21-CR: AN HVAC&R RESEARCH COLLABORATION

Glenn C. Hourahan & Mark S. Menzer

Air-Conditioning & Refrigeration Technology Institute (ARTI)
4301 North Fairfax Drive, Suite 425, Arlington, VA 22203 USA

ABSTRACT

This paper describes the "HVAC&R Research for the 21st Century" (21-CR) Program. It notes that the program will undertake precompetitive research to resolve technological hurdles and difficulties that prevent or impede manufacturers from commercializing "next-generation" components and systems. The paper identifies five strategic areas of research including alternative equipment, high-efficiency equipment, system integration, indoor environmental quality, and environmentally-friendly working fluids. Projects currently underway in each strategic area are identified.

KEYWORDS

21-CR, HVAC&R, air-conditioning, efficiency, IAQ, research, collaboration, ARTI

INTRODUCTION

The HVAC&R industry, which experienced evolutionary change until the early 1990's, is continuing to undergo a period of unprecedented transformation. The pressures driving these changes – protection of the outdoor environment and conservation of natural resources – will only become more pronounced in the future. In response to this challenge, the Air-Conditioning and Refrigeration Technology Institute (ARTI) is spearheading a government-industry collaboration whose mission is to identify, prioritize, and undertake research that focuses on decreasing energy consumption while improving indoor environmental quality within buildings.

By providing a solid basis for industry collaboration in precompetitive technology areas, the 21-CR program, a five to seven year research effort, will catalyze progress in a number of strategic areas. Cumulatively, twenty-five projects are underway (at a value of approximately $3.5 million US$) in five focus areas.

21-CR FOCUS AREAS

Alternative Equipment

Scope: *Advocates R&D aimed at developing and understanding the underlying concepts, benefits and challenges of promising HVAC&R system technologies other than traditional electrically driven mechanical vapor compression equipment with conventional refrigerants. Examples include transcritical CO_2, thermoacoustic cooling, advanced absorption concepts, hybrid systems, etc. The focus is on technologies that could be commercialized in 10 to 20 years, that are environmentally friendly, and provide benefits to society.*

Projects Currently Underway:

- Micro-channel Heat Exchangers with CO_2
- Efficiency Limits of H_2O Vapor Compressors Suitable for Air-Conditioning Applications
- Evaluation of the Performance Potential of CO_2 as a Refrigerant in Air-to-Air Conditioners and Heat Pumps: System Modeling and Analysis
- Evaluating the Performance of Thermoacoustic Cooling

Equipment Energy Efficiency

Scope: *Focuses on research needed to improve the efficiency of existing HVAC&R equipment used in various applications (e.g., unitary, chillers, refrigeration, etc). Examples include: 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.*

Projects Currently Underway:

- High Temperature Mold Materials to Die-Cast Copper Motor Rotors for Improved Motor Efficiency
- High Performance Heat Exchangers for AC&R Applications (non-circular tubes)
- Refrigerant Evaporation Characteristics Inside Flat Passages
- Evaluating the Ability of Unitary Equipment to Maintain Adequate Space Humidity Levels (co-funding of ASHRAE's 1121-RP)
- Potential Benefits of Smart Refrigerant Distributors
- High Condensing Temperature Heat Transfer Performance of Low Critical Temperature Refrigerants

System Integration

Scope: *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 focus area identifies precompetitive research that will facilitate better integration of*

HVAC&R equipment with other related systems for 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.

Projects Currently Underway:

- State-of-the-Art Review, Whole Building and Building Envelope Simulation and Design Tools
- State-of-the-Art Review, HVAC Component and System Simulation and Design Tools
- Energy Savings Potential of Flexible & Adaptive HVAC Distribution Systems for Office Buildings
- Methods for Automated and Continuous Commissioning of Building Systems
- Automated Integration of Real Time Information Into Building Management Systems

Indoor Environmental Quality

Scope: *Foster investigations that support industry's ability to provide high quality indoor environments for comfort, health, and productivity. This encompasses air quality, and other physio-psychological factors (i.e., noise, lighting, 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.*

Projects Currently Underway:

- Investigation of the Causes of "Black Soot Phenomena"
- Health, Energy & Productivity in Schools
- Defining the Effectiveness of UV Lamps Installed in Circulation Air Ductwork
- Investigation of Building Exhaust Air Re-Entrainment into Outside Air Intakes of Packaged Outdoor HVAC Equipment – Phase I (focus on equipment without environmental-, site-, or building-related factors)
- Baselining Residential Indoor Air Quality

Working Fluids

Scope: *Refrigerants, absorption fluids, lubricants, and secondary heat transfer fluids are required for the successful operation of HVAC&R equipment. Contaminates within working fluids (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*

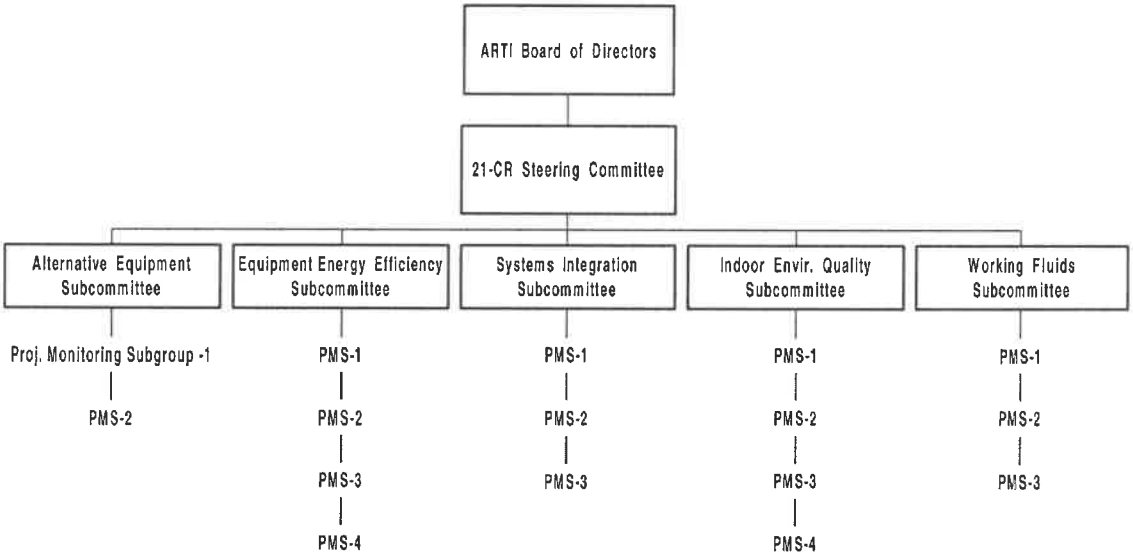
fluids, lubricants, secondary heat transfer fluids, and process fluids are likely to be needed in the future. When assessing new fluids and applications, this focus area is to consider issues related to system efficiency, equipment reliability, compatibility, safety, and environmental impacts.

Projects Currently Underway:

- Investigation of AC&R Systems Operated Near and Above the Refrigerant Critical Temperature
- Determination of Refrigerant Lower Flammability Limits in Compliance with ASHRAE 34p (co-funding of ASHRAE's 1073-RP)
- ARTI Refrigerant Database
- Assessing the Commercial Implications for ASHRAE A3 Flammable Refrigerants Used in Air Conditioning and Refrigeration Systems
- Study the Effects of Water in Synthetic Lubricant Systems and Clathrate Formation

ORGANIZATIONAL STRUCTURE

A committee structure has been established to guide the 21-CR program and to direct the research. The volunteer experts for the various committees are drawn from industry, research organizations, universities, utilities, scientific laboratories, and government.



Steering Committee

The Steering Committee, comprising senior executives, assures that the work is of value to the industry and has a path to commercialization. These executives also assure that the subcommittee members have access to necessary information, resources, and personnel. The 21-CR Steering Committee assigns priority levels and approves funding support for projects recommended by its five Subcommittees.

21-CR Subcommittees

The five 21-CR subcommittees are comprised of senior industry engineers and technologists as well as competent, knowledgeable persons from pertinent private-public sectors. The subcommittees identify 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 Project Monitoring Subgroups provide technical review of contractor-submitted proposals, recommend contractor selection, monitor and oversee the on-going research, perform on-site reviews, and review the final reports. In performing their duties, the subcommittees review, monitor, and interact with (where possible) industry and public-sector precompetitive research of others. 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 while also striving to minimize duplication of effort.

SHARING OF RESEARCH RESULTS

Results from the 21-CR program will be disseminated at periodic seminars and symposia at suitable industry conferences. The intent is to maximize the information dissemination to benefit the HVAC&R community.

CONCLUSION

The aim of the 21-CR program is to resolve technological hurdles and difficulties that prevent or impede HVAC&R practitioners from introducing next generation equipment and services. Once these technical challenges have been addressed, the various stakeholders are positioned to apply the 21-CR research results and to produce the products and services that satisfy market needs within the HVAC&R sector. The ultimate winners are the building owners/operators and building occupants who will enjoy reduced operating costs, greater equipment reliability/flexibility, and improved comfort levels.

More information on the 21-CR program can be obtained via the Internet by accessing the ARTI website: http://www.ARTI-21CR.org. Contact: Glenn C. Hourahan, P.E., ARTI Vice President, 4301 North Fairfax Drive, Suite 425, Arlington, VA 22203, tel: 703/524-8800, fax: 703/522-2349, e-mail: Hourahan@ari.org.

Current *Sponsors, Supporters,* and *Endorsers* of the 21-CR Program:

21-CR Sponsors

Air-Conditioning & Refrigeration Institute (ARI)
Copper Development Association (CDA)
New York State Energy Research and Development Authority (NYSERDA)
U.S. Department of Energy (DOE)

21-CR Supporters

Heating, Refrigeration Air-Conditioning Institute of Canada (HRAI)
Refrigeration Service Engineers Society (RSES)

21-CR Endorsers

Air-Conditioning Contractors of America (ACCA)
Edison Electric Institute (EEI)
Energy Center of Wisconsin (ECW)
Geothermal Heat Pump Consortium (GHPC)
Institute of Gas Technology (IGT)
Iowa Energy Center (IEC)
National Association of Plumbing-Heating-Cooling Contractors (NAPHCC)
Thermal Technology Center (TTC), National Research Council Canada (NRC)