Creating Energy-Efficient Equipment and Jobs

Buildings consume 41% of the nation's primary energy, of which equipment uses 57% to provide comfortable indoor temperature and humidity levels, healthy air quality, heated water, and refrigeration. Increasing concerns over rising costs, resource scarcity, and climate change are driving interests in improving equipment efficiency.

ORNL collaborations with industry have led to game-changing advancements that are helping overcome these concerns, clearing the way to more energy-efficient equipment, greater market acceptance, and job creation.

Technology Achievements

- Using a combination of advanced measurement techniques such as thermal and neutron imaging and sophisticated modeling techniques such as computational fluid dynamics, low cost, improved efficiency heat exchanger designs are being developed to reduce energy consumption for HVAC, appliances, and refrigeration systems.

- Water heater designs that are environmentally friendly are being developed with two approaches under investigation: a gas-fired absorption system with a patent-pending additive to enable use at low temperatures, and a CO_2-based vapor compression system design. Both will result in significant reductions in greenhouse gas emissions through lower energy consumption and the use of refrigerants with low global warming potential.

- Several styles of air-source integrated heat pumps are under development, promising to reduce residential space conditioning and water heating energy use by 50%.

GeoSpring™ electric heat pump water heater

Key Accomplishments

- GE Appliances launched its GeoSpring™ unit only 20 months after its collaboration with ORNL began. This technology saves 62% on energy use and pays for itself in under 2.5 years when compared to standard models. In 2012, the product created 100 GE manufacturing jobs in Louisville, Kentucky, and over 1,000 estimated US jobs.

- In 2012, following collaborations with ORNL, ClimateMaster launched the Trilogy™ 40 Q-Mode™—a variable speed geothermal (ground-source) integrated heat pump manufactured in Oklahoma City. The new product reduces annual energy use by up to 65% compared with conventional systems for space conditioning and water heating in residential applications.

- In 2011, Southwest Gas, under the NextAire™ brand, launched an engine-driven rooftop unit with heat recovery for space conditioning. This is the first product to emerge from ongoing collaborations with ORNL to bring to market new commercial and residential products for space conditioning, water heating, backup power, and/or micro-cooling, -heating, and -power.

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- A transcritical CO_2 supermarket refrigeration system is under development with the potential to reduce energy use by 25% and equivalent emissions by 75% compared with typical R-404A multiplex direct expansion systems.

- An investigation is underway to develop the next generation cooling technology for HVAC and appliance applications. The magnetocaloric cooling cycle eliminates the need for refrigerants (a significant contributor to global warming) while delivering comparable efficiency levels.

- In the 1990s, the Appliance Research Consortium (members including Frigidaire, General Electric, and Whirlpool) controlled 95% of the domestic refrigerator-freezer (RF) market. Under a Cooperative Research and Development Agreement (CRADA), ARC and ORNL developed technologies enabling the production of 1 kWh/day RFs that consumed 50% less energy than the minimum efficiency standard at the time.

- ORNL's work in the CRADA with ARC provided the essential technological foundation that enabled the DOE Codes and Standards group to promulgate more stringent minimum efficiency standards for refrigerator/freezers that took effect in 1993.

- In the 1990s under a CRADA with the Alternative Fluorocarbon Environmental Acceptability Study (AFEAS), a chemical manufacturers consortium, ORNL developed the total equivalent warming impact (TEWI) concept – the first global warming index that considered the net lifetime global warming impact of alternative refrigerants and technologies including both the direct chemical emissions (such as refrigerant leakage from a device) with the emissions impact from energy use of the device over service life. TEWI is still in use today, forming the core of the more comprehensive life cycle climate performance (LCCP) index.

- In the 1980s when the effort to develop alternatives to chlorofluorocarbon (CFC) and hydrochlorofluorocarbon (HCFC) refrigerants (e.g., R-11, R-12, R-22, and R-502) having zero ozone depletion potential (ODP) was getting underway, ORNL measured and published the first performance data on refrigeration cycles using zero-ODP refrigerants R-32, R-125, and R-143a. These fluids form the basis for the R-404A, R-410A, and R-507A blends, which today serve as the principal replacements for CFC/HCFC refrigerants in heat pumps, air-conditioners, and commercial refrigeration systems worldwide, facilitating phase-out of the ozone-depleters in these applications well ahead of the Montreal Protocol schedule.

- In the late 70s and early 80s, ORNL worked in collaboration with a major US appliance compressor manufacturer to foster development and commercialization of the first refrigerator compressor with a rated energy efficiency ratio (EER) of 5. Most refrigerators at the time used compressors with EER of 4 or less.

- In the late 70s and early 80s, ORNL developed an unequal compressor control system with floating pressure for supermarket refrigeration systems in conjunction with Foster Miller. Results from a field test indicated 14% lower energy consumption for the advanced system versus the conventional approach. The system was subsequently adopted by every major supermarket refrigeration system supplier.