# RESIDENTIAL AIR-CONDITIONING FIELD PERFORMANCE STATUS AND FUTURE PRIORITIES

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## THE SITUATION

The non-profit Alternative Energy Corporation (AEC) was established in 1980 by the North Carolina Utilities Commission and the state's major electric utility organizations. The AEC is the nation's only cooperative joint venture in energy between government and public and private power organizations. Under its charter, AEC concentrates on promoting the economic and efficient use of electricity and moderating its future cost. AEC projects are designed to produce useful and significant results in the near-term.

North Carolina has been in a very fortunate situation with moderate electricity costs for many years derived from significant electrical use throughout the entire year. During the last 10 years utility peak loads have occurred in both winter and summer as growth and development added to the electric system. Because of new economic competition from other fuels and because air conditioning is now a feature of over 80% of the dwelling units of the State, there is a definite trend toward a more dominant summer peaking utility situation. The coincident peak demand of residential air conditioning, the significant owner/occupants costs to operate air conditioning, and the high penetration statistics provide AEC with strong motives to increase the energy efficiency of air conditioning.

## THE PROBLEM

Delivering air conditioning to an owner or occupant involves many different actors including the manufacturers, distributor, dealer, developer or speculative builder, installer, service technician, and the supplying utility. These actors typically view their industry as driven by least cost (commodity marketing) and the goal of "moving the product". Because of this "commodity" perspective, many advocates of energy efficiency have concluded that only government regulation can truly improve the homeowner's actual air conditioning efficiency. This approach has resulted in the National Appliance Energy Conservation Act federal legislation which mandates EER (energy efficiency ratio) of room air conditioners to above eight beginning in 1990, SEER (seasonal energy efficiency ratio) of split system air conditioners and heat pumps to above 10 in 1992, and SEER of package system to about 9.7 in 1993. (Note: EER and SEER are not directly related, however, both are indicative of air conditioning energy efficiency. A higher value of either indicator denotes more energy efficiency.)

Central air conditioners/heat pumps are interesting manufactured products in that, unlike most manufactured goods i.e. automobiles, the final assembly occurs in individual homes rather than in the factory. There are factors in this final

assembly - sizing, system airflow, system charge, and additional maintenance factors - which are critical determinants of the actual energy efficiency a user will receive - as opposed to the 'manufactured' energy efficiency. AEC field tests (Table I. and Refrigeration Service Contracting, October 1987) documented that the average lost energy efficiency due to this final assembly and servicing could be in the order of 30% - 40% of the manufactured efficiency. This 'lost efficiency' and resulting shortened equipment life are significant in terms of both customer costs and utility peak demands.

Table I. Field test summary.

| Manufacture-Related Performance | | | | Measured Performance | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Unit** | **Capacity** | | **EER** | **Airflow** | **Capacity** | | **EER** | | Life & Efficiency |
| | Btuh | Nominal Tons | | CFM/Ton | Btuh | % Rated | Measured | % Rated | Related Problems |
| 1 | 35,660 | 3 | 7.2 | 390 | 36,266 | 102% | 9.1 | 126% | Overfused Lightning Problem |
| 2 | 36,225 | 3 | 6.9 | 290* | NA<br>42,282 | NA<br>117% | NA<br>9.8 | NA<br>142% | Inadequate Airflow |
| 3 | 35,400 | 3 | 7.1 | 460[o] | 34,222 | 97% | 7.0 | 99% | Comfort Complaint |
| 4 | 24,150 | 2 | 6.2 | 505[o] | NA<br>31,329 | NA<br>130% | NA<br>8.3 | NA<br>134% | DANGER! - Serious Overcharge Problem |
| 5 | 50,193 | 4 | 6.7 | 330* | NA<br>40,331 | NA<br>80% | NA<br>6.1 | NA<br>91% | Inadequate Airflow |
| 6 | 42,607 | 3.5 | 7.0 | 354 | 31,755 | 75% | 6.45 | 92% | Undercharged |
| 7 | 33,000 | 2.75 | 7.5 | 395 | NA<br>10,555 | NA<br>32% | NA<br>2 | NA<br>27% | Compressor Bad Very serious |
| 8 | 33,000 | 2.75 | 7.5 | 432 | 22,453 | 68% | 5.23 | 70% | Probably Overcharged |
| 9 | 38,200 | 3 | 8.0 | 420 | 37,179 | 97% | 8.83 | 110% | Slightly overcharged Best unit yet |
| 10 | 39,960 | 3 | 6.0 | 438 | 29,052 | 73% | 6.5 | 108% | Very undercharged Dirty coils |

*Airflow too low
[o]Airflow too high

AEC estimated that if all units actually delivered their total rated performance this could produce a savings to North Carolina of $26.5 million per year in air conditioning operating cost and a summer utility peak reduction of 562 MW.

## THE APPROACH

AEC's first activity was to involve the leadership of the North Carolina Heating, Ventilation, and Air Conditioning (HVAC) industry in identifying problems of residential installation and service in air conditioning and heat pumps, and to recommend corrective activities. The residential HVAC industry is characterized as extremely entrepreneurial, and easy to enter or to fail in attempting a business. The only limitation to starting a residential HVAC business is that one member of the company must have a state license which is based on a written examination focusing primarily on business problems as opposed to technical service of the equipment. The industry tends to have a special feeling about their relationship to utilities that supply fuels utilized by the industry equipment.

A full report of the industry leadership consensus findings is given in AEC-R-87-1 (Racey, 1986). In summary, the first agreement was that a major industry problem is "poor technician performance." Three consensus causes for this problem were identified: (1) The industry is based totally on price competition because consumers lack a focus on quality; (2) There is a lack of performance standards, training, recognition, and pay scales measured against quality; and (3) There is a lack of education and training for consumers, for technicians, and for business managers.

The leaders reached consensus on eight (8) actions which could positively impact the HVAC industry and the customers actual air conditioning efficiency. These actions recognized that service technicians are the premier employees of the industry and can be instrumental in effecting a major change to introducing quality into the purchase decisions of the industry.

The AEC began to develop a project for in-service training of experienced HVAC service technician which could potentially become a permanent program leading to recognition and promotion of a "quality" technician. The training plan built on the outstanding success of heat pump technician training recently instituted by Georgia Power Company and Alabama Power Company. Elements of the training include: (a) Designed for experienced service technicians only (> 2 years experience), (b) One week training periods, (c) Limited class size, i.e. no more than 10 trainees per trainer, (d) Emphasis on "hands-on" skills development, not just knowledge, (e) Remote training location to enhance learning environment, and (f) A system of favored treatment weighed against rigid training and high expectations. The AEC training added at least two new focus points: (1) A heavy emphasis on factors critical to efficiency, i.e. making the equipment run 'right' - not just run and (2) The use of recognized, experienced technical experts as trainers.

The training curriculum offered focuses on routine tasks of service technicians performed efficiently at quality levels necessary to insure energy efficiency and long life - but in excess of 'standard practice' and far beyond what is routinely done in the field. Specific tasks emphasized include:

(a) Measuring air flow across the indoor coil.
(b) Proper charging - to within less than one ounce of design.
(c) Achieving dehydration in evacuating a system - use of a micron gauge.
(d) Assessing the electrical integrity of a sealed compressor - meggering.
(e) Field testing for energy efficiency - EER.

All training is reinforced by hands-on activities to actually perform the tasks - not just to have them explained or demonstrated.

The impact of the training becomes most apparent when the technicians realize that not only can they perform at the desired high levels of quality but also, that as they use instruments, tools, and equipment which are dependable and which work, they actually complete their service tasks faster. Major deterrents to quality service of air conditioners and heat pumps seem to be (1) that technicians do not truly understand 'hows' and 'whys' which make the equipment work and (2) there is frequent misleading information due to wrong indications by test instruments or equipment.

## THE FUTURE

AEC has established a training facility, a focused core training plan, and has exposed 106 experienced North Carolina HVAC service technicians to one week of selected training. All trainees were pre-tested and offered a week specifically directed to their critical needs. The training works (27% technical improvement) and the technicians concur that quality is needed (prime evaluation factor by trainees is - "I want more!").

The impact of training is extremely difficult to quantify and the AEC project used several techniques to try to accomplish this task. The technical knowledge measurement instrument was a version of the Refrigeration Service Engineers Society (RSES) national technician test. The 27% improvement on this test (pre-training to post-training) is especially significant since the training was focused on hands-on skills enrichment not simply written test improvement. The second instrument utilized was technician and supervisor ratings before and after training. Both technicians and supervisors indicated significant changes in both job performance and job attitudes as shown in Table II.

Table II. Survey results of training impact.

| | By Supervisors Before / After | | By Technicians Before / After | |
|---|---|---|---|---|
| Average Electrical Skills Rating | 3.2 | 3.8 | 3.5 | 4.2 |
| Average Refrigeration Skills Rating | 3.0 | 3.7 | 3.2 | 4.1 |
| Average Job Attitude Rating | 3.8 | 4.0 | 4.3 | 4.4 |

The final - and most impressive evaluation - was verbal follow-up with both bosses and technicians. The testimonies of new instruments and equipment purchased are numerous from all sources in the business. The use of the new knowledge and the better service equipment will definitely benefit North Carolina air conditioning customers.

AEC has initiated a 10-member committee of HVAC and electric utility leaders which has designated itself as the "North Carolina Heat Pump Standards Advisory Board." This 'Board' has accepted the task of developing quality standards for technicians and these will be promoted to the electric utilities for possible implementation, enforcement, and promotion. The quality will hopefully be based on successful training and skills evaluation along with possession and use of quality tools. There will likely be an updating requirement. It is hoped that successfully achieving "quality" service technicians is the key element to introducing a marketplace recognized definition of "quality" into residential HVAC which the customers will support and reward. The end result is that a homeowner will actually receive the energy efficiency for which he has paid.

Racey, Fred, The Role of Technicians in Residential Air Conditioning Efficiency - Final Report of Phase I, Contractor Final Report, AEC-R-87-1, September 19, 1986.

Real Life Residential Air-Conditioning, Refrigeration Service Contracting, October 1987, pp. 24-27.