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21-CR: An Industry R&D Program

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21-CR: AN INDUSTRY R&D PROGRAM

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ABSTRACT

This paper outlines a new aggressive R&D program – *HVAC&R Research for the 21st Century* (21-CR) – initiated by the heating, ventilation, air-conditioning and refrigeration (HVAC&R) industry. The areas of research to be undertaken, program organization, and manner that interested experts can participate in the effort are identified.

The intent of the 21-CR initiative is to undertake research that will enable industry manufacturers to offer equipment and services in the next decade that, once integrated into building and process applications, will utilize dramatically less energy (as compared to today's applications) while addressing the refrigeration needs and the comfort and indoor environmental quality (IEQ) needs of building occupant.

INTRODUCTION

The 21-CR initiative is a private-public sector research collaboration of the heating, ventilation, air-conditioning and refrigeration (HVAC&R) industry, with the mission to identify, prioritize, and undertake precompetitive research that focuses on decreasing energy consumption, increasing indoor air quality, and safeguarding the environment.

The 21-CR effort is guided by experts from industry, related trade and professional organizations, national laboratories, governmental agencies, universities, utilities, and other interested stakeholders. The Air-Conditioning and Refrigeration Technology Institute (ARTI[1]), a research entity associated with the Air-Conditioning and Refrigeration Institute (ARI), is the administrator for the effort. It is ARTI's role to provide guidance and cohesiveness to the overall investigation while providing an umbrella for related research by others which advances the goals of the 21-CR program.

The 21-CR program fosters an environment where technical barriers are identified, research priorities set, solutions investigated, and information shared. The effort will undertake precompetitive research that focuses on resolving technological hurdles and difficulties that prevent or impede manufacturers from introducing next generation systems and components. Once these technical challenges have been addressed, the various stakeholders are positioned to apply the 21-CR research results and to produce the products/services that satisfy market needs within the HVAC&R sector.

BACKGROUND

The U.S. HVAC&R industry is a mature one in which product innovations have been gradually accepted by the marketplace. Achieving rapid marketplace acceptance of new innovations is complicated in that HVAC&R products generally are viewed as commodities where sales are extremely price sensitive; a small price difference can sway a purchase decision. Yet, industry's long-term viability, as well as the needs of its customer base, is dependent upon the development of novel, breakthrough technologies. Implementation of innovative ideas into HVAC&R products will serve to offer customers added benefits by reducing energy consumption costs, improving indoor comfort for building occupants, and further reducing the impact that operation of HVAC&R equipment has on the environment.

Energy reduction is a large component of this HVAC&R initiative. Some statistics on site-consumed energy usage[2] within the U.S. are:

- U.S. Commercial Buildings[3]
  - Approximately 5.5 quads[4] of energy (i.e., electricity, natural gas, fuel oil, and district steam or hot water from a central plant or utility) are consumed in commercial buildings each year at an annual cost of $71.8 billion.[5]
  - Comfort conditioning (e.g., heating, cooling, and ventilation) and refrigeration is the single largest component of this overall requirement and uses 48% (2.67 quads/yr) of the site-consumed energy.[6]
- U.S. Residential Households[7]
  - Approximately 10 quads of energy (i.e., electricity, natural gas, fuel oil, and liquefied gas) are consumed in residential applications each year at an annual cost of $124 billion.
  - Comfort conditioning (e.g., heating and cooling) is the single largest component of this overall requirement and uses 45% (4.54 quads/yr) of the site-consumed energy.
- U.S. buildings consume about 35% of the country's total energy (all fuel types).
- Including fuel used to generate electricity, commercial buildings account for over 15% of the U.S. carbon dioxide emissions; residential buildings account for 19%.

The direct payback from improved HVAC&R products is dramatic. Annual U.S. energy bills for comfort conditioning and refrigeration equipment are approximately $90 billion. Increasing overall HVAC&R equipment efficiencies by 25% (a reasonable target if a concentrated research program is pursued) could ultimately yield an annual energy savings of $22 billion. There would also be a proportionate decrease in the emissions of gases that are associated with global warming, as carbon dioxide emissions from power plants would decrease by nearly 60 million metric tons per year.[8]

PROGRAM JUSTIFICATION

The envisioned research is on the "cutting-edge" of the HVAC&R industry and entails a high degree of technical risk. Currently, personnel and testing resources within individual HVAC&R companies are spread thin because of the pace of product changes necessitated by development of

new equipment that use alternative refrigerants and/or offer improved efficiencies. Precompetitive collaboration among HVAC&R companies and other interested entities will enable significant resources to be applied to strategic research areas. As a result, substantial savings should be realized by building owners and operators through reduced operating costs, greater equipment reliability, and improved comfort levels.

It is worth noting that any process, application, or operation that depends on heating, ventilation, air-conditioning, or refrigeration will benefit from enhancements in HVAC&R equipment and services. Additionally, a number of improvements developed by the industry have applications to other sectors of the economy. Hence, advances in the HVAC&R industry will have a profound impact on the overall economy and the international competitiveness of numerous industries.

21-CR FOCUS AREAS

Through this new HVAC&R initiative, it is anticipated that the development and marketplace introduction of advanced equipment and applications will be greatly accelerated. In recognition of the needs for energy efficiency and minimal adverse environmental impact, five areas of strategic focus have been identified:

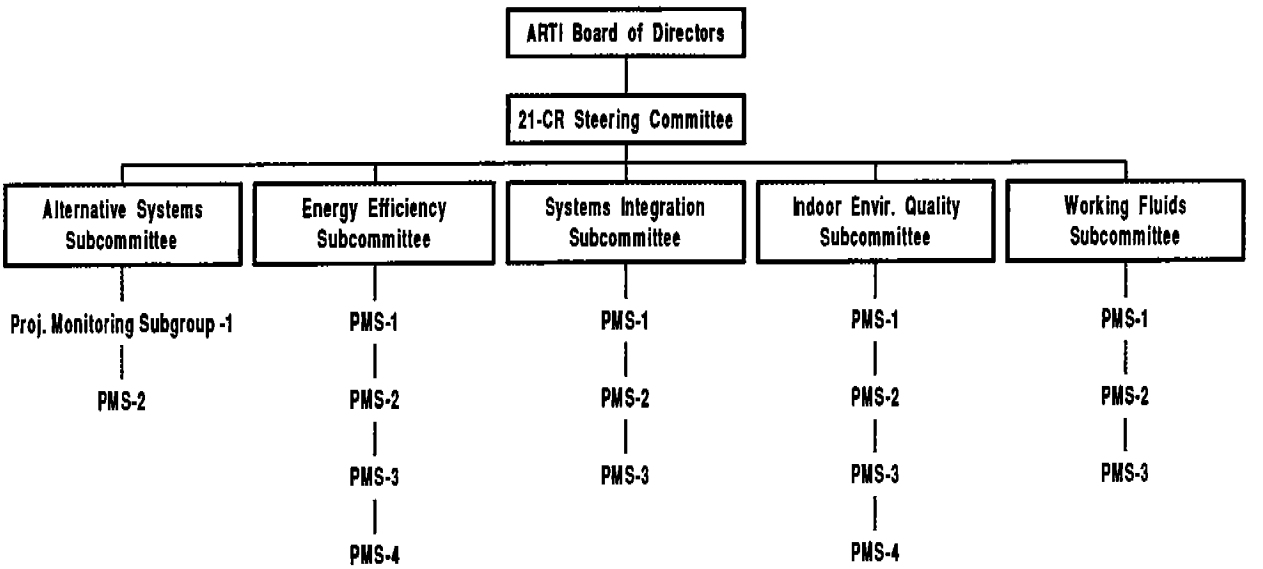
- *alternative equipment* (systems other than fluorocarbon vapor compression cycles);
- *high efficiency equipment* (improved heat exchangers, motor systems, compressors, controls and sensors, air handlers, testing, diagnostics, pumps and pump controls, etc.);
- *system integration* (improved distribution systems, zone control, waste heat recovery, integration of envelope and lighting with mechanical systems, advanced controllers, communications, etc.);
- indoor environmental quality (enhanced control of temperature, moisture, indoor contaminants, ventilation, sound, lights and drafts); and
- *environmentally-friendly working fluids* (refrigerants, lubricants, secondary heat transfer fluids, eutectics, etc.).

ORGANIZATION OF THE 21-CR EFFORT

A committee structure has been established to guide the 21-CR initiative and to monitor the research. The committee membership comprises authorities in the research area drawn from industry, research organizations, universities, utilities, scientific laboratories, and government.

Steering committee

A Steering Committee will assure that the work will be of value to the industry and has a path to commercialization. The Steering Committee members will assure that the subcommittee members have access to necessary information, resources, and personnel. Additionally, they will assign priority levels and approve funding support of individual projects recommended by its five newly-formed Subcommittees (see *Scopes* at end of paper).



21-CR subcommittees

The five 21-CR Subcommittees, comprising senior industry engineers and technologists as well as capable, knowledgeable persons from various industry sectors, will identify specific project needs, prepare work statements, prioritize the research, and identify contractors capable of performing the individual research. Once individual projects have been approved for funding by the Steering Committee, the pertinent Subcommittees will provide technical review of contractor-submitted proposals, recommend contractor selection, monitor and oversee the on-going research, perform site reviews, and review the submitted final reports. In performing their duties, the Subcommittees will review/monitor and coordinate (where possible) industry/public-sector precompetitive research. The purpose of this ancillary focus is to encourage other entities (e.g., government laboratories, university researchers, etc.) to perform work of interest to the industry and to minimize duplication of effort.

In lieu of serving on a subcommittee, there are other ways for interested industry experts to be involved with the 21-CR effort:

- Specific projects can be identified for the 21-CR program to consider; suggestions can range from a simple one-paragraph needs assessment to a complete draft work statement.
- Pertinent research efforts of others can be identified for possible 21-CR support or to assist in the minimization of duplicate effort.
- Researchers can respond to *request-for-proposals* (RFPs) and seek contracts to perform specified work.
- Unsolicited research proposals will be considered for appropriateness.

Additionally, in 1999 there will be opportunities for individuals to serve on monitoring subgroups for various research projects. Also, it is expected that the Subcommittees will undergo a certain amount of "rotation" after the second year and new members will be needed to fill the open slots.

CONCLUSION

The HVAC&R industry, which has been experiencing evolutionary growth for the last 40 years, is currently undergoing a period of unprecedented change. The pressures driving these changes -- protection of the environment and conservation of our natural resources -- will only become more pronounced in the future. Developing new technologies to address these pressures will necessitate a large concerted effort. By providing a solid basis for industry collaboration in precompetitive technology areas, the 21-CR program will catalyze progress in a number of strategic areas. When carried out as a part of a coherent plan, this emphasis on precompetitive investigations advances the capabilities of the HVAC&R industry to meet the broader objectives of decreasing energy consumption, increasing indoor environmental quality, and safeguarding the environment.

End notes

1. ARTI, a not-for-profit organization for scientific research in the public interest incorporated in Delaware; has its principal offices in Arlington, Virginia. ARTI holds tax-exempt status under Section 501(c)(3) of the Internal Revenue Code.

2. Energy utilized on site is without consideration of conversion and distribution losses.

3. Includes buildings used for assembly, education, food sales, food services, health care, lodging, mercantile and service, office, warehouse, and other.

4. 1 quad of energy = 1 quadrillion (1×10^{15}) BTUs.

5. Source: Errata, Commercial Buildings Energy Consumption and Expenditures 1992, U.S. DOE Energy Information Administration, Office of Energy Markets and End Use, Report # DOE/EIA-0318 (92), October 1995.

6. Source: Energy End-Use Intensities in Commercial Buildings, U.S. DOE Energy Information Administration, Office of Energy Markets and End Use, Report # DOE/EIA-0555 (94), September 1995.

7. Source: Household Energy Consumption and Expenditures 1993, U.S. DOE Energy Information Administration, Office of Energy Markets and End Use, Report # DOS/EIA-0321(93), 5 October 1995.

8. In 1992, carbon dioxide emissions from a generic building (including emissions occurring at the utility power plant for electricity) totaled 15.32 million metric tons per quad of site-consumed energy. (Source: Core Databook, U.S. DOE, Office of Building Technology, Table 8, 24 June 1994). [25% of 15.5 quads of energy (for commercial and residential buildings in 1992) x 15.32 = 59.4]

21-CR SUBCOMMITTEE SCOPES

Alternative Systems:

This Subcommittee advocates R&D aimed at ascertaining the role that non-traditional equipment can play in future HVAC&R applications. This includes recommending investigations to identify and evaluate alternative concepts and, for those that appear viable, recommending research to resolve specific limitations that affect their commercialization. Examples would include desiccant cooling, hybrid systems, absorption, heat-operated, etc.

Equipment Energy Efficiency:

This Subcommittee focuses on research needed to improve the efficiency of existing HVAC&R equipment used in various applications (e.g., unitary, chillers, refrigeration, etc). Heat exchangers, motor systems, compressors, controls and sensors, air handlers, application of working fluids (cycle analysis, heat transfer, etc.), testing, diagnostics, efficiencies across the operating range, pumps and pump controls are examples of specific areas falling under the Subcommittee.

System Integration:

To provide substantial improvements in energy consumption and comfort levels, there is a need to treat buildings, with their individual subsystems, as complete optimized entities, not as the sum of a number of separately-designed and separately sub-optimized components. This Subcommittee identifies precompetitive research that will enable better integration of HVAC&R equipment into the various applications. Examples of project interests are distribution systems (e.g., air duct systems and water circulation systems), zone control, advanced application and equipment controllers, identification of ways to recover and reuse waste energy within buildings and refrigeration processes, standardized external communications (i.e., for standardized diagnostics, utility control, mating with building systems, etc.), and influences and impacts of lighting, thermal envelope, etc. on HVAC&R equipment. The initial emphasis will be on residential applications with commercial and refrigeration applications timed-phased for a later start.

Indoor Environmental Quality:

The IEQ Subcommittee fosters investigations that support industry's ability to provide high quality indoor environments for comfort, health, and productivity. This encompasses air quality, sound quality (i.e., noise control), etc. The primary concern is in recommending research that will position manufacturers to offer equipment that recognizes, measures, and controls defined indoor environmental concerns. Emphasis areas would include indoor air quality control strategies, identification of anti-microbial materials, improved concepts for particulate or gas-phase filtration, and enhanced control of temperature, moisture and humidity, ventilation, sound, and air velocity.

Working Fluids:

Refrigerants, absorption fluids, lubricants, and secondary heat transfer fluids are required for the successful operation of HVAC&R equipment. Contaminates (including cutting oils, detergents, lubricants, and anti-rust compounds used to manufacture component parts) can affect the reliability of HVAC&R equipment. New refrigerants, absorption fluids, lubricants, and secondary heat transfer fluids and new process fluids are likely to be needed in the future. This Subcommittee will anticipate the need for precompetitive research to provide and apply new working fluids. In assessing new fluids and applications the Subcommittee will consider issues including system efficiency, equipment reliability, compatibility, safety, and environmental impacts.