PATH
PARTNERSHIP FOR ADVANCING TECHNOLOGY IN HOUSING

U.S. DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT

Nothing Lacking from the 'Not So Big'
NSBSH in Orlando, Florida

TECHNOLOGY HIGHLIGHTS:

No Longer at Odds: Changing the Perception of *Form Following Function*

In 1896, architect Louis Henri Sullivan said, "Form ever follows function." Over the years this has come to signify a greater importance of function over form, but it actually only articulates that the two are intricately intertwined and inseparable. Homes that are built nowadays are typically done by various trades that don't interact unless necessary. The *Not So Big Showhouse* is form meeting function in an elegant and environmentally conscious way.

Sarah Susanka's Not So Big Showhouse debuted for the 2005 International Builders Show in Orlando.

This project demonstrates the design concepts of architect and author Sarah Susanka, while incorporating the principles of energy efficiency and sustainability found in the Sustainable Building Industry Council's (SBIC) *Green Building Guidelines* and strategies developed in Building America research. The house was built by Bradford Building Corp. with technical help from building science consultant Steve Easley and builder Ron Jones. As a Building America team leader, Steven Winter Associates, Inc. (SWA) provided the HVAC design. By maintaining a continuous dialogue throughout the design and build process to ensure that all the various trades, from the architect, to the builder, to the mechanical systems designer, and on through to the interior designer, were able to design a space that minimizes energy usage while still accentuating the elegance and comfort desired by today's homeowners.

Located in Orlando in the popular East Orange County Corridor, NorthLake Park at Lake Nona is part of a premier master planned community designed to have a Charleston-style feel, which includes features such as attractive parks, thoughtful landscaping, and pedestrian-friendly "front porch" architecture. While maintaining a showcase quality home, this 'Not So Big' home also incorporates both active and passive solar design, high-efficiency mechanical equipment, and comfort control strategies all into a cozy 2,700 square foot two-story slab-on-grade home.

"Many of the new products let us build faster and better. I am considering changing my whole operation to include a lot of these new techniques."
- Cameron Bradford

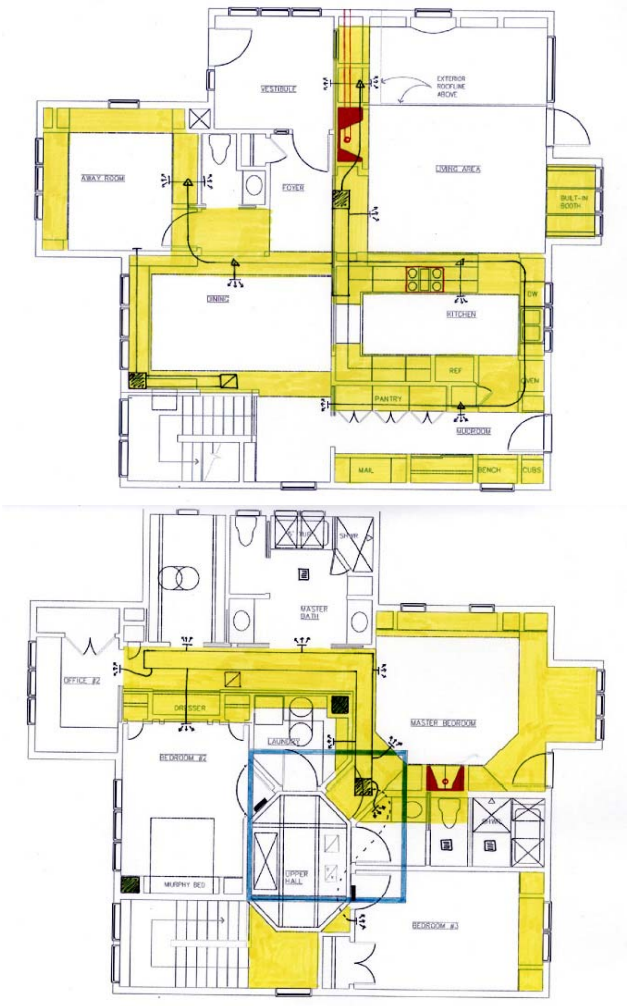
PATH Technologies Take Form

It is the goal of the US Department of Housing and Urban Development's Partnership for Advanced Technology in Housing (PATH) to accelerate the development and use of technologies that radically improve the quality, durability, energy efficiency, environmental performance, and affordability of America's housing market. As the HVAC designers, SWA intended to incorporate numerous PATH technologies, both mature and emerging. The primary focus of SWA was to locate the HVAC Equipment & Duct Installation Within Conditioned Space.

HVAC equipment and duct installation within conditioned space

Why do we allow ductwork to only be insulated up to R-6 when we typically see wall and ceiling insulation levels of R-13+ and R-30+, respectively. Ducts outside the building envelope are notorious leakage pathways, drawing in outside air and/or bleeding air that has been heated or cooled. As much as 20-35% of the energy supplied can be lost through a combination of air leakage and conduction when ducts are located in unconditioned spaces. This can also be a concern for indoor air quality, as these leakage pathways could pull in pollutants, irritants, or moisture from crawl spaces and attics.

To keep the air handlers and ductwork within conditioned space, the whole building construction and materials had to worked out during the initial design stages. Even with extensive coordination, situations arose during the building process that simply could not be avoided and the design had to be reworked. Rather than basing the HVAC equipment sizing on common "rules-of-thumb" methods, the true design load requirements of the home were calculated using computer software. The Wrightsoft residential design tool was used to perform Manual J and D calculations (HVAC Sizing Practice) to ensure that the equipment and ductwork would be properly sized system. Oversized equipment results in larger ductwork and causes the system to cycle more frequently. Shorter run times reduce the effective latent capacity, as condensate does not have sufficient time to drain and will be evaporated back into the air stream during the fan-only stage at the end of the cycle.



Finding places to hide ductwork within the conditioned space often poses a challenge. In this home, SWA took advantage of architectural soffits which Sarah Susanka commonly uses as a design element in her homes. This was a perfect case of form and

function. By running the ductwork primary through the soffits and the trim-able open-web floor trusses, few changes to the building layout were necessary. A corner of the laundry room was boxed out to allow for a supply trunk to the first floor, but is not noticeable due to the layout of the counter space in the room. In this manner, all the ductwork was able to be integrated into the conditioned space with as minimal a footprint as possible.

Photos courtesy of FSEC

To allow for a more compact duct design and improved system balance, central return ducts were positioned on each floor. The return ducts required a generous amount of space (to minimize velocities and reduce noise). To accomplish this, the depth of some closets/bookshelves were reduced to hide the chases behind them. This required some additional effort for the builder. While framing the rear of the cubbies that flank the Murphy bed in the second bedroom, a problem arose where the dining room central return duct was intended to go through the Insulspan ceiling panel into the attic. There was a roof truss bisecting the return and limiting the duct's width by 3". The only solution that was apparent on site was to convert these two ducts to 9" flex ducts, rather than the original rectangular ductboard returns.

The mechanical room in the attic is insulated so the equipment cabinets and connecting ductwork are considered to be in conditioned space. In a few instances, ductwork serving the second floor was run through the attic, but for these cases, the ductwork was intended to be foamed over with one inch of a closed-cell polyurethane to provide a net R-value of ~13, which would better simulate those ducts being in the conditioned space. This polyurethane would prevent moisture problems by acting as an air barrier between the attic and the ducts, thereby inhibiting humid attic air from coming in contact with the duct wrap. In addition, polyurethane is an excellent insulator (R-7 per inch at an applied density of 2 lb/ft^3). Thus its outside surface will be too warm to cause the condensation of any humid attic air. Also, one inch of 2 lb/ft^3 polyurethane is a vapor barrier, so it will prevent moisture diffusion between the attic and the ducts.

The HVAC contractor placed a few more runs in the attic than were initially anticipated which wouldn't be a concern if they were all foamed over. Unfortunately this hasn't happened as of yet, so these ducts only have an R-value of 6. As in any project, things change between the original design and the as-built home. This is simply another example of the need for strong quality control and contractor education.

"Builders and consumers are realizing that by reducing a home's footprint through better design, they can put the savings into details that are high-quality, energy-efficient and environmentally sound."
- Sarah Susanka

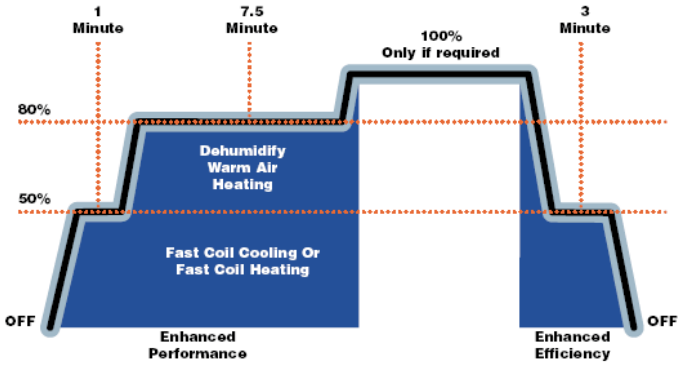
By maintaining most of the HVAC equipment and ductwork within the conditioned space, duct leakage to the outside should be minimal, if not negligible, especially due to the construction materials used, which allow for a tighter building envelope. This not only saves energy but improves comfort and minimizes the need for over-sizing systems and ductwork. To further minimize duct leakage, all duct connections were sealed with mastics to help prevent dust, soil and other pollutants from entering the system.

Central Air Purification /Ventilation/ Dehumidification Systems

With such a high profile showhouse, comfort was a high priority. The house was separated into two zones, upstairs and downstairs, to try to eliminate the common problem of air stratification and uncomfortable conditions on the second floor during the summer months. With the high traffic rate of visitors to the house, ventilation, air purification, and dehumidification were a concern. Before having to utilize a dedicated whole-house system, the design team looked into high performance cooling equipment that could meet these loads. From the Manual J calculations, a total cooling capacity of ~2.5 tons was determined to be sufficient for this house, but the HVAC contractor wasn't comfortable with this based on his years of experience. Working with HVAC contractors across the

country, SWA often faces resistance to change from the HVAC contractors. Often, a balance needs to be found to ensure the HVAC contractor that there won't be any capacity issues. Even those contractors who understand the benefits of 'right-sizing' have hesitated until it can be demonstrated. As the people responsible for call backs and homeowner complaints, the contractors are often fearful of eliminating safety factors commonly built into their system design.

Trane's XL16i two-stage heat pumps were installed due to their exceptional efficiency rating (17 SEER / 10.55 HSPF) and Comfort-R control. This allows the heat pumps to run primarily on the low-stage, while still having the capacity to meet higher loads if need be. When matched with a variable speed air handler, the heat pumps provide greater latent capacity by having lower air flow across the coil at start up which cools the coil more rapidly than standard systems.



To deal with air purification, Trane's 'Perfect Fit' Electronic Air Cleaners were installed on each air handler to filter out 95% of airbourne particles.

If this were just a typical home, these efforts would be sufficient to maintain the comfort throughout the year. Since this is a showhouse, there are times when there are large gatherings of people in the house. This provides a large internal load that the system would not likely be able to handle in a short period of time. For this reason, a whole-house dehumidifier was integrated into the HVAC system design. Though this system has not been installed as of yet, the house was laid out so that this can be dropped in at a later date. Thermastor's Ultra-Aire APD 100V was specified as the whole-house dehumidifier to be installed to provide additional dehumidification capacity. This system was chosen over other competing manufacturers because its controls are independent of the air handler. Instead of providing an outdoor air intake ducted to the return plenum, the outdoor air intake would be ducted to the dehumidifier. With an 8" dedicated return on the second floor and a 6" outdoor intake, the system would be connected via an 8" duct to the return plenum of the first floor to promote circulation of air throughout the house. Thermastor recommends ducting from the dehumidifier back to the system in the supply plenum, but as the process not only removes moisture but adds heat to the outgoing air, the Florida Solar Energy Center (FSEC) recommended ductting back to the return so that the mixed air can be cooled by the heat pump, if needed.

Appropriate ventilation strategies vary depending on climate. In a humid climate like Florida, it is preferable to slightly pressurize the house when ventilating. This prevents humid outdoor air from entering wall cavities and condensing. Not only would the Ultra-Aire provide additional latent capacity but it has a ventilation timer that can be connected to a mechanical damper on the outdoor air duct to provide the desired air changes per

hour. The dehumidifier fan moves around 220 cfm of air, with approximately 75 cfm coming from the outdoor intake.

Local exhaust was provided by Fantech vents installed in each bathroom. Removing moist air from the bathrooms decreases potential problems from mold and mildew. The common bath has a standard bath vent while the master bath has a multi-port in-line fan. This system uses a single fan to draw exhaust from several locations. In this case, it was the main shower area and the commode. The fan was located in the attic to reduce the fan noise that might impact the homeowner. Fantech's FD60EM push button timer was used to control fan operation for a set period. This provides enhanced moisture removal, unlike an on/off switch, which users typically switch off prematurely when they leave the bathroom.

Photo courtesy of FSEC

Solar Water Heaters / Tankless Water Heaters

The *Not So Big Showhouse* has a solar thermal hot water system with a tankless water heater as back-up. The active indirect drainback solar thermal system consists of 64 ft² of solar collectors, a thermosyphon heat exchanger, and an 80 gallon storage tank. This system will reduce hot water heating by taking advantage of available free solar energy. Bosch's tankless water heater provides domestic hot water on demand. This propane gas-fired equipment (Model GWH 635 ESO Pro) will be able to meet the hot water heating loads of the *Not So Big Showhouse,* even without the solar thermal system. With an efficiency rating of 87%, this system offers a substantial improvement in water-heating efficiency as compared to standard storage type water heaters by eliminating storage tank losses. In addition, the modulating capacity allows for a seemingly endless supply of hot water.

Trim-able Open Web Floor Truss

Photo courtesy of FSEC

Open web trusses were utilized to simplify the duct layout coordination and as they are trim-able, they are an 'off-the-shelf' product. In addition, the open webs eliminated the need for the mechanical contractor and other trades to cut through the joists, which could potentially compromise the structural system. It also reduced installation time, aided in trade coordination, and minimized the amount of waste. The ability to use 'off-the-shelf' floor trusses versus having to order custom floor trusses was an added benefit which helped the construction move along.

Structural Insulated Panels / Panelized Wall and Roof Systems

SIP panels provide an exceptional thermal barrier with an R-value of 24 compared to the regional standard practice of R-13 for framed construction. The *Not So Big Showhouse* was built to withstand Category 5 hurricane winds. With punishing weather conditions such as those that battered Florida three times in last year's unusually harsh hurricane season, it was a goal of the design team to demonstrate how SIPs can be used to create structures that hold up to gale-force winds. In addition to the strength of the wall system, it also allows for a tighter building envelope and can be assembled quicker than standard frame construction, thereby reducing labor costs. The contractors still had some problems with running wiring and plumbing through the SIPs to the exterior and attic, but these issues weren't significant compared to the benefits.

Programmable Thermostats / Humidity-Sensing Control Device

Honeywell's Trane branded Vision Pro Touch-screen Thermidistats are used to control the indoor conditions. These units not only control the mechanical systems based on temperature, but will provide supplemental dehumidification control if the latent load is too large for the whole-house dehumidifier, which has its own humidity control device. In addition, the thermidistats let homeowners save energy by allowing them schedule set-back/setup temperatures for when the house is not typically occupied.

Additional Technologies

The show house is scheduled to be commissioned by the Florida Solar Energy Center (FSEC). In addition to a monitoring system to log the HVAC performance and indoor conditions, FSEC will be performing Blower Door and Duct Blaster Testing to quantify the building envelope tightness and duct leakage to the exterior, respectively. An initial duct leakage test was performed during the rough ductwork installation to allow for sealing, if needed, before the walls were closed in. With the ductwork sealed, each system (upstairs and downstairs) had a duct leakage of less than 3% of the rated air handler flow.

"…to put new tools into my tool belt. A lot of these new building materials and techniques will be standard in a few years. I want to keep ahead of the curve." - Cameron Bradford

Low-E Glass and Spectrally Selective Glazing

Low-E coated windows help reduce cooling loads by minimizing the solar heat gain that enters the conditioned space. In the winter, these windows will help trap the heat in the conditioned space. Many times the energy savings from low-e windows and possible reduction in HVAC equipment sizing will pay for the additional cost of the higher efficiency glazing.

Fiber-Cement Siding

Fiber-cement siding provides the look of wood, but is cheaper and requires less maintenance, since it wears better (holds paint longer) than wood siding. Relative to other siding materials, it is stronger and more resistant to the elements. With a lower initial cost and reduced maintenance (costs compared to wood), fiber-cement siding also has the benefits of having a class 1 fire rating, will not rot, and is impervious to wood-boring insects, such as termites.

Tubular Skylights

Solar tubes were utilized to provide daylighting into the core of the building (laundry room and WIC) where sunlight typically wouldn't reach. Not only will this allow for the conservation of electrical lighting, it provides a more inviting/open feeling to typically dark spaces. In addition to the solar tubes, skylights with electrochromic glass were installed in the master bathroom. These windows can be tinted to control the light penetration into the bathroom space.

Structured Wiring Systems

A Square D home automation system was installed into the *Not So Big Showhouse* to provide lighting, security, and audio control of the house from a standard internet browser that a homeowner can log onto. This system also has the option of incorporating the thermostat control into the automation system. Due to the desire for more humidity control, we chose to go with an independent thermidistat instead, but it would have been possible if the whole-house dehumidifier were installed.

Photo courtesy of FSEC

Prefabricated Storm Shelter

Located in Florida where hurricanes can be experienced seasonally, it was decided that the *Not So Big Showhouse* should be designed with all appropriate safety precautions and provisions. Along with the SIP construction, a storm shelter was installed in the pool bath area. This prefabricated storm shelter was quick to install and, with its Kevlar reinforcement, it will provide added safety and assurance to the homeowner. The nice feature of this DuPont storm shelter is that it can be easily integrated into homes, as both the interior and exterior surfaces can be finished to match the homes décor. In addition, the room is vented and can be setup with an electrical connection.

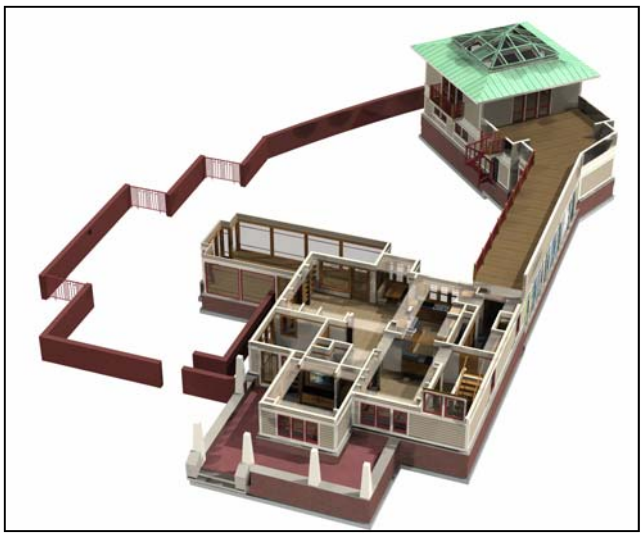
Some other technologies that can be found in the *Not So Big Showhouse* are:

- photovoltaic panels for on-site electrical generation (grid-tied),

- an energy-efficient lighting package,
- flexible plumbing that integrates the fire sprinklers with the cold water plumbing system (aluminum-plastic composite water piping),
- an Energy Star high-efficiency refrigerator,
- low-flow plumbing fixtures,
- sun-blocking shutters to help keep heat out,
- and a horizontal axis clothes washer.

Conclusion

The *Not So Big Showhouse* is a good example of how these technologies can be incorporated into homes of all sizes and budgets. During a walk-through of the home, it is easy to miss many of the key features of the home, but that is truly the beauty of the design. Thru forethought and careful planning, you can achieve the energy and performance benefits without sacrificing aesthetics. The *Not So Big Showhouse* demonstrates that form and function don't have to be balanced against each other, but rather can be integrated into a stylish and energy-efficient design.



Product Link and Additional Information:

Heat Pump: Two-stage heat pump, Trane XL16i (SEER 16/HSPF 8.65)
Air Handler: Variable-speed 'Air-Tite' air handler, Trane 4TEE3F31A
Air Filtration: 'Perfect Fit' electronic air cleaners, Trane TFE215A9AH1
Dehumidifier: Thermastor whole-house dehumidifier, Ultra-Aire APD 100V
Hot Water: Solar Energy Inc.
Hot Water Backup: Bosch 635 ESO propane tankless water heater
Photovoltaic: BP Solar and Square D
Structural Insulated Panels: 6" Insulspan (R-24)
Ventilation Bathroom Fan + Timer: Fantech FR125 fan + FD60EM push button timer
Trim-able Open Web Floor Truss: OpenJoist 2000
Windows: Aluminum–clad wood Marvin Windows 3/4" IG LoE II Argon (U-0.32, SHGC-0.30)
Fiber-cement Siding: James Hardie
Skylights: Velux and Sage Electrochromics
Storm Shelter: DuPont StormRoom with Kevlar
Structured Wiring System: Square D
Metal Roof: Englert with BASF reflective coating
Appliances: Electrolux and Whirlpool
Lighting: Juno and TCP

For a complete list of products in the *Not So Big Showhouse* go to the sponsor spotlight.

Architect: Sarah Susanka
Design Consultants: Steve Easley and Ron Jones
Builder: Cameron Bradford, Bradford Construction
Building America team members: Steven Winter Associates, Florida Solar Energy Center, and Building Science Corporation

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