FLORIDA SOLAR ENERGY CENTER®

CONTRACT REPORT

Improved Specifications for Federally Procured Ruggedized Manufactured Homes for Disaster Relief in Hot/Humid Climates

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Authors:
Stephanie Thomas-Rees
Subrato Chandra
Stephen Barkaszi
Dave Chasar
Carlos Colon

1679 Clearlake Road, Cocoa, FL 32922-5703 • Phone: 321-638-1000 • Fax: 321-638-1010
www.fsec.ucf.edu

A Research Institute of the University of Central Florida

Executive Summary

The Federal Emergency Management Agency (FEMA) uses ruggedized manufactured homes to provide short term housing solutions during the repair and rebuilding phase after a natural disaster.

Federally procured manufactured homes are currently constructed in accordance with the Housing and Urban Development's (HUD) manufactured housing standards and typically built to the minimum code requirements. These homes can consume more energy than their site built comparatives and use materials and mechanical systems that can potentially contribute to poor indoor quality and low durability. Two improved specifications are presented in this report to enhance energy efficiency, sustainability, indoor air quality and provide back up power, without compromising human health, safety or comfort, in typical ruggedized temporary housing.

Starting with the specifications from the base case or typically procured ruggedized home, two specifications were developed, the EnergyStar (*ES*) and the Building America Structural Insulated Panel (*BASIP*) manufactured home. These were evaluated using the FSEC developed EnergyGauge® USA (Version 2.5.9) software which, predicts building energy consumption. The *ES* home saved 14% in energy costs over the base case, which amounts to savings of $25.9 million during the first year of existence ($4.5 million in energy savings and $21.4 million in construction costs) when procuring 25,000 ruggedized manufactured homes for temporary use. The *BASIP* home, which has a roof integrated, 3.25 kWp photovoltaic (pv) array, projects energy savings of 78% or $25.4 million over the base case. The *BASIP* without the pv array would be about 38% more energy efficient than the base case (analysis based on units located in New Orleans, LA and utility rates of $0.13/ kWh). The annual equivalent life cycle costs for the base case and the two alternatives were calculated to be $5,413 per year, $3,670 per year and $3,649 per year for the base, *ES* and *BASIP* respectively.

Analysis considered not only tangible benefits such as having back up power capability for essential loads during extended power outages but also intangible benefits like more daylit spaces and potential mating of two units. This report also generated areas for further investigation of innovative technologies and construction methods.

The improved specification presented by this work will allow for better quality control of construction and also include renewable energy strategies that encourage occupants to take ownership if the situation warrants. The inclusion of renewable energy would create a self-powered strategy that would provide power for essential functions during power outages and interferences associated with neighborhood reconstruction following a natural disaster.

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Abstract

Before reconstruction can begin after a natural disaster, temporary housing is essential to stabilization of a community. The offsite, rapid construction, and the ability to transport (and relocate) are two advantages of the ruggedized manufactured home. Two improved specifications, *EnergyStar* (*ES*) and the *Building America Structural Insulated Panel* (*BASIP*) manufactured home, are suggested in this report that enhance the energy efficiency, sustainability, and indoor air quality and provide back up power, without compromising human health, safety or comfort. The energy performance of the *ES* and *BASIP* manufactured homes are compared to the base case or currently specified ruggedized manufactured home using the FSEC developed EnergyGauge® USA (Version 2.5.9) software. The specifications presented in this paper allow for better quality construction and includes renewable energy. This not only reduces utility bills during regular operations but provides electricity and hot water for essential functions during power outages associated with reconstruction following a natural disaster.

1.0 Introduction

Hurricane Katrina caused major devastation to parishes, communities and entire cities requiring accommodations of mass quantities and extreme urgency. The Federal Emergency Management Agency (FEMA) responded to the temporary housing needs by procuring over 100,000 travel trailers and over 25,000 ruggedized manufactured homes. However, finding the proper location and the costs associated with constructing, transporting, installing, maintaining and operating these temporary housing accommodations has become controversial. Local governments denied installments within flood zones (which is where most of the destruction and devastation occurred and where the temporary housing was needed) and local citizens brought opposition citing that they feared these "FEMA Cities" would increase crime rates and lower their property values. Critics believe that dispersing the money they spent per home, directly to each of the victims they provided accommodations to, is a better use of taxpayer dollars than purchasing these units for temporary and often, one time only, use. While the temporary housing program is antiquated, it is what the law allows.

FEMA procured manufactured homes are used to accommodate victims of natural disasters. As hurricanes are predicted to intensify and increase in numbers, more temporary structures will be needed. When Hurricane Katrina struck the shores of Louisiana, Mississippi and Alabama last year, 25,000 manufactured homes and 100,000 travel trailers were ordered (and built) to help accommodate the thousands of victims who could not find and/or afford safe housing while their homes were being repaired or in some cases, rebuilt completely. By extrapolating information from recent articles, the costs associated with recent mobile home and travel trailer purchases amounts to approximately 2.9 billion dollars. Each travel trailer costs about $10,000. Each manufactured home costs about $76,800 per dwelling, which includes purchase, transportation, installation, maintenance, cleaning and disposal. However, these figures do not include energy costs and environmental impacts, associated with the manufactured homes that are currently used.

Continued to be scrutinized for temporary home expenditures, FEMA is complying with what law allows. The Stafford Act limits the amount of money FEMA can grant directly to an individual at $26,200[1]. While this may seem like adequate funds to support a household for a period of 18 months, some times, as experienced during Hurricane Katrina, safe housing accommodations are not available because an entire community has been devastated. The program for providing ruggedized manufactured homes was developed in the 70's and thus the program or procurement specifications warrant improvement.

Manufactured homes, utility expenses, maintenance, etc. are provided at no cost to the victims until they can move back into their existing homes or find other permanent housing. The manufactured homes are typically provided for a period of not more than 18 months. Once the 18 month period has expired, the manufactured homes are vacated and immediately transported to a staging area for future reuse or sale through the GAS website (http://gsaauctions.gov/gsaauctions/gsaauctions). If displaced residents can not find affordable housing, extensions are granted by FEMA. Most recently, the Punta Gorda, FL village has extended the remaining occupants' stay until September 2006, totaling a 24 month housing period for these residents. In Florida there are 4,160 mobile homes or trailers still occupied by storm victims, down from a 2004 peak of more than 17,000. There were 551 families at one time in the Punta Gorda village that opened in November 2004 (see photo of typical FEMA temporary community, the one pictured is in Arcadia, FL).[1]

FEMA City, Arcadia, FL
Photo Credit: FEMA

The procurement process that FEMA initiates when manufactured home orders are needed, start with FEMA requesting quotes from manufactured home builders to build the homes in accordance with HUD Manufacturing Housing Standards, also known as Title 24 (HUD, 1999) . These standards often result in large energy use for manufactured homes compared to their site built equivalents. The specifications recently used in hot and humid climates (i.e. areas where Hurricane Katrina struck) have the potential for indoor air quality and high maintenance concerns, in addition to high energy use. Poor indoor air quality can induce medical complications in occupants with asthma or other chronic illnesses and with energy costs on the rise, procurement specifications necessitate energy efficient solutions without compensating human comfort or safety.

If FEMA's current procurement process is to remain standard procedure, this report recommends two specifications for consideration. The *Energy Star Ruggedized*

[1] http://www.fema.gov/library/stafact.shtm#sec408

Manufactured Home (ES) and the *Building America Structural Insulated Panel Manufactured Home (BASIP)* specifications, included in this report, provide improved temporary shelter accommodations suitable for multiple moves, and have capabilities to provide power for essential loads during extended power outages. Not only are the tangible benefits associated with energy cost savings the justification for this report, but indoor air quality plays and increasingly demanding role amongst occupants with sensitivities to asthma and other environmental related health conditions. Also included in this report are energy cost comparisons and analysis.

The *ES* manufactured home specification is modeled from the Energy Star guidelines for manufactured homes (MHRA 2003). An ENERGY STAR labeled manufactured home must be at least 30% more energy efficient in its heating, cooling and water heating than a comparable home built to the 1993 Model Energy Code (MEC) (Chasar, et al 2004)[2].

The specification for *BASIP* goes a little further in creating a specification that results in optimal indoor air quality, increased energy savings and also provides "free energy". Table 1 summarizes the window, and surface U values as well as other characteristics (details of specifications are attached in Appendix A).

Table 1
Summary of Construction of the Existing and Proposed Specifications for FEMA Ruggedized Manufactured Homes

Characteristic	**Base Home** (existing)	**Energy Star** (proposed)	***BASIP*** (proposed)
Floor Insulation	R-19	R-21	R-19
Wall Insulation	R-13	R-13.5	>R-15.4
Ceiling Insulation	R-21	R-18.5 roof deck radiant barrier	>R-23
Roof	Dark shingle	Light shingle with Radiant Barrier	White metal raised seam roof
Windows	Single Pane, Metal Frame	Low-E Vinyl Frame	Low-E Vinyl Framed with Storm Shutters
Heating System	Electric Resistance Furnace, COP:1	Heat Pump HSPF7.5	Heat Pump HSPF7.7
Cooling System	Central Air (Split System) Conditioning SEER13 - 2 ton	Wall Hung Heat Pump SEER13 – 2.0 ton	Wall Hung Heat Pump SEER13 – 1.5 ton
Water Heater	Electric Water Heater 40 gallon capacity	Electric Water Heater 40 gallon capacity	Solar Water Heater – 40 gallon capacity with ICS

[2] http://www.fsec.ucf.edu/bldg/baihp/pubs/estar-hudcert/index.htm

Duct system	Under floor	Above ceiling in vented attic	Under SIP roof (in conditioned space, unvented attic)
Duct Joints (leakage expressed as CFM25 to out as % of floor area)	Industry Standard – 6% leakage to out	Sealed with Mastic-3% leakage to out	Sealed with Mastic (inside thermal envelope) 0% leakage
House air tightness (in terms of ACH50)*	7.5	5.10	4.00
Retractable Awning	n/a	Optional (provides additional square footage/ outdoor space)	Optional (provides additional square footage/ outdoor space)
On site Generated Power	n/a	n/a	3.25kW system

*Figures from measured data of blower door test of US manufactured housing (Baechler, et al, 2002)

2.0 Base Case, Energy Star, and Building America Structural Insulated Panel, Manufactured Home Characteristics

Improving the construction methods and energy efficiency of federally procured ruggedized manufactured homes, used as temporary accommodations, will increase the durability and expand the life expectancy and reusability. The improved specifications and revised roof layout of the *BASIP* will also accommodate mating of "single wide" units to make a larger "double wide" unit that would provide a more comfortable environment and a more mainstream approach to typical home floor plans (see end wall elevations as illustrated in Figure 4). This report does not explore floor plan redesign at this time; however it does identify some of the few designs that have evolved since Hurricane Katrina left so many victims homeless (see Appendix C).

The base case or currently procured and the proposed *ES* ruggedized manufactured home has overall dimensions of 14'x 60' (Figure 1). The specifications FEMA distributed during the request for quotes after Hurricane Katrina, are outlined in Table 2. The units specified have 3 bedrooms and 2 baths. The base case and *ES* units have ventilated attics and gabled roof plans (Figure 2). The *BASIP* unit has been lengthened to accommodate a mechanical room and mono-sloped roof (Figures 3 & 4).

The *ES* specification uses an advanced framing method. While the base case uses typical 2x4 stud construction spaced on 16" centers, the advanced framing method uses 2x6 studs spaced on 24" centers. Advanced framing methods may reduce wood use up to 25% and improve wall thermal resistance values from 5 to 10%. It can also decrease labor with fewer pieces going together, therefore saving money[3]. The *BASIP* specification uses structural insulated panel method with integral wire chases for walls and the roof but the floor system uses advanced framing method, locating the plumbing requirements in the "belly", as does the base case and *ES.*

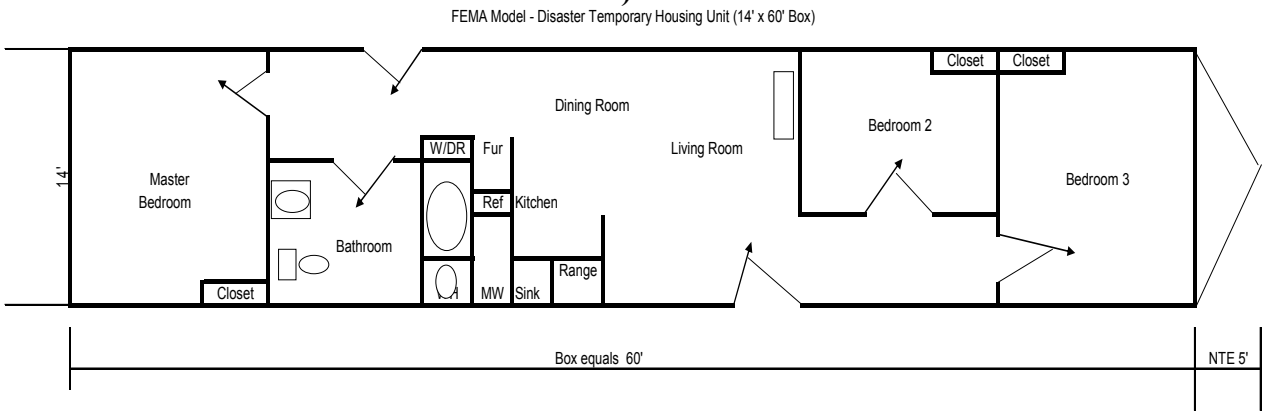
[3] http://www.energystar.gov/ia/partners/bldrs_lenders_raters/downloads/BuilderGuide3D.pdf

The *BASIP* specifies a photovoltaic integrated metal roof system with a skylight and Integrated Collector Storage (ICS) solar hot water system. The elevations illustrate "Bahama" style shutters that provide hurricane protection and solar shading. The end wall elevation (Figure 4) illustrates the inclusion of a retractable awning that also provides solar shading and additional square footage.

Table 2
Base case manufactured home specification distributed by FEMA as dated September 8, 2005

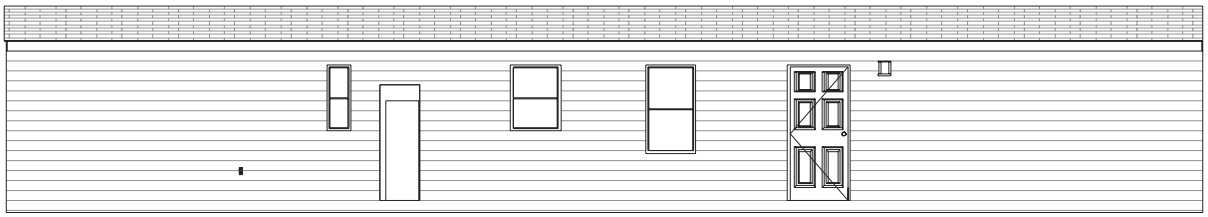
Zoning Requirements. Structural design to be incorporated into each unit.	
Roof Load Zone:	Middle
Thermal (U/O) Zone:	2
Wind Zone:	3
Structural Design	Must be built for multiple installations and removals.
Size and Configuration	
Type	Model: FEMA All-Electric Manufactured Home
Exterior Length	60 ft (box length)
Exterior Width	14 ft (box width)
Electrical System – AMPS	200 A. Electrical panel is located in the back bedroom on the right wall behind the bedroom door.
Electrical System – Volts	120/240 V
Furnishing	Fully Furnished and dinette set (table and chairs) built for six. Absolutely no carpet in the unit.
Bedrooms	3 (Each bedroom designed for 2 people) Fully furnished.
Bathroom	1
Refrigerator	Yes 18 cubic Foot Frost Free with Freezer
Range and Oven	Yes, electric
Washer and Dryer Capacity	Yes, washer and dryer not included.
Air Conditioner	Yes, electric, central air (No window units)
Furnace	Yes, electric
Microwave	Yes 1.2 cubic foot with child lock
Water Heater	Yes, Electric, 40 Gal (dual element) quick recovery and located behind the kitchen and bathroom. Not behind bedroom wall.
Exterior Covering	Vinyl siding (Color: white or off-white)
Smoke Detector	Yes, electric w/battery-back-up (all bedrooms, living room, kitchen, bathroom, and hallways)
Fire Extinguisher	Yes
Floor Plan	Each home must use the following basic floor plan. Beginning with the front of the unit and working toward the rear, the layout shall be: • Bedroom #3: Size: 8x13 Approximate • Bedroom #2: Size: 7x9 Approximate • Living Room • Kitchen/Dining Room • Furnace/Water Heater/Plumbing Chase • Laundry/Bathroom • Bedroom (Master): Size: 9x13 Approximate Note: All hallways shall be 42"wide and all doorways 36" wide.

Figure 1. Floor Plan for the Base Case (Distributed by FEMA)

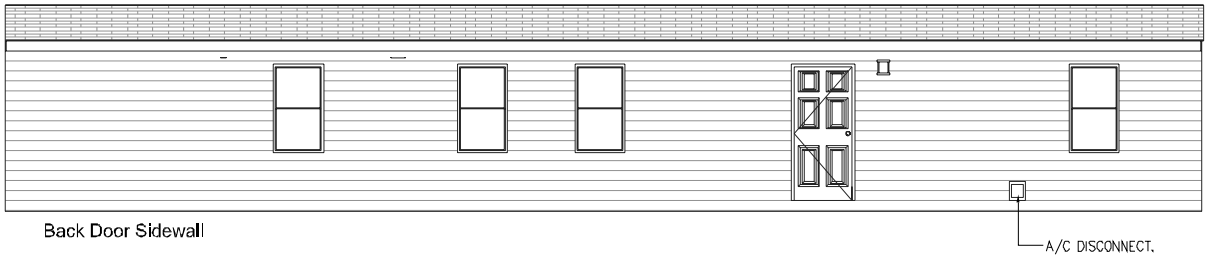


WH	Water Heater
BT/S	Bathtub/Shower
W/DR	Washer/Dryer
MW	Microwave
Ref	Refridgerator
Fur	Furnance
NTE	Not To Exceed

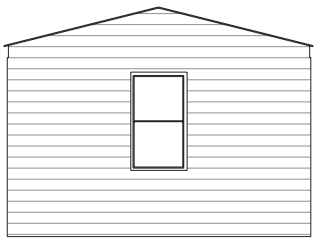
Figure 2
Elevations for the Base Case (Courtesy of Palm Harbor Homes)



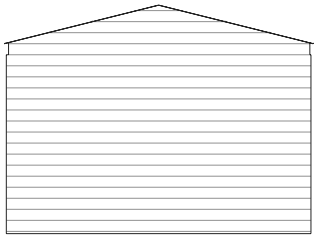
Front Door Sidewall



Back Door Sidewall



Hitch Endwall



Rear Endwall

Figure 3
Floor Plan (by Palm Harbor Homes, et al.) for the Energy Star & Building America Structurally Insulated Panel Manufactured Homes

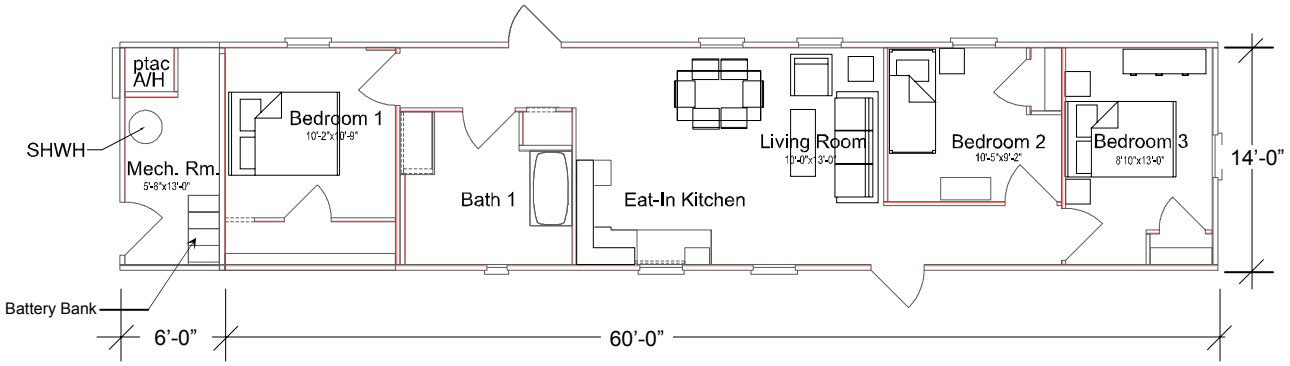
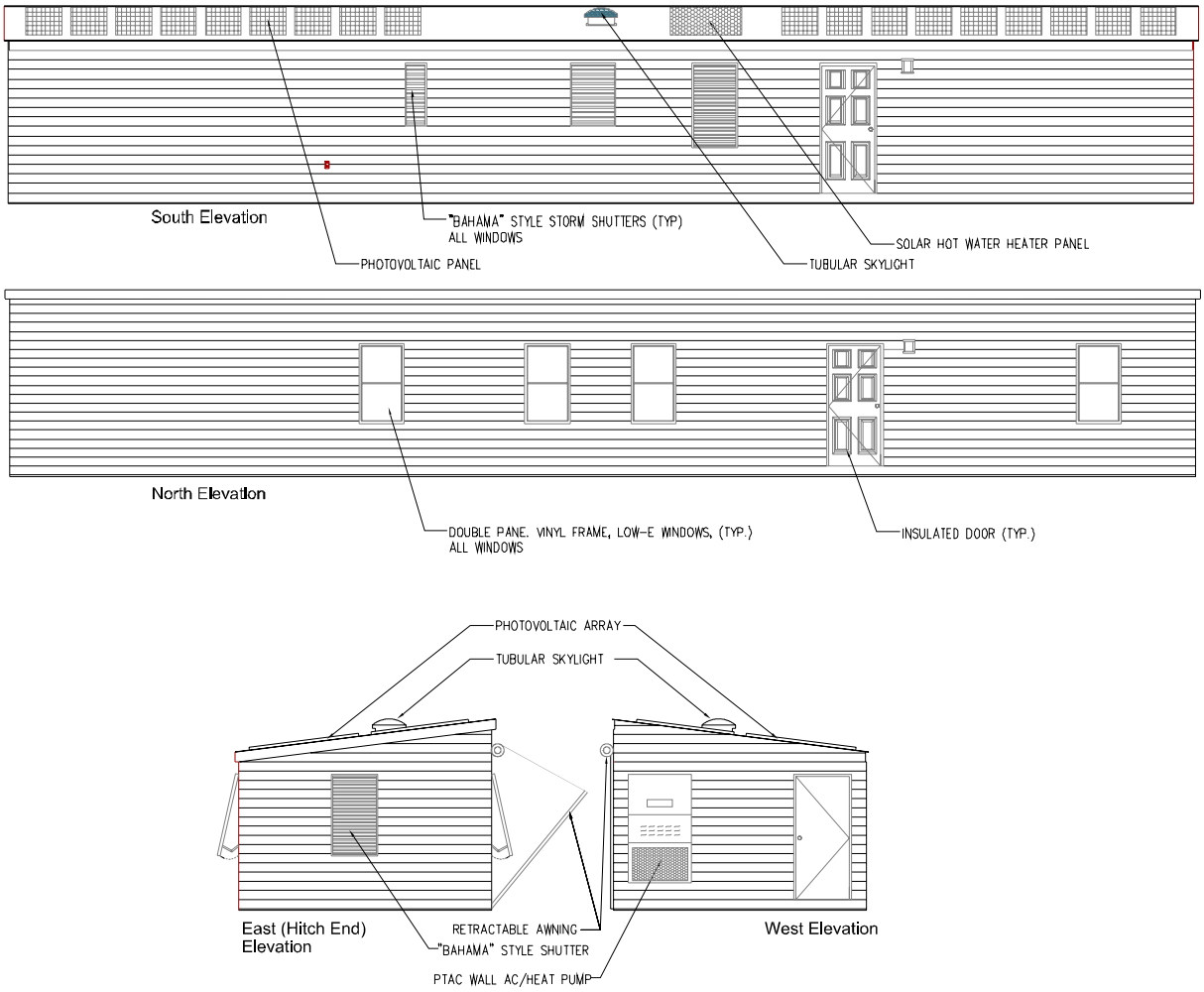


Figure 4
Elevations for the Building America Structurally Insulated Panel Manufactured Home



3.0 Energy Analysis Using EnergyGauge® USA

The proposed specifications and the base case federally procured manufactured home are analyzed using the FSEC developed EnergyGauge® USA (Version 2.5.9) software program. This program predicts building energy consumption using the DOE2 analysis engine with a user friendly front end that develops DOE2 input files and models that are more appropriate for residential building systems (Parker, et. al, 1999).

An analytical model was developed for each of the manufactured home specifications. These models were essentially the same with differences only in the R-values in the various building envelope components, the duct leakage values, the heating and cooling equipment, fenestration properties and the integration of renewable energy sources, i.e. photovoltaics and solar hot water heating. The base case and *ES* are similar in geometry but differ in hvac systems engineering and hvac equipment location. The EnergyGauge® USA simulations for each specification and the Input Summary Sheets are detailed in Appendix B.

Considering the energy costs alone, these specification recommendations facilitate significant utility demand reductions. During a 12 month period, the latest order of 25,000 FEMA specified ruggedized manufactured homes will consume about 250 GWh, which will cost the Federal Government approximately 32.55 million dollars (at $0.13/kWh). If these units were deployed to other areas like Hawaii, where utility rates are almost 44% higher, the government's electric bill could cost over 46 million dollars. The *ES*, which proposes to improve the energy efficiency by at least 14%, would provide a savings of over 4.5 million dollars in a 12 month period. The *BASIP,* proposes to improve the efficiency by at least 78% (see Table 3). This equates to about 19.5 GWh of electricity saving approximately 25.4 million dollars.

The *ES* manufactured home would eliminate approximately 23,500 tons of greenhouse gas emissions, equivalent to removing 3,815 passenger cars and light trucks from the highway for one year or saving our reliance on 49,595 barrels of oil. The *BASIP* specification would remove approximately 119,000 tons of greenhouse gas emissions, equivalent to removing 19,318 passenger cars and light trucks from the highway for one year or saving our reliance on 251,134 barrels of oil.[4]

[4] http://www.usctcgateway.net/tool/

Table 3
Summary of Comparisons of Simulated Savings

End-Use	**Base** (existing)	**Energy Star** (proposed)	**% savings over Base**	***BASIP*** (proposed)	**% savings over Base**
Annual Energy Use (kWh)	10,017	8,622	14	*2,189 (6,161)total	78
Annual Energy Costs ($)	1,302	1,122	14	286	78
Annual Co2 output (tons)	5.85	4.91	16	1.09	81
AC	2,181	1,652	24	1,458	33
Heat	1,316	373	72	487	63
Hot Water	2,768	2,652	4	**1,346	51
Lighting	1,111	1,111	0	479	57

*Net Energy Usage = Total Energy Usage – PV Produced (see Figure 6 for details)
**This figure differs from figure in Appendix B (page B12) to include additional energy usage during the freeze protection months of December, January and February)

4.0 Integrated PV Array

The *BASIP* specification proposes the integration of a 3.25kWp photovoltaic array that would generate the peak power requirements (see design loads in detailed *BASIP* specification, Appendix A). This is especially beneficial when manufactured homes need to be deployed to areas where utilities have not been restored or during times when service is interrupted. EnergyGauge® models the annual energy use and the annual energy produced by the pv array for the home located in New Orleans, LA. Figure 5 illustrates the summary of monthly averages and Figure 6 illustrates the summary of hourly averages. The pv array produces a net energy of 4,224 kWh. Total consumption is 6,413 kWh annually for a net energy use of 2,189 kWh and 78% savings. If the pv array was omitted, the *BASIP* would produce 38% savings over the base case.

Figure 5
Monthly Electrical Consumption & Production

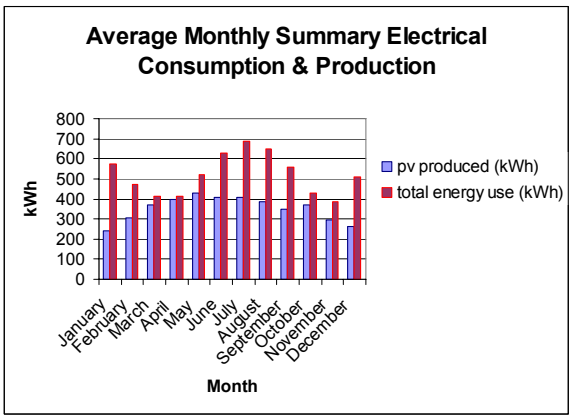


Figure 6
Hourly Summary Electrical Consumption & Production

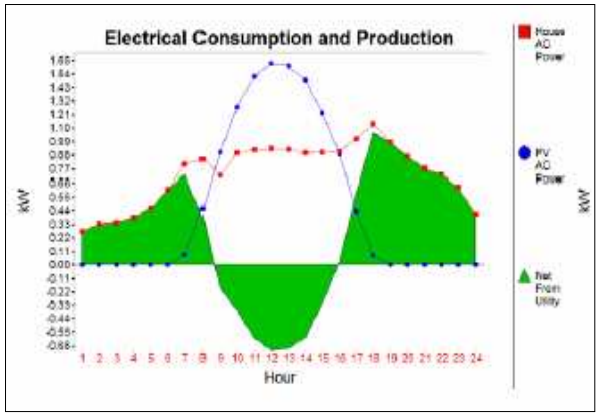
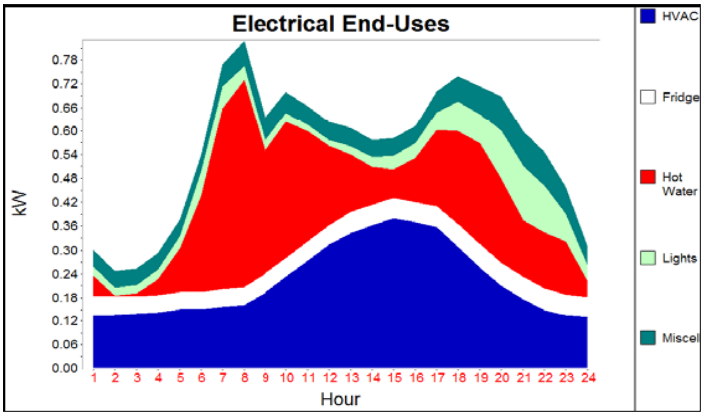


Figure 7 demonstrates the average hourly electrical uses for the whole year, revealing the hvac and hot water require the largest demand (which is also typical in the base case and *ES* models).

Figure 7
***BASIP* Manufactured Home Electrical End Uses**



5.0 HVAC

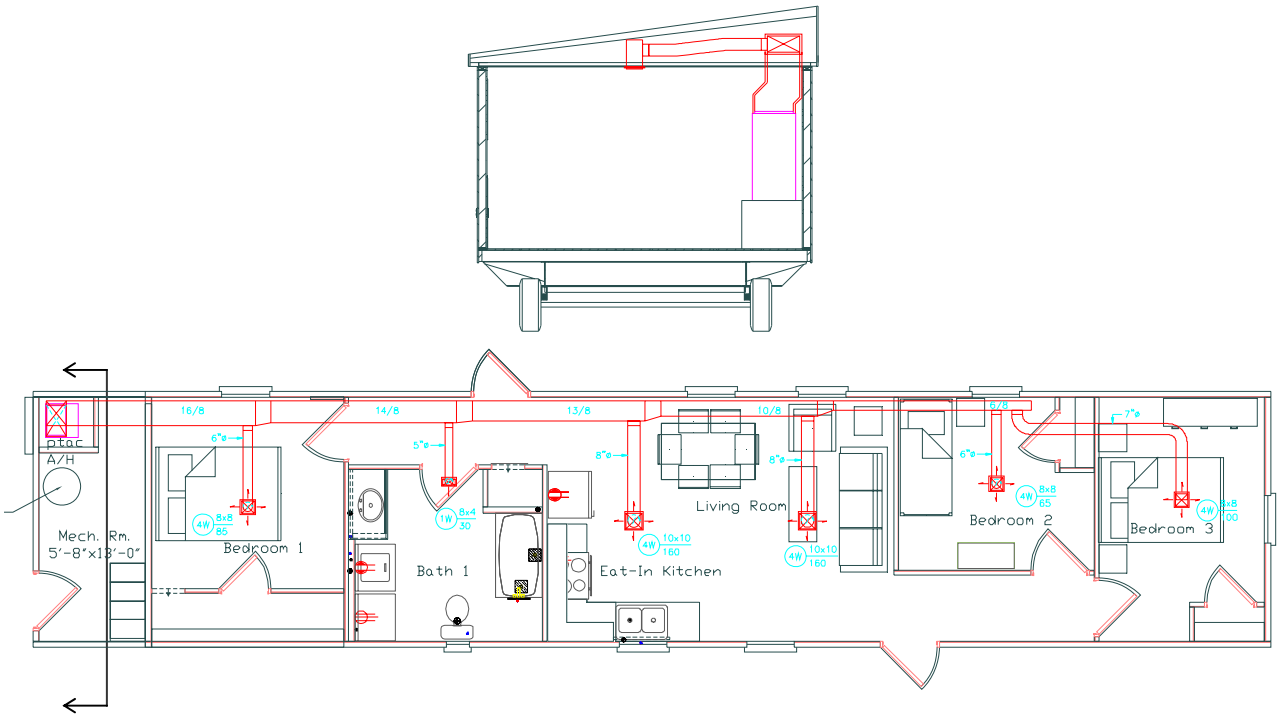
The base case manufactured home as it is constructed today uses a mechanical system that is ducted under the floor of the home (referred to as "in the belly"). The air handling equipment is in the interior of the home and the compressor is set onto a concrete pad once the manufactured home is delivered to the site. This requires coordination and additional personnel to connect the system on site and also almost never involves any commissioning or verification that the system is functioning properly as designed. The *ES* manufactured home models an improved hvac system with higher energy efficiency and improved requirements on duct sealing. It also relocates the ductwork above the ceiling, as does the *BASIP*. However, the *BASIP* creates a conditioned space for the ductwork due to the sip system. The relocation of ductwork above the ceiling eliminates the risk of supply vents being covered with furniture. The *BASIP* uses the plenum above the ceiling and below the sip for return air supply (see Figure 8). This may create an example where innovative technology precedes code development; because flame spread ratings and fire code issues may need to be investigated further to ensure code compliance.

The *BASIP* specification proposes a hvac system that is installed onto the home in the factory, allowing the mechanical system to be completely operational upon delivery. The *BASIP* also properly sizes the unit with respect to its characteristics, allowing proper humidity removal and better indoor air quality.

The heating and cooling energy savings from the improved specifications amount to 44% and 45% for the *ES* and *BASIP* respectively over the base case. While one might expect greater savings from *BASIP* over the *ES*, the *BASIP's* forced ventilation specification assesses a minimal energy penalty in return for optimal air quality. In addition, the

BASIP has an increased volume due to the vaulted ceiling and mechanical room addition. The *BASIP* can credit optimal air quality to the increased energy efficient rating and the properly sizing of the system. The SIP, in addition to tight ducts, results in tighter construction, less leakage and better indoor air quality because of the added mechanical system.

Figure 8
***BASIP* Cross Section an HVAC Layout**



6.0 Domestic Hot Water

The *BASIP* manufactured home specifies an Integral Collector Storage (ICS) hot water system which saves about 50% energy over the base case and *ES* home (see Figure 9). In the ICS shown in Figure 10, the hot water storage system is the collector. Cold water flows progressively through the collector where it is heated by the sun. Hot water is drawn from the top, which is the hottest, and replacement water flows into the bottom. This system is simple because pumps and controllers are not required. On demand, cold water from the house flows into the collector and hot water from the collector flows to a standard hot water auxiliary tank within the house (Harrison, et. al, 1997). The benefit to using an ICS system over a drain back system is less mechanical parts and pumps. The *BASIP* unit will have a user's manual and diagrams installed at the water heating system (located in the mechanical room, see Figure 3 and 8) that indicate freeze protection procedures during the months of December, January and February, as well as during transportation and relocation when the ICS system is to be drained and made non-operational. Another benefit of using an ICS system is the availability of hot water during power outages.

Figure 9
Hot Water Electrical Demand Comparisons

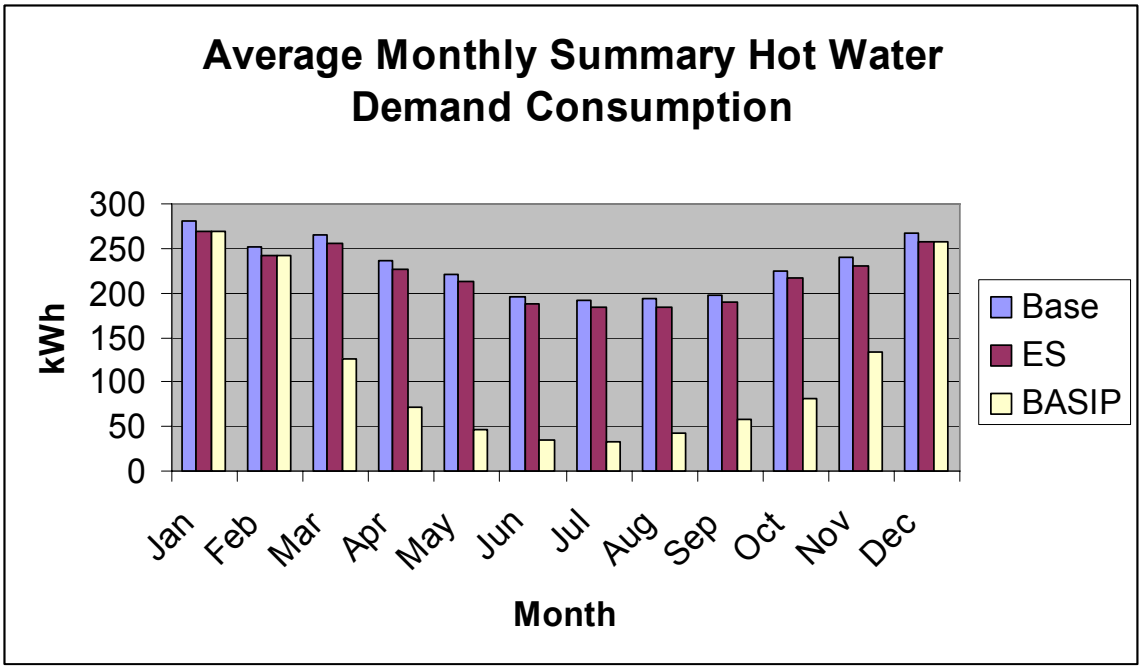
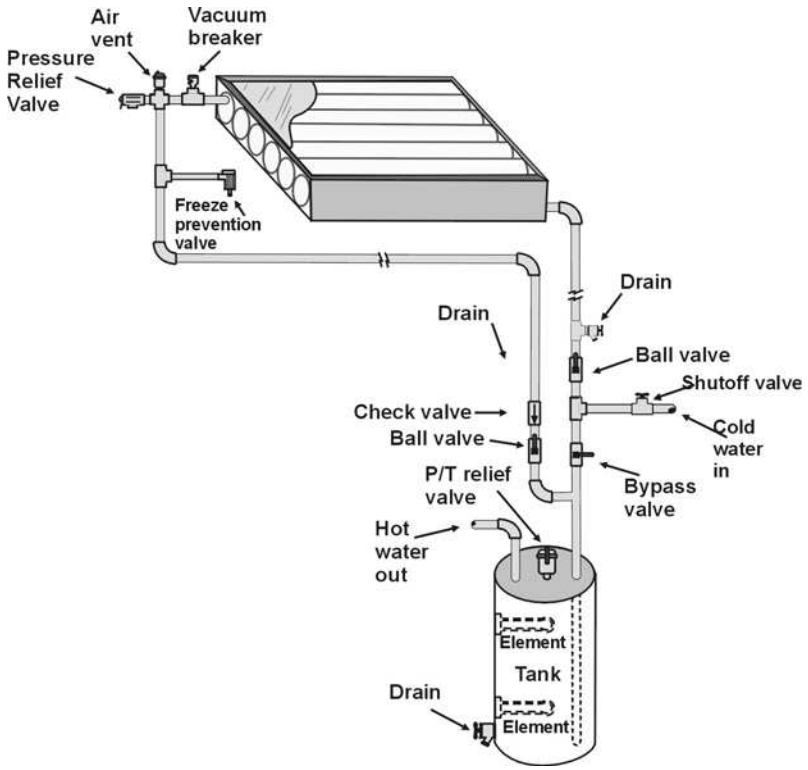


Figure 10
Integrated Collector Storage



7.0 Preliminary Economics

Early in the research of this report, incremental cost estimates were generated for the *ES* manufactured home of about $900. However, due to the proposed wall mount hvac system, third party mechanical system installation costs are omitted (and for each relocation). These charges are estimated at $700 per move. Table 4 estimates incremental costs per component and assumes two moves. This results in a net savings of approximately $854 over the base case, including other proposed upgrades. The proposed *BASIP* manufactured home specifications have incremental costs associated with the skylight, pv, solar hot water system, high efficiency hvac system and sip construction. The pv array is a large incremental cost in the *BASIP* manufactured home specification. Systems can generally costs about $10K per kW of pv array. This would amount to approximately $32.5k for the specified *BASIP* system. Optimistically and with bulk pricing for many of these systems purchased, the array could be procured as low as $6 per kW or about $20k (the figured used in Table 5). Another large incremental costing component is the ICS hot water system. This is estimated at a $2,300 up charge from the typical electric water heaters, which cost about $200. The other incremental costs in Table 4 are likely much higher than would be actually realized due to the experimental nature of the proposal. With these caveats understood, Table 4 illustrates the incremental costs, energy savings and simple payback periods for each specification. Note that the savings and paybacks will vary in accordance with the home's location in respect to the utility rates.

Table 4
Incremental Costs Comparisons and Savings

	Incremental Cost	**Incremental Cost ($/ft^2)**	**Electric Rate ($)**	**Energy Savings (kWh/day)**	**Annual Energy Savings ($)**	**Simple Payback (yrs)**	**Annual Life Cycle Costs/yr**
ES Home	($854)	($1.04)	$0.13/kwh	$4.27	$201	-	$3,670
BASIP Home	$27,301	$29.55	$0.13/kwh	$21.59	$1,023	27	$3,649

Table 5
Component/Incremental Cost Estimates for *ES* & *BASIP*

	***ES* Home Component**	***ES* Home Component Cost Increment**	***BASIP* Home Component**	***BASIP* Home Component Cost Increment**
HVAC (equipment)	Wall hung AC/HP, SEER 13	$101	Wall hung AC/HP, SEER 13	$101
HVAC Labor (based on 2 moves)	Negative cost due to equipment attached to unit	($1,400)	Negative cost due to equipment attached to unit	($1,400)
Framing	Advanced framing, less material, less labor	$0	Sip (walls & roof) ±$3.25 square foot	$2000
Windows	Vinyl frame, dbl. pane, low-e	$400	Vinyl frame, dbl. pane, low-e	$400
Roof	Light colored asphalt shingle	$0	White, raised seam, metal roof	$2,200
Floor Plan	N/A	N/A	Lengthened floor plan	$700
Jump Duct	Jump duct for return air from wall hung at end of unit	$45	n/a	n/a
Retractable awning	Optional	N/A	12'w x 10'd	$300
Bahama shutters	N/A	N/A	See figure 4	$400
Skylight	N/A	N/A	(1) skylight 18sq.ft.	$200
Solar Hot Water	N/A	N/A	ICS w/aux. elec. tank	$2400
PV system	N/A	N/A	3.25kW array	$20,000
Total Incremental Cost		**($854)**		**$27,301**

8.0 Conclusions

Through various programs that the federal government has initiated, the search for more affordable, energy efficient and sustainable temporary housing is taking a more aggressive stance in the building environment. When FSEC was tasked to develop a proposal for improved specifications for FEMA, we sought input from various industry partners to discuss different ways to improve the current FEMA specifications. This included manufactured home building personnel, material manufacturers, building science researchers and others. FEMA personnel was contacted on numerous occasions but declined to comment. These discussions along with several published reports formed the basis for the proposed recommendations in this report. One such published report was a site visit conducted by a member of the Building America Industrialized Housing Partnership and others affiliated with manufactured housing industry in September of 2004. The report discloses possible moisture-related problem areas and made recommendations for manufactured homes built for FEMA and destined for Hurricane Charley victims. The largest problem areas were the vapor barrier placement, duct

leakage and oversized hvac systems (Chasar, et. al. 2004). In July of 2000 the first HUD-Code home made of sips was tested, instrumented and monitored for energy efficiency (Baechler, et al., 2002). The results of this experiment provided the premise from which the *BASIP* was developed.

Imagine the headlines revised from "The Land of 10,770 Empty FEMA Trailers"[5], to "10,770 Zero Energy Trailers Provide Power for Small Community". If these units had been built with the *BASIP* specifications, they could generate enough power to run a small parish. With more and more headlines like "FEMA Homes Stranded in NC"[6], "Thousands Still Waiting for FEMA Trailers"[7];

More than 10,000 trailers were sitting at the airport in Hope, AK
Photo Credit: AP Photo by Danny Johnston

how does FEMA justify the process for temporary housing? Placing manufactured homes into communities affected by natural disasters, such as Hurricane Katrina has met enormous resistance by neighboring communities, as well as, local officials. "The NIMBY (not in my backyard) effect goes beyond the Big Easy itself: Half of Louisiana's parishes have banned new trailer parks"[8]. The Punta Gorda FEMA Park (largest-ever trailer park) has received accusations about drug dealing, domestic abuse, theft and vandalism. Despite those concerns, some believe extraordinary events require extraordinary cooperation.

The proposed specifications still need further investigation with regards to code exceptions and/or exemptions and fire resistance compliance due to innovative technologies that have evolved since the development and implementation of the HUD Code. Space planning and overall layout should also be examined further. While this report does not explore floor plan redesign at this time, it does identify a few designs that have evolved since Hurricane Katrina left so many victims homeless (see Appendix C and D). Hurricane Katrina brought about many design charettes and discussions by architects, developers, politicians and manufactured housing executives. We can even look historically at measures taken after the San Francisco earthquake of 1906 left thousands homeless and over 5,600 "temporary cottages" were built. The consensus is that affordable, temporary housing needs to take on a new shape and mission. The U.S Department of Energy's Office of Energy Efficiency and Renewable

1906 San Francisco earthquake cottage
Photo credit: Will Elder, National Park Service

[5] http://www.latimes.com/news/printedition/asection/la-na-trailers10feb10,0,4926000,print.story?coll=la-news-a_section
[6] http://www.newsobserver.com/102/story/411776.html
[7] http://www.msnbc.msn.com/id/10399646/from/RL.5/
[8] http://www.cbsnews.com/stories/2005/12/29/earlyshow/main1169004.shtml

Energy Department's annual Solar Decathlon, a competition to design, build, and operate the most attractive and energy-efficient solar-powered home, displays examples every year of self sufficient innovative homes, that have been transported to the Mall in Washington D.C. Regardless, Hurricane Katrina has proved that a new process and strategy is in need, one that is healthy, sustainable, reusable and before an energy crisis hits home again, one that is energy efficient and responsible.

9.0 References

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10.0 Acknowledgement

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.

11.0 Appendices

Appendices

Appendix A

Detailed Specifications of Federally Procured Manufactured House: Base, EnergyStar and Building America Structural Insulated Panel Manufactured House

Photo: University of Massachusetts Dartmouth
2005 DOE Solar Decathlon Entry

Characteristic	Base Case – Wind Zone 3, Thermal Zone 2
Envelope	
Roof	roof assembly flush with side and end walls; installed with adequate ventilation; composition shingle
Ceiling	ceiling cavity insulated with flame retardant insulation; thermal insulation and condensation control (vapor barrier) shall be in compliance with Title 24 HUD Code section 3280.504, Thermal [U/O] Zone 2.
Skylights	n/a
Wall	exterior covering to be white or off-white vinyl siding; wall cavity insulated with flame retardant, batt insulation; thermal insulation and condensation control (vapor barrier) shall be in compliance with Title 24 HUD Code section 3280.504 Thermal [U/O] Zone 2
Retractable Awning w/ crank[1]	n/a
Exterior Doors	Each exterior door is to be an industry standard 36” by 76” minimum insulated steel door. The door shall be pre-hung, and open inward and is fully insulated with no voids and includes safety chain, weather stripping, and a built in, non-operable window completely caulked with a non-hardening sealant. The doors shall be mounted in such a manner that the hinged side is toward the front of the unit and when fully opened the door shall not come in contact with any window. The doors will not be on the same side. When facing the unit from the drawbar the front door will be on the left side and the rear door will be on the right side near the back. Each entrance door must have Weiser type or equivalent passage locks installed. All locks shall be master keyed. The threshold of the doorway should be even with the adjacent floor.
Windows & Egress Windows	Single pane, aluminum frame, no storm shutters
Exterior Water Heater Access Door	All homes shall have insulated exterior access door to the water heater compartment.
Interior Doors	All interior passage must be 36" wide when the door is open in a 90° position. The threshold of the doorway should be even with the adjacent floor.
Floor	floor cavity insulated with flame retardant insulation; thermal insulation and condensation control (vapor barrier) shall be in compliance with Title 24 HUD Code section 3280.504 thermal [U/O] Zone 2
Bottom Board	Bottom board of the home shall be secured to prevent rodents from entering the unit and shall be moisture resistant under the entire home. The underside of the home shall be a board of 3/8” exterior graded plywood of which the exposed side shall be coated with a waterproof, asphalt base undercoating. The bottom board must be installed in a manner that it terminates on the structural members for proper securing. Allowance to install cross tie anchoring buckles shall be made.

Characteristic	Base Case – Wind Zone 3, Thermal Zone 2
Indoor Climate Systems	
Air Supply Ductwork	All warm air supply ductwork shall be constructed of aluminum with a minimum thickness of .013" and be complete with joint stays and sealed ends. All seams will be sealed with UL 181A-listed duct mastic with mechanical fastening to assure airtight construction and allow no air to pass into the floor system. No construction debris or sawdust may be left in the duct system.
Furnace	The unit will be equipped with an electric furnace (central heating system) capable of maintaining an average of 75 degrees Fahrenheit temperature. The furnace shall also be built or equipped for the installation of a split- system air conditioner and have space in the furnace cabinet for an A-coil evaporator unit and a 4-wire thermostat connects completely installed. Each furnace shall have instructions attached to the furnace. The furnace shall be complete with a factory-supplied base suitable for a forced air duct distribution system an exhaust stack, and a metal, wind deflecting roof cap. The BTU output shall not be less that 64,000.
Air Conditioner	The home shall have an appropriate sized air conditioner that is compatible with the furnace and unit size. The air conditioner must be ready to be completely installed. This includes duct work, installation manual, and any other materials needed for the installation. (Note: The air conditioner must be provided with the home). The air conditioner must be the type that is installed on the side of the home and not under the home and must be able to maintain an average of 75 degrees Fahrenheit temperature. Unit shall have minimum SEER 12 unit.
Ventilation	n/a
Interior Finishes	
Interior Ceiling Finish	Industry standard.
Interior Wall Finish	Industry standard. Vinyl-covered gypsum with neutral color permitted. All panels shall begin and terminate at on wall studs. All panels shall be installed to have a 1/8” nominal joint clearance which will be concealed by a color matching strip of batten moldings. All panels shall be secured to each wall stud it comes in contact with.
Interior Floor Finish	All interior floor covering shall be durable and low maintenance, be continuous roll, non-foam resilient, non-skid floor covering. Carpet is not acceptable anywhere in the home. A scrap of carpet approximately 30” by 15” shall be placed at each entrance as a foot-wipe pad. Heat duct openings will be covered with a 4" x 10" minimum, metal, adjustable louvered covering (register).

Characteristic	Base Case – Wind Zone 3, Thermal Zone 2
Electrical Service	
Electrical System	The unit electrical service shall consist of a 200 amp, 120/240 volts 4-wire panel board, complete with master and branch circuit breakers. The distribution panel board shall be flush mounted inside the left exterior wall in the rear bedroom. The panel board shall be of a dead front, safety type, equipped with thermal magnetic molded case circuit breakers of the quick break type having trip indicators and common trip on all multiple breakers. A circuit directory will be permanently affixed to the inside of the circuit breaker access door. All circuits will be clearly and legibly identified.
Service Entrance Junction Box	Each home will be equipped with an appropriate hinged, metal service entrance junction box mounted to a floor joist between the I-beam and the sidewall in such a manner that the distance from the bottom side of the junction box to the floor joist is no more than eight inches (8"). The junction box shall be mounted at a sufficient distance beneath the unit to prevent rainwater penetration without installing special rain shield and located the behind the rear entrance/exit door without impeding the entrance or exit of the home. The conductors shall be continuously and appropriately color-coded or coded using colored tape wrapped around both ends of the conductors for a minimum of three inches (3"). Paint is not acceptable for coding wires.
Lighting Requirement	Minimum interior lighting requirements shall include a ceiling mounted fixture in the bedrooms, hallways, kitchen, living room, dining area, water heater compartment, and bathroom. All lighting fixtures will be standard fixtures, and wall switch controlled. No hanging lights. The bathroom shall have a lighted exhaust ceiling fan.
Telephone/Cable inlet	Each home will be equipped telephone/cable inlet. The telephone junction box inlet will be located four feet behind the rear entrance/exit door and must not impede the entrance or exit of the home. The inlet must be functional, accessible and does not obstruct access to and/or from the door.

Characteristic	Base Case – Wind Zone 3, Thermal Zone 2
Electrical Service	
Fixtures & Receptacles	
Exterior Fixtures	An “UL” approved weatherproof exterior lighting fixture and associated wiring will be provided at each exterior entrance/exit door. An interior wall switch will be installed near the exterior entrance/exit door the light serves. The fixture shall be metal with a non-breakable globe.
Interior Receptacles	All electrical outlets shall be 18" off of floor. All switches and thermostat shall set at 48" off of floor. Electrical receptacles will be installed in accordance with industry standard except that self-contained devices are not permitted. Receptacles near wet areas will be protected with ground fault interrupter protection. A minimum of four receptacles are required in the kitchen area above the counter. The receptacle for the range shall be flush mounted in the wall to the rear of the appliance. The receptacle for the refrigerator shall be located so it can be unplugged without moving the appliance. The unit will be equipped for washer and dryer hook-up. Each bedroom shall have a receptacle on each wall.
Interior Lighting Fixtures	All interior lighting fixtures shall be ceiling mounted, wall-switched controlled, have dual sockets, be equipped with non-breakable shades, and 60-watt bulbs installed. Lighting fixtures shall be provided in the living room, kitchen, all bedrooms, bathroom, hallways, and dining area.
Appliances	All appliances must be high-efficiency appliances.
Refrigerator	18 c. f. frost-free refrigerator with freezer. The refrigerator shall be secured to the floor and to a wall stud. The refrigerator shall be plugged into its receptacle. The receptacle must be located in a position that the refrigerator can be unplugged without being moved.
Domestic Water Heater	A 40-gallon electric dual element quick recovery water heater. The water heater will be complete with a pressure relief valve, drain pan, and a metal tank drain valve. The valves shall be separately piped four inches (4") to six inches (6") below the bottom board of the home and shall be at least five inches (5") away from the water inlet pipe.
Range	30" electric cooking range. Include four (4) burners, thermostatically controlled oven, and a lighted, power-vented range hood (one-piece construction). A separate sidewall vent is not acceptable. The range shall be secured to the floor with two (2) angle (gusset type) brackets. The range shall be plugged into the receptacle.
Microwave oven	Each unit will have a minimum 1.2 cu. ft microwave with child lock

Characteristic	Base Case – Wind Zone 3, Thermal Zone 2
Plumbing Services	
Drainage System	All fixtures will be provided with an adequate drainage system, each connecting to a main sewer line, which will run below the floor and above the bottom board to the place of exit in the rear of the axles. The sewer line will exit the home not less than two feet (2') but not more than three feet (3') behind the rear axle. The exit pipe shall protrude at least six inches (6"), but not more than eight inches (8"), from the bottom board, shall have a threaded end, and be capped with a removable plastic cap and chain. The drainage system must be accessible without removing the axles for installations and deactivations. All water lines shall be installed to a point above the flooring in such a manner that opening of the valves result in the complete drainage of the water lines. The drain valves shall be brass.
Furnishings	Furnishings shall be the manufacturer's standard for functional quality. All furniture shall be assembled with all packing material removed. All furniture shall be upright and bunched against the front wall of the room or area it services. Tape shall not be used to secure furniture.
Safety Equipment	
Cabinetry	Particleboard chipboard or wood fiberboard will not be acceptable for any construction material within the unit.
Transport	
Miscellaneous	

Characteristic	Energy Star Ruggedized Manufactured Home – Wind Zone 3, Thermal Zone 1
Envelope	
Roof	Minimum 3" overhang to allow for adequate attic ventilation but overall building width not to exceed 14'-0"; light or white colored composition shingle with a minimum solar reflectance equal to or greater than Energy Star specifications for low sloped roof products (see http://www.energystar.gov/ia/partners/product_specs/eligibility/roofs_elig.pdf). A radiant barrier insulation system is also recommended.
Ceiling	Ceiling cavity insulated with minimum R19, flame retardant insulation and insulation baffle installed to secure insulation and maintain clearance above roof sheathing; Finish shall be vapor semi-permeable (see glossary).
Skylights	n/a
Wall	To frame exterior walls, use 2 x 6 studs, 24 inches on center to frame the exterior walls; exterior covering to be white or off-white vinyl siding or equivalent; wall cavity insulated with minimum R13.5, flame retardant, batt insulation; Interior finish shall be vapor semi-permeable (see glossary).
Retractable Awning w/ crank[1]	Optional
Exterior Doors	Each exterior door is to be an industry standard 36" by 76" minimum, insulated steel door. The door shall be pre-hung, and open outward and is fully insulated with no voids and includes safety chain, weather stripping, and a built in, non-operable window completely caulked with a non-hardening sealant. The doors R value shall be no less than R3.5. The doors shall be mounted in such a manner that the hinged side is toward the hitch end of the unit and when fully opened the door shall not come in contact with any window. The doors will not be on the same side. When facing the unit from the drawbar the front door will be on the left side and the rear door will be on the right side near the back. Each entrance door must have Weiser type or equivalent passage locks installed. All locks shall be master keyed. The threshold of the doorway should be even with the adjacent floor.
Windows & Egress Windows	Double pane, low-E Vinyl frame; maximum SHGC 0.35, maximum U factor 0.36; no shutters
Exterior Water Heater Access Door	no changes recommended
Interior Doors	no changes recommended
Floor	floor cavity insulated with minimum R11, flame retardant insulation; Finish shall be a vapor semi-permeable (see glossary), solid surface (non-carpet) finish.
Bottom Board	Bottom board of the home shall be secured to prevent rodents from entering the unit and shall be moisture resistant under the entire home. The exposed underside of the home shall be a material of which the exposed side shall be coated with a vapor impermeable undercoating. The bottom board material must be installed in a manner that it terminates on the structural members for proper securing. Allowance to install cross tie anchoring buckles shall be made.
Vented Crawlspace	No skirting shall be installed around perimeter of home

Characteristic	Energy Star Ruggedized Manufactured Home – Wind Zone 3, Thermal Zone 1
Indoor Climate Systems	
Air Distribution Ductwork	All conditioned air distribution ductwork to be constructed of minimum R4 insulation. Ducts/registers to be located in chase at ceiling or may be exposed and painted (see section). All seams including ducts, mains, trunks, branches and plenums will be sealed with UL 181A-listed duct mastic with mechanical fastening to assure airtight construction and allow no air to pass into the floor system. Sum of supply and return leakage divided by fan flow shall be no more than 10% or 40 cfm/ton assuming 400 cfm/ton. For multiple speed and variable speed systems use no less than 400 CFM/ton. No construction debris or sawdust may be left in the duct system.
Return Air Transfer	Return air transfers shall be provided so that pressure differentials across interior partitions may not exceed 0.01 in w.g. (2.5 Pa) (Florida Building Code, Mechanical Volume, May 2001, Section 601.4, Balanced Return Air). Filter shall be located in hallway and shall have a minimum surface area of 400 square inches.
Cool/Heat System	The home shall have an appropriate sized heating/cooling system in accordance with ASHRAE ACCA Manual J for climate equivalent to Title 24 HUD Code section 3280.504, Thermal [U/O] Zone 1. The system shall be a packaged unit, wall hung (not under the home) heat pump air conditioner with ERV. The rough opening shall be sealed with mastic so that cavity air distribution is contained through ductwork and not the building cavity. The system must be ready to be completely installed. This includes duct work, installation manual, and any other materials needed for the installation. (Note: The system must be provided with the home and located in the mechanical room – see floor plan). The system must be able to maintain an average of 76 degrees Fahrenheit temperature. The system must have a minimum SEER 13, HSPF 7.7 rating. A programmable thermostat shall also be integrated with the cool/heat system and mounted in the hallway.
Ventilation	1) Each bathroom exhaust fan must exhaust minimum 50 CFM directly to the outside. This is the measured flow, as installed, and not the rated flow by manufacturer. 2) Kitchen exhaust fan must exhaust minimum 100 CFM directly to outside. This is the measured flow, as installed. 3) There must be a whole house ventilation system that supplies 40CFM of filtered outside air when the cool/heat system is operating.

Characteristic	Energy Star Ruggedized Manufactured Home – Wind Zone 3, Thermal Zone 1
Interior Finishes	
Interior Ceiling Finish	Finish shall be vapor semi-permeable (see glossary).
Interior Wall Finish	Interior finish shall be vapor semi-permeable (see glossary) with neutral color permitted. All panels shall begin and terminate on wall studs. All pre-finished gypsum panel joints shall be concealed by a color matching strip of batten moldings. All panels shall be secured to each wall stud it comes in contact with. If wall panels are painted, all seams shall be mud, taped and painted.
Interior Floor Finish	All interior floor covering shall be durable and low maintenance, be continuous roll, non-foam resilient, non-skid floor covering. Carpet is not acceptable anywhere in the home. A foot wipe pad (non-carpet), approximately 30” by 15” shall be placed at each entrance. Tile flooring throughout, is acceptable.
Electrical Service	
Electrical System	The unit electrical service shall consist of a 200 amp, 120/240 volts 4-wire panel board, complete with master and branch circuit breakers. The distribution panel board shall be flush mounted inside the left exterior wall in the rear bedroom. The panel board shall be of a dead front, safety type, equipped with thermal magnetic molded case circuit breakers of the quick break type having trip indicators and common trip on all multiple breakers. A circuit directory will be permanently affixed to the inside of the circuit breaker access door. All circuits will be clearly and legibly identified.
Service Entrance Junction Box	Each home will be equipped with an appropriate hinged, metal service entrance junction box mounted to a floor joist between the I-beam and the sidewall in such a manner that the distance from the bottom side of the junction box to the floor joist is no more than eight inches (8"). The junction box shall be mounted at a sufficient distance beneath the unit to prevent rainwater penetration without installing special rain shield and located the behind the rear entrance/exit door without impeding the entrance or exit of the home. The conductors shall be continuously and appropriately color-coded or coded using colored tape wrapped around both ends of the conductors for a minimum of three inches (3"). Paint is not acceptable for coding wires.
Lighting Requirement	Minimum interior lighting requirements shall include a ceiling mounted fixture in the bedrooms, hallways, kitchen, living room, dining area, water heater compartment, and bathroom. All lighting fixtures will be wall switch controlled. No hanging lights. The bathroom shall have a lighted exhaust ceiling fan (see ventilation for acceptable measured exhaust rates).
Telephone/Cable inlet	no changes recommended

Characteristic	Energy Star Ruggedized Manufactured Home – Wind Zone 3, Thermal Zone 1
Electrical Service	
Fixtures & Receptacles	
Exterior Fixtures	An “UL” approved weatherproof exterior photosensored lighting fixture and associated wiring will be provided at each exterior entrance/exit door. Fixture shall be equipped with CFL bulb equivalent to 60 watt incandescent bulb. An interior wall switch will be installed near the exterior entrance/exit door the light serves. The fixture shall be metal with a shatter-resistant acrylic globe.
Interior Receptacles	All electrical outlets shall be 18" off of floor. All switches and thermostat shall set at 48" off of floor. Electrical receptacles will be installed in accordance with industry standard except that self-contained devices are not permitted. Receptacles near wet areas will be protected with ground fault interrupter protection. A minimum of four receptacles are required in the kitchen area above the counter. The receptacle for the range shall be flush mounted in the wall to the rear of the appliance. The receptacle for the refrigerator shall be located so it can be unplugged without moving the appliance. The unit will be equipped for washer and dryer hook-up. Each bedroom shall have a receptacle on each wall.
Interior Lighting Fixtures	All interior lighting fixtures shall be ceiling mounted, wall-switched controlled, have dual sockets, be equipped with non-breakable shades, and CFL bulb equivalent to 60-watt bulbs installed. Recessed lighting fixtures are allowed if they are IC rated. Lighting fixtures shall be provided in the living room, kitchen, all bedrooms, bathroom, hallways, and dining area. All lighting fixtures will be standard fixtures and equipped with CFL bulbs.
Appliances	All appliances must be energy star qualified, except for domestic hot water heater (see specifications for efficiency rating requirement).
Refrigerator	18 c. f. frost-free refrigerator with freezer. The refrigerator shall be secured to the floor and to a wall stud. The refrigerator shall be plugged into its receptacle. The receptacle must be located in a position that the refrigerator can be unplugged without being moved. All appliances shall be Energy Star qualified.
Domestic Water Heater	A 40-gallon electric dual element quick recovery water heater with minimum energy factor of 0.91. The water heater will be complete with a pressure relief valve, drain pan, and a metal tank drain valve. The valves shall be separately piped four inches (4") to six inches (6") below the bottom board of the home, shall be at least five inches (5") away from the water inlet pipe, and exit away from the crawlspace and ground cover.
Range	30" electric cooking range. Include four (4) burners, thermostatically controlled oven, and a lighted, power-vented range hood (one-piece construction) vented directly to outside. The range shall be secured to the floor with two (2) angle (gusset type) brackets. The range shall be plugged into the receptacle. The range shall be Energy Star qualified. The power-vented range hood shall also be wired to the bathroom exhaust fan.
Microwave oven	no changes recommended
Plumbing Services	
Drainage System	no changes recommended

Characteristic	Energy Star Ruggedized Manufactured Home – Wind Zone 3, Thermal Zone 1
Furnishings	no changes recommended
Safety Equipment	no changes recommended
Cabinetry	no changes recommended
Transport	no changes recommended
Miscellaneous	no changes recommended

Notes:	
*2004 Northwest Energy Efficient Manufactured Home Program In-Plant Inspection Manual	

Glossary

[9]**Vapor Impermeable:** Materials with a permeance of 0.1 perm or less (rubber membranes, polyethylene film, glass, aluminum foil)

Vapor Permeable: Materials with a permeance of greater than 10 perms (housewraps, building papers)

Vapor Retarder: A vapor retarder is the element that is designed and installed in an assembly to retard the movement of water by vapor diffusion. There are several classes of vapor retarders:

Class I vapor retarder 0.1 perm or less
Class II vapor retarder 1.0 perm or less and greater than 0.1 perm
Class III vapor retarder 10 perms or less and greater than 1.0 perm

The test procedure for classifying vapor retarders is ASTM E-96 Test Method A — the desiccant or dry cup method.

Vapor Semi-Impermeable: Materials with a permeance of 1.0 perm or less and greater than 0.1 perm (oil-based paints, most vinyl coverings)

Vapor Semi-Permeable: Materials with a permeance of 10 perms or less and greater than 1.0 perm (plywood, OSB, most latex-based paints)

[9] http://www.buildingscience.com/resources/glossary.htm

Characteristic	Building America Structural Insulated Panel Ruggedized Manufactured Home – Wind Zone 3, Thermal Zone 1
Envelope	
Roof	Roof slope maximum shall allow for no greater than 14'-0" high roof peak from ground, after construction. Roof slope shall be a mono-sloped roof with minimum 3" overhang (see elevations); Structure to be a SIP (structural insulated panel) with minimum thickness designed and constructed capable of sustaining the roof design load requirements that Title 24 HUD Code 3280.305 mandates for South zone, plus 5psf dead load. The exterior skin of the SIP shall be vapor impermeable, a white or light colored, satin matte, aluminum clad, raised seam, roofing system, with a minimum solar reflectance equal to or greater than Energy Star specifications for low sloped roof products (see http://www.energystar.gov/ia/partners/product_specs/eligibility/roofs_elig.pdf). The exterior skin shall also be weather, alkaline, scratch, corrosion and fade resistant. The core shall be EPS (Expanded Polystyrene) minimum 0.9 pounds per cubic foot minimum weight or PU (Polyisocyurnate foam). Blowing agent shall be pentane or an appropriate non-CFC blowing agent. SIP assemblies shall have R value no less than R19. Eaves shall be finished with aluminum drip edge. Fascia to be ¾" x width of entire thickness of required SIP, pre-finished cement fiber board trim painted to match exterior wall finish. Fascia to be fastened with stainless steel shake nails, one pair every 16" o.c. Provide mounting brackets at factory for solar thermal and photovoltaic array. Roof panels shall be fastened into wall SIP plates with epoxy coated 10" SIP screws, 8'-0" max. to resist wind uplift requirements for wind zone 3 as indicated in Title 24 HUD Code 3280.305. The interior skin of SIP to be a light colored, gypsum wallboard product, or equal having a Class A rating with FSR of 25 or less and shall be vapor semi-permeable (see glossary).
Photovoltaic Array	PV modules must meet current versions of UL Std. 1703 for Flat Plate Photovoltaic Modules and Panels. PV modules shall meet qualification tests consistent with the standards: *IEEE 1262 - Recommended Practice for Qualification of Photovoltaic (PV) Modules, or IEC 61215 - Crystalline Silicon Terrestrial Photovoltaic (PV) Modules - Design Qualification and Type Approval*. The modules shall be attached to the roof structure through appropriate mounting methods. Any roof penetrations must be sealed in accordance with the roofing manufacturer's guidelines. Evidence of independent test results or certification from a licensed engineer certifying that the array mounting system design is capable of adequately supporting the modules within specified deflection limits under loading conditions of at least 55 lbs/ft shall be provided. (see electrical system for requirements for photovoltaic array and associated equipment).
Inverter/Charger	The PV array shall be connected to a sine wave inverter/charger that is specifically designed for grid-tie and stand-alone operation. Inverters and charge controllers must meet UL Std. 1741 for Inverters, Converters, and Controllers for use in Independent Power Systems.
Battery Bank	The battery location and operation shall comply with applicable standards including: IEEE 937 - Recommended Practice for Installation and Maintenance of Lead-Acid Batteries for Photovoltaic (PV) Systems and IEEE 1145 - IEEE Recommended Practice for the Installation and Maintenance of Nickel-Cadmium Batteries for Photovoltaic (PV) Systems

Characteristic	Building America Structural Insulated Panel Ruggedized Manufactured Home – Wind Zone 3, Thermal Zone 1
Envelope (continued)	
Ceiling	Ceiling shall be part of SIP roof system. Interior skin finish shall be gypsum or cement fiber board (see roof specification). All exposed panel edges, such as access panels, shall be covered with permanently attached non-plastic edging. Supply duct chase may be exposed and shall be painted to match interior ceiling finish. If supply ducts are concealed in chase, supply registers shall be cut into chase and attached with code compliant flexible ducting to the supply trunk. Finish shall be light colored.
Skylights	(1) Skylight whose area shall not exceed a total of 18 square feet, minimum NFRC-rated at U=.042 or as approved; vertical shaft shall be insulated to a level at least equal to the exterior wall R-value and must extend up to roof decking; skylight shall be integrated with photovoltaic and solar thermal arrays if applicable so as not to compromise the integrity of the arrays and/or roof system
Wall	Walls to be made of structural insulated panels (SIPs) with minimum thickness designed and constructed capable of sustaining the design load requirements that Title 24 HUD Code 3280.305 mandates for the South zone. The exterior skin to be 10", white or light colored, aluminum, vinyl or cement fiber board lap siding with 8" exposure. The exterior skin shall be weather, alkaline, scratch, corrosion and fade resistant. The core shall be EPS (Expanded Polystyrene) minimum 0.9 pounds per cubic foot minimum weight or PU (Polyisocyurnate foam). Blowing agent shall be pentane or an appropriate non-CFC blowing agent. The SIPs assembly shall have an R value no less than R15. The interior skin of the SIP shall be a light colored finish, gypsum or cement fiber board or equal, having a Class A rating with FSR of 25 or less. The interior finish shall be vapor semi-permeable (see glossary). Horizontal wiring chases shall be within the SIPs at a height corresponding with the electrical outlet requirements, switches and thermostats (see electrical plan for coordination). All seals, joints, door and window frames and corners, etc. will be color matched or color coordinated to the interior finish. All exposed panel edges, such as access panels, shall be covered with permanently attached non-plastic edging. Any fasteners used on the exterior side of SIPs shall be stainless steel, hot dipped galvanized or epoxy coated.
Retractable Awning w/ crank[1]	12w'x10d' UV resistant fabric, PVC Protected Cassette Cover; Powder-coated galvanized mounting bar; Powder-coated aluminum frame; Powder-coated aluminum gear box
Insulation Installation	Insulation shall be installed with a “Grade I” installation protocol. This is described in detail in appendix A of the 2006 R*ES*NET Mortgage Industry National Home Energy Rating Systems Standards (http://resnet.us/standards/R*ES*NET_Standards-2006.pdf)

Characteristic	Building America Structural Insulated Panel Ruggedized Manufactured Home – Wind Zone 3, Thermal Zone 1
Envelope (continued)	
Exterior Doors	Each exterior door is to be an industry standard 36” by 76” minimum, insulated steel door. The door shall be pre-hung, and open outward and is fully insulated with no voids and includes safety chain, weather stripping, and a built in, non-operable window completely caulked with a non-hardening sealant. The doors R value shall be no less than R3.5. The doors shall be mounted in such a manner that the hinged side is toward the front of the unit and when fully opened the door shall not come in contact with any window. The doors will not be on the same side. When facing the unit from the drawbar the front door will be on the left side and the rear door will be on the right side near the back. Each entrance door must have Weiser type or equivalent passage locks installed. All locks shall be master keyed. The threshold of the doorway should be even with the adjacent floor. If area between door jamb and rough opening is greater than 1/2", spray foam insulation into space*; doors should be thermally broken or as approved*
Windows & Egress Windows	Double pane, low-E, vinyl frame; maximum SHGC 0.35, maximum U factor 0.36. The minimum nominal opening shall be 30" x 54"and be listed and labeled for use as an egress window with operating instructions affixed to each window. Screens shall be held in place during transit with a removable, reusable, non-corrosive, metal shipping clip(s). Tape or other temporary securing methods shall not be utilized to secure screens. All windows shall have operable, storm resistant shutters tested and certified to meet Miami-Dade, 2004 Florida Building Code and/or the Texas Department of Insurance building code requirements (see elevation). All windows shall have approved childproof mini-blinds installed.
Exterior Water Heater Access Door	no changes recommended
Interior Doors	no changes recommended
Floor	Floors to be made of structural insulated panels (SIPs) with weather, alkaline, scratch, corrosion and fade resistant aluminum or vinyl exterior skin, or equivalent. Minimum thickness designed and constructed capable of sustaining the design load requirements that Title 24 HUD Code 3280.305 mandates for the South zone. The core shall be EPS (Expanded Polystyrene) minimum 0.9 pounds per cubic foot minimum weight or PU (Polyisocyurnate foam). Blowing agent shall be pentane or an appropriate non-CFC blowing agent. SIPs assembly shall have R value no less than R21. The interior skin shall be vapor semi-permeable (see glossary), with solid surface (non-carpet) finish, having a Class A rating with FSR of 25 or less. Alternate finish: add 5/8" OSB with clear polyurethane finish on sub-deck surface with maximum FSR 25.
Bottom Board	Bottom board may not be necessary (hvac equipment is below roof system in conditioned space and the exterior finish of the SIPs floor system is vapor impermeable).
Vented Crawlspace	No skirting shall be installed around perimeter of home

Characteristic	Building America Structural Insulated Panel Ruggedized Manufactured Home – Wind Zone 3, Thermal Zone 1
Indoor Climate Systems	
Air Distribution Ductwork	All conditioned air distribution ductwork to be constructed of minimum R4 insulation. Ducts/registers to be located in chase at ceiling or may be exposed and painted (see section). All seams including ducts, mains, trunks, branches and plenums will be sealed with UL 181A-listed duct mastic with mechanical fastening to assure airtight construction and allow no air to pass into the floor system. Sum of supply and return leakage divided by fan flow shall be no more than 10% or 40 cfm/ton assuming 400 cfm/ton. For multiple speed and variable speed systems use no less than 400 CFM/ton. No construction debris or sawdust may be left in the duct system.
Return Air Transfer	Return air transfers shall be provided so that pressure differentials across interior partitions may not exceed 0.01 in w.g. (2.5 Pa) (Florida Building Code, Mechanical Volume, May 2001, Section 601.4, Balanced Return Air). Filter shall be located in hallway and shall have a minimum surface area of 400 square inches.
Cool/Heat System	The home shall have an appropriate sized heating/cooling system in accordance with ASHRAE ACCA Manual J for climate equivalent to Title 24 HUD Code section 3280.504, Thermal [U/O] Zone 1. The system shall be a packaged unit, wall hung (not under the home) heat pump air conditioner with ERV. The rough opening shall be sealed with mastic so that cavity air distribution is contained through ductwork and not the building cavity. The system must be ready to be completely installed. This includes duct work, installation manual, and any other materials needed for the installation. (Note: The system must be provided with the home and located in the mechanical room – see floor plan). The system must be able to maintain an average of 76 degrees Fahrenheit temperature. The system must have a minimum SEER 13, HSPF 7.7 rating. A programmable thermostat shall also be integrated with the cool/heat system and mounted in the hallway.
Ventilation	4) Each bathroom exhaust fan must exhaust minimum 50 CFM directly to the outside. This is the measured flow, as installed, and not the rated flow by manufacturer. 5) Kitchen exhaust fan must exhaust minimum 100 CFM directly to outside. This is the measured flow, as installed. 6) There must be a whole house ventilation system that supplies 40CFM of filtered outside air when the cool/heat system is operating.

Characteristic	Building America Structural Insulated Panel Ruggedized Manufactured Home – Wind Zone 3, Thermal Zone 1
Interior Finishes	
Interior Ceiling Finish	Finish shall be vapor semi-permeable (see glossary).
Interior Wall Finish	Interior finish shall be vapor semi-permeable (see glossary) with neutral color permitted. All panels shall begin and terminate on wall studs. All pre-finished gypsum panel joints shall be concealed by a color matching strip of batten moldings. All panels shall be secured to each wall stud it comes in contact with. If wall panels are painted, all seams shall be mud, taped and painted.
Interior Floor Finish	All interior floor covering shall be durable and low maintenance, be continuous roll, non-foam resilient, non-skid floor covering. Carpet is not acceptable anywhere in the home. A foot wipe pad (non-carpet), approximately 30" by 15" shall be placed at each entrance. Tile flooring throughout, is acceptable.
Electrical Service	
Electrical System	"Photovoltaic package" that includes roof system to support additional dead load (approximately 5psf) of photovoltaic panels, wire chases for the array source circuits, and additional conduit drops at the panel box for the AC interconnection and instrumentation wiring. This should be coordinated with SIPs roof system. The PV system electrical design shall conform to all relevant sections of the applicable version of the National Electric Code. Balance of System (BOS) components shall be compliant with applicable product listings for major components from Underwriters Laboratory (UL) or other recognized laboratory. The overall system design and installation requirements shall conform to IEEE 929 - Recommended Practice for Utility Interface of Photovoltaic (PV) Systems and IEEE 1374 - Guide for Terrestrial Photovoltaic Power System Safety. The electrical system shall be designed with a main service panel for all standard loads and a sub-panel for designated critical loads. The inverter shall interface with the utility grid through the mail panel and serve as the feed to the sub-panel. The inverter shall automatically disconnect from the main service panel to isolate the sub-panel from the utility grid when operating in stand-alone mode. The inverter shall automatically reconnect and synchronize with the utility grid when service is restored.
Design Parameters for PV	The photovoltaic (PV) array shall be composed of PV modules with minimum combined dc rated output of 3.25 kW peak. The array shall have a maximum rooftop footprint of 700 square feet. The inverter/charger system shall have a minimum rated output of 3500 W peak. The battery bank shall be comprised of a minimum of eight (8) 12v, 100Ah, deep cycle batteries configured in banks as dictated by the inverter and charging system. The battery type shall be sealed AGM or sealed gel cell. Additional or larger capacity batteries may be required to meet the design loads.

<table>
<tr><th>Characteristic</th><th>Building America Structural Insulated Panel Ruggedized Manufactured Home – Wind Zone 3, Thermal Zone 1</th></tr>
<tr><td>Electrical Service (continued)</td><td></td></tr>
<tr><td>Sub-Panel Schedule</td><td>1- Master Bedroom ceiling fan / light
2- Bedroom 2 ceiling fan / light
3- Bedroom 3 ceiling fan / light
4- Kitchen ceiling fan / light
5- Living room ceiling fan / light
6- 6 ceiling fan / light
7- Microwave outlet (kitchen)
8- Refrigerator outlet (kitchen)
9- Clothes washer
10- Miscellaneous loads/cell phone charger outlet (living room)
11- TV/VCR/DVD outlet (living room)
12- Computer outlet (living room)</td></tr>
<tr><td>Design Loads</td><td>The following table is an estimate of the loads anticipated for the PV system when operating autonomously:
<table>
<tr><th>Description</th><th>kW</th><th>Hrs/day</th><th>kWh</th></tr>
<tr><td>Six (6) Ceiling fans with CFL lights</td><td>0.60</td><td>8</td><td>4.80</td></tr>
<tr><td>20 cu ft refrigerator</td><td>0.20</td><td>12</td><td>2.40</td></tr>
<tr><td>Microwave</td><td>0.60</td><td>1.5</td><td>0.90</td></tr>
<tr><td>Clothes washer</td><td>0.50</td><td>1.5</td><td>0.75</td></tr>
<tr><td>Small TV</td><td>0.15</td><td>6</td><td>0.90</td></tr>
<tr><td>DVD/VCR</td><td>0.05</td><td>3</td><td>0.15</td></tr>
<tr><td>Cell phone charger/ miscellaneous loads</td><td>0.05</td><td>4</td><td>0.20</td></tr>
<tr><td>Laptop</td><td>0.05</td><td>6</td><td>0.30</td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td>Total</td><td>10.4</td></tr>
</table></td></tr>
<tr><td>Lighting Requirement</td><td>All lighting fixtures will be standard fixtures equipped with CFL bulbs, and wall switch controlled. No hanging lights. The bathroom shall have a lighted exhaust ceiling fan. Ceiling fan shall be on an automatic humidistat control (see "Ventilation" specification for details).</td></tr>
<tr><td>Telephone/Cable inlet</td><td>no changes recommended</td></tr>
<tr><td>Exterior Fixtures</td><td>An “UL” approved weatherproof exterior photosensored lighting fixture and associated wiring will be provided at each exterior entrance/exit door. Fixture shall be equipped with CFL bulb equivalent to 60 watt incandescent bulb. An interior wall switch will be installed near the exterior entrance/exit door the light serves. The fixture shall be metal with a shatter-resistant acrylic globe.</td></tr>
</table>

Characteristic	Building America Structural Insulated Panel Ruggedized Manufactured Home – Wind Zone 3, Thermal Zone 1
Electrical Service (continued)	
Interior Receptacles	All electrical outlets shall be 18" off of floor. All switches and thermostat shall set at 48" off of floor. Electrical receptacles will be installed in accordance with industry standard except that self-contained devices are not permitted. Receptacles near wet areas will be protected with ground fault interrupter protection. A minimum of four receptacles are required in the kitchen area above the counter. See electrical plan for panel schedule. The receptacle for the refrigerator shall be located so it can be unplugged without moving the appliance. The unit will be equipped for future dryer hook-up. Each bedroom shall have a receptacle on each wall. All receptacles shall be labeled accordingly and an information sheet/user guide shall be located within the unit that explains services.
Fixtures & Receptacles	
Interior Lighting Fixtures	All interior lighting fixtures shall be ceiling mounted, wall-switched controlled, have dual sockets, be equipped with non-breakable shades, and CFL bulb equivalent to 60-watt bulbs installed. Recessed lighting fixtures are allowed if they are IC rated. Lighting fixtures shall be provided in the living room, kitchen, all bedrooms, bathroom, hallways, and dining area. All lighting fixtures will be standard fixtures and equipped with CFL bulbs.
Appliances	All appliances must be energy star qualified, where applicable; see energy efficiency rating requirement in domestic hot water heater specifications.
Refrigerator	Small less than 18 c.f. refrigerator (1.5 - 2.0 kWh/day). Higher value with heavy use/loading (see interior receptacles specification for panel schedule.
Solar Domestic Water Heater with Auxiliary Storage	Solar Water Heater System shall be certified by the Solar Rating & Certification Corporation (SRCC) OG300; Solar system shall be glazed with integral collector storage (ICS) having minimum 32.0 square feet (3.0 m^2) of surface area installed on roof; Solar integrated tank shall be a minimum of 40 gallon (151 l); fluid shall be water; Minimum SEF (Solar Energy Factor) shall be 1.0. The auxiliary storage tank shall be minimum 40 gallon (151.l) storage capacity with two electric heating elements; Collector mount shall comply with Title 24 HUD Code 3280.305 wind zone 3. A pressure relief valve (150 psi) shall be installed on the solar return line above the service shut-off valve and connected to the discharge ¾" pressure relief drain pipe. A ½" vacuum breaker with minimum temperature rating of 300 F (149 C) shall be installed at a level above the collector (1" minimum). A diagram/label and instructions shall be affixed adjacent to the hot water heater/system for draining and filling prior to and after cold season. Manufacturer shall provide user manual and user instructions to be located in the mechanical room.

Characteristic	Building America Structural Insulated Panel Ruggedized Manufactured Home – Wind Zone 3, Thermal Zone 1
Appliances (continued)	
Range	30" electric cooking range. Include four (4) burners, thermostatically controlled oven, and a lighted, power-vented range hood (one-piece construction) vented directly to outside. The range shall be secured to the floor with two (2) angle (gusset type) brackets. The range shall be plugged into the receptacle. The range shall be Energy Star qualified. See "Ventilation" specification for power-vented range hood ventilation requirements.
Microwave oven	Each unit will have a minimum 1.2 cu. ft microwave with child lock.
Plumbing Services	
Drainage System **Hot Water Heater Plumbing Components**	All shower heads and faucets shall have low flow aerators that limit water flow to 0.5 gpm or less; all toilets shall have a maximum water flow of 1.6gpf. The auxiliary 40 gallon tank shall use a ball type shut-off valve at the cold inlet pipe. Solar collector supply and return lines shall be ¾" (O.D.) copper. Solar collector cold inlet supply line shall include a 3-way ball valve (brass) allowing bypass of integrated solar collector during winter season. Hot water collector return shut-off isolation valve (brass) shall be installed downstream of service (drain/fill) valves. Quarter turn ball valves, connected to tee branches off supply and return lines, shall be used to drain/fill servicing of solar system. Drain/fill service piping shall be directly plumbed to a ¾" drain pipe allowing proper set up or drain during transport, unoccupied periods or winter time. Exposed (above roof exterior) plumbing and piping routed through attic shall be insulated with minimum of R-4. A diagram/label and instructions shall be affixed adjacent to the hot water heater/system for filling and draining during cold weather. Manufacturer shall provide user manual and user instructions to be located in the mechanical room. For plumbing systems with backflow prevention, a thermal expansion tank with a minimum capacity of 1.5 U.S. gallons is required.
Furnishings	no changes recommended
Safety Equipment	no changes recommended
Cabinetry	Appropriate framing member within panels at designated cabinetry locations may be required. All cabinetry shop drawings to be reviewed and coordinated by sip manufacturer.
Transport	no changes recommended
Miscellaneous	no changes recommended
User Manuals/ Instructions	User manuals and instructions shall be provided for all mechanical, domestic hot water and photovoltaic systems and shall be located in the mechanical room. The instructions shall cover setup, moves and normal operation during occupied and non-occupied periods.

Characteristic	Building America Structural Insulated Panel Ruggedized Manufactured Home – Wind Zone 3, Thermal Zone 1
Notes:	
*2004 Northwest Energy Efficient Manufactured Home Program In-Plant Inspection Manual	

Glossary

Core: internal substance between the two skins of a structural insulating panel

Sip: structural insulated panel

[10]**Vapor Impermeable:** Materials with a permeance of 0.1 perm or less (rubber membranes, polyethylene film, glass, aluminum foil)

Vapor Permeable: Materials with a permeance of greater than 10 perms (house wraps, building papers)

Vapor Retarder: A vapor retarder is the element that is designed and installed in an assembly to retard the movement of water by vapor diffusion. There are several classes of vapor retarders:

Class I vapor retarder 0.1 perm or less
Class II vapor retarder 1.0 perm or less and greater than 0.1 perm
Class III vapor retarder 10 perms or less and greater than 1.0 perm

The test procedure for classifying vapor retarders is ASTM E-96 Test Method A — the desiccant or dry cup method.

Vapor Semi-Impermeable: Materials with a permeance of 1.0 perm or less and greater than 0.1 perm (oil-based paints, most vinyl coverings)

Vapor Semi-Permeable: Materials with a permeance of 10 perms or less and greater than 1.0 perm (plywood, OSB, most latex-based paints)

[10] http://www.buildingscience.com/resources/glossary.htm

Appendix B

EnergyGauge® Annual Energy Summary and Input Summary of FEMA Base Manufactured House, EnergyStar Manufactured House and Building America Structural Insulated Panel Manufactured House

Annual Energy Summary

FEMA
Any Place
New Orleans, LA,
Registration #:

Title: FEMA Base0906
User

TMY City: LA_NEWORLEANS
Elec Util: PHH1
Gas Util: EnergyGauge Default
Run Date: 09/08/2006 09:42:44

Singlewide FEMA HUD home, 13/21/19, sgl-mtl

End-Use	Energy Consumption	Annual Cost
Cooling (24 kBtu/hr)	1801 kWh	$234
Cooling Fan	380 kWh	$49
Mechanical Vent Fan	0 kWh	$ 0
Total Cooling	**2181 kWh**	**$283**
Heating (12.9 kBtu/hr)	1250 kWh	$162
Heating Fan/Pump	66 kWh	$9
Mechanical Vent Fan	0 kWh	$ 0
Total Heating	**1316 kWh**	**$171**
Hot Water	2768 kWh	$360
Hot Water Pump	0 kWh	$0
Total Hot Water	**2768 kWh**	**$360**
Ceiling Fans	0 kWh	$0
Clothes Washer	0 kWh	$0
Dishwasher	145 kWh	$19
Dryer	891 kWh	$116
Lighting	1111 kWh	$144
Miscellaneous	383 kWh	$50
Pool Pump	0 kWh	$0
Range	447 kWh	$58
Refrigerator	775 kWh	$101
Total (kWh)	10017 kWh	$1302
Total (Therms)	0 Therms	$0
Total (Oil Gallons)	0 Gallons	$0
Total (Propane Gallons)	0 Gallons	$0
PV Produced (kWh)*	0 kWh	$0
* Assumes net metering		
Total Cost		$1302

Emissions (Calculated as Total - PV Produced)

SO2	34.05 Lbs.
NOX	27.55 Lbs.
CO2	5.85 Tons

Building Input Summary Report

PROJECT

Title:	FEMA Base0906			Adress Type:	Street Address
Building Type:	User	New/Existing:	New (From Plans)	Lot #	
Owner:	FEMA	Bedrooms:	3	SubDivision:	
# of Units:	1	Bathrooms:	3	PlatBook:	
Builder Name:	Palm Harbor Homes	Conditioned Area:	820	Street:	Any Place
Permit Office:		Total Stories:	1	County:	
Jurisdiction:		Worst Case:	No	City, State, Zip:	New Orleans ,
Family Type:	Single-family	Rotate Angle:	0		LA ,
Comment:	Singlewide FEMA HUD home, 13/21/19, sgl-mtl				

CLIMATE

Design Location	Tmy Site	Design Temp 97.5 %	Design Temp 2.5 %	Int Design Temp Winter	Int Design Temp Summer	Heating Degree Days	Design Moisture	Daily Temp Range
LA, New Orleans	LA_NEWORLEANS	33	92	70	75	1437	58	Medium

UTILITY RATES

Fuel	Unit	Utility Name	Monthly Fixed Cost	$/Unit
Electricity	kWh	PHH1	0	0.13
Natural Gas	Therm	EnergyGauge Default	0	0.682
Fuel Oil	Gallon	EnergyGauge Default	0	1.1
Propane	Gallon	EnergyGauge Default	0	1.4

SURROUNDINGS

Ornt	Type	Shade Trees Height	Shade Trees Width	Shade Trees Distance	Adjacent Buildings Exist	Adjacent Buildings Height	Adjacent Buildings Width	Adjacent Buildings Distance
N	None	ft	ft	ft		0 ft	ft	0 ft
NE	None	ft	ft	ft		0 ft	ft	0 ft
E	None	ft	ft	ft		0 ft	ft	0 ft
SE	None	ft	ft	ft		0 ft	ft	0 ft
S	None	ft	ft	ft		0 ft	ft	0 ft
SW	None	ft	ft	ft		0 ft	ft	0 ft
W	None	ft	ft	ft		0 ft	ft	0 ft
NW	None	ft	ft	ft		0 ft	ft	0 ft

FLOORS

#	Floor Type	Exposed Perimeter	Wall Ins. R-Value	Area	Floor Joist R-Value	Tile	Wood	Carpet
1	Crawlspace	148 ft	0	820 ft²	21	0	1	0

ROOF

#	Roof Type	Materials	Attic Type	Attic Area	Roof Color	Solar Absor.	RBS	Deck Insul.	Attic Vent Ratio (1in)	Pitch
1	Gable or shed	Composition shingles	Full attic	820 ft²	Dark	0.92	N	0	300	18.4 deg

CEILING

#	Ceiling Type	R-Value	Area	Framing Fraction	Truss Type
1	Under Attic	18.5	820 ft²	0.11	Wood

Building Input Summary Report

WALLS

Wall orientation below is as entered. Actual orientation is modified by rotate angle shown in "Project" section above.

#	Ornt	Adjacent To	Wall Type	R-Value	Width Ft	Width In	Height Ft	Height In	Area	Framing Fraction	Solar Absor.
1	N	Exterior	Frame - Wood	13.5	13.7		7.5		102.75 ft²	0.23	0.5
2	S	Exterior	Frame - Wood	13.5	13.7		7.5		102.75 ft²	0.23	0.5
3	E	Exterior	Frame - Wood	13.5	60		7.5		450 ft²	0.23	0.5
4	W	Exterior	Frame - Wood	13.5	60		7.5		450 ft²	0.23	0.5

DOORS

#	Wall ID	Door Type	Storms	U-Value	Width Ft	Width In	Height Ft	Height In	Area
1	3	Insulated	None	0.28		38		80	21.11 ft²
2	4	Insulated	None	0.28		38		80	21.11 ft²

WINDOWS

#	Wall ID	Frame	Panes	Storm	U-Factor	Tint	Coef.	Area	Overhang Depth	Overhang Separation	Interior Shade	Screening
1	1	Metal	Single	N	1.08	Clear	1	11.04 ft²	0 ft 6 in	1 ft in	Drapes/blinds	None
2	3	Metal	Single	N	1.08	Clear	1	11.04 ft²	0 ft 6 in	1 ft in	Drapes/blinds	None
3	3	Metal	Single	N	1.08	Clear	1	7.5 ft²	0 ft 6 in	1 ft in	Drapes/blinds	None
4	3	Metal	Single	N	1.08	Clear	1	3.5 ft²	0 ft 6 in	1 ft in	Drapes/blinds	None
5	4	Metal	Single	N	1.08	Clear	1	44.17 ft²	0 ft 6 in	1 ft in	Drapes/blinds	None

INFILTRATION & VENTING

Method	SLA	CFM 50	ELA	EqLA	ACH	ACH 50	---- Forced Ventilation ---- Supply	Exhaust	Run Time	Terrain/Wind Shielding
Proposed ACH(50)	0.0003	769	42.2	79.4	0.254	7.50	0	0	0	Suburban / Suburban

MASS

Mass Type	Area	Thickness	Furniture Fraction
No Added Mass	0 ft²	0 ft	0.3

COOLING SYSTEM

#	System Type	Efficiency	Capacity	Air Flow	SHR	WH Fans	Cross Vent
1	Central Unit	SEER: 13	24 kBtu/hr	489 cfm	0.75		

HOT WATER SYSTEM

#	System Type	EF	Cap	Use	SetPnt	Credits
1	Electric	0.88	40 gal	59.96 gal	120 deg	None

HEATING SYSTEM

#	System Type	Efficiency	Capacity
1	Electric Strip Heat	COP: 1	12.5 kBtu/hr

SOLAR HOT WATER

Collector Type	Collector Tilt	Azimuth	Surface Area	Loss Coef.	Absorp. Prod.	Trans Corr.	Tank Volume	Tank U-Value	Tank Surf Area	Heat Exch Eff	PV Pumped	Pump Energy

Building Input Summary Report

DUCTS

#	Supply Location	Supply R-Value	Supply Area	Return Location	Return Area	Number	Leakage Type	Air Handler	CFM 25	Percent Leakage	QN	RLF
1	Interior	4.2	70 ft²	Interior	1 ft²	1	Proposed Qn	Interior	49.20 cfm	6.83 %	0.06	0.10

TEMPERATURES

Programable Thermostat: N Ceiling Fans: N

Cooling	[X] Jan	[X] Feb	[X] Mar	[X] Apr	[X] May	[X] Jun	[X] Jul	[X] Aug	[X] Sep	[X] Oct	[X] Nov	[X] Dec
Heating	[X] Jan	[X] Feb	[X] Mar	[X] Apr	[X] May	[X] Jun	[X] Jul	[X] Aug	[X] Sep	[X] Oct	[X] Nov	[X] Dec
Venting	[X] Jan	[X] Feb	[X] Mar	[X] Apr	[X] May	[X] Jun	[X] Jul	[X] Aug	[X] Sep	[X] Oct	[X] Nov	[X] Dec

Thermostat Schedule: PHH 1

Schedule Type		Hours 1	2	3	4	5	6	7	8	9	10	11	12
Cooling (WD)	AM	78	78	78	78	78	78	78	78	78	78	78	78
	PM	78	78	78	78	78	78	78	78	78	78	78	78
Cooling (WEH)	AM	78	78	78	78	78	78	78	78	78	78	78	78
	PM	78	78	78	78	78	78	78	78	78	78	78	78
Heating (WD)	AM	68	68	68	68	68	68	68	68	68	68	68	68
	PM	68	68	68	68	68	68	68	68	68	68	68	68
Heating (WEH)	AM	68	68	68	68	68	68	68	68	68	68	68	68
	PM	68	68	68	68	68	68	68	68	68	68	68	68

APPLIANCES &

Appliance Schedule: HERS 2006 Reference

Schedule Type		Hours 1	2	3	4	5	6	7	8	9	10	11	12
Ceiling Fans (Summer)	AM	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.33	0.33	0.33	0.33	0.33
% Released: 100	PM	0.33	0.33	0.33	0.33	0.33	1	0.9	0.9	0.9	0.9	0.9	0.65
Annual Use: 0 kWh/Yr		Peak Value: 0 Watts											
Clothes Washer	AM	0.105	0.081	0.046	0.046	0.081	0.128	0.256	0.57	0.849	1	0.977	0.872
% Released: 60	PM	0.779	0.698	0.605	0.57	0.581	0.57	0.57	0.57	0.57	0.488	0.43	0.198
Annual Use: 0 kWh/Yr		Peak Value: 0 Watts											
Dishwasher	AM	0.139	0.05	0.028	0.024	0.029	0.09	0.169	0.303	0.541	0.594	0.502	0.443
% Released: 60	PM	0.377	0.396	0.335	0.323	0.344	0.448	0.791	1	0.8	0.597	0.383	0.281
Annual Use: 145 kWh/Yr		Peak Value: 44 Watts											
Dryer	AM	0.2	0.1	0.05	0.05	0.05	0.075	0.2	0.375	0.5	0.8	0.95	1
% Released: 10	PM	0.875	0.85	0.8	0.625	0.625	0.6	0.575	0.55	0.625	0.7	0.65	0.375
Annual Use: 891 kWh/Yr		Peak Value: 200 Watts											
Lighting	AM	0.16	0.15	0.16	0.18	0.23	0.45	0.4	0.26	0.19	0.16	0.12	0.11
% Released: 90	PM	0.16	0.17	0.25	0.27	0.34	0.55	0.55	0.88	1	0.86	0.51	0.28
Annual Use: 1111 kWh/Yr		Peak Value: 363 Watts											
Miscellaneous	AM	0.48	0.47	0.47	0.47	0.47	0.47	0.64	0.71	0.67	0.61	0.55	0.53
% Released: 90	PM	0.52	0.5	0.5	0.5	0.59	0.73	0.79	0.99	1	0.96	0.77	0.55
Annual Use: 383 kWh/Yr		Peak Value: 70 Watts											
Pool Pump	AM	0	0	0	0	0	0	0	0	0	1	1	1
% Released: 0	PM	1	1	1	1	0	0	0	0	0	0	0	0
Annual Use: 0 kWh/Yr		Peak Value: 0 Watts											
Range	AM	0.057	0.057	0.057	0.057	0.057	0.114	0.171	0.286	0.343	0.343	0.343	0.4
% Released: 100	PM	0.457	0.343	0.286	0.4	0.571	1	0.857	0.429	0.286	0.229	0.171	0.114
Annual Use: 447 kWh/Yr		Peak Value: 165 Watts											
Refrigeration	AM	0.85	0.78	0.75	0.73	0.73	0.73	0.75	0.75	0.8	0.8	0.8	0.8
% Released: 100	PM	0.88	0.85	0.85	0.83	0.88	0.95	1	0.98	0.95	0.93	0.9	0.85
Annual Use: 775 kWh/Yr		Peak Value: 106 Watts											
Well Pump	AM	0.05	0.05	0.05	0.05	0.05	0.05	0.1	0.1	0.1	0.1	0.1	0.1
% Released: 0	PM	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Annual Use: 0 kWh/Yr		Peak Value: 0 Watts											

Annual Energy Summary

FEMA
Any Place
New Orleans, LA,
Registration #:

Title: FEMA
User

TMY City: LA_NEWORLEANS
Elec Util: FEMa Utility
Gas Util: EnergyGauge Default
Run Date: 09/08/2006 09:51:23

Singlewide FEMA HUD home, 13/21/19, dbl-vnl

End-Use	Energy Consumption	Annual Cost
Cooling (24 kBtu/hr)	1369 kWh	$178
Cooling Fan	283 kWh	$37
Mechanical Vent Fan	0 kWh	$ 0
Total Cooling	**1652 kWh**	**$215**
Heating (10.9 kBtu/hr)	321 kWh	$42
Heating Fan/Pump	52 kWh	$7
Mechanical Vent Fan	0 kWh	$ 0
Total Heating	**373 kWh**	**$49**
Hot Water	2652 kWh	$345
Hot Water Pump	0 kWh	$0
Total Hot Water	**2652 kWh**	**$345**
Ceiling Fans	193 kWh	$25
Clothes Washer	0 kWh	$0
Dishwasher	145 kWh	$19
Dryer	891 kWh	$116
Lighting	1111 kWh	$144
Miscellaneous	383 kWh	$50
Pool Pump	0 kWh	$0
Range	447 kWh	$58
Refrigerator	775 kWh	$101
Total (kWh)	8622 kWh	$1122
Total (Therms)	0 Therms	$0
Total (Oil Gallons)	0 Gallons	$0
Total (Propane Gallons)	0 Gallons	$0
PV Produced (kWh)*	0 kWh	$0
* Assumes net metering		
Total Cost		$1122

Emissions (Calculated as Total - PV Produced)

SO2	28.57 Lbs.
NOX	23.12 Lbs.
CO2	4.91 Tons

Building Input Summary Report

PROJECT

Title:	FEMA EnergyStar0906			Adress Type:	Street Address
Building Type:	User	New/Existing:	New (From Plans)	Lot #	
Owner:	FEMA	Bedrooms:	3	SubDivision:	
# of Units:	1	Bathrooms:	3	PlatBook:	
Builder Name:	Palm Harbor Homes	Conditioned Area:	820	Street:	Any Place
Permit Office:		Total Stories:	1	County:	
Jurisdiction:		Worst Case:	No	City, State, Zip:	New Orleans ,
Family Type:	Single-family	Rotate Angle:	0		LA ,
Comment:	Singlewide FEMA HUD home, 13/21/19, dbl-vnl				

CLIMATE

Design Location	Tmy Site	Design Temp 97.5 %	Design Temp 2.5 %	Int Design Temp Winter	Int Design Temp Summer	Heating Degree Days	Design Moisture	Daily Temp Range
LA, New Orleans	LA_NEWORLEANS	33	92	70	75	1437	58	Medium

UTILITY RATES

Fuel	Unit	Utility Name	Monthly Fixed Cost	$/Unit
Electricity	kWh	FEMa Utility	0	0.13
Natural Gas	Therm	EnergyGauge Default	0	0.682
Fuel Oil	Gallon	EnergyGauge Default	0	1.1
Propane	Gallon	EnergyGauge Default	0	1.4

SURROUNDINGS

Ornt	Type	Shade Trees Height	Shade Trees Width	Shade Trees Distance	Adjacent Buildings Exist	Adjacent Buildings Height	Adjacent Buildings Width	Adjacent Buildings Distance
N	None	ft	ft	ft		0 ft	ft	0 ft
NE	None	ft	ft	ft		0 ft	ft	0 ft
E	None	ft	ft	ft		0 ft	ft	0 ft
SE	None	ft	ft	ft		0 ft	ft	0 ft
S	None	ft	ft	ft		0 ft	ft	0 ft
SW	None	ft	ft	ft		0 ft	ft	0 ft
W	None	ft	ft	ft		0 ft	ft	0 ft
NW	None	ft	ft	ft		0 ft	ft	0 ft

FLOORS

#	Floor Type	Exposed Perimeter	Wall Ins. R-Value	Area	Floor Joist R-Value	Tile	Wood	Carpet
1	Crawlspace	148 ft	0	820 ft²	21	0	1	0

ROOF

#	Roof Type	Materials	Attic Type	Attic Area	Roof Color	Solar Absor.	RBS	Deck Insul.	Attic Vent Ratio (1in)	Pitch
1	Gable or shed	Composition shingles	Full attic	820 ft²	Light	0.92	Y	0	300	18.4 deg

CEILING

#	Ceiling Type	R-Value	Area	Framing Fraction	Truss Type
1	Under Attic	18.5	820 ft²	0.07	Wood

Building Input Summary Report

WALLS

Wall orientation below is as entered. Actual orientation is modified by rotate angle shown in "Project" section above.

#	Ornt	Adjacent To	Wall Type	R-Value	Width Ft	Width In	Height Ft	Height In	Area	Framing Fraction	Solar Absor.
1	N	Exterior	Frame - Wood	13.5	13.7		7.5		102.75 ft²	0.16	0.5
2	S	Exterior	Frame - Wood	13.5	13.7		7.5		102.75 ft²	0.16	0.5
3	E	Exterior	Frame - Wood	13.5	60		7.5		450 ft²	0.16	0.5
4	W	Exterior	Frame - Wood	13.5	60		7.5		450 ft²	0.16	0.5

DOORS

#	Wall ID	Door Type	Storms	U-Value	Width Ft	Width In	Height Ft	Height In	Area
1	3	Insulated	None	0.28		38		80	21.11 ft²
2	4	Insulated	None	0.28		38		80	21.11 ft²

WINDOWS

#	Wall ID	Frame	Panes	Storm	U-Factor	Tint	Coef.	Area	Overhang Depth	Overhang Separation	Interior Shade	Screening
1	1	Vinyl	Low-E Double	N	0.36	SHGC[wi	0.35	11.04 ft²	0 ft 6 in	1 ft in	Drapes/blinds	None
2	3	Vinyl	Low-E Double	N	0.36	SHGC[wi	0.35	11.04 ft²	0 ft 6 in	1 ft in	Drapes/blinds	None
3	3	Vinyl	Low-E Double	N	0.36	SHGC[wi	0.35	7.5 ft²	0 ft 6 in	1 ft in	Drapes/blinds	None
4	3	Vinyl	Low-E Double	N	0.36	SHGC[wi	0.35	3.5 ft²	0 ft 6 in	1 ft in	Drapes/blinds	None
5	4	Vinyl	Low-E Double	N	0.36	SHGC[wi	0.35	44.17 ft²	0 ft 6 in	1 ft in	Drapes/blinds	None

INFILTRATION & VENTING

Method	SLA	CFM 50	ELA	EqLA	ACH	ACH 50	---- Forced Ventilation ---- Supply	Exhaust	Run Time	Terrain/Wind Shielding
Proposed ACH(50)	0.0002	523	28.7	54.0	0.173	5.10	40	0	0	Suburban / Suburban

MASS

Mass Type	Area	Thickness	Furniture Fraction
No Added Mass	0 ft²	0 ft	0.3

COOLING SYSTEM

#	System Type	Efficiency	Capacity	Air Flow	SHR	WH Fans	Cross Vent
1	Central Unit	SEER: 13	24 kBtu/hr	393 cfm	0.75		

HOT WATER SYSTEM

#	System Type	EF	Cap	Use	SetPnt	Credits
1	Electric	0.91	40 gal	60 gal	120 deg	None

HEATING SYSTEM

#	System Type	Efficiency	Capacity
1	Electric Heat Pump	HSPF: 7.5	9.3 kBtu/hr

SOLAR HOT WATER

Collector Type	Collector Tilt	Azimuth	Surface Area	Loss Coef.	Absorp. Prod.	Trans Corr.	Tank Volume	Tank U-Value	Tank Surf Area	Heat Exch Eff	PV Pumped	Pump Energy

Building Input Summary Report

DUCTS

#	Supply Location	Supply R-Value	Supply Area	Return Location	Return Area	Number	Leakage Type	Air Handler	CFM 25	Percent Leakage	QN	RLF
1	Interior	4.2	70 ft²	Interior	1 ft²	1	Proposed Qn	Interior	24.60 cfm	3.42 %	0.03	0.10

TEMPERATURES

Programable Thermostat: N Ceiling Fans: Y

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Cooling	[X]	[X]	[X]	[X]	[X]	[X]	[X]	[X]	[X]	[X]	[X]	[X]
Heating	[X]	[X]	[X]	[X]	[X]	[X]	[X]	[X]	[X]	[X]	[X]	[X]
Venting	[X]	[X]	[X]	[X]	[X]	[X]	[X]	[X]	[X]	[X]	[X]	[X]

Thermostat Schedule: PHH 1

Schedule Type		Hours 1	2	3	4	5	6	7	8	9	10	11	12
Cooling (WD)	AM	78	78	78	78	78	78	78	78	78	78	78	78
	PM	78	78	78	78	78	78	78	78	78	78	78	78
Cooling (WEH)	AM	78	78	78	78	78	78	78	78	78	78	78	78
	PM	78	78	78	78	78	78	78	78	78	78	78	78
Heating (WD)	AM	68	68	68	68	68	68	68	68	68	68	68	68
	PM	68	68	68	68	68	68	68	68	68	68	68	68
Heating (WEH)	AM	68	68	68	68	68	68	68	68	68	68	68	68
	PM	68	68	68	68	68	68	68	68	68	68	68	68

APPLIANCES &

Appliance Schedule: HERS 2006 Reference

Schedule Type		Hours 1	2	3	4	5	6	7	8	9	10	11	12
Ceiling Fans (Summer)	AM	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.33	0.33	0.33	0.33	0.33
% Released: 100	PM	0.33	0.33	0.33	0.33	0.33	1	0.9	0.9	0.9	0.9	0.9	0.65
Annual Use: 328 kWh/Yr		Peak Value: 64 Watts											
Clothes Washer	AM	0.105	0.081	0.046	0.046	0.081	0.128	0.256	0.57	0.849	1	0.977	0.872
% Released: 60	PM	0.779	0.698	0.605	0.57	0.581	0.57	0.57	0.57	0.57	0.488	0.43	0.198
Annual Use: 0 kWh/Yr		Peak Value: 0 Watts											
Dishwasher	AM	0.139	0.05	0.028	0.024	0.029	0.09	0.169	0.303	0.541	0.594	0.502	0.443
% Released: 60	PM	0.377	0.396	0.335	0.323	0.344	0.448	0.791	1	0.8	0.597	0.383	0.281
Annual Use: 145 kWh/Yr		Peak Value: 44 Watts											
Dryer	AM	0.2	0.1	0.05	0.05	0.05	0.075	0.2	0.375	0.5	0.8	0.95	1
% Released: 10	PM	0.875	0.85	0.8	0.625	0.625	0.6	0.575	0.55	0.625	0.7	0.65	0.375
Annual Use: 891 kWh/Yr		Peak Value: 200 Watts											
Lighting	AM	0.16	0.15	0.16	0.18	0.23	0.45	0.4	0.26	0.19	0.16	0.12	0.11
% Released: 90	PM	0.16	0.17	0.25	0.27	0.34	0.55	0.55	0.88	1	0.86	0.51	0.28
Annual Use: 1111 kWh/Yr		Peak Value: 363 Watts											
Miscellaneous	AM	0.48	0.47	0.47	0.47	0.47	0.47	0.64	0.71	0.67	0.61	0.55	0.53
% Released: 90	PM	0.52	0.5	0.5	0.5	0.59	0.73	0.79	0.99	1	0.96	0.77	0.55
Annual Use: 383 kWh/Yr		Peak Value: 70 Watts											
Pool Pump	AM	0	0	0	0	0	0	0	0	0	1	1	1
% Released: 0	PM	1	1	1	1	0	0	0	0	0	0	0	0
Annual Use: 0 kWh/Yr		Peak Value: 0 Watts											
Range	AM	0.057	0.057	0.057	0.057	0.057	0.114	0.171	0.286	0.343	0.343	0.343	0.4
% Released: 100	PM	0.457	0.343	0.286	0.4	0.571	1	0.857	0.429	0.286	0.229	0.171	0.114
Annual Use: 447 kWh/Yr		Peak Value: 165 Watts											
Refrigeration	AM	0.85	0.78	0.75	0.73	0.73	0.73	0.75	0.75	0.8	0.8	0.8	0.8
% Released: 100	PM	0.88	0.85	0.85	0.83	0.88	0.95	1	0.98	0.95	0.93	0.9	0.85
Annual Use: 775 kWh/Yr		Peak Value: 106 Watts											
Well Pump	AM	0.05	0.05	0.05	0.05	0.05	0.05	0.1	0.1	0.1	0.1	0.1	0.1
% Released: 0	PM	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Annual Use: 0 kWh/Yr		Peak Value: 0 Watts											

Annual Energy Summary

FEMA
Any Place
New Orleans, LA,
Registration #:

Title: FEMA BAIHP SIP, ICS, PV,SEER13HP0906
User

TMY City: LA_NEWORLEANS
Elec Util: MyUtility
Gas Util: EnergyGauge Default
Run Date: 09/08/2006 09:54:24

Single w.m FEMA HUD home, 17/17/25, dbl-vnl,

End-Use	Energy Consumption	Annual Cost
Cooling (18 kBtu/hr)	1183 kWh	$154
Cooling Fan	250 kWh	$32
Mechanical Vent Fan	26 kWh	$ 3
Total Cooling	**1459 kWh**	**$189**
Heating (10.4 kBtu/hr)	413 kWh	$54
Heating Fan/Pump	67 kWh	$9
Mechanical Vent Fan	7 kWh	$ 1
Total Heating	**487 kWh**	**$64**
Hot Water	1094 kWh	$142
Hot Water Pump	0 kWh	$0
Total Hot Water	**1094 kWh**	**$142**
Ceiling Fans	382 kWh	$50
Clothes Washer	0 kWh	$0
Dishwasher	0 kWh	$0
Dryer	891 kWh	$116
Lighting	479 kWh	$62
Miscellaneous	482 kWh	$63
Pool Pump	0 kWh	$0
Range	447 kWh	$58
Refrigerator	441 kWh	$57
Total (kWh)	6162 kWh	$801
Total (Therms)	0 Therms	$0
Total (Oil Gallons)	0 Gallons	$0
Total (Propane Gallons)	0 Gallons	$0
PV Produced (kWh)*	-4224 kWh	$-549
* Assumes net metering		
Total Cost		$252

Emissions (Calculated as Total - PV Produced)

SO2	5.37 Lbs.
NOX	4.34 Lbs.
CO2	0.92 Tons

Building Input Summary Report

PROJECT

Title:	FEMA BAIHP SIP, ICS, PV,S			Adress Type:	Street Address
Building Type:	User	New/Existing:	New (From Plans)	Lot #	
Owner:	FEMA	Bedrooms:	3	SubDivision:	
# of Units:	1	Bathrooms:	3	PlatBook:	
Builder Name:	FSEC specified	Conditioned Area:	871	Street:	Any Place
Permit Office:		Total Stories:	1	County:	
Jurisdiction:		Worst Case:	No	City, State, Zip:	New Orleans ,
Family Type:	Single-family	Rotate Angle:	0		LA ,
Comment:	Single w.m FEMA HUD home, 17/17/25, dbl-vnl, SEER1				

CLIMATE

Design Location	Tmy Site	Design Temp 97.5 %	Design Temp 2.5 %	Int Design Temp Winter	Int Design Temp Summer	Heating Degree Days	Design Moisture	Daily Temp Range
LA, New Orleans	LA_NEWORLEANS	33	92	70	75	1437	58	Medium

UTILITY RATES

Fuel	Unit	Utility Name	Monthly Fixed Cost	$/Unit
Electricity	kWh	MyUtility	0	0.13
Natural Gas	Therm	EnergyGauge Default	0	0.682
Fuel Oil	Gallon	EnergyGauge Default	0	1.1
Propane	Gallon	EnergyGauge Default	0	1.4

SURROUNDINGS

Ornt	Type	Shade Trees Height	Shade Trees Width	Shade Trees Distance	Adjacent Buildings Exist	Adjacent Buildings Height	Adjacent Buildings Width	Adjacent Buildings Distance
N	None	ft	ft	ft		0 ft	ft	0 ft
NE	None	ft	ft	ft		0 ft	ft	0 ft
E	None	ft	ft	ft		0 ft	ft	0 ft
SE	None	ft	ft	ft		0 ft	ft	0 ft
S	None	ft	ft	ft		0 ft	ft	0 ft
SW	None	ft	ft	ft		0 ft	ft	0 ft
W	None	ft	ft	ft		0 ft	ft	0 ft
NW	None	ft	ft	ft		0 ft	ft	0 ft

FLOORS

#	Floor Type	Exposed Perimeter	Wall Ins. R-Value	Area	Floor Joist R-Value	Tile	Wood	Carpet
1	Crawlspace	160 ft	0	871 ft²	15.4	0	1	0

ROOF

#	Roof Type	Materials	Attic Type	Attic Area	Roof Color	Solar Absor.	RBS	Deck Insul.	Attic Vent Ratio (1in)	Pitch
1	Gable or shed	Metal	Full cathedral ceilin	871 ft²	White	0.92	N	0	0	18.4 deg

CEILING

#	Ceiling Type	R-Value	Area	Framing Fraction	Truss Type
1	Cathedral/Single Assembly	23	871 ft²	0	Wood

Building Input Summary Report

WALLS

Wall orientation below is as entered. Actual orientation is modified by rotate angle shown in "Project" section above.

#	Ornt	Adjacent To	Wall Type	R-Value	Width Ft	Width In	Height Ft	Height In	Area	Framing Fraction	Solar Absor.
1	N	Exterior	Frame - Wood	15.4	65.3		9.5		620.35 ft²	0	0.3
2	S	Exterior	Frame - Wood	15.4	65.3		7.5		489.75 ft²	0	0.3
3	E	Exterior	Frame - Wood	15.4	13.7		8.5		116.45 ft²	0	0.3
4	W	Exterior	Frame - Wood	15.4	13.7		8.5		116.45 ft²	0	0.3

DOORS

#	Wall ID	Door Type	Storms	U-Value	Width Ft	Width In	Height Ft	Height In	Area
1	2	Insulated	None	0.28		38		80	21.11 ft²
2	1	Insulated	None	0.28		38		80	21.11 ft²
3	3	Insulated	None	0.28		38		80	21.11 ft²

WINDOWS

#	Wall ID	Frame	Panes	Storm	U-Factor	Tint	Coef.	Area	Overhang Depth	Overhang Separation	Interior Shade	Screening
1	1	Vinyl	Low-E Double	Y	0.36	SHGC[wi	0.35	44.17 ft²	0 ft 3 in	2 ft 10 in	Drapes/blinds	Exterior 50%
2	2	Vinyl	Low-E Double	Y	0.36	SHGC[wi	0.35	11.04 ft²	0 ft 3 in	0 ft 10 in	Drapes/blinds	Exterior 50%
3	2	Vinyl	Low-E Double	Y	0.36	SHGC[wi	0.35	3.5 ft²	0 ft 3 in	0 ft 10 in	Drapes/blinds	Exterior 50%
4	Skylt	Metal	Double	N	0.36	SHGC[wi	0.35	6 ft²	0 ft in	0 ft in	None	None
5	2	Vinyl	Low-E Double	Y	0.36	SHGC[wi	0.35	7.5 ft²	0 ft 3 in	0 ft 10 in	Drapes/blinds	Exterior 50%
6	3	Vinyl	Low-E Double	Y	0.36	SHGC[wi	0.35	11.04 ft²	0 ft 3 in	0 ft 22 in	Drapes/blinds	Exterior 50%

INFILTRATION & VENTING

Method	SLA	CFM 50	ELA	EqLA	ACH	ACH 50	---- Forced Ventilation ---- Supply	Exhaust	Run Time	Terrain/Wind Shielding
Proposed ACH(50)	0.0002	494	27.1	51.0	0.153	4.00	40	0	0	Suburban / Suburban

MASS

Mass Type	Area	Thickness	Furniture Fraction
No Added Mass	0 ft²	0 ft	0.3

COOLING SYSTEM

#	System Type	Efficiency	Capacity	Air Flow	SHR	WH Fans	Cross Vent
1	Central Unit	SEER: 13	18 kBtu/hr	393 cfm	0.75		

HOT WATER SYSTEM

#	System Type	EF	Cap	Use	SetPnt	Credits
1	Electric	0.91	40 gal	60 gal	120 deg	Solar System

HEATING SYSTEM

#	System Type	Efficiency	Capacity
1	Electric Heat Pump	HSPF: 7.7	10.4 kBtu/hr

Building Input Summary Report

SOLAR HOT WATER

Collector Type	Collector Tilt	Azimuth	Cover Area	Tank Loss Coef.	Trans Prod.	Volume Cap
Integrated Collector Storage	18.4	180	2.8 m²	9 W/C	0.82	156

DUCTS

#	---- Supply ---- Location	R-Value	Area	---- Return ---- Location	Area	Number	Leakage Type	Air Handler	CFM 25	Percent Leakage	QN	RLF
1	Interior	4.2	70 ft²	Interior	1 ft²	1	Proposed Qn	Interior	24.60 cfm	3.42 %	0.03	0.10

TEMPERATURES

Programable Thermostat: Y Ceiling Fans: Y

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Cooling	[X]	[X]	[X]	[X]	[X]	[X]	[X]	[X]	[X]	[X]	[X]	[X]
Heating	[X]	[X]	[X]	[X]	[X]	[X]	[X]	[X]	[X]	[X]	[X]	[X]
Venting	[X]	[X]	[X]	[X]	[X]	[X]	[X]	[X]	[X]	[X]	[X]	[X]

Thermostat Schedule: PHH 1

Schedule Type		Hours 1	2	3	4	5	6	7	8	9	10	11	12
Cooling (WD)	AM	78	78	78	78	78	78	78	78	78	78	78	78
	PM	78	78	78	78	78	78	78	78	78	78	78	78
Cooling (WEH)	AM	78	78	78	78	78	78	78	78	78	78	78	78
	PM	78	78	78	78	78	78	78	78	78	78	78	78
Heating (WD)	AM	68	68	68	68	68	68	68	68	68	68	68	68
	PM	68	68	68	68	68	68	68	68	68	68	68	68
Heating (WEH)	AM	68	68	68	68	68	68	68	68	68	68	68	68
	PM	68	68	68	68	68	68	68	68	68	68	68	68

Building Input Summary Report

APPLIANCES &

Appliance Schedule: HERS 2006 Reference		Hours											
Schedule Type		1	2	3	4	5	6	7	8	9	10	11	12
Ceiling Fans (Summer)	AM	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.33	0.33	0.33	0.33	0.33
% Released: 100	PM	0.33	0.33	0.33	0.33	0.33	1	0.9	0.9	0.9	0.9	0.9	0.65
Annual Use: 652 kWh/Yr				Peak Value: 128 Watts									
Clothes Washer	AM	0.105	0.081	0.046	0.046	0.081	0.128	0.256	0.57	0.849	1	0.977	0.872
% Released: 60	PM	0.779	0.698	0.605	0.57	0.581	0.57	0.57	0.57	0.57	0.488	0.43	0.198
Annual Use: 0 kWh/Yr				Peak Value: 0 Watts									
Dishwasher	AM	0.139	0.05	0.028	0.024	0.029	0.09	0.169	0.303	0.541	0.594	0.502	0.443
% Released: 60	PM	0.377	0.396	0.335	0.323	0.344	0.448	0.791	1	0.8	0.597	0.383	0.281
Annual Use: 0 kWh/Yr				Peak Value: 0 Watts									
Dryer	AM	0.2	0.1	0.05	0.05	0.05	0.075	0.2	0.375	0.5	0.8	0.95	1
% Released: 10	PM	0.875	0.85	0.8	0.625	0.625	0.6	0.575	0.55	0.625	0.7	0.65	0.375
Annual Use: 891 kWh/Yr				Peak Value: 200 Watts									
Lighting	AM	0.16	0.15	0.16	0.18	0.23	0.45	0.4	0.26	0.19	0.16	0.12	0.11
% Released: 90	PM	0.16	0.17	0.25	0.27	0.34	0.55	0.55	0.88	1	0.86	0.51	0.28
Annual Use: 479 kWh/Yr				Peak Value: 157 Watts									
Miscellaneous	AM	0.48	0.47	0.47	0.47	0.47	0.47	0.64	0.71	0.67	0.61	0.55	0.53
% Released: 90	PM	0.52	0.5	0.5	0.5	0.59	0.73	0.79	0.99	1	0.96	0.77	0.55
Annual Use: 482 kWh/Yr				Peak Value: 88 Watts									
Pool Pump	AM	0	0	0	0	0	0	0	0	0	1	1	1
% Released: 0	PM	1	1	1	1	0	0	0	0	0	0	0	0
Annual Use: 0 kWh/Yr				Peak Value: 0 Watts									
Range	AM	0.057	0.057	0.057	0.057	0.057	0.114	0.171	0.286	0.343	0.343	0.343	0.4
% Released: 100	PM	0.457	0.343	0.286	0.4	0.571	1	0.857	0.429	0.286	0.229	0.171	0.114
Annual Use: 447 kWh/Yr				Peak Value: 165 Watts									
Refrigeration	AM	0.85	0.78	0.75	0.73	0.73	0.73	0.75	0.75	0.8	0.8	0.8	0.8
% Released: 100	PM	0.88	0.85	0.85	0.83	0.88	0.95	1	0.98	0.95	0.93	0.9	0.85
Annual Use: 441 kWh/Yr				Peak Value: 60 Watts									
Well Pump	AM	0.05	0.05	0.05	0.05	0.05	0.05	0.1	0.1	0.1	0.1	0.1	0.1
% Released: 0	PM	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Annual Use: 0 kWh/Yr				Peak Value: 0 Watts									

PHOTOVOLTAICS

Array Type	Azimuth	Tilt	Line Loss	Eff Coeff	Inverter Type	Battery Type	Capacity
Shell (Siemens) SP75	180	18	0.0035	0.0043	Trace U 2512/24/32/36/48	NiCad	38.4 kWh

Appendix C

Alternative Design Responses for Federally Procured Manufactured Home

1906 San Francisco earthquake cottage
www.nps.gov/prsf/history/1906eq/cottages.htm

1. Katrina Cottage by Marianne Cusato in response to Mississippi Renewal Forum
http://www.mississippirenewal.com/info/dayJan-11-06.html

2. Tumbleweed Tiny House Company by Jay Shafer
http://www.tumbleweedhouses.com/

3. Carters Modular
http://www.spec-net.com.au/press/1004/futurebuild3.htm

4. DOE Solar Decathlon Entrants
http://www.eere.energy.gov/solar_decathlon

5. Concretables by Royal Concrete Concepts (Category 5 Hurricane Resistant)
http://www.royalconcreteconcepts.com/hom_view_lex.htm

Appendix D

Comments from Industry Stakeholders after Report Written

16 June 2006

Ms. Stephanie Thomas-Rees
Research Architect
MSc Architecture, Energy Efficient Design
Florida Solar Energy Center
1679 Clearlake Road, Cocoa, Florida 32922

Re: Paper on Improved FEMA Ruggedized Manufactured Home

Dear Stephanie,

First of all, a big "Thank You" is due you for working on this project and helping to put out a terrific idea to the appropriate Institution at the right time. Reports from friends who have visited the region have informed me that the conditions in the Katrina Region are far worse and of much larger scope than the popular press have so far reported. The need is both large and dire.

Secondly, another "Thank You" is due you for extending the invitation to me to become involved. You know I only reflect the wishes of the entire Construction Community who all want to extend helping hands, but none more so than SIPA and its members and also the Architectural Community.

The paper as it stands represents a giant step in the right direction, but a few additional suggestions are put forth here in the hopes that the product may be ratcheted up a few additional notches in Performance, and at the same time lower Production Costs. It is in this spirit of Constructive Improvement through Iteration or Evolution that the following points are suggested.

1. **Plan Changes**
   While I am aware that Plan Changes were largely precluded from discussion – although desperately required from this architects point of view – apparently lengthening the plan by 6 feet to accommodate the additional Mechanical Equipment was an acceptable amendment. I would rather see such additional space inserted between the kitchen and bathroom, and not positioned usurping such "premium real estate" as the end of the building where windows and access for people might be. Certainly Bedroom No.1 is the "Master" and should enjoy the possibility of cross ventilation, allowing for increasing the times when NO Air Conditioning is used, thus most effectively reducing operating costs (increasing overall efficiency and affordability) and reducing the production of additional greenhouse gases. Bedroom No.3 should also have an additional window for the same reason.

   I am sure that additional windows, though perhaps increasing the envelope losses slightly, would lower net energy consumption by reducing A/C run time as effective ventilation would be substituted for mechanical space conditioning for a significant number of hours. I would guess that the additional windows, apart from contributing

greatly to the mitigation of feeling as though one is living in a "tin can," would allow for the user to choose between saving a little money by utilizing Natural Ventilation or spending it and enjoying the additional comfort provided by the dehumidification that only mechanical A/C provides. A little "User Empowerment" achieved by enabling the occupant to have choices is always a good thing for helping to insure user satisfaction.

The other reason for the suggested plan change is to eliminate the need for putting any piping in a stick-built "belly" as described in the Paper. An 8 inch (nominal) SIP floor would, I am sure, be more cost effective to construct as "switching gears" from one construction system to another inherently is the enemy of efficiency. A full SIP floor system would also go al long way toward increasing envelope efficiency as this is an unprotected element of the building subject to the same winds and conductive losses as the walls and roof. So therefore:

2. **SIP Floor Construction**
   Change the stick floor construction to 8 inch nominal (8 ¼" actual) SIP construction. Please note that a few "outrigger braces" that run from the main longitudinal steel members to under the exterior walls will still be required, as specified in the original specifications for the trailer bed.

3. **Reduce Wall Thickness**
   Although the my original recommendations for SIP wall construction depict nominal 6" walls, I believe that 4" SIP walls are what you show in terms of thermal rating. I think this is correct for two reasons, the first is that such minimal overall thermal performance improvement is achieved as to render the increment insignificant, and that the 4" additional interior usable width is a significant improvement when the overall building width of 14 feet – a restriction generated by over-the-road requirements – is so narrow. In fact, it is a 4/152 or 2 ½% improvement. The strength of the construction is reduced a little, but 4"SIP walls only 8 feet high will provide all the strength needed to far exceed all design loads, even for a Type V hurricane. The box will become air-borne before its geometry is at all compromised.

4. **Change Roof Configuration**
   For several reasons I would strongly suggest that the roof be reconfigured from that of a mono-pitched shed to a symmetrical gable. First of all, this greatly impacts the efficiency of SIP construction. The lowest cost and quickest construction with SIPs is achieved through the strategy of using the largest panels available – 4 feet x 24 feet – with the fewest seams and joints. The mono-pitch scheme requires one long wall to be 10 feet high instead of 8 feet. It also requires the 8 foot wide roof SIPs to span over 14 feet from one side to the other, using about 9 panels to do so with 8 transverse joints and remaining lengths of under 10 feet, so there is much waste. Orienting the SIPs to run lengthwise requires 3 SIPs on each side with only two transverse joints, although we concede that the ridge joint is now necessary to deal with. However, no structural ridge support is required.

   Additionally, no ceiling rafters or construction is required. The pitch should be 4 / 12. This will now allow for the use of ordinary asphalt shingle roofing. The standing

seam roofing it replaces results in a savings of over $2000.00.

5. **Roofing Change**
   The roofing change described in item 4 above will lower construction costs as noted. If the additional area is required for solar collectors – to the extent that most of the roofing is covered, any aesthetic considerations are negated. Not to be harsh, but it appears that aesthetic considerations were not on the table at all anyway. The asphalt roofing – properly installed – may be highly wind resistant, and more importantly repaired and maintained by unspecialized labor. One side still presents tremendous area for solar collectors.

6. **PV Solar Installation Size**
   I understand it is desirable to have a solar electric system installed so that when, not if, weather events cause electric service to the Unit to go down it still remains serviceable. However I question the need for such temporary (two weeks?) service to provide adequate power to keep the A/C system fully operational. I have a 2.4 Kw system on my own home of 2400 square feet and find that the critical items to maintain in times of Power Failure are refrigeration and water. Reducing the size will allow installation on the single side of the gable roof. Efficiencies of collectors is creeping up. I applaud the use of the Solar Domestic Hot Water System as being a much better investment and more valuable to maintain in time of crises than air conditioning – see item No.1 above about ventilation.

7. **Air Conditioning System**
   Locate the system to a more central location as per item No.1 above. This will allow reduction in trunk sizes and lower the cost of the system. Study the section of the SIP Proposal (PDF Attached) it shows a central ridge installation with only a trunk and no branches. This further reduced system costs. No code violations are anticipated as referred to in the Paper, as attic duct distribution trees are one of the most commonly installed designs. The curved cover shown eliminates ceiling construction, yields a "cathedral" ceiling throughout which fight the living-in-a-can feeling mentioned above, and is removable with screws in sections as may be required. This continuous chase may also serve for electrical distribution and eliminate the need for such chases in the roof SIPs.

   It may be wise to investigate the application of ductless A/C-Heat Pump systems that are now available with SEER labeling exceeding 14. They may prove to be the most economical and serviceable of all. See http://www.mini-split.com.

   I believe this completes my list for now. Best wishes in the continuing fight ahead to provide decent affordable housing to those in need,

Bill Chaleff