PHRC Report #36: A Manufacturer's Reference Guide to the Design and Optimization of Energy Efficient HVAC Systems for Modular Houses

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BACKGROUND:

Many modular house manufacturers in the northeast do not install ducting for central heating and air-conditioning because of the difficulty encountered making connections between modules. Unfortunately, this can significantly hinder the competitiveness of the home in a market where customers typically demand central heating and air-conditioning.

When an integrated HVAC system design and installation does not take place in the modular manufacturing process, these functions are relegated to HVAC contractors who must find a method of distributing hot and cool air after the house is built. Some modular manufacturers factory-install branch ductwork and terminal registers to facilitate site installation of HVAC systems. However, these often involve attic-installed equipment and ductwork to serve the second floor. The installation of HVAC equipment in unconditioned attics is known to degrade equipment performance, produce higher duct heat losses and reduce overall system performance.

This report describes the work completed by the PHRC to fulfill the requirements for Pennsylvania Energy Office (PEO) Grant Number ME92801. It is part of a larger project primarily funded by the U.S. Department of Energy (DOE), with additional support from modular house manufacturers, HVAC (heating, ventilating, and air conditioning equipment manufacturers, and gas utilities. Specific objectives guiding this project were: a) to assess the technical feasibility of installing existing HVAC equipment in modular houses; and b) to estimate the first costs and annual energy costs associated with each system.

SUMMARY OF RESULTS:

Six of the HVAC system options considered for testing were found to be **technically** feasible for modular houses: baseboard electric resistance; electric resistance furnace; gas furnace; gas boiler; combined space heat and domestic hot water; air source heat pump; and ground source heat pump systems. Air-tightness of the structure, air-distribution rates, equipment and installation costs, utility rates and value of energy savings over time were also analyzed to determine a total life cycle HVAC cost. A simple procedure for determining the optimum HVAC system for modular houses, based on BLAST computer simulations, was developed and results given for three typical modular houses sizes in 34 different northeast locations.

Findings show the integration of HVAC system design and installation into the modular manufacturing process will benefit both the modular manufacturer and the housing consumer. Forced-air distribution systems must, however, be installed inside conditioned space and not within attic areas. A procedure for connecting ductwork between first and second story modules was created and tested. An easy to use method devised for this study will help determine which HVAC system is more cost effective in a given locale. Results are based upon the HVAC system first cost estimates, season efficiency, local utility rates, and house size.