# Vapor Compression Cycle Model Spurs Advances in Equipment Efficiency

Electric equipment providing space conditioning, water heating, and refrigeration consumes 12.5% of the nation's primary energy. Most of this electricity is used to drive vapor compression cycles, which are the heart of air conditioners, heat pumps, chillers, supermarket refrigeration systems, and more. Global use of electricity to drive such devices will have to increase dramatically if living standards including food preservation and comfort are to rise in the developing world. Over the past 30 years vapor compression equipment has advanced dramatically in efficiency while successfully transitioning to more environmentally-acceptable refrigerants.

Whether involving design of specific new products or refrigerants to which the entire industry should migrate, ORNL's Heat Pump Design Model (HPDM) is a world-class hardware-based vapor compression cycle model for research and product design at the decision-making core for much of the industry.

## Technology Achievements

- Extensive component library for build-up of compression machine models, e.g., phase-to-phase fluted tube-in-tube coils, segment-to-segment fin-and-tube coils, segment-to-segment micro-channel heat exchangers, and segment-to-segment brazed plate heat exchangers; vapor injection compressor, variable-speed compressor, fan, and pump models; and flexible refrigerant property connectivity.

- Flexible modeling of vapor compression system configurations including multi-functional integrated heat pumps, multi-split variable refrigerant flow systems, cold climate heat pumps, desiccant coupled vapor compression systems, gas engine driven heat pumps, high efficiency window air conditioner units, and supermarket refrigeration systems.


Maytag air conditioner incorporating the NORDYNE iQ Drive® inverter-driven rotary compressor

## Key Accomplishments

- NORDYNE, using HPDM, developed the iQ Drive® inverter-driven rotary compressor air conditioner, the highest efficiency product on the market when introduced in 2006.

- Emerson Climate Technologies, Inc., a business unit of Emerson Electric Co. and the nation's largest compressor manufacturer with Copeland Scroll™, uses HPDM as the engine for its system design tool.

- The National Appliance Energy Conservation Act minimum efficiency standards for some product categories are based on analysis using HPDM.

- Under the Montreal Protocol and US Clean Air Act, replacement refrigerants for chlorofluorocarbons and hydrochlorofluorocarbons were selected in part based on analysis using HPDM.

- HPDM is actively used by companies and in research collaborations between ORNL and firms designing equipment to achieve industry-leading efficiency levels.

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- Based on the similar component-based modeling approach Modelica/Dymola, HPDM offers more advanced solving capabilities and can be integrated to the Modelica environment. Example, HPDM library can be integrated to Dymola in form of dynamic link library, so as to interact with other building energy models for quasi-steady state energy simulations.

- HPDM capabilities enable optimization, auto-calibration, control strategy determination, interconnectivity to whole-building models, etc.

- In the early 1990's Allied-Signal (now part of Honeywell) employed the HPDM to analyze the performance of unitary heat pump systems with R-410A, a non-ozone depleting refrigerant blend. This helped speed development and commercialization of R-410A which today is the primary replacement for R-22 (an ozone deleter) in the US; this has facilitated the US' compliance with Montreal Protocol requirements to eliminate most uses of R-22 well ahead of the official 2020 phase-out deadline.

- Accessible on the Web: http://www.ornl.gov/~wlj/hpdm/MarkVII.shtml