NextGen Final Report
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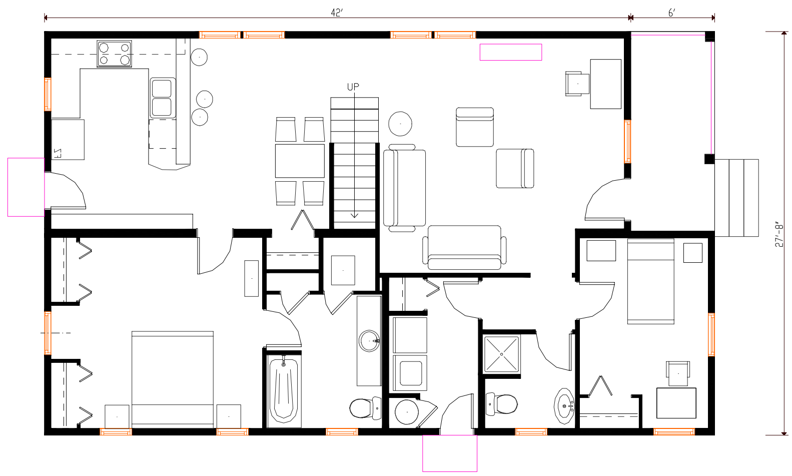
6/13/2000

Executive Summary

By its retail price and final installed cost, the NextGen HUD-Code house demonstrates it is affordable to a broad spectrum of potential buyers. Its choice of energy-efficient materials, and the results of energy software simulations and on-site energy testing, show that this is a very efficient house that will have a reduced demand on environmental resources over its lifetime.



Introduction

Location: Danbury, CT

Project type: Single-family detached manufactured housing

House profile:1344 sf footprint manufactured house with enclosed porch on first floor, one site- finished room and one storage room on second floor.

Team profile: HUD-Code manufacturer– New Era Building Systems, Strattanville, PA
Owner/Developer– Danbury Housing Authority, Danbury, CT
Architect/Project manager–Steven Winter Associates, Norwalk, CT;
Installer– Jensen's Residential Communities, Southington, CT

Partners in the Project: Owens Corning; Simonton Windows; GE Appliances; Stanley Doors Inc.; LaSalle- Bristol building products; Tamarack Technologies; Capri Bath Products; Apollo Hydroheat and Fabwell Industries.

PATH Technologies incorporated into the project: Blower door testing, engineered wood products, flexible gas piping, horizontal axis washing machine, HVAC within-the-envelope, modular Air Handler Hot water coil, tankless water heater, two story manufactured home and ventilation control systems.

PATH GOALS

The finished cost of the NextGen house was about $100,000 <u>not including land.</u> Danbury city lots of this type run $20,000 to $40,000 depending on location. New home prices of this size sell for over $200,000 and even in a down market would sell for about $175,000. The buyer of this house would save a minimum of $35,000 or 20%, which meets the affordability criteria, and probably more. Savings due to energy efficiencies will amount to an estimated $180 per year, and not having to hire painters every 5-10 years (it is vinyl sided) will save many thousands of dollars over the 30-year life expectancy of the siding.

The energy efficiency of this house exceeds Energy Star requirements by almost 18%.

Energy Star standards require at least 30 % savings over conventional Model Energy Code. Based on the REMDesign (see appendix) data, the house will approach a 50% savings over Model Energy Code. Recycled materials were not chosen for this house because of the added first cost to the buyer. Recycled carpeting and polymer decking would have been considered had the budget permitted.

The durability of this house should be high based on the standards of construction utilized– 2x6 stud exterior walls, 2x4 interior walls, 2x4 and 2x6 lumber hinged roof trusses, composite steel and wood floor system, and a poured-in-place concrete foundation wall. These are features found in better constructed residence. Compared to minimum standard HUD-Code houses, the NextGen exceeds the structural standards significantly. In terms of maintenance, the house is constructed to reduce maintenance.

Building this house primarily in a factory leads to an increased chance for accidents relative to site building, according to a 1989 Bureau of Labor Statistics survey. However, there were no documented cases of accidents occurring in the factory during the building of this house and there was a case of work loss in the field by a member of the installation crew who suffered short term disability from back problems.

Case Study

Pre-Construction: The house design was derived from earlier sketches first published in the *Next Generation of Manufactured Housing, Design Phase* book produced by HUD's Office of Policy Development and Research. A steep roof Cape style design was chosen because of the positive associations the house has as a classic "American" house and the pleasing proportion of roof size to house mass. The process began by choosing a double-wide house of moderate size that would be easily accommodated by standard factory assembly processes. A two-bedroom, 1200-1300 sf plan was selected as a good size for the main floor. The completion of additional rooms on the second floor was left to be resolved on site. (No second floor finishes were contemplated for the factory process and approval from the DAPIA was based on the condition that no required factory installations were to be done in the field by the manufacturer. The owner chose to complete the second floor as a post installation site improvement.) The choice of design was done through a series of presentations to the manufacturer which selected one that would that would best meet their market needs and follow general principles of good design. Engineering was not a factory issue because the manufacturer had experience with modular cape style houses and had to modify very little to get the house approved under the HUD-Code. Conventional structural engineering services were employed to design the foundation on the moderately sloping site in Danbury.

Heating equipment and duct sizes were determined using the Air Conditioning Contractors of America Manual J and Manual D procedures. The heating load for the home at a 2 F design temperature is 22,010 Btuh. More detailed reports are provided in the Appendix.

The duct design for this home is unusual for manufactured homes. Rather than using the typical downflow air handling unit with below floor supply plenums, a crossover duct, and floor registers, this home's duct system is located entirely within the conditioned space. An upflow air handling unit is used to supply a ceiling plenum within a dropped soffit which runs down the center of the home. High supply registers throw warm air from the interior walls towards the exterior walls. A diagram of the air distribution system is included at the end of this report.

The low space-heating requirements and the desire to have the air handler located in the center of the conditioned space suggested a hydro-air type of system. A direct-vent water heater which supplies the heat source for the air handler is located on an outside wall and feeds the centrally located hydronic coil in the air-handling unit as well as providing domestic hot water.

<u>Product Availability</u>

The availability of most products was not an issue. There were some shipping delays and errors that occurred that slowed the project down, but for the most part, these were not unique to this type of work. They included windows that were shipped and received at the factory only to find out that they were labeled incorrectly. This problem led to a change during the factory construction process, but did not slow the schedule in any way.

After a review of available HUD-Code certified water heaters from several manufacturers, it was determined that no HUD-Code certified water heater had sufficient output capacity to meet the combined space and domestic hot water heating demands. The burner input for 40-gallon direct vent water heaters for manufactured homes is 30,000 to 32,000 Btuh. This is in contrast to ratings of 38,000 to 40,000 Btuh for conventional home water heaters. The lower capacity would not handle a morning pick-up space heating demand that is coincident with hot water demand.

This finding moved the design from a domestic water heater-based system to a boiler-based system. Unfortunately, none of the major U.S. boiler manufacturers have a product that is HUD-Code certified for manufactured homes. An Italian-made COSMOGas system was the only product that met the design needs and had been approved for use in HUD-Code or manufactured homes. This is a wall-mounted combination boiler and instantaneous domestic water heater. The smallest unit has a space heating capacity of 73,000 Btuh at an 84% AFUE and the instantaneous domestic water heater is capable of producing 2 gallons per minute at a 75 F temperature rise.

Local Codes and Approvals

This house was approved for construction in Danbury and had to demonstrate it met or exceeded current BOCA and Connecticut building and life safety standards. The job did not cause special delays or difficulties because it was a manufactured house. The Danbury plan reviewer did ask for a copy of the installation manual to include with the permit application. In virtually all respects, this project was treated the same as any other new house permit application would be treated.

Contracts and Subcontracts

The prime contractor for this house was the manufacturer who also provided shipping. Installation was handled by Jensen's which was hired by Danbury Housing to install the house on the foundation and complete the gable ends after installation. The Housing Authority contracted with local carpenters and site contractors to complete the hook-ups and finishing, inside and install landscaping, decks etc. outside.

CONSTRUCTION

Estimates and Costs:

Initial estimates for the cost of the units were first generated by New Era based on similar sized Capes that sell for about $52,000. Once the list of sponsors products was finalized, New Era revised their price to reflect their actual product costs and the price was reduced by about $10,000 to $42,000. This price quotation became the invoiced amount that was paid by the Danbury Housing Authority. Bids for installation were too high because they included site finishing processes that were not seen as significant by general construction experience. This proved true. The installation cost by the "set" crew, of $5,200, enabled the Housing Authority to chose its finishing contractor to do the balance of the work and better control costs. Grading, excavating, paving, and similar tasks were done on a cost-plus basis. The actual project cost was about $95,000, although extra upstairs finishes and landscaping features that the Housing Authority wanted pushed the final price to about $100,000.

Complexity of installation:

The installation of the two sections of the house went smoothly and was completed in one day. Full day crane services made it look easy but much could have gone wrong. This is one area where professionals with experience in this type of product are well worth the roughly $5,200 cost which also included crane charges. There were no problems with either the foundation or the unit. Installation manuals are provided to the home owner, but they would be inadequate to guide a first time installer. The only problem in the installation process was the delay that resulted from the crane being unavailable when the units were finally shipped which resulted from factory delays in shipping.

Project Schedule/ Cycle Time

The project took very little time once permits and approvals were in place. The first approval phase took place with the manufacturer and took over 6 months largely because this was the first time a two story Cape, HUD-Code house had ever been done. After a fire forced the first manufacturer to withdraw, New Era agreed to build the SWA design and already had modular experience building them. They were ready to schedule production within 2 weeks of initial contact. Finalizing an agreement between New Era and Danbury Housing Authority expended a total of six to eight weeks mostly due to caution and the uncertainty that the Housing Authority had with this kind of building. Getting a buildable lot and a building permit proved another lengthy phase– about 6 months in all due mostly to bureaucratic delays. Six weeks after approvals the site and foundation were ready for the units. Factory construction took about a week and delivery another week, though this could have been shortened with better factory coordination. Installation took one day, and final finishing took only about 5 weeks in labor time. However, due to inclement winter weather and scheduling looseness with subcontractors, it took almost 4 more months after setting before the house was ready for occupancy.

Systems Integration

The most challenging system for the factory to integrate was building the supply ducts and installing them into a ceiling soffit. Built out of ductboard, these ducts are normally installed in the floor structure where a lack of craftsmanship can go unseen and unnoticed. Because the manufacturer prepared all the shop drawings for production and did not allow time for SWA to review them before construction, some errors were not corrected until construction began. The most serious problem encountered during factory construction was with the water heater which turned out to be not HUD-Code approved. Because a water heating device was being used for heating and domestic water, conventional HUD-Code approved heaters were not large enough to satisfy the demand. The sealed combustion Cosmo unit was suggested by the factory and the problem was solved. There are some reservations about its capability to supply enough hot water during high heating periods in winter because the instantaneous heater's output is less than 2.5 gpm. The domestic water, septic system, and electrical service entrance all encountered field problems or delays but they were not the cause of the manufacturing process, per se, just usual construction problems. The placing of the house on the foundation was accomplished without special problems or any more

difficulty than what is normal with site building (shimming, squaring, aligning walls, etc.)

<u>Construction Waste</u>
Construction waste is plant managed and waste wood is recycled to the community. The minimal site waste generated during finishing and final painting was hauled off-site to a transfer station.

POST CONSTRUCTION

REMDesign (version 9.03) energy simulation software was used to evaluate the energy efficiency of the home. This software tool was also used to confirm that the home qualified for the Energy Star rating with a home energy rating of 89.5. The REMDesign Building File Report for the NextGen home is provided in the Appendix.

A natural infiltration rate of 0.35 air changes per hour was used based upon blower door test results. Duct leakage based upon the blower door subtraction method was found to be only 49 cfm at 25 Pascals because all of the ducts are essentially within the conditioned space. The duct leakage represents 6% of the system design air flow.

The energy efficiency of the prototype home was compared to a home built to New Era's standard specifications as well as a home built to comply with the 1995 Model Energy Code. The NextGen home consumes 26 % less energy for space and water heating than the manufacturer's standard home.

<u>Conclusion</u>
Builder/owner reaction to this project has been very favorable as has been newspaper and magazine coverage. They believe they got better quality and lower cost than they were expecting to receive or could have gotten in the stick-built marketplace. Some of this may be due to the savings that were passed on to them from project sponsors. Based on visitor reactions, the house would still be seen very positively even without the$10,000 cost saving

that was passed on to them from New Era (via sponsor donations). Project manager David Ghio of the Danbury Housing Authority has said he would like to build more of these units. Strong buyer interest has been expressed by local private investors in Danbury, Washington Depot, CT and from several Housing Authorities in the Hudson Valley of New York State and from several other regions of the country.

Relative Energy Efficiency Chart