e.g. quiet operation)
   viii. Low maintenance
   ix. Utility rebate
   x. Comfort
   xi. Other

b. How does high efficiency fit in the mix of factors?

5. Key Barriers to Purchase of Efficient Equipment?

a. What are the principal barriers to increasing the share of high efficiency HVAC equipment and how important is each? (Ask as an open-ended question but prompt to be sure to include the following)
   i. Customer perception of high first cost
   ii. Lack of interest of the contractor in selling high efficiency
   iii. Lack of understanding of efficiency by the homeowner
   iv. Skepticism as to the claims of the contractor/manufacturer

v. Price competition between contractors on a first cost basis forcing low cost equipment to be proposed
vi. Low stock of high efficiency equipment in the field
vii. Lack of interest of the distributor in selling high efficiency
viii. Demand for less efficient, oversized units
ix. Poor training of the contractor

b. In your opinion what steps could be taken to lower each of these barriers? (ask as an open-ended question but prompt to be sure to include the following)
   i. Financing programs (Do you offer these?)
   ii. Contractor/dealer education/training (Do you offer?)
   iii. Consumer education
   iv. Subsidy programs (Rebates)
   v. Increasing the local availability of high efficiency equipment. (How could this be alleviated?)
   vi. Other
c. What involvement do manufacturers have in ensuring that contractors properly install their products? What more could be done to address the following:
   i. Proper refrigerant charge
   ii. Proper airflow over the indoor coil
   iii. Duct leakage
   iv. Correct system sizing
d. Do you sponsor coop advertising promoting high-efficiency?

e. How could utility programs promoting high efficiency residential HVAC equipment be improved?

f. Do you support contractor training?

6. Role of ENERGY STAR

a. How long has your company been an ENERGY STAR HVAC participant?
b. What benefits did you anticipate arising from participation? Have these expectations been met?
c. Have other, unanticipated benefits occurred?
d. Do you incorporate the ENERGY STAR logo in all, most, or little of your product marketing?
e. Do contractors and customers understand the ENERGY STAR message? If not, what could be done to approve ENERGY STAR awareness and understanding?

7. New Product Development

a. What is the focus of the your research and product development effort?
   i. Efficiency
   ii. Quality features (quiet operation, low maintenance, etc.)
   iii. Lower cost manufacturing

b. How important is efficiency in the mix?

c. Has this focus changed in the recent years?

d. Are there technologies on the horizon that you are exploring?

8. Future Trends in High Efficiency Market

a. Is the HVAC market changing and how will it evolve in the future? Why?
    i. How will distribution change? (consolidators, direct to contractor)
    ii. How will the competitive makeup of the industry shift? (consolidation)
b. How will the high-efficiency portion of the market change in the future?
c. How do you believe the impending new DOE efficiency standards for CAC and HP will impact your business?

Appendix E
On-Site Survey

Rev 2 Advanced Energy HVAC Survey

Surveyor _____ **Date** _____

1. Customer Name _____

2. Address _____

_____

3. When occupied by Customer _____
MONTH YEAR

4. When occupied by Previous Occupant_____
MONTH YEAR

5. How Many People Live Here?_____

6. Building Type

- ❑ 1. One Story
- ❑ 2. Two Story
- ❑ 3. One & a half Story
- ❑ 4. Split level
- ❑ 5. Two & a half Story
- ❑ 6. Three Story
- ❑ 7. Duplex
- ❑ 8. Townhouse
- ❑ 9. Apartment

7. Foundation Type(s)

- ❑ 1. Slab on grade
- ❑ 2. Full Basement
- ❑ 3. Partial Basement
- ❑ 4. Ventilated Crawlspace
- ❑ 5. Unventilated Crawlspace
- ❑ 6. Post or Pier

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8. Garage Location

- ❑ 0. None
- ❑ 1. Attached, within conditioned footprint
- ❑ 2. Attached, outside conditioned footprint
- ❑ 3. Detached

9. Garage Level (if attached**)**

- ❑ 0. Not applicable
- ❑ 1. At first floor level
- ❑ 2. At basement level

10. Number of conditioned floors above grade: (single-family detached only)

- ❑ 0. NA
- ❑ 1. One
- ❑ 2. One & a half
- ❑ 3. Two
- ❑ 4. Two & a half
- ❑ 5. Three
- ❑ 6. Three & a half

11. Exterior Perimeter_____**Feet**

12. Net Conditioned Area_____Sq. Ft.

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If Duplex, Townhouse,

13. How many floors in bldg.? _____

14. How many units in building? _____

15. If more than one unit deep, are units:

- ❑ 0. Not applicable
- ❑ 1. Divided by central corridor
- ❑ 2. Back-to-back

16. What floor(s) is unit on? _____

17. How many floors in unit? _____

18. What floor is main entrance on? ___

19. How many outside walls does unit have?

- ❑ 1.
- ❑ 2.
- ❑ 3.

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BUILDING FOOTPRINT

(Show Dimensions and Compass Orientation--North Arrow)
(Note: For apartments, Show Location of Unit in Building,
Give Measurements & Drawing For Unit)
[For multi-story homes, do a drawing for each story.]

HOUSE ELEVATIONS: Show all Doors,Windows& Other Significant Features

1. Front. Compass Orientation _____ Show locations of each zone if possible.

2. Compass Orientation:_____

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3. Compass Orientation: _____

4. Compass Orientation: _____

HOUSE ELEVATIONS: Show all Doors Windows& Other Significant Features

1. Front. Compass Orientation _____ [Show location of each zone if possible]	**2. Compass Orientation _____**
3. Compass Orientation _____	**4. Compass Orientation _____**

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BASEMENT/CRAWL SPACE

Perimeter Foundation Wall

22. Length _____Feet **23.** Average Height _____Feet **24**. Area _____ sq. ft.

25. Percentage Above Grade _____% **26.** Percentage Below Grade _____%

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Basement Ceiling (circle one) Crawlspace Ceiling

27a. Basement ceiling area _____ sq. ft	**27b.** Crawlspace ceiling area _____ sq. ft.
28a. Average Ceiling Height of Basement _____feet	**28b.** Average Ceiling Height of Crawlspace _____feet
29a. Basement Ceiling Insulation Type _____	**29b** Crawlspace Ceiling Insulation Type _____
30a. R-Value _____	**30b** R-Value _____

.

Basement Wall Insulation

31 Insulation Type _____ **32.** R-Value_____ **33.** Percentage below grade _____%

34. Basement Wall Insulation Location : ❑ 1. Interior ❑ 2. Exterior ❑ 3. Cannot Determine

35. Foundation Insulation Depth: _____in.

36. Percentage of crawl space floor covered by moisture retarder _____%

37. COMMENTS ON QUALITY OF BASEMENT/CRAWLSPACE INSULATION :

38. Is Basement Intentionally Heated? Y N

39. How many months are registers open? _____months

40. Is Basement Intentionally Cooled? Y N

41. How many months are registers open? _____months

Slab (Conditioned space only)

42. Exterior perimeter _____feet. **43.** Slab Area _____sq. ft. **44.** Slab Insulation Level R-_____

45. Slab Insulation Type _____ **46.** Perimeter Insulation Depth _____in.

47. Slab Insulation Location

- ❑ 1. Under Slab
- ❑ 2. Perimeter
- ❑ 3. Unable to determine

48. Total Exterior Perimeter _____feet (Sum of 31 + 55)

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CONDITIONED VOLUME

Zone	A Avg Hgt Flat Ceilings	B Net Floor Area	C Volume (A X B)	D Avg Hgt Sloped Ceilings	E Net Floor Area	F Volume (D X E)	G Total Volume of Zone (C + F)	Area of Flat Ceilings **	Area of Sloped Ceilings **
1									
2									
3									
4									

Total Conditioned Floor Area (B + E): _____Sq. Ft.	**Total Conditioned Volume (G): _____CU. FEET**

** Enter data from tables below.

ATTIC/CEILING

Radiant Barrier (circle)

1. None 2. On top side of rafters 3. On underside of rafters 4. On top side of ceiling joists

Percentage of roof or ceiling covered by radiant barrier _____%

Flat Ceiling

ID	Over Which Zone?	Insulation Type	Insulation Depth (Inches)	R-Value	Length	Width	Area	Roof Pitch
FC1				R-				
FC2				R-				
FC3				R-				
FC4				R-				
FC5				R-				
FC6				R-				
FC7				R-				

Sloped Ceiling

ID	Over Which Zone?	Insulation Type	Insulation Depth (Inches)	R-Value	Length	Width	Area	Roof Pitch
SC1				R-				
SC2				R-				
SC3				R-				
SC4				R-				
SC5				R-				
SC6				R-				
SC7				R-				

COLOR of ROOF Light/Dark (circle one)

COMMENTS ON QUALITY OF ATTIC/ROOF INSULATION:

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WALLS

100. Framing

1. 2 x 4 lumber
2. 2 x 6 lumber
3. other _____

101. Frame Spacing

1. 16" O.C.
2. 24" O.C.
3. Other_____

ID	Zone	Orien tation	Length	Height	Gross Wall Area	Insulation Type	Insulation Level	Sheathing Type	Interior Finish	Exterior Finish	Overhang Width	Overhang Depth	Avg. Height Overhang to Top of Windows
WA1							R-						
WA2							R-						
WA3							R-						
WA4							R-						
WA5							R-						
WA6							R-						
WA7							R-						
WA8							R-						
WA9							R-						
WA10							R-						
WA11							R-						
WA12							R-						
WA13							R-						
WA14							R-						
WA15							R-						
WA16							R-						
WA17							R-						
WA18							R-						
WA19							R-						
WA20							R-						
WA21							R-						
WA22							R-						
WA23							R-						
WA24							R-						

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WINDOWS (Enter by zone, skip a line between zones, and total window areas for each zone)

ID	Zone	Orien-tation N,S,E W	Window Type	Glazing Type	Frame Type	Width	Height	Area	Insulation Device? Yes /No	External Shading Device ? Yes /No
w1										
w2										
w3										
w4										
w5										
w6										
w7										
w8										
w9										
w10										
w11										
w12										
w13										
w14										
w15										
w16										
w17										
w18										
w19										
w20										
w21										
w22										
w23										
w24										
w25										
w26										
w27										
w28										
w29										
w30										

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DOORS (Enter by zone. Total door areas for each zone)

ID	Orientation	Zone	Door Type	Width	Height	Area	Unglazed Area
d1							
d2							
d3							
d4							
d5							

d6							

Total Door Area Zone 1 =_____sq.ft. Zone 2= _____sq.ft. Zone 3= _____sq.ft.

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MECHANICAL SYSTEMS

Primary Heating Systems	Secondary Heating Systems
ZONE 1 **System Type _____** **Distribution system _____** **Location _____** **Brand _____** **Model # _____** **Serial # _____** **Capacity (BTU Input)_____** **Capacity (BTU Output)_____** **Notes _____** **_____** **_____** **HSPF or AFUE (circle) _____**	***ZONE 1*** **System Type _____** **Distribution system _____** **Location _____** **Brand _____** **Model # _____** **Serial # _____** **Capacity (BTU Input)_____** **Capacity (BTU Output)_____** **Notes _____** **_____** **_____** **HSPF or AFUE (circle) _____**
ZONE 2 **System Type _____** **Distribution system _____** **Location _____** **Brand _____** **Model # _____** **Serial # _____** **Capacity (BTU Input)_____** **Capacity (BTU Output)_____** **Notes _____** **_____** **_____** **HSPF or AFUE (circle) _____**	***ZONE 2*** **System Type _____** **Distribution system _____** **Location _____** **Brand _____** **Model # _____** **Serial # _____** **Capacity (BTU Input)_____** **Capacity (BTU Output)_____** **Notes _____** **_____** **_____** **HSPF or AFUE (circle) _____**

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[Note: If there are more than 2 systems, use another sheet, & be sure to indicate which zones they relate to.]

Cooling System

Zone 1 Unit	Zone 2 Unit	Room Units
System Type _____	**System Type _____**	**# of Units / Frequency of Use**
Indoor Unit Brand_____	**Indoor Unit Brand_____**	**Zone 1**
Indoor Unit Model #_____	**Indoor Unit Model #_____**	**Zone 2**
Indoor Unit Serial # _____	**Indoor Unit Serial # _____**	**Zone 3**
Indoor Unit Capacity _____	**Indoor Unit Capacity _____**	**Zone 4**
Outdoor Unit Brand_____	**Outdoor Unit Brand_____**	
Outdoor Unit Model # _____	**Outdoor Unit Model # _____**	**Frequency codes:**
Outdoor Unit Serial # _____	**Outdoor Unit Serial #: _____**	**F Frequent O Occassional**
Outdoor Unit Capacity _____	**Outdoor Unit Capacity _____**	**S Seldom N Never**

Coil Model # _____ SEER_____	**Coil Model # _____ SEER_____**	

Charging

Type Refrigerant_____R-_____

Stamped charged_____

Line size Stamped _____Actual _____

Type metering device TXV____ CAP____ ORIFACE_____

Indoor Wb _____ Db _____

Outdoor Wb _____ Db _____

Charge

Low pressure_____

High pressure_____

Suction line Temperature _____

Liquid Line Pressure_____

Condition of coil opt _____ Model # _____

Entering Air Wb _____ Db _____

Leaving Air Wb _____ Db _____

Airflow_____CFM

Electric or Gas (Circle one)

If gas:

AFUE_____

Type vent _____

Other connectors _____

Soot present _____

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Motorized vent

_____

Signs of downdraft

_____

Rust on casing

_____

Ventilation System

Number of fireplaces _____

Heat recovery Ventilation? Y N How is it controlled? _____

Other Mechanical Ventilation ? Y N Describe _____
Whole House Fan Y N

Powered Attic Vent Fan? Y N If yes, Pressure reading, House WRT outside with fan operating. _____

DUCT SYSTEM--ZONE 1

Customer Name _____

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Type of Duct System (Check):	**How Sealed (Check):**	**Location of Returns**	**Duct Tightness Test**
❑ Rectangular Metal w/ flex runouts ❑ Rectangular Ductboard w/ flex runouts ❑ Flex & Box ❑ Other (Describe) _____ _____ _____ _____ ___	❑ Not Sealed ❑ Mastic ❑ Silicone ❑ Tape ❑ Grey cloth or vinyl ❑ Aluminum backed ❑ Labelled aluminum-backed. Label _____ _____ ❑ Other (Describe)_____ _____	❑ High ❑ Low	Duct Pressure _____ Ring _____ Fan Pressure _____ CFM_{25} _____

Ductwork in Unconditioned Areas

	Linear Footage of Duct **SUPPLY RETURN**	**R-Value of Duct Insulation in**	**Insulation Type**	**Percentage Insulated**	**How are Ducts Insulated ?**
Attic					
Crawlspace					
Garage					
Other (_____)					

Zone 1 Pressure Pan Readings:

Location	DP	Location	DP	Location	DP	Location	DP	Location	DP
1. ____	____	7. ____	___	13. ____	____	19. ____	____	25. _____	___
2. ____	____	8. ____	___	14. ____	____	20. ____	____	26. _____	___
3. ____	____	9. ____	___	15. ____	____	21. ____	____	27. _____	___
4. ____	____	10. ____	___	16. ____	____	22. ____	____	28. _____	___
5. ____	____	11. ____	___	17. ____	____	23. ____	____	29. _____	___
6. ____	____	12. ____	___	18. ____	____	24. ____	____	30. _____	___

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DUCT SYSTEM--ZONE 2

Customer Name _____

Type of Duct System (Check):	**How Sealed (Check):**	**Location of Returns**	**Duct Tightness Test**
❑ Rectangular Metal w/ flex runouts ❑ Rectangular Ductboard w/ flex runouts ❑ Flex & Box ❑ Other (Describe) _____ _____ _____ _____ ___	❑ Not Sealed ❑ Mastic ❑ Silicone ❑ Tape ❑ Grey cloth or vinyl ❑ Aluminum backed ❑ Labelled aluminum-backed. Label _____ _____ ❑ Other (Describe)_____ _____	❑ High ❑ Low	Duct Pressure _____ Ring _____ Fan Pressure _____ CFM_{25} _____

Ductwork in Unconditioned Areas

	Linear Footage of Duct SUPPLY RETURN	**R-Value of Duct Insulation in**	**Insulation Type**	**Percentage Insulated**	**How are Ducts Insulated?**
Attic					
Crawlspace					
Garage					
Other (_____)					

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Zone 2 Pressure Pan Readings:

Location	DP	Location	DP	Location	DP	Location	DP	Location	DP
1. ____	____	7. ____	___	13. ____	____	19. ____	____	25. _____	___
2. ____	____	8. ____	___	14. ____	____	20. ____	____	26. _____	___
3. ____	____	9. ____	___	15. ____	____	21. ____	____	27. _____	___
4. ____	____	10. ____	___	16. ____	____	22. ____	____	28. _____	___
5. ____	____	11. ____	___	17. ____	____	23. ____	____	29. _____	___
6. ____	____	12. ____	___	18. ____	____	24. ____	____	30. _____	___

Definitions

Window Types	Glazing Types	Window Frame Types
DH Double Hung SH Single Hung C Casement A Awning F Fixed S Slider SGD Sliding Glass Door FD French Door WD Window in door SK Skylight	S Single-glazed SS Single-glazed w/storm D Double-glazed DS Double-glazed w/ storm DE Double-glazed w/ Low-E GEG Double-glazed w/ Low-E & Gas-filled T Triple-glazed TE Triple-glazed w/ Low-E TE G Triple-glazed w/ Low-E Gas-filled A Acrylic CD Cannot Determine	W Wood WV Wood w/vinyl cladding V Vinyl M Metal MT Metal w/ Thermal break CD Cannot Determine
Insulation Types	**Sheathing Types**	**Interior Finish Types**
FB Fiberglass Batts F Blown Fiberglass C Cellulose R Rockwool RB Rigid Board FFDW Faced Fiberglass Duct Wrap N None CD Cannot Determine	I Insulated Sheathing IF Insulated Sheathing w/ foil U Blackboard P Plywood or OSB or Particle Board CD Cannot Determine	D Drywall P Plaster SW Solid Wood PW Plywood paneling O Other
Exterior Finish Types	**Door Types**	**Lighting Location Codes**
BV Brick Veneer BL Block S Stucco ST Stone HW Horizontal wood H Hardboard V Vinyl P Plywood (T-111) WS Wood Shingles D Drywall O Other	IM Insulated Metal IF Insulated Fiberglass SW Wood HW Hollow core Wood w/S with Storm Door	K Kitchen L Living Room D Dining Room B Bedroom BA Bath C Closet H Hallway G Garage BM Basement O Other

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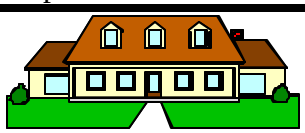
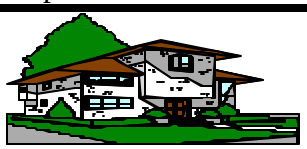
Mechanical System Types	Distribution System Types	Duct Insulation
1. Resistance Electric 2. Heat Storage System (ETS) 3. Air-to-air Heat Pump 4. Propane Heater 5. Vertical-well Ground-Coupled Heat Pump 6. Horizontal Loop Ground-Coupled Heat Pump 7. Dual-fuel Resistance Heating System 8. Dual Fuel Heat Pump 9. Gas Furnace 10. Oil Furnace 11. Other (specify) 12. Central Air Conditioner	1. Forced air central system 2. Hydronic central system 3. Unitary (room) units	I Internally E Externally N Not Insulated CD Cannot Determine

Surveyor's Comments and other relevant information

House Characterization			
	Ō if Yes	Observations	Possible reccomendations
Knee Wall and Fireplace			
Floor system, porch to floor and fireplace			
Side wall attic, roof to room and fireplace			
 Dormers, roof to room and fireplace			
 Cantilevers, bay windows and roof to room			
Crawl space, split level connection and roof to room			
The house that has everything			

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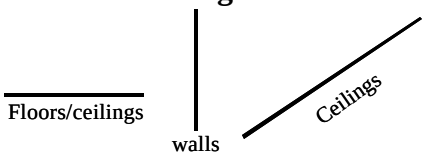
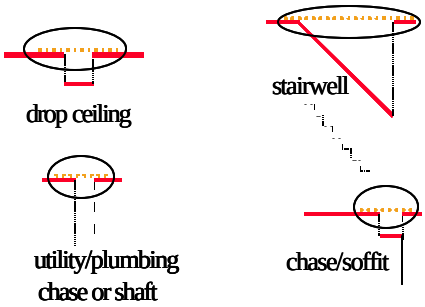
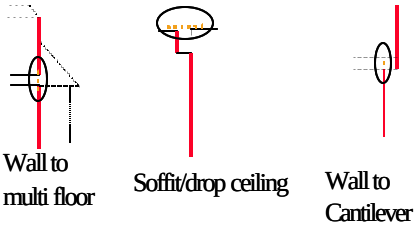
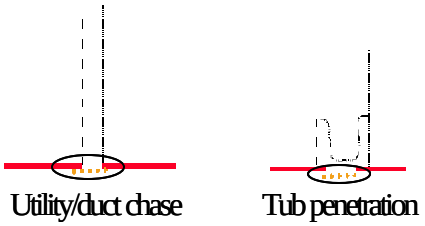
Porch to floor, floor system and fireplace			

Framing Characteristics

Uneven and Broken Building Planes	Ö if Yes	Observations	Possible reccomendations
			
Broken Ceiling Planes 			
Broken Wall Planes 			
Broken Floor Planes 			

Notes:

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Insulation Characteristics			
	Ö if Yes	Observations	Possible reccomendations
Gaps			
Voids			
Compression			
Misalignment			
Wind intrusion			
Pressure Characteristics			
Central return systems			
Interior door closes when air handler comes on			
Duct Leaks			
Discolored carpet under doors			
Power attic ventilators			
Small children			
Teenagers			
Pets			

Notes:

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