Hot, Humid Climate Region
40+% Energy Savings

12020 Desoto Drive

North Port, FL

Developer/Owner:	Dwell Green, Inc.
Location:	North Port, Florida
Building Type:	Single Family Detached
Building Size:	1,408 sq ft 3 bedrooms, 2 baths
Price:	$189,000
Status:	1 completed
SWA Contact:	Srikanth Puttagunta

(credit to Harold Bubil, Sarasota Herald-Tribune)

"This house reflects affordable living at its highest. It's really strong, it's super energy-efficient, and it affords a high quality of life. Your house should be working for you, rather than you working for your house."
- John Lambie, quote from Sarasota Herald-Tribune

In 2006, CARB partnered with Home Front, Inc. (manufacturer of panelized homes based in Venice, Florida), John Lambie of DwellGreen Inc. (developer), Osborn Sharp Architects (designer), and Brian Bishop (contractor) to design this home. Home Front's goal is to provide efficient, affordable homes to builders and homeowners. They accomplish this by manufacturing a concrete-skinned structural insulated panel package, which is offered to builders as a complete home "kit". Home Front partnered with CARB to improve the performance of the "kit" and include items such as energy-efficient mechanical systems, HVAC, and solar water heating. A model prototype home was constructed in North Port, FL. For this prototype, Home Front also acted as the builder and CARB provided design assistance necessary to achieve the Building America target of 40% total energy savings.

The showcase prototype home built at 12020 DeSoto Drive is a 1,408 square foot single-story detached home with 3 bedrooms and 2 baths. The glass to floor area ratio of this home is approximately 23%. This high amount of glazing includes both windows and French doors. The French doors span the rear elevation (west orientation) of the home but are covered with a wide overhang. To achieve the desired reduction in energy use, CARB recommended low-emissivity windows; tightly sealed envelope; Freus air conditioner; ducts in unvented attic to achieve negligible duct leakage to outside; and ENERGY STAR fixtures and appliances.

Energy Efficient Features

- Aluminum frame IG low-e windows (U-0.45, SHGC-0.39)
- 6" aluminum faced fiber-cement SIPs (R-25) for roof deck
- Cool roof white membrane
- 4.5" fiber-cement SIPs (R-16) for exterior walls
- Uninsulated slab-on-grade foundation
- Freus water-cooled condenser unit for air conditioning (16 SEER)
- Enhanced dehumidification heat pipe evaporative coil
- 10kW electric resistance heating
- 72% compact fluorescent lighting
- Energy Star® Appliances
- ASHRAE 62.2 compliant supply-only ventilation
- Mastic-sealed ductwork
- 32 sq ft solar thermal system (w/ PV pump) and electric tank backup (0.92 EF)

Green Building Features

- Paperless drywall
- Water-saver faucets and showerheads
- Dual-flush toilets
- Low-VOC paints and caulks
- Native drought-resistant landscaping

Certifications

- Exceeds 1999 Energy Star® Homes Standards
- FGBC's Green Home Standard (226 pts out of 300)

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Cost - Neutrality

12020 Desoto Drive

North Port, FL

The long-term goal of the Building America program is to develop cost-effective systems for homes that can produce as much energy as they use—a zero energy home. As teams increase the savings targets towards zero energy homes, maintaining cost neutrality is a key component. The added cost of higher efficiency technologies can typically be offset by reducing unnecessary waste in other systems or through utility bill savings. The annual mortgage payment was calculated based on a 30 year mortgage with a 7% fixed interest rate. At that time, the cost neutrality was not positive, but as utility rates continue to increase, the cash flow will turn positive.

12020 DeSoto Drive Prototype	Incremental Cost
Structure:	
Welded steel wind frame	-
4.5" fiber-cement SIP walls	-
6" alum-faced SIP roof	-
Welded FiberTite EPA Cool Roof	$1,800
Moisture Resistance:	
DensArmor Plus GP Paperless Drywall	$900
Steel framing	-
Windows:	
Aluminum Low-e insulated ESP with solarban 60	$1,200
HVAC:	
Freus (1.5 ton)	$1,500
Dehumidification Z-coil	$500
Wild return plenum	-
Energy Star Appliances:	$200
Lighting:	
T8 and CFLs	$200
Water Conservation:	
Low flow fixtures	-
Dual flush toilets	$100
Native landscape	-
Solar Thermal DHW System:	$2,200
Total Cost of Improvements:	$8,600
Estimated Annual Energy Savings:	$682
Annual Mortgage Payment (30 year, 7% interest rate):	($693)
Net Cash Flow:	($11)

Testing & Evaluation

CARB performed short-term monitoring to quantify the performance of the air conditioning system. Additional testing included a blower door test to quantify the air infiltration through the building envelope, a duct blaster test to quantify the duct leakage of the HVAC distribution system, and balometer measurements to verify room airflow distribution.

The blower door testing showed 604 cfm @ 50 Pascals. This is equivalent to an annual natural infiltration rate of 0.09 air changes per hour (ACH_{nat}). With similar new construction projects, CARB typically sees natural ACH_{nat} in the 0.15 – 0.50 range depending on the construction type (CMU block or stick framing). This prototype home was very tight due to the exterior walls and roof being SIPs construction.

The duct blaster test showed a total supply duct leakage of 132 cfm. If 600 cfm is assumed for a 1.5 ton unit (400 cfm/ton), it would mean that there is almost 22% supply duct leakage in the distribution system. Though the duct leakage to the outside was negligible (no energy penalty), there is the potential for comfort issues.

Small amounts of duct leakage can occur at many places, such as the flex duct to boot/junction box connection, the supply register to ceiling connection, and at the air handler unit. Though each leak is small, they add up over the entire distribution system.

A low flow balometer was used to determine the airflow rates at each supply register. The total supply flow rate to the house was 1,143 cfm. A flow plate was also used to confirm the air flow rate, which came in at 1,188 cfm. This is too high for a 1.5 ton system. Airflow across the evaporator coil was twice what it should be to have the air conditioning system properly cooling and controlling humidity. This prevents the evaporative coil from providing sufficient temperature reduction or moisture removal.

The air handler could not be adjusted to reduce the fan speed, so a new motor had to be installed by the HVAC contractor. It is unclear as to why the improper air handler was initially installed but it was replaced. The system was rebalanced after the proper fan motor was installed.

Building Specifications

12020 Desoto Drive

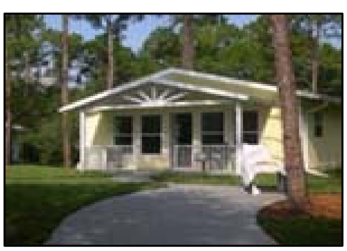
North Port, FL

The Home Front "Kit"

Home Front's structural insulated panel (SIP) package includes:

- Complete building plans, engineering data required for permitting, and assembly instructions. Included are panel layout drawings, exterior electrical wire pull diagrams, foundation details, and floor track details.
- Steel post and beam moment frames, complete with concrete embeds and all fasteners.
- All metal connections including slab tracks, Z flashing, corner splines, regular splines, ridge cap, and gable roof trim.
- R-16 concrete-skinned SIP wall panels, cut to shape with wiring chases and all windows and doors installed.
- Standard windows have aluminum frames with clear, double-pane glazing (low-e option)
- Sliding glass door assemblies and glass blocks,
- All required fasteners, including: anchor bolts, stainless steel self taping screws for panels, matching color TEK fasteners for facia and trim, and roof panel bolts. All fasteners are stainless steel with the exception of anchor bolts and facia fasteners.
- All required waterproofing materials including caulks and peel & seal roofing tapes.
- Temporary support angles to stabilize the structure during assembly.

Home Front walls are fiber-cement faced structural insulated panels (SIPs). The 4" expanded polystyrene (EPS) core provides R-16 wall insulation, and the six-inch, aluminum-faced roof SIPs provide R-25. Though the thermal resistance of the building envelope is not as critical in this climate region due to the smaller temperature differentials between ambient and indoor conditions, the SIPs provide superior strength and hurricane resistance than traditional construction.



Before Hurricane Charley

After Hurricane Charley

Solar Water Heating

A major energy improvement for the prototype was to be the inclusion of a solar water heating system. To be a viable part of the Home Front home "kit" package, a system had to be low-cost, simple to install, reliable, and effective. A thermosyphon system was pursued, because of the higher overall system efficiency compared to ICS systems.

Unlike most commercially available thermosyphon systems, which have storage tanks on the roof, the Home Front collector was to be plumbed through the roof panels (via engineered plumbing chases) to a tank located inside the home near the roof ridge in the garage. The system would be a direct system, i.e. potable water is the collection medium. An electric element in the storage tank would provide auxiliary water heating.

Home Front manufactured a ¼-scale mock-up to test the thermosyphoning capability. Results were promising. Unfortunately, HomeFront wasn't able to incorporate this into the prototype home due to time restraints. A solar thermal system was still installed but rather than being a thermosyphon, it utilized a 10W Yingli solar panel connected to a pump to move water from the collector to a 50 gal GE Smartwater electric water heater located against the garage wall and back to the collector.

Cool Roof

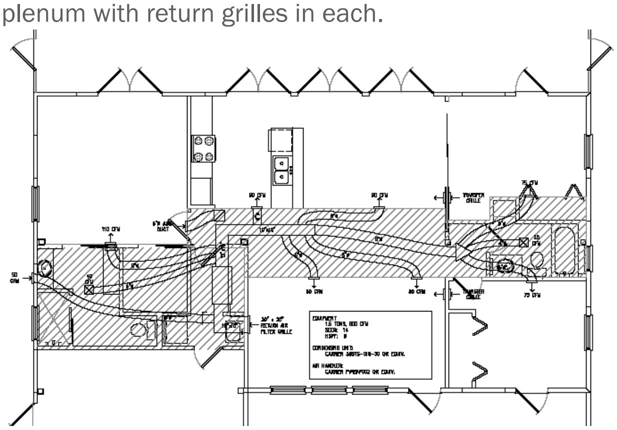
Conventional roof surfaces heat up to 150 to 190°F (66 to 88°C) at midday during the summer. Cool roofs consist of materials that have high reflectance and high emittance to reflect the sun's energy from the roof surface. Cool roofs typically only warm to 100 to 120°F (38 to 49°C) in the summer sun.

By reducing the heat transferred into the building envelope, cool roofs help to: (1) reduce annual electricity bills by reducing summer air conditioning, (2) reduce peak electricity demand for the utility, (3) improve occupant comfort, (4) increase the life expectancy of the roof, and (5) reduce heat island effects.

Heating and Cooling Systems

A typical HVAC system for this climate would be a air-source heat pump. For this project, CARB investigated a 1.5 ton Freus air conditioner, which is a water cooled condensing unit. For heating, the air handler unit had a 10kW electric resistance heating element. Though electric resistance heating is not optimal, this shouldn't be a significant concern as there is minimal heating loads in this climate (<535 heating degree days).

The HVAC plan is shown below. The air handler and all ducts were located in a dropped area and soffit (the shaded area in the HVAC plan). As the conditioned space extends to the SIP roof, the entire HVAC system was within conditioned space. Rather than ducting the return, the dropped ceiling was used as the return plenum with return grilles in each.



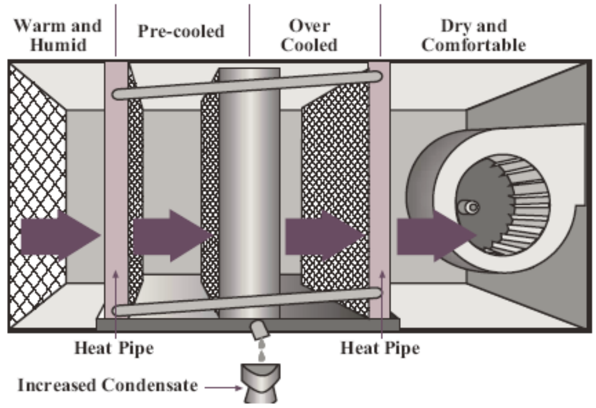
Air Conditioning

The Freus (http://www.freus.com/) is a water-cooled condensing unit which has an equivalent efficiency of SEER 16+. This unit is a drop-in replacement for a standard air-cooled condenser in a typical split-system air conditioning system.

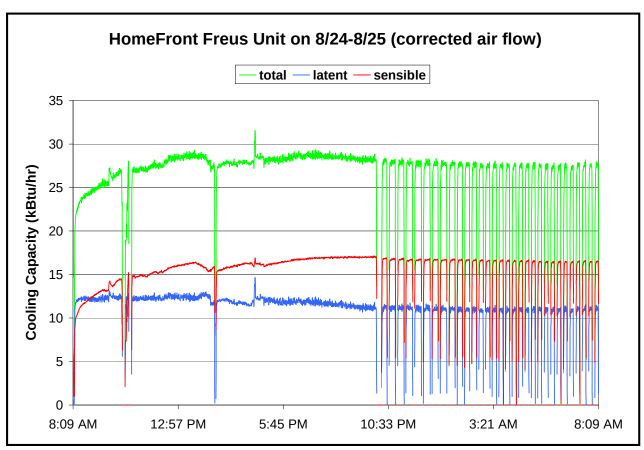
This unit has similar electrical and refrigerant connections to a conventional air-cooled system, with the addition of a water supply tap. When the thermostat calls for cooling, water is circulated from the sump at the base of the unit over the condensing coils. After eight hours of operation, the sump water is bled off and replaced with new water to prevent the build-up of mineral deposits. The bleed water can be plumbed to a waste water pipe or used for irrigation purposes.

Enhanced Dehumidification

The Dinh™ Z-Coil by Heat Pipe Technology (http://www.heatpipe.com/) is a drop-in replacement of the evaporative coil at the air handler. The first heat pipe section absorbs heat from the return air before it reaches the cooling coil, lowering the operating temperature of the evaporator coil and increasing moisture removal an estimated 50-100%. The heat absorbed by the first pipe section is transferred to the second heat pipe section to reheat the cold supply air for humidity control. Lower-humidity indoor air feels more comfortable, so cooling temperature thermostat settings can be set higher to save more energy.



(image from Heat Pipe Technology Inc.)



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