6. GREENCRAFT BUILDERS PROSPER HOUSE, DALLAS, TX

6.1 Executive Summary

Gate 2 - Prototype: Prosper House, Greencraft Builders, Dallas, TX

Overview

Greencraft Builders LLC is a custom home builder that has been constructing Building America prototypes for three years. The partners involved in the effort are the builder (Greencraft), the architect (William Peck and Associates) and Building Science Corporation. The Prosper house was constructed to the highest standards in efficiency, durability and sustainability. It is a quality demonstration of the type of construction that a Building America Prototype should endeavor to be.

Key Results

The Prosper house was constructed to Building America standards by Greencraft Builders LLC. It will serve as a demonstration house for guests to tour and then it will be occupied by a family. This house incorporates many advanced technologies advocated by Building America and Building Science Corporation.

Gate Status

Table 6.1-1: Stage Gate Status Summary

"Must Meet" Gate Criteria	Status	Summary
Source Energy Savings	Pass	The Prosper house meets the 50% minimum source energy savings threshold as defined by the 2009 Building America Benchmark.
Prescriptive-Based Code Approval	Pass	The Prosper House meets the local building code – 2006 IBC.
Quality Control Requirements	Pass	Greencraft maintains quality control through constant communication and onsite reviews by the builder and the architect. Detailed drawing sets from the architect and documented specifications from BSC augments the quality service that Greencraft provides.

"Should Meet" Gate Criteria	Status	Summary
Neutral Cost Target	Pass	This home exceeds the neutral cost target when the cost of improvements is financed as part of a 30 year mortgage. This annual amortized cost is less than the energy savings of the homes compared to the BA Benchmark.
Quality Control Integration	Pass	Quality control is specified by documents between Greencraft and Building Science Corporation.
Gaps Analysis	Pass	BSC and Greencraft attempted to integrate XPS insulation on the slab edge but were unable to. Greencraft will try to include this and other characteristics in future homes.

Conclusions

The Prosper house is a custom single detached home constructed by Greencraft Builders LLC, based out of Dallas, TX. This house began construction in March 2008 and finished

September 2009. It was commissioned by Building Science Corporation and was found to perform exemplary. This house exceeds the 50% energy savings threshold as defined by the Building America Benchmark. The Prosper house is rated at a HERS 53. This house is expected to save $2418 annually due to the advanced technologies implemented in the construction of the home. Greencraft is a stalwart Building America partner and will continue to work closely with Building Science Corporation for the foreseeable future.

6.2 Introduction

6.2.1. Project Overview

Building Science Corporation has been working with Greencraft Builders, based out of Dallas, TX, for the past three years. Greencraft Builders has been using William Peck and Associates as their architect during this period. Greencraft started construction in 2008 on the Prosper House, which is also referred to as the Greenspoint house. Construction did not finish until fall 2009 because of delays and onsite theft. This house demonstrates the energy efficiency and durability upgrades that BSC has been advocating to Greencraft for the past three years. The Prosper house is a culmination of our efforts to construct a model home that will educate builders, designers, and future homeowners on the Building America program. The Prosper house is a two story home with a slab on grade foundation and an unvented attic. Greencraft has been successfully constructing unvented attics for years and is a strong advocate of the design.

Figure 6.2.1: Greencraft Prosper House – Greenspoint House

BSC provided consulting services for Greencraft and recommended numerous efficiency and durability improvements. Key upgrades include an unvented roof, exterior walls with low density spray foam insulation, and supplemental dehumidification. Other upgrades that contributed to increased building efficiency and durability are LoE^3 next generation spectrally selective glazing treatment and a high efficiency HVAC system.

This house is in a Mixed-Humid climate zone. Major partners involved with Greencraft Builders in the development of the 2009 Prosper House are:

- Department Of Energy: Building America – Building Science Corporation
- EPA Energy Star® for Homes
- MASCO Environments for Living®
- Green Built™ North Texas
- NAHB National Green Building Program™
- US Green Building Program LEED®

Figure 6.2.2: Rear View

6.2.2. Project Information Summary Sheet

PROJECT SUMMARY	
Company	Greencraft Builders, LLC
Company Profile	GreenCraft Builders L.L.C. is the culmination of more than 30 years of experience building and remodeling homes in the Dallas/Fort Worth metroplex. Since 2004, Chris Miles, principal of GreenCraft, has been recognized as a leader in the North Texas green building industry, first as a producer and project manager, and now as a builder with his company, GreenCraft Builders L.L.C.
Contact Information	Chris Miles GreenCraft Builders L.L.C. 105 West Main Street Lewisville, TX 75057 (214) 718-8424 http://www.greencraftbuilders.com/ http://www.greencraftbuilders.com/greenspointhouse.html
Company Type	Custom Home Builder
City, State	Prosper, TX
Climate Region	Mixed-Humid, IECC Climate Zone 3A

SPECIFICATIONS	
Number of Houses	1
Municipal Address(es)	81 Stonybrook Drive, Prosper, TX 75078
House Style(s)	Custom single family home with attached garage
Number of Stories	2
Number of Bedrooms	4
Plan Number(s)	Greenspoint
Floor Area	3323 sf
Estimated Energy Reduction	55% over BA Benchmark
Estimated Energy Savings	$2418
Estimated Cost	$395,000 total
Construction Start	June 2008
Expected Buildout	September 2009

6.2.3. Targets and Goals

Building America Prototype houses must reach a minimum of 50% vs. the 2008 Building America Benchmark in Mixed-Humid climates. This is an energy efficiency target established by Building America to promote quality design and construction.

Specific goals of the 2009 Prosper house are:

- To promote spray foam unvented roofs as an effective way to locate the HVAC system within the building enclosure, and to reduce building infiltration.
- To utilize full Optimum Value Engineering (OVE) Advanced Framing in the enclosure construction. This consists of 2x6 studs at 24"o.c. with two stud energy corners, single top plate and reduction in window framing. Also included is stacked framing with both the floor joists and roof trusses spaced at 24"o.c.
- To encourage supplemental dehumidification to provide annual comfort control separate from the HVAC system.

6.3 Whole-House Performance and Systems Engineering

6.3.1. Energy Analysis Summary

Table 6.3-1: Estimated Whole House Energy Use for the Prosper House

ESTIMATED WHOLE HOUSE ENERGY USE		
Source (10^6 BTU/yr)	Site (10^6 BTU/yr)	Area + Bsmt (sq ft)
199	66	3323 + 0
	% Electric	No. of Bedrooms
	69%	4

With the enclosure and mechanical characteristics presented in Table 6.3 and Table 6.4, this plan achieves a performance level of 55% reduction relative to the Building America Benchmark.

6.3.1.1. Parametric Energy Simulations

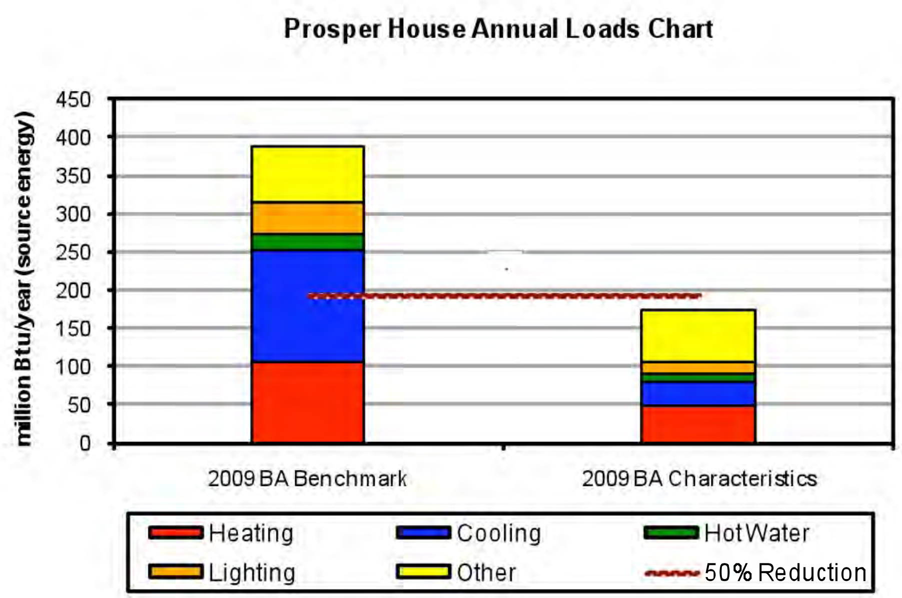


Figure 6.3.1: Annual Loads Chart

6.3.1.2. End-Use Site and Source Energy Summaries

Table 6.3-2: Summary of End-Use Site-Energy

	Annual Site Energy			
	Benchmark		Prototype	
End-Use	kWh	therms	kWh	therms
Space Heating	8978	0	3917	0
Space Cooling	13077		2541	
DHW	0	201	0	91
Lighting*	3465		1318	
Appliances + Plug	5413	114	4962	114
OA Ventilation**	62		582	
Total Usage	30995	315	13320	205
Site Generation	0		0	
Net Energy Use	30995	315	13320	205

Table 6.3-3: Summary of End-Use Source-Energy and Savings

	Estimated Annual Source Energy		Source Energy Savings	
			% of End-Use	% of Total
	Benchmark	Prototype	Prototype	Prototype
End-Use	10^6 BTU/yr	10^6 BTU/yr	savings	savings
Space Heating	103.1	45.0	**56%**	**15%**
Space Cooling	150.1	29.2	**81%**	**31%**
DHW	21.9	9.9	**55%**	**3%**
Lighting*	39.8	15.1	**62%**	**6%**
Appliances + Plug	74.6	69.4	**7%**	**1%**
OA Ventilation**	0.7	6.7	**-839%**	**-2%**
Total Usage	390	175	**55%**	**55%**
Site Generation	0	0		**0%**
Net Energy Use	390	175	**55%**	**55%**

The following incremental improvements had the largest impact on the efficiency of the prototype vs. the benchmark (in order, not including renewable installations):

1. Vinyl framed double paned windows with LoE^3 spectrally selective coating
2. 100% Compact Fluorescent Lighting
3. 16 SEER Air source heat pump
4. Air Seal to 1.1 in^2 per 100 ft^2 of enclosure area
5. Ducts inside conditioned space and duct leakage to outside reduced to 1% of flow

6.3.2. Discussion

6.3.2.1. Enclosure Design

Table 6.3-4 (below) summarizes the building enclosure assemblies used for this project.

Table 6.3-4: Enclosure Specifications

ENCLOSURE		SPECIFICATIONS
Ceiling		
	Description -	Composition shingle on truss roof – unvented roof
	Insulation -	R-30 low density spray foam on underside of roof
Walls		
	Description -	Full OVE framing, 2x6 wood studs 24” o.c., two stud corners single top plate Stacked framing with floor joists and roof trusses at 24”o.c.
	Insulation -	R-19 open cell low density spray foam + ¾” R-4 XPS insulating sheathing
Foundation		

ENCLOSURE	SPECIFICATIONS
Description -	Post tensioned slab on grade with Termimesh® termite barrier system Slab is 51% fly ash
Insulation -	No insulation
Windows	
Description -	Double pane viny framed with LoE[3] spectrally selective glazing
Manufacturer -	Jeld-Wen® Windows
U-value -	U = 0.33
SHGC -	SHGC = 0.21
Infiltration	
Specification -	2.5 in^2 leakage area per 100 ft^2 envelope (2224 CFM 50 goal)
Performance test -	1.1 in^2 leakage area per 100 ft^2 envelope (994 CFM 50 measured)

Greencraft constructed a slab on grade foundation without any insulation. Insulating the slab edge to R-10 with 2" of XPS insulation was considered. However, the energy model predicted only a minor improvement in the annual energy consumption. Also, the slab was designed to be post tensioned, due to expanding soils, and that presented a difficult design challenge. Despite not installing any slab insulation for the Prosper house, Greencraft is interested in integrating it starting in 2010.

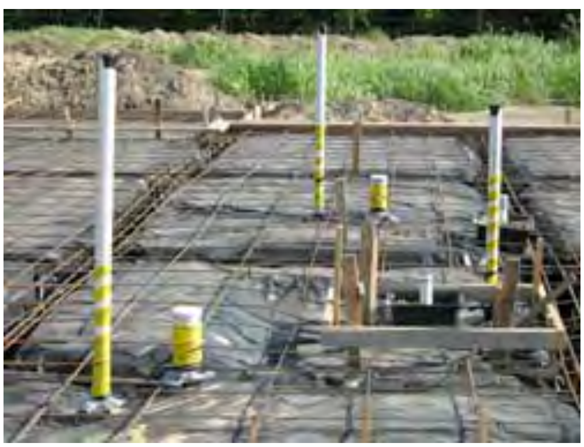


Figure 6.3.2: Termimesh® barrier system installed around slab penetrations before casting

Figure 6.3.3: Penetrations after slab casting

Exterior framing is 2x6 with R-19 low density spray foam in the stud cavity. Greencraft is implementing full advanced framing, and has been doing so successfully for the past four years. Full advanced framing includes:

- 2x6 studs at 24" o.c.
- Single top plate
- Two stud corners with drywall clips
- Single window headers installed to the outboard face of the exterior wall
- Stacked framing

- No window cripples adjacent to jack studs and minimum cripples installed

Below are a group of photos that show the various aspects of full advanced framing.

Figure 6.3.4: Two stud "energy corner"

Figure 6.3.5: Single top plate joined at corners with steel plate

Figure 6.3.6: Single top plate

Figure 6.3.7: Another view of the single top plate

Figure 6.3.8: One method of joining the single top plates together: through a 24" splice

Figure 6.3.9: Another method of joining the single top plates together: line the joint on top of an existing stud

Figure 6.3.10: Stack framing of the floor joists on the

Figure 6.3.11: Another method of joining the single top plates together: line the joint on top of an existing stud

The exterior walls have ¾" insulating sheathing. This reduces the energy losses from thermal bridging through the exterior studs. At the corners ½" OSB is installed for structural support. The OSB is installed 4' from the corner and then the wall resumes the ¾" XPS in the field. ¼" XPS is installed over the OSB to add insulation and to provide a smooth surface for continuing the construction of the exterior wall. DuPont™ Tyvek® ThermaWrap™ is installed as a housewrap on the entire enclosure. It serves as a water resistive membrane to drain water out from the wall assembly.

The exterior wall is clad half in stone and half in fiber cement board. The transition between the two cladding systems is critical to be installed correctly in order to effectively control rainwater entry and air infiltration. The housewrap continually envelopes behind both wall claddings so there is no leakage at the joint between the stone and the fiber cement.

Figure 6.3.12: ¾" XPS insulating sheathing with ½ OSB at the corners for structural support

The windows were installed after the housewrap. The Greenspoint house was able to procure vinyl framed windows with state of the art LoE³ spectrally selective glazing coating. This resulted in an NFRC SHGC rating of 0.21. This glazing coating, coupled with extensive overhangs in the floor plan, results in a greatly reduced cooling peak load and annual cooling energy use. They were installed and flashed according the specifications provided to them by Building Science Corporation. DuPont™ FlexWrap™ is installed as the sill flashing. DuPont™ StraightFlash™ is installed at the jambs and head to prevent water from entering the rough opening. The space between the rough opening and the window is sealed using low expanding polyurethane spray foam. That acts as an air barrier to limit infiltration through the window assembly.

Figure 6.3.13: FlexWrap™ installed at the window sill

Figure 6.3.14: StraightFlash™ installed on the jambs and at the head of the rough opening

Figure 6.3.15: Vinyl framed windows before cladding installation

Figure 6.3.16: Vinyl windows with stone cladding installed

The 2x6 wall cavity is entirely filled with open cell low density spray foam to an R-19.

Figure 6.3.17: Wall cavities insulated

Figure 6.3.18: Insulation continues up the rim joist and under the roof sheathing

The roof has R-30 low density spray foam installed under the roof deck to create an unvented attic.

Figure 6.3.19: Unvented cathedralized attic with R-30 open cell low density spray foam installed under the roof deck

The roof is comprised of mostly compositions shingles. The overhangs are framed separately and have a standing seam metal roof. This was an aesthetic preference by the architect.

Figure 6.3.20: Wall cavities insulated

Figure 6.3.21: Insulation continues up the rim joist and under the roof sheathing

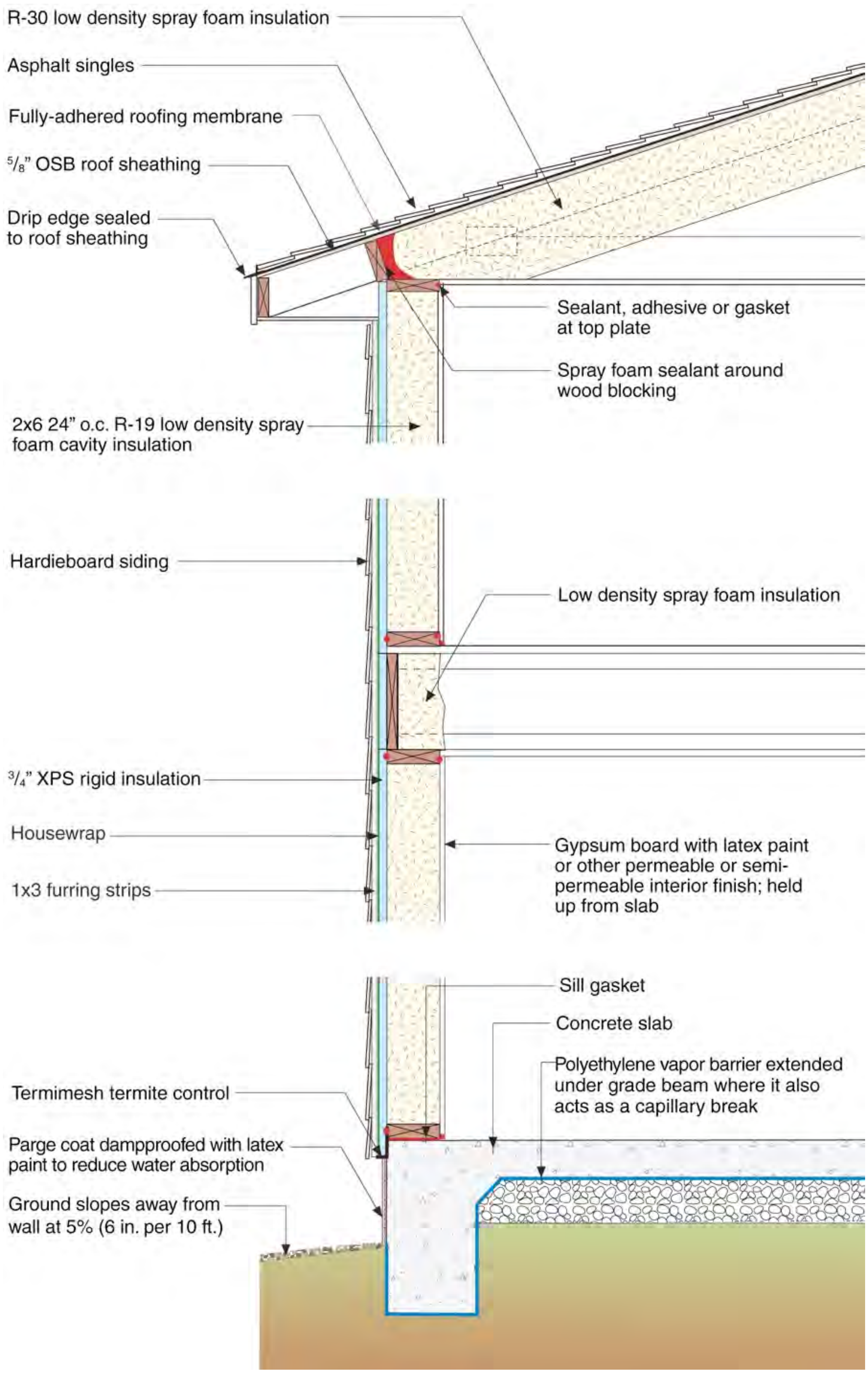


Figure 6.3.22: Enclosure Building Section

6.3.2.2. Mechanical System Design

Table 6.3-6 (below) summarizes the mechanical systems used by this project.

Table 6.3-5: Mechanical system specifications

MECHANICAL SYSTEMS	SPECIFICATIONS
Heating	
Description -	9.5 HSPF air source heat pump
Manufacturer & Model -	Amana® ASZ Series
Cooling (outdoor unit)	
Description -	16 SEER
Manufacturer & Model -	Amana® ASZ Series
Cooling (indoor unit)	
Description -	Air Handler with heat pump coil
Manufacturer & Model -	Amana® Air Handler
Domestic Hot Water	
Description -	(2) Instantaneous natural gas hot water heaters, 0.82
Manufacturer & Model -	Rinnai® R94LSi
Distribution	
Description -	R-6 flex ducts in conditioned unvented attic
Leakage -	5% or less duct leak to outside
Performance -	15 CFM 25 to outside – 0.75% of total flow (2000 CFM)
Ventilation	
Description -	Supply-only system integrated with AHU Aprilaire VCS 8126 ventilation controller 50 CFM 33% Duty Cycle: 10 minutes on; 20 minutes off
Manufacturer & Model -	XCI Contols Programmable Thermostat
Return Pathways	
Description -	Central return on first and second floor, jump ducts in bedrooms
Dehumidification	
Description -	Whole house dehumidifier
Manufacturer & Model -	GeneralAire® Model 1300

Greencraft chooses to construct an insulted unvented cathedralized attic because it is easier to locate the ductwork in conditioned space. Ductwork in conditioned space is one of the top characteristics of any Building America home.

The Greenspoint house has two HVAC systems, one for the first floor (3-ton) and a second unit (2-ton) for upstairs.

A 16 SEER heat pump contributes much to the overall efficiency of the prototype and is a important efficiency upgrade in a Mixed-Humid climate like Dallas, with a significant cooling load.

The two units were both horizontally installed in the conditioned unvented cathedralized attic, as shown below.

Figure 6.3.23: Unit 1 (3-ton) for the first floor

Figure 6.3.24: Unit 2 (2-ton) for the second floor

Figure 6.3-25 below shows the HVAC design that integrates the air handler with the whole house dehumidification system.

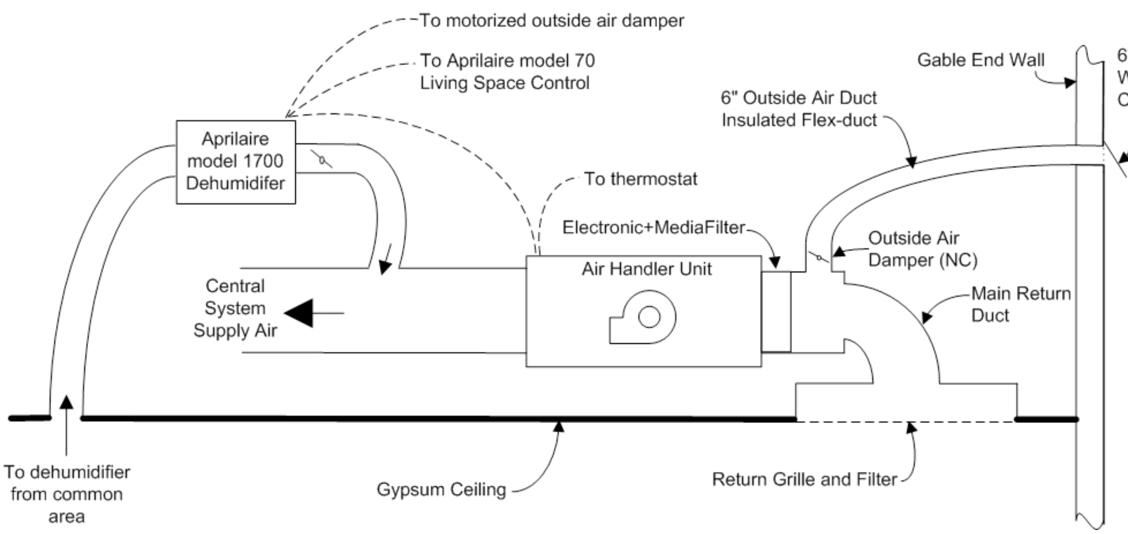


Figure 6.3-25: Central Fan Integrated Supply Ventilation Schematic with Supplemental Dehumidification

Supplemental dehumidification is one of the key improvements to the prototype, and is necessary because of the very efficient enclosure. The sensible load has been reduced such that the ratio of sensible to latent load is very different than in a standard home. Supplemental dehumidification will provide the occupant with the ability to control indoor humidity levels all year round. This will have a beneficial impact on the comfort and durability of the structure by preventing high humidity levels and potential mold risks. In this prototype, the whole house dehumidifier is installed on the first floor HVAC unit. Only one HVAC system, usually the system that will be on more often than the other, needs to have a whole house dehumidifier installed in order to effectively control humidity throughout the year.

Figure 6.3.26: GeneralAire® Model 1300 whole house dehumidifier

Figure 6.3.27: Dehumidifier integrated with duct system in the conditioned unvented cathedralized attic

Greencraft Builders utilizes Central Fan Integrated Supply ventilation that draws outside air via a 6" flex duct to the return plenum of the HVAC system. This allows the introduction of outside air to the living space whenever space conditioning is already operating. The Aprilaire® 8126 VCS fan cycling controller was installed at the Prosper house. Fan cycling will turn on the fan at a 33% duty cycle (10 minutes on, 20 minutes off) in order to provide outside air during periods of no space conditioning. A manual damper is installed on the 6" duct to allow the installer to reduce flow to the recommended 50 CFM if needed during commissioning. A 6" mechanical damper is also installed on the 6" outside air duct. This is controlled by the fan cycler and will close off the outside air duct during periods of consistent space conditioning to prevent over ventilation of the living space.

Figure 6.3.28: 6" insulated flex duct installed as an outside air duct that draws in outside air to the return plenum

Figure 6.3.29: Aprilaire® 8126 VCS fan cycling control installed on the return plenum

Bathroom exhaust fans and a kitchen hood are installed to provide spot ventilation when necessary. These are all routed to the outside and are not re-circulating fans. One of the bathroom fans is rated to provide ASHRAE 62.2 ventilation so that the house can be operated at that rate when needed.

6.3.2.3. Lighting and Miscellaneous Electrical Loads

Greencraft Builders installed 100% Energy Star rated screw base CFL lights in the 2009 prototype. An Energy Star refrigerator, dishwasher, and clothes washer are also installed.

6.3.2.4. Site-generated Renewable Energy

Greencraft was unable to procure and site generated renewable energy installations for the 2009 prototype house.

6.4 Construction Support

6.4.1. Construction Overview

Construction began in June 2008 and finished September 2009. Greencraft did not come across any major enclosure related problems as they have constructed this type of enclosure before. The mechanical installation also is not experiencing any problems.

The site did experience severe vandalism and theft. All of the windows were stolen along with other building materials. This delayed construction for months. This was the first house in the development so the building was left vulnerable for theft.

6.4.2. Educational Events and Training

Greencraft Builders makes a large effort to use each Building America Prototype house as a demonstration for interested parties to tour. The Prosper house will be open for touring on October 24th, 2009. Historically, Greencraft Building America prototype homes attract many interested visitors ranging from homebuyers to individual trades, local builders and energy raters. Greencraft along with their product sponsors invest a lot of money and time into educating the public about the Building America standard of construction.

6.4.3. Systems Testing

Testing and commissioning of the building enclosure and mechanical systems was performed to ensure the house will operate as designed. The following tests will be performed:

- Air leakage testing with a multipoint blower door
- Duct leakage testing with a duct blaster
- Local air flows measured with a flow hood
- System external static pressure measured with a monometer
- Outside air duct air flow measured with a monometer and flow hood
- Proper configuration of the GeneralAire® Model 1300 whole house dehumidifier

6.4.4. Monitoring

Unlike in previous and in future Greencraft homes, Building Science Corporation has no immediate plans to monitor the Prosper house.

6.5 Project Evaluation

The following sections evaluate the research project results based on the ability to integrate advanced systems with production building practices in prototype homes. References are made to the results from field tests and energy simulations, which are included as an appendix to this report.

6.5.1. Source Energy Savings

Requirement:	*Final production home designs must provide targeted whole house source energy efficiency savings based on BA performance analysis procedures and prior stage energy performance measurements.*
Conclusion:	***Pass***

The Prosper house exceeds the 50% minimum targeted whole house source energy savings vs. the 2009 Building America Benchmark. The percentage savings were calculated with FSEC's Energy Gauge USA v. 2.8.02 and the 2009 Building America Benchmark defined the comparison home. The source energy savings for the Prosper house is 55% less than the benchmark. This is achieved through the design and construction of a high quality enclosure and the installation of highly efficient mechanical systems.

6.5.2. Prescriptive-based Code Approval

Requirement:	*Must meet prescriptive or performance safety, health and building code requirements for new homes.*
Conclusion:	***Pass***

The city of Prosper currently adopts the 2006 International Building Code. The Prosper house meets this and all local building codes and has been designed and constructed to maintain a healthy living environment. Full advanced framing has been accepted by the local code officials for the past four years. Greencraft has been changing the way the code officials understand advanced framing and has served as a local example of exemplary construction.

6.5.3. Quality Control Requirements

Requirement:	*Must define critical design details, construction practices, training, quality assurance, and quality control practices required to successfully implement new systems with production builders and contractors.*
Conclusion:	***Pass***

BSC worked with Greencraft to ensure proper quality control through implementation of quality construction practices into their building environment. Greencraft maintains excellent quality control from initial design to the finished building. The architect creates very detailed drawing sets with details that specifically outline a certain characteristic. The owner of Greencraft as well as a superintendent both tour the homes regularly and will demand any deviations from the design to be remedies immediately.

Greencraft maintains constant communication within the company and between contractors or the architect. Contractors are made aware of their responsibility and their work is checked often.

6.5.4. Neutral Cost Target

Requirement:	*The incremental annual cost of energy improvements, when financed as part of a 30 year mortgage, should be less than or equal to the annual reduction in utility bill costs relative to the BA Benchmark.*
Conclusion:	***Pass***

Incremental cost data came from either Greencraft Builders or were estimated by BSC. The Neutral Cost Analysis Worksheet below shows that the Prosper house does qualify. The house is expected to save $1551 a year compared to the additional amortized mortgage payments. The mortgage is assumed to be a 30 year plan at a rate of 7%. This is an important selling point that Greencraft uses with prospective home buyers.

Table 6.5-1: Prosper House Neutral Cost Analysis

	Annual Electric Use (Site)		Annual Gas Use (Site)		
	Benchmark	Prototype House	Benchmark	Prototype House	Annual Utility Bill Reduction vs Benchmark
End Use	**(kWh/yr)**	**(kWh/yr)**	**(therms/yr)**	**(therms/yr)**	**($/yr)**
Space Heating	9144	3917	0	0	$680
Space Cooling	12795	2541	0	0	$1,333
DHW	0	0	201	91	$138
Lighting	3465	1318	0	0	$279
Appliances and MELs	5413	4962	114	114	$59
Ventilation	62	582	0	0	($68)
Total Usage	**30879**	**13320**	**315**	**205**	**$2,420**
Site Generation	0	0	0	0	$0
Net Energy Use	**30879**	**13320**	**315**	**205**	**$2,420**
Added Annual Mortgage Cost w/o Site Gen.					**$1,269**
Net Cash Flow to Consumer w/o Site Gen.					**$1,151**

The analysis took into account the fees required for third party testing as well as the benefits back to the builder relative to the federal tax credit.

The estimated annual utility savings were based on local utility rates provided by Greencraft Builders LLC (Natural Gas $1.25/therm; Electricity $0.13/kWh).

6.5.5. Quality Control Integration

Requirement:	*Health, Safety, Durability, Comfort, and Energy related QA, QC, training, and commissioning requirements should be integrated within construction documents, contracts and BA team scopes of work.*
Conclusion:	***Pass***

Quality control is specified by documents between Greencraft and Building Science Corporation. See the appendix for documents that pertain to energy analysis, ventilation schematics and site reports.

6.5.6. Gaps Analysis

Requirement:	*Should include prototype house gaps analysis, lessons learned, and evaluation of major technical and market barriers to achieving the targeted performance level.*
Conclusion:	***Pass***

A gap that was noted during the construction of the Prosper house was the lack of any slab insulation. BSC and Greencraft attempted to include exterior slab insulation but the post tensioned slab design did not work. BSC suggested that the slab be a stem wall in order to avoid the post tensioning that was blocking the continuity of the slab insulation. This was unable to be achieved in the Prosper house but Greencraft would like to readdress this design in future prototype homes.

BSC is also recommending that the exterior insulating sheathing be increased from ¾" XPS to 1" XPS. Greencraft is also considering upgrading to 1" of foil-faced polyisocyanurate sheathing as a way to further reduce thermal bridging losses.

6.6 Conclusions/Remarks

Greencraft Builders constructed a 50% Building America Prototype house in 2009 that incorporates advanced building technologies that positively impact the durability and efficiency of the residence as well as ensuring higher levels of comfort and health in the living space.

Significant aspects of the design include the low density spray foam unvented roof and supplemental dehumidification. The low density spray foam installed in the unvented roof, as well as in the walls will result in a very tight building enclosure. Supplemental dehumidification will ensure occupant comfort all year round and will control humidity levels separately from the HVAC system. Other important design elements include LoE^3 vinyl windows, CFL lights and Energy Star® appliances.

The Prosper house is rated to save 55% on source energy vs. the BA Benchmark. This translates to around $2,418 saved annually. The house also is rated 53 on the HERS Index, qualifying it for the Builder's Challenge.

This house will receive much attention during the next year. It will serve as a model home for Greencraft, like all of their Building America prototypes.

Gaps and lessons learned were identified throughout the design and construction process. These include insulating the slab on grade and increasing the insulating sheathing. BSC is also negotiating with Greencraft to upgrade a heat pump with modulating gas reheat. This will eliminate the need for a separate whole house dehumidifier.

6.7 Appendices

6.7.1. BSC Project Case Study – Greencraft Prosper House

6.7.2. Drawings and Specifications

6.7.3. Energy Modeling

6.7.4. Mechanical System Design

6.7.5. Site Visit Reports

6.7.6. Builder's Challenge Certificate

Appendix D.6.7.1
BSC Project Case Study: Greencraft Prosper House

Case Study

GreenCraft Builders 2008 Greenspoint House Prototype

Prosper, Texas

Project Profile

U.S. Department of Energy Energy Efficiency and Renewable Energy
Bringing you a prosperous future where energy is clean, abundant, reliable, and affordable

Project Team: Greencraft Builders, LLC, Building Science Corporation

Address: 2481 Stonybrook Drive, Prosper, Texas

Description:
3,323 ft^2 one-story single family home

Completion Date:
January, 2009

Estimated Annual Energy Savings:
Average 52.7% projected source energy savings relative to the 2008 Building America Benchmark

Project Website:
www.greencraftbuilders.com/greenspointhouse.html

Overview

BSC collaborated with Greencraft Builders in Prosper, TX on a 2008 prototype house called the Greenspoint House. This house demonstrates the energy efficiency and durability upgrades that Greencraft has been promoting for years. The architect for the Greenspoint house was William Peck and Associates, out of Lewisville, TX. The Greenspoint house is located in Prosper, TX.

BSC provided consulting services for Greencraft and recommended numerous efficiency and durability improvements. Key upgrades include an unvented roof with low density spray foam insulation and supplemental dehumidification. Other upgrades that contributed to increased building efficiency and durability are LoE^3 next generation spectrally selective glazing treatment and a high efficiency HVAC system.

Enclosure Design

Greencraft employed full advanced framing throughout the enclosure. This includes 2x6 at 24" o.c. with stacked framing through the floor joists and roof rafters. A single top plate and 2 stud energy corners minimize thermal bridging in the wall system. The wall and roof are insulated with low density spray foam. One-half inch OSB sheets are installed at the

Building Science Corporation
30 Forest Street
Somerville, MA 02143
www.buildingscience.com

Builder Profile

GreenCraft Builders L.L.C. is the culmination of more than 30 years of experience building and remodeling homes in the Dallas/ Fort Worth metroplex. Since 2004, Chris Miles, principal of GreenCraft, has been recognized as a leader in the North Texas green building industry, first as a producer and project manager, and now as a builder with his company, GreenCraft Builders L.L.C.

Participating Programs & Certifications

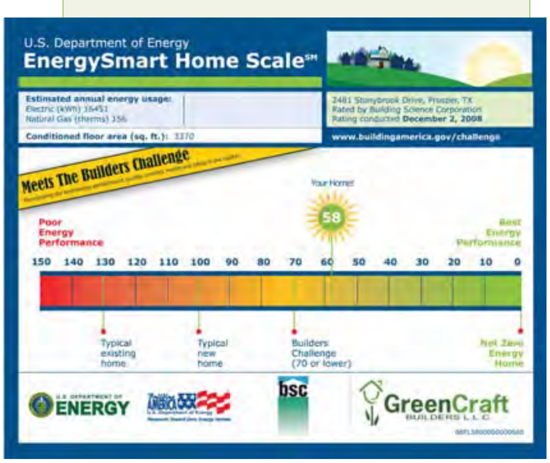
U.S. Department of Energy's Building America Program

U.S. Green Building Council LEED® for Homes

U.S. Environmental Protection Agency ENERGY STAR® Program

Masco Environments for Living®

NAHB National Green Building Program™



corners for structural integrity. Three-quarters of an inch of unfaced XPS is installed as insulating sheathing on the walls. The enclosure does not contain any impermeable components and this allows accumulated moisture to dry out via vapor diffusion and prevent wetting and subsequent mold.

The Greenspoint house was able to procure, with help from BSC, vinyl framed windows with state of the art LoE³ spectrally selective glazing coating. This resulted in an NFRC SHGC rating of 0.21 as well as a U-value of 0.35. This glazing coating, coupled with extensive overhangs in the floor plan, results in a greatly reduced cooling peak load and annual cooling energy use.

Mechanical Design

A high efficiency duel fuel heat pump/sealed combustion gas furnace (15 SEER/8.5 HSPF-93% AFUE) is installed along with a stand-alone dehumidifier in the unvented roof. The duel fuel heating will allow the heating system to switch from the air source heat pump to the gas furnace when the outdoor temperature drops below 40 °F to maintain a high level of heating efficiency.

The entire duct system is located in the unvented conditioned attic is sealed extremely tight. Jump ducts provide passive returns from the bedrooms. High efficiency exhaust ducts are installed at all the bathrooms and at the kitchen hood.

Greencraft Builders utilizes Central Fan Integrated Supply (CFIS) ventilation that draws outside air via a 6" flex duct to the return plenum of the HVAC system. This allows for the introduction of outside air to the living space whenever space conditioning is already operating. The SCI ERV Super thermostat has fan cycling included in its circuitry. Fan cycling will turn on the fan at a 33% duty cycle (10 minutes on, 20 minutes off) in order to provide outside air during periods of no space conditioning. A manual damper is installed on the 6" duct to allow the installer to reduce flow to the recommended 50 CFM if needed during commissioning. A 6" mechanical damper is also installed on the 6" outside air duct. This is controlled by the fan cycler and will close off the outside air duct during periods of constant space conditioning to prevent over ventilation of the living space.

Bathroom exhaust fans plus a kitchen hood are installed to provide spot ventilation when necessary. These are all routed to the outside and are not re-circulating fans. One of the bathroom fans is rated to provide ASHRAE 62.2 ventilation so that the house can be operated at that rate if needed.

Quality Assurance & Quality Control

- Design follows BSC Building America Performance Criteria
- Manual J8 analysis ensures right-sized mechanical systems and ductwork

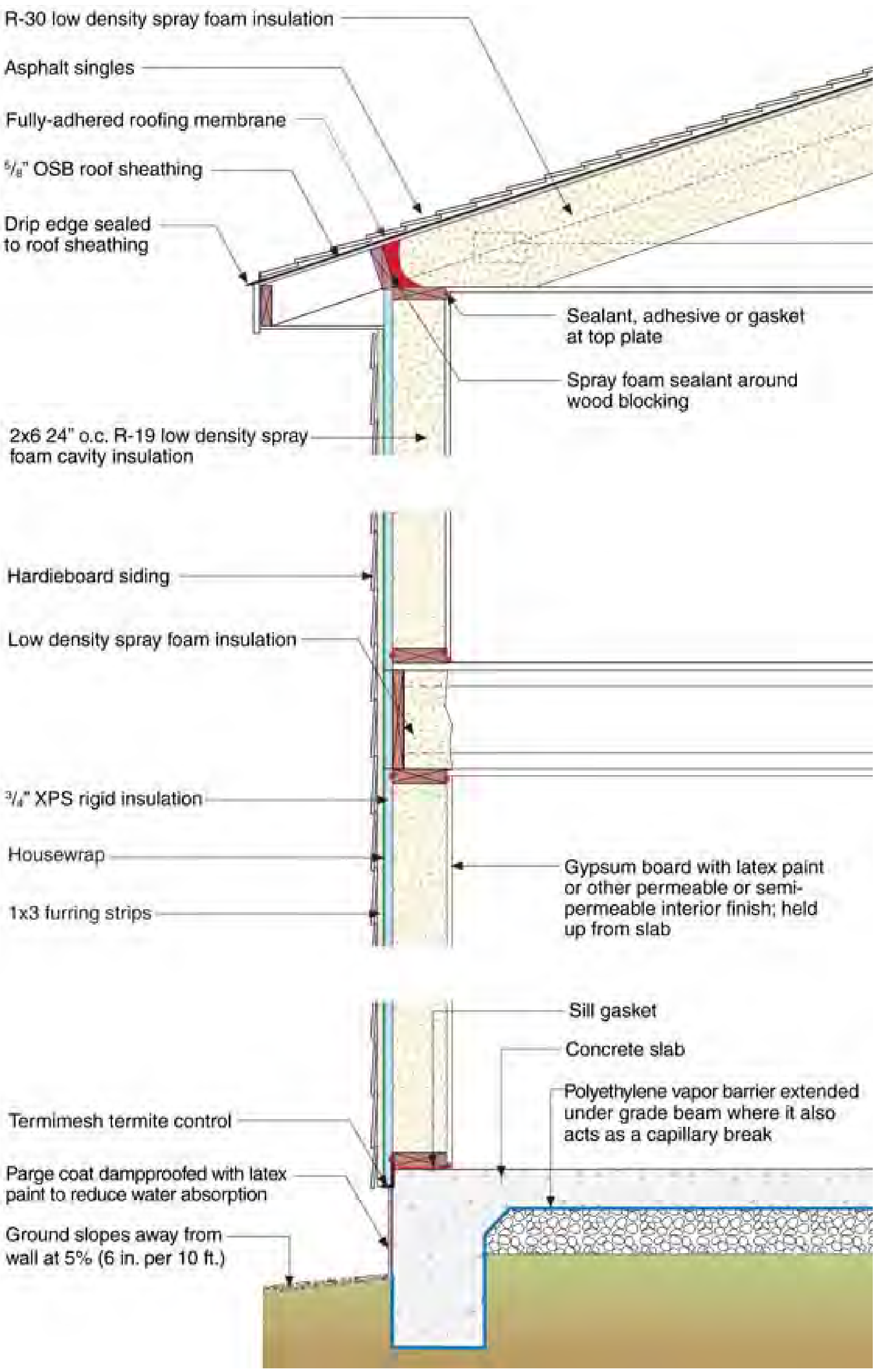
System Testing

Testing and commissioning of the building enclosure and mechanical systems was performed to ensure the house will operate as designed. The following tests were performed:

- Air leakage
- Duct leakage
- Local air flows
- System external static pressure
- Outside air duct air flow
- Proper configuration of SCI Super ERV thermostat with fan cycling control

Monitoring

Monitoring plans have not been discussed at length as of this time. Building Science Corporation may install a monitoring system similar to the Bannister 2007 house. This would include T/RH HOBOs installed throughout the house and unvented attic plus HVAC run time monitoring.



Building Enclosure

1 Roof Insulation: Unvented conditioned attic the 8 1/2" R-30 low density spray foam installed to the underside of the roof deck and on vertical gable end walls

Wall Insulation: 2x6 walls at 24" o.c. with 5 1/2" R-19 low density spray foam insulation installed in the stud by onto 3/4" exterior OSB

2 Window Specifications: Vinyl frame Lo-E^3; U=0.33, SHGC=0.21

Air Sealing: Enclosure air sealing is provided via low density spray foam being installed on all walls and roof of the building. Low expanding spray foam is installed around windows and penetrations. Sealants and adhesives used between framing components.

3 Uninsulated Slab: Uninsulated slab-on-grade with sloping gradient and mulch for proper drainage

4 Drainage Plane: Tyvek® ThermaWrap™ spun housewrap serves as a drainage plane behind fiber cement clapboard

Infiltration: 2.5 in^2 leakage area per 100 ft^2 envelope

Mechanical Design

HERS Index Score: 58

Heating: Duel fuel 9.5 HSPF heat pump/sealed combustion 93% AFUE gas furnace

Cooling: 16 SEER heat pump

❶ **Supplemental Dehumidification:** GeneralAire Model 1300 whole house dehumidifier configured to draw air from main living space and supply dehumidified air to the supply plenum. This allows for dehumidified air to be distributed throughout the house and for the dehumidifier to run only when dehumidification is needed.

Ventilation: Central Fan Integrated Supply Ventilation controlled by Aprilaire 8126 Ventilation Control System (VCS)

Return Pathways: Jump ducts at bedrooms

❸ **Ducts:** R-8 flex ducts in unvented conditioned attic; leak-free to outside (5% or less)

DHW: Natural gas 0.82 EF instantaneous gas hot water heater

Appliances: Energy Star dishwasher, refrigerator and clothes washer

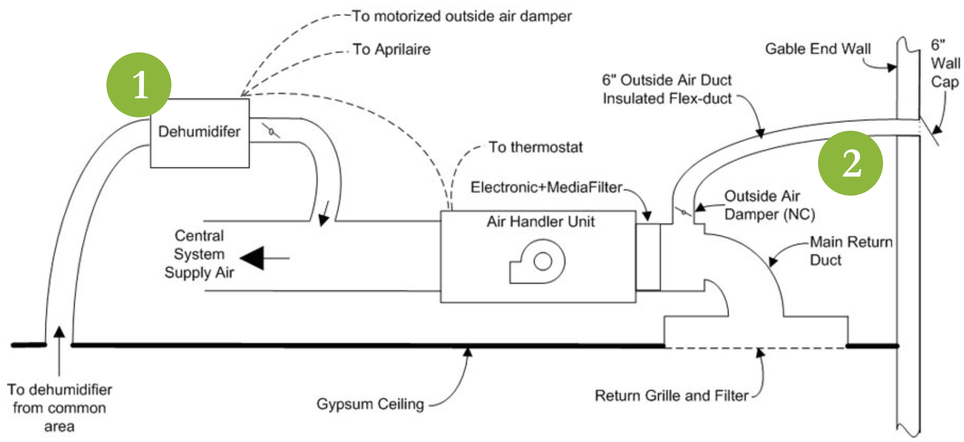
Lighting: 100% Energy Star CFLs

Site Generated Power: None

Water Management

Landscape Plan: Plan minimizes water run-off from the site

Plumbing Fixtures: Very high efficiency—faucets, showerheads and toilets



Lessons Learned & Future Projects

Greencraft first observed incorrect installation of the Tyvek® ThermaWrap™ drainage plane over the window headers. The housewrap was initially lapped behind the nailing flange rather than over it. The installers had to come back and install a cut piece of housewrap over the header with acrylic based adhesive backed polypropylene tape (Tyvek® Tape). The installers have been instructed how to properly install the housewrap in future Greencraft homes.

Technology Gaps & Barriers

• Increasing insulating sheathing levels: Greencraft plans on upgrading the $^{3}/_{4}$" XPS sheathing to a full inch in future homes.

This case study has been prepared by Building Science Corporation for the Department of Energy's Building America Program, a private/public partnership that develops energy solutions for new and existing homes. The views and opinions of authors expressed herein do not necessarily state or reflect the those of the United States government or any agency thereof.

For more information about Building America go to www.buildingamerica.gov

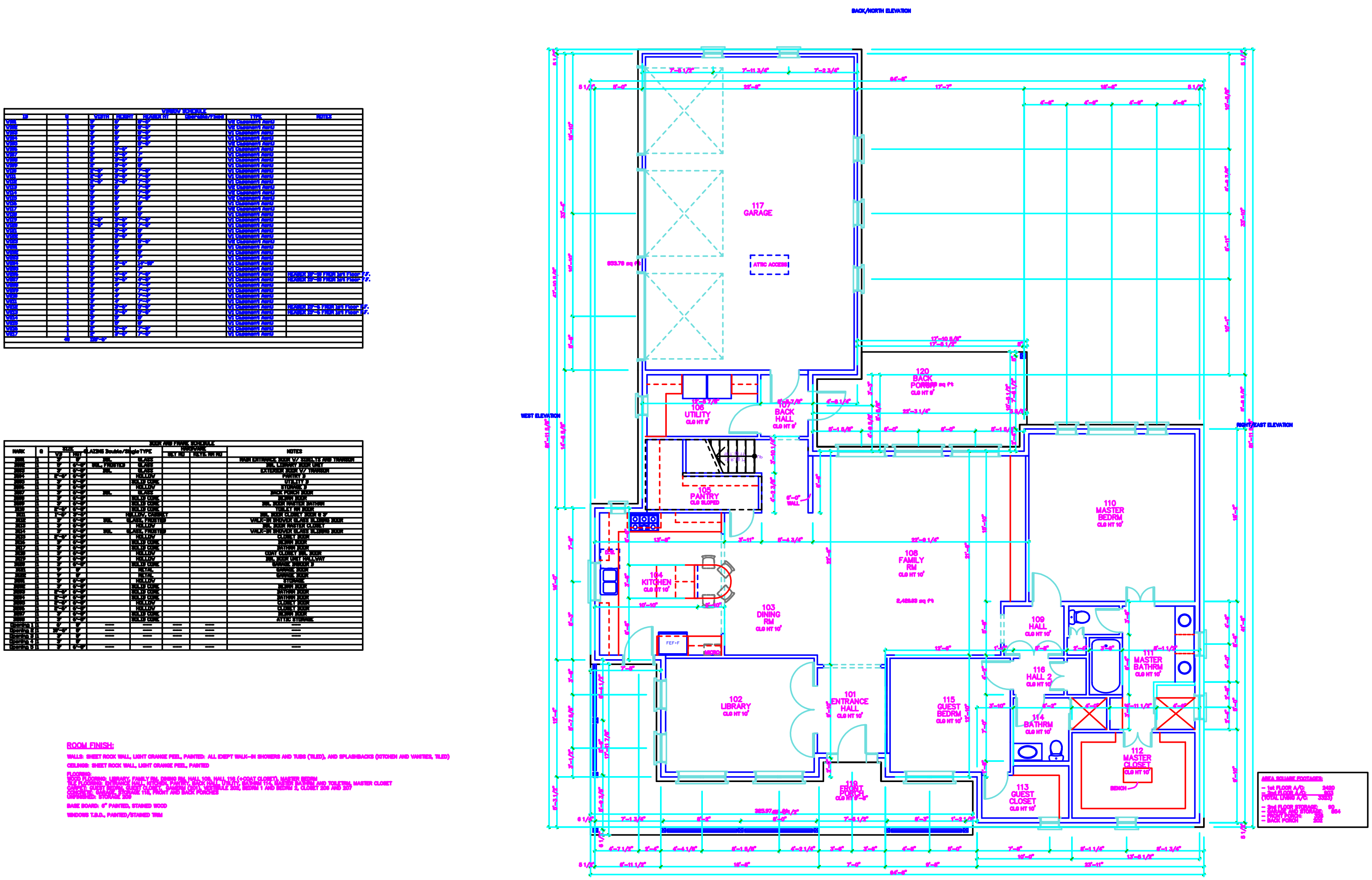
Building America U.S. Department of Energy Research Toward Zero Energy Homes

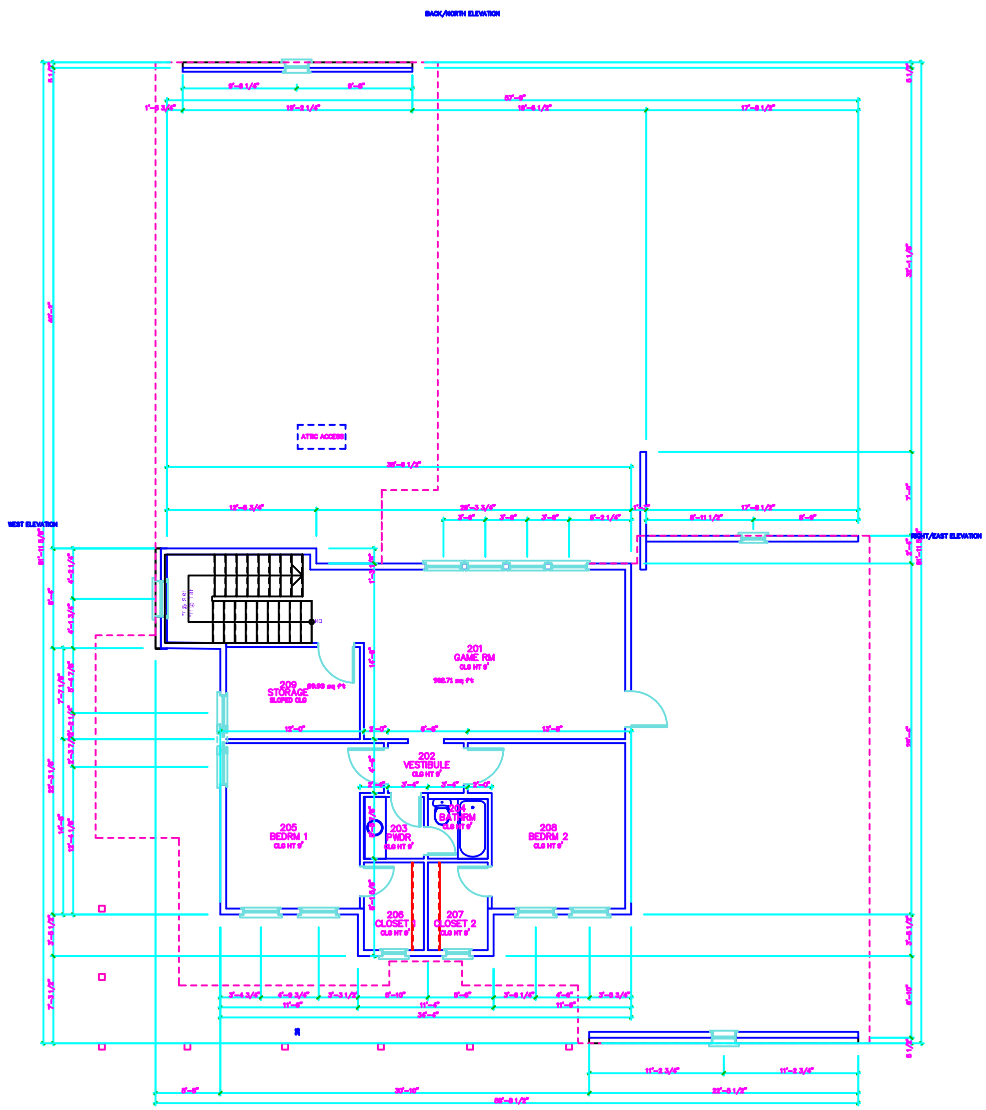
Building Science Corporation
30 Forest Street
Somerville, MA 02143
www.buildingscience.com

For more information about this or other case studies by Building Science Corporation and the Building America Program go to: www.buildingscienceconsulting.com/buildingamerica

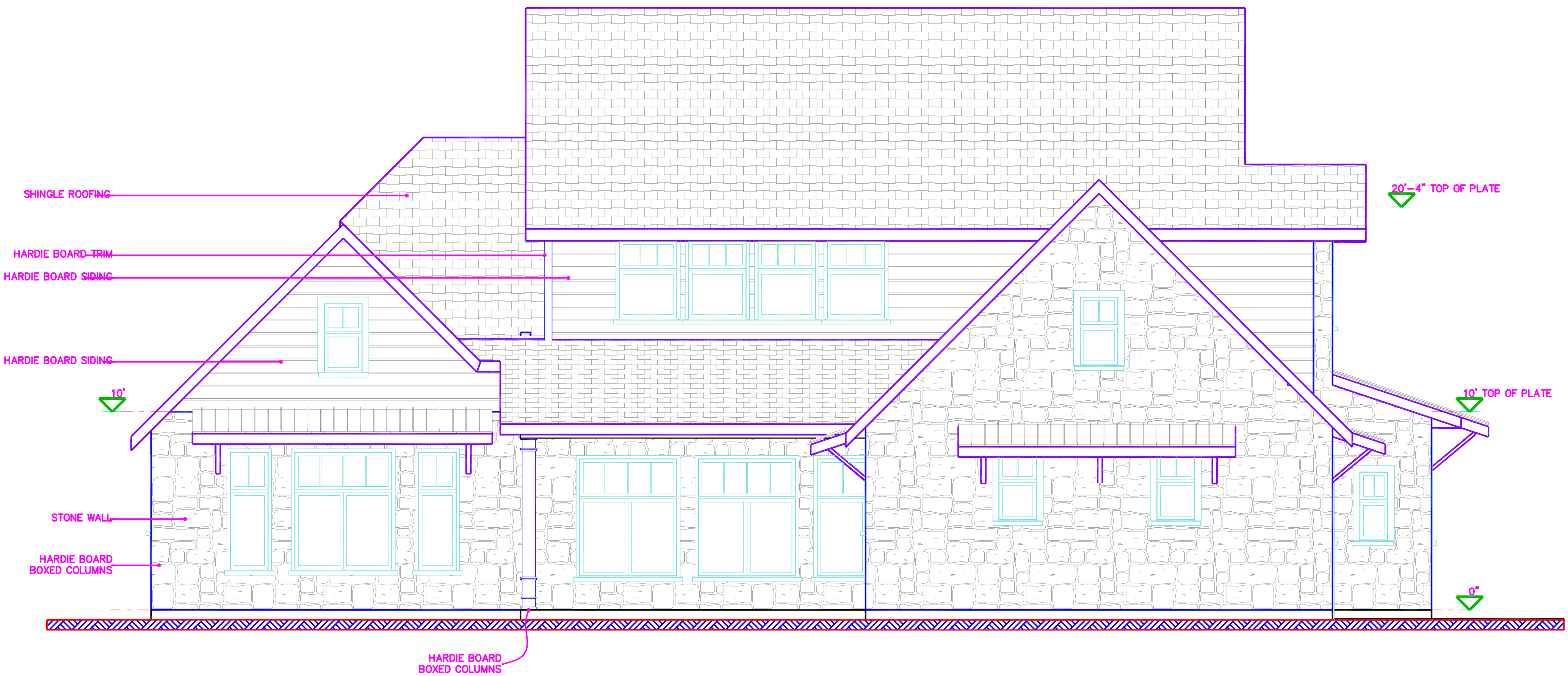
Appendix D.6.7.2
Drawings and Specifications

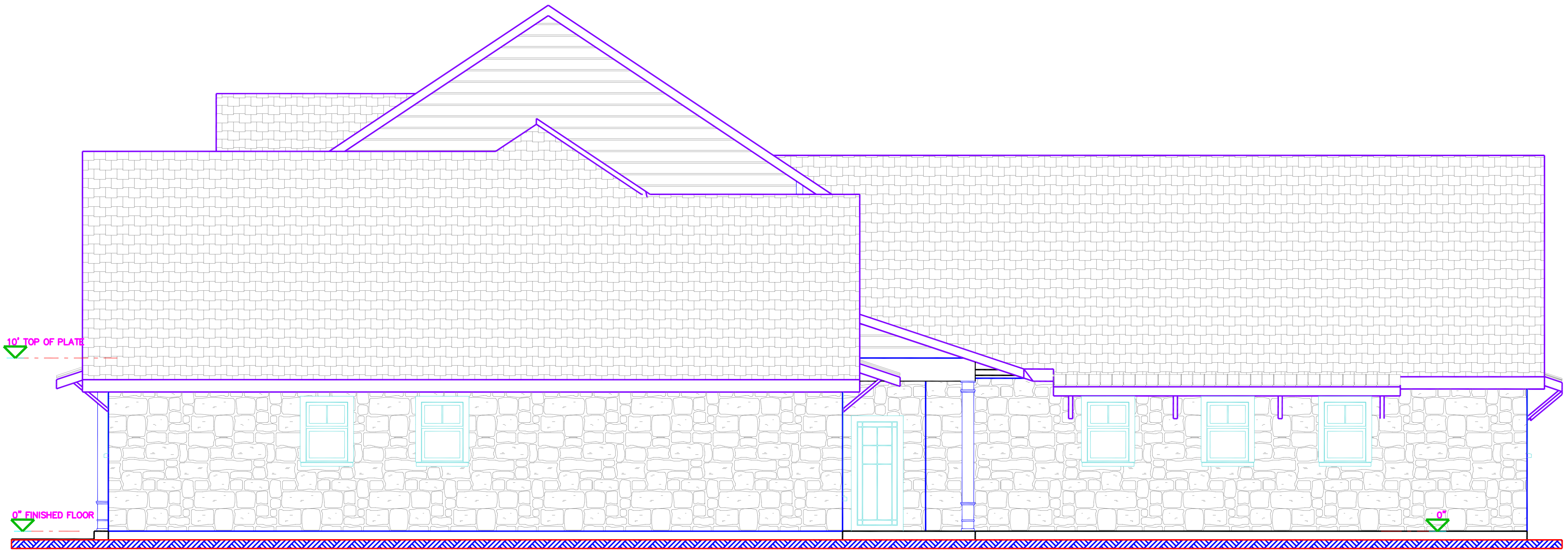
BA-0911: Prototype House Evaluations—Greencraft Builders Prosper House

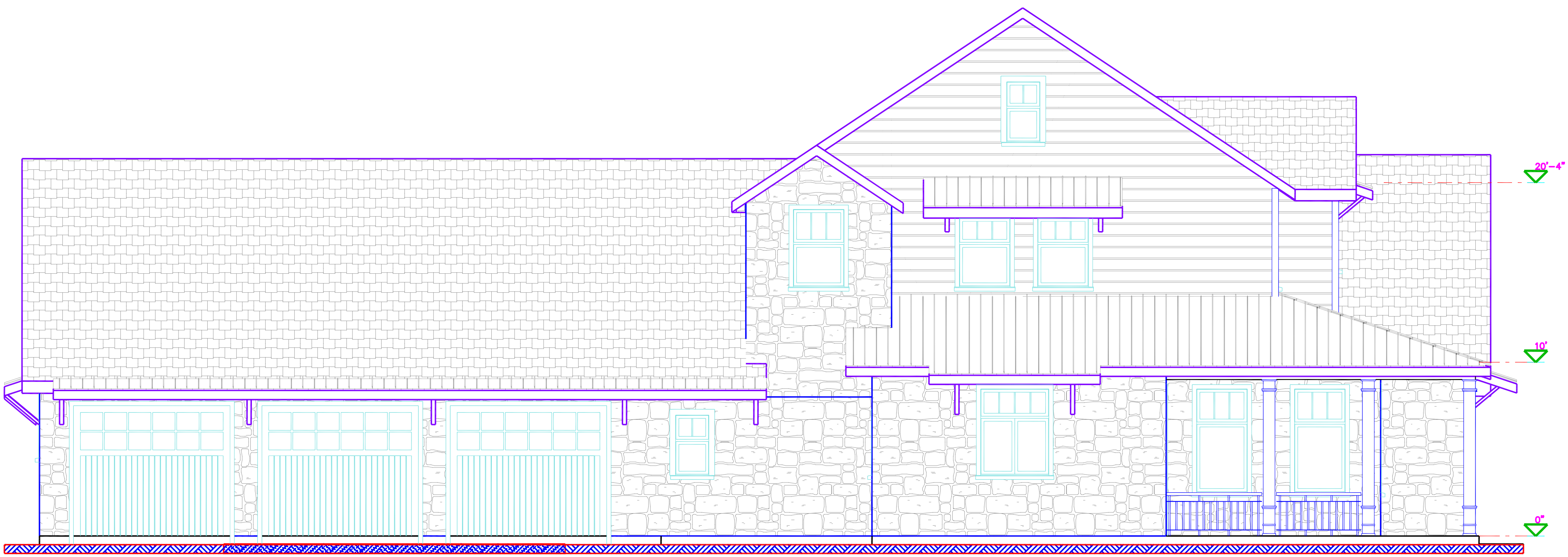


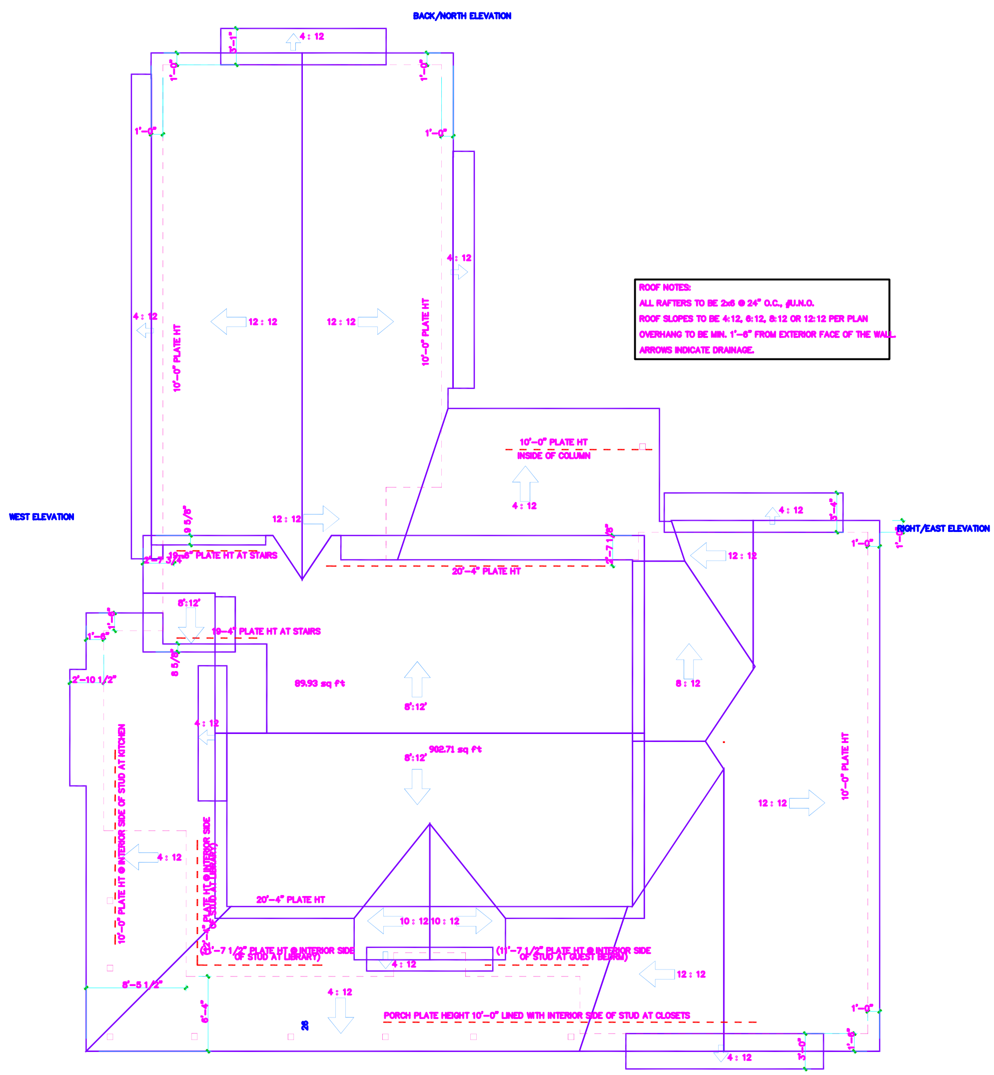

BACK/NORTH ELEVATION
WEST ELEVATION
RIGHT/EAST ELEVATION
ATTIC ACCESS
201
GAME RM
202
VESTIBULE
203
PWDR
204
BATHRM
205
BEDRM 1
206
CLOSET 1
207
CLOSET 2
208
BEDRM 2
209
STORAGE

BA-0911: Prototype House Evaluations—Greencraft Builders Prosper House


SHINGLE ROOFING
HARDIE BOARD TRIM
HARDIE BOARD SIDING
HARDIE BOARD SIDING
10'
STONE WALL
HARDIE BOARD
BOXED COLUMNS
HARDIE BOARD
BOXED COLUMNS
20'-4" TOP OF PLATE
10' TOP OF PLATE
0"


10' TOP OF PLATE
0" FINISHED FLOOR
0"


20'-4"
10'
0"


BACK/NORTH ELEVATION
WEST ELEVATION
RIGHT/EAST ELEVATION
ROOF NOTES:
ALL RAFTERS TO BE 2x6 @ 24" O.C., #U.N.O.
ROOF SLOPES TO BE 4:12, 6:12, 8:12 OR 12:12 PER PLAN
OVERHANG TO BE MIN. 1'-6" FROM EXTERIOR FACE OF THE WALL.
ARROWS INDICATE DRAINAGE.
4 : 12
12 : 12
8:12
8 : 12
10 : 12
10'-0" PLATE HT
10'-0" PLATE HT INSIDE OF COLUMN
20'-4" PLATE HT
19'-4" PLATE HT AT STAIRS
89.93 sq ft
992.71 sq ft
10'-0" PLATE HT @ INTERIOR SIDE OF STUD AT KITCHEN
PORCH PLATE HEIGHT 10'-0" LINED WITH INTERIOR SIDE OF STUD AT CLOSETS
1'-0"
1'-6"
2'-10 1/2"
8'-5 1/2"

Appendix D.6.7.3
Energy Modeling

June 17, 2008

Chris Miles
GreenCraft Builders LLC
105 W. Main Street
Lewisville, Texas
214-718-8424

Prosper House Energy Star Index and Federal Tax Credit

Mr. Miles,

Below is an updated BA Analysis that includes the new AAON heat pump with modulating hot gas reheat for supplemental dehumidification. Also included is the projected HERS Index and the projected Federal Tax Credit score.

The HERS Index is projected to be 57, which also qualifies it for the Building America Builder's challenge.

If you have any questions you can email me at phil@buildingscience.com or call 617 800 2633 extension 222.

Sincerely,

Philip Kerrigan Jr., PE
Building Science Corporation

Cc: Betsy Pettit, AIA (Building Science Corporation)
Joseph Lstiburek, Ph. D., P. Eng. (Building Science Corporation)

Executive Summary

Below are the Building America Characteristics for this plan. These characteristics are represented in Parametric Run 1: 2008 BA Characteristics.

Building Enclosure	**Building America Version**
Ceiling	R-30 spray foam at roof deck to create Conditioned attic Icynene®
Walls	2x6, 24" oc framing with 3/4" XPS with R-19 Spray foam Icynene®
Foundation	51% Flyash concrete monolithic slab with Termimesh termite control
Windows	Pella ® fiberglass LoE³ (U=0.28, SHGC=0.24)
Infiltration	2.5 sq in leakage area per 100 sf envelope

Mechanical systems	
Heat	AAON 8.7 HSPF air source heat pump
Cooling	AAON 17 SEER air source heat pump with reheat coil
DHW	Rinnai R94LSi Instantaneous Hot Water EF=0.82
Ducts	R-4.2 flex runouts in unvented attic or in floor joists
Leakage	none to outside (5% or less)
Dehumidification	Modulating reheat coil on AAON air source heat pump
Ventilation	AirCycler™ FR-V Supply-only system integrated with AHU
	33% Duty Cycle: 10 minutes on; 20 minutes off, 50 CFM average flow
Return Pathways	Transfer grilles/jump ducts at bedrooms
Lighting	CFL lighting package all screw base
Appliances	Energy Star fridge, DW, clothes washer

Below is a summary of the Prosper House dimensions:

Plan	**Floor area** (ft^2)	**Surface** (ft^2)	**Volume** (ft^3)	**Glazing Ratio** (%)
Prosper House	3323	9033	51197	17.8%

Parametric Analysis

The spreadsheet below outlines the parametric analysis step by step.

		Total Source Energy Savings (H/C/DHW/Lights/Appliances/Plug)					
Parametric Run ID	**Description of change**	**over BA Benchmark**	**Annual energy cost**	**Item Savings**	**HERS INDEX**	**Cooling Design**	**Heating Design**
						kBtu/hr	kBtu/hr
0	2008 BA Benchmark	n/a	$4,731	n/a	113.0	106.2	106.6
1	2008 BA Characteristics	52.3%	$2,265	$2,466	57.0	37.5	52.5

Tax Credit Certification Report

PROJECT

Title:	TX Greencraft Prosper Proto	Family Type:	Single-family	AdressType:	StreetAddress
Building Type:	User	New/Existing:	New (From Plans)	Lot #	
Owner:		Bedrooms:	4	SubDivision:	
# of Units:	1	Conditioned Area:	3323	PlatBook:	
Builder Name:	Greencraft	Total Stories:	2	Street:	
Permit Office:		Worst Case:	No	County:	
Jurisdiction:		Rotate Angle:	0	City, State, Zip:	,
Comment:	2008 Greencraft House				,

QUALIFICATION CRITERIA

Energy Use:

	Qualifying Home	Reference Home
Cooling Energy	15.38 MBtu*	44.81 MBtu
Heating Energy	24.89 MBtu*	39.28 MBtu
Total	40.27 MBtu	84.09 MBtu
Total Energy Use Savings =	52.11 %	

Envelope:

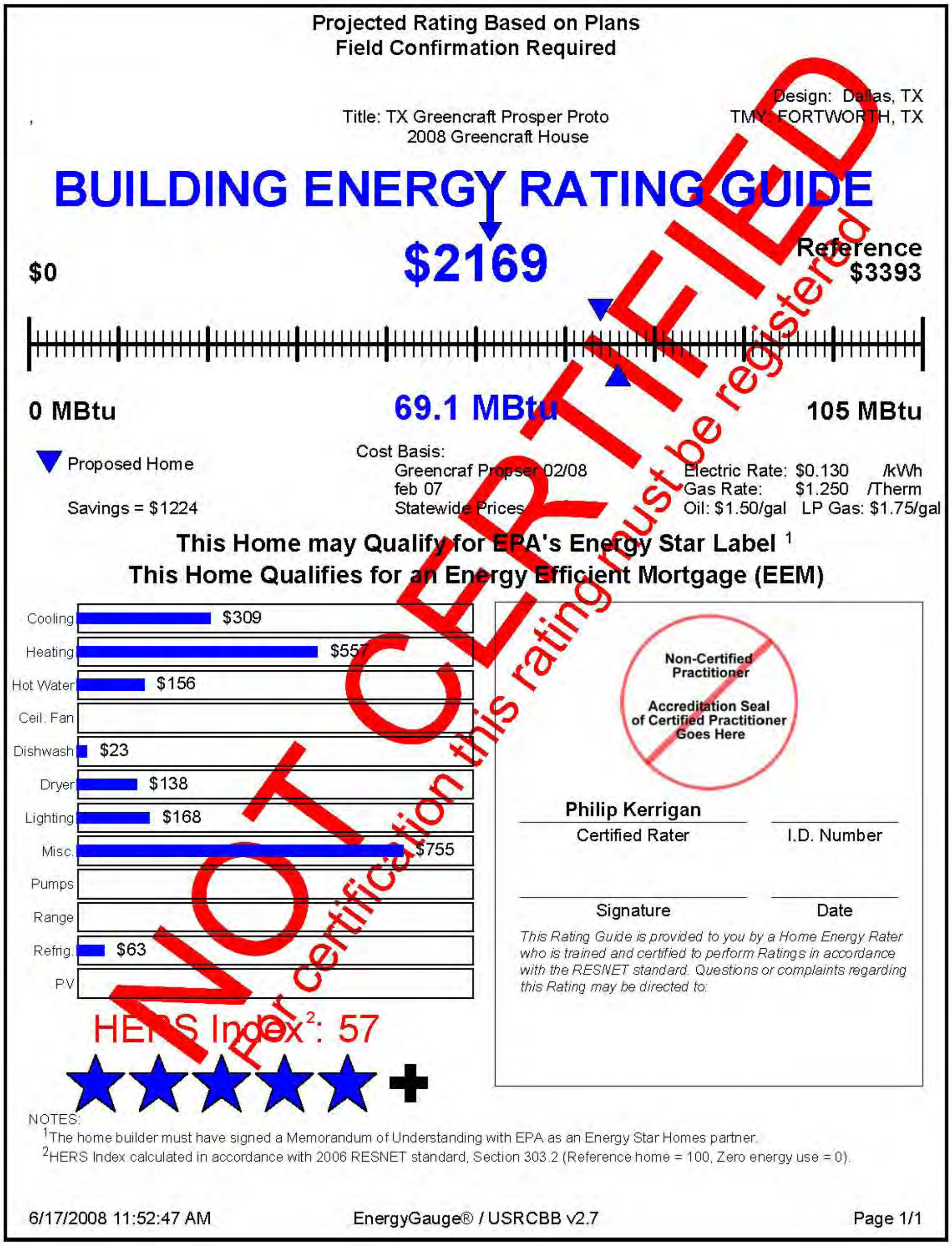
	Qualifying Home	Reference Home
Cooling Loads	24.81 MBtu	44.81 MBtu
Heating Loads	36.73 MBtu	39.28 MBtu
Total	61.54 MBtu	84.09 MBtu
Total Envelope Savings =	26.82 %	

All homes may qualify for a $2,000 federal tax credit to the builder if their heating and cooling energy use has been reduced by 50% or more and the home has achieved envelope savings of 10% or more. HUD Code manufactured homes may also qualify for a $1,000 tax credit to the manufacturer if their heating and cooling energy use has been reduced by 30% or more and the home has achieved envelope savings of 10% or more.

* Energy uses determined in accordance with RESNET Publication No. 06-001, "Procedures for Certifying Residential Energy Efficiency Tax Credits for New Homes."

Heating and cooling energy and cost savings have been calculated in the manner prescribed in section 2.02 of IRS Notice 2006-27. Field inspections of the dwelling unit (or of other dwelling units using the sampling protocol found in the current ENERGYSTAR for Homes Sampling Protocol Guidelines) performed by the eligible certifier during and after the completion of the construction have confirmed that all features of the home affecting such heating and cooling energy consumption comply with the design specifications provided to the eligible certifier.

Eligible Certifier ____________ Address ____________



Projected Rating Based on Plans
Field Confirmation Required

Design: Dallas, TX
TMY: FORTWORTH, TX

,

Title: TX Greencraft Prosper Proto
2008 Greencraft House

BUILDING ENERGY RATING GUIDE

$0 **$2169** **Reference $3393**

0 MBtu **69.1 MBtu** **105 MBtu**

Proposed Home

Savings = $1224

Cost Basis:
Greencraf Propser 02/08
feb 07
Statewide Prices

Electric Rate: $0.130 /kWh
Gas Rate: $1.250 /Therm
Oil: $1.50/gal LP Gas: $1.75/gal

This Home may Qualify for EPA's Energy Star Label [1]
This Home Qualifies for an Energy Efficient Mortgage (EEM)

Cooling	$309
Heating	$557
Hot Water	$156
Ceil. Fan	
Dishwash	$23
Dryer	$138
Lighting	$168
Misc.	$755
Pumps	
Range	
Refrig.	$63
PV	

Non-Certified Practitioner
Accreditation Seal of Certified Practitioner Goes Here

Philip Kerrigan
Certified Rater

I.D. Number

Signature

Date

This Rating Guide is provided to you by a Home Energy Rater who is trained and certified to perform Ratings in accordance with the RESNET standard. Questions or complaints regarding this Rating may be directed to:

HERS Index[2]: 57

NOT CERTIFIED

For certification this rating must be registered

NOTES:
[1]The home builder must have signed a Memorandum of Understanding with EPA as an Energy Star Homes partner.
[2]HERS Index calculated in accordance with 2006 RESNET standard, Section 303.2 (Reference home = 100, Zero energy use = 0).

6/17/2008 11:52:47 AM EnergyGauge® / USRCBB v2.7 Page 1/1

HERS 2006 Summary Report

Title: TX Greencraft Prosper Proto
User

TMY City: TX_FORTWORTH
Elec Util: Greencraf Propser 02/
Gas Util: feb 07
Run Date: 06/17/2008 11:52:26

Registration #:

2008 Greencraft House

Energy Uses	Rated Home	Reference Home	e-Ratio
Heating	14.62 MBtu	23.08 MBtu	0.63
Cooling	8.12 MBtu	23.67 MBtu	0.34
Hot Water	12.54 MBtu	15.30 MBtu	0.82
Lighting	4.42 MBtu	10.63 MBtu	0.42
Refrigerator	1.66 MBtu	2.64 MBtu	0.63
Dishwasher	0.59 MBtu	0.59 MBtu	1.00
Ceiling Fans	0.00 MBtu	0.00 MBtu	
Non-Rated Uses	23.46 MBtu	23.46 MBtu	1.00
Total	65.42 MBtu	99.36 MBtu	0.66

Building Loads	Rated Home	Reference Home	e-Ratio
Heating	24.89 MBtu*	39.28 MBtu	0.63
Cooling	15.38 MBtu*	44.81 MBtu	0.34
Hot Water	5.10 MBtu*	10.28 MBtu	0.50
Lighting	4.42 MBtu	10.63 MBtu	0.42
Refrigerator	1.66 MBtu	2.64 MBtu	0.63
Dishwasher	0.59 MBtu	0.59 MBtu	1.00
Ceiling Fans	0.00 MBtu	0.00 MBtu	
Non-Rated Uses	23.46 MBtu	23.46 MBtu	1.00
Total	75.50 MBtu	131.69 MBtu	0.57

* normalized modified loads

On-site energy production	
System Type	None
Gross Production	0.00 MBtu
Fuel Consumption	0.00 MBtu
Net Production	0.00 MBtu
PEfrac	100.00 %

*This report was produced by a non-certified practitioner and is intended for preliminary analysis. To be valid for official purposes, the information contained in the report must be confirmed and attested to by

6/17/2008 11:53 AM EnergyGauge® / USRCBB v2.7 Page 1 of 1

February 22, 2008

BEopt – EGUSA BA Performance Analysis Comparison: Prosper House, TX

All,

I finished a BEopt model as well as an EGUSA simulation for the 2008 Greencraft Prosper House in Dallas, TX. A comparison of the results shows that the BA percent savings calculation is quite off between the two (60% BA savings for BEopt and 44% for EGUSA). I am inclined at this point to believe the 44% generated by EGUSA, because of my familiarity with the EGUSA and the BA performance analysis protocol (60% would be nice though!).

Of course, we would like to know why this difference exists. The biggest contributor to this spread is the heating and cooling load, the rest of the loads appear to be pretty close by comparison. The limited input method of BEopt makes it difficult to ascertain any specific problems with the program, but there are a couple things.

1. It appears that BEopt doesn't allow for unvented attics, so that would be an obvious problem to start with, since this house has one.
2. The method of inputting walls and windows in BEopt is not very specific; this probably also plays a big role in the different heating and cooling loads. For wall areas, only the aspect ratio of the building shape is entered. For windows, only a glazing ratio plus a rough window percentage per orientation is inputted. Window overhang inputs are very limited as well in BEopt.

This house has a slab on grade, so the basement modeling problem that some are aware of about wouldn't apply

I would like to go over the results with the BEopt guys and hopefully clear things up a bit.

Philip Kerrigan Jr., PE
Building Science Corporation

Executive Summary

Below are the Building America Characteristics for this plan. These characteristics are represented in Parametric Run 1: 2008 BA Characteristics.

Building envelope	Building America Version
Ceiling	R-30 spray foam at roof deck to create Conditioned attic Icynene®
Walls	2x6, 24" oc framing with 3/4" XPS with R-19 Spray foam Icynene®
Foundation	51% Flyash concrete monolithic slab with Termimesh termite control
Windows	Vinyl LoE3 (U=0.30, SHGC=0.26)
Infiltration	2.5 sq in leakage area per 100 sf envelope
Mechanical systems	
Heat	9.5 HSPF Air Source Heat Pump in conditioned attic
Cooling	16 SEER split system in conditioned attic
DHW	Instantaneous Hot Water EF=0.84
Ducts	R-4.2 flex runouts in unvented attic or in floor joists
Leakage	none to outside (5% or less)
Dehumidification	Aprilaire Model 1700 integrated with HVAC system
Ventilation	Aprilaire VCS 8126 Supply-only system integrated with AHU
	33% Duty Cycle: 10 minutes on; 20 minutes off, 50 CFM average flow
Return Pathways	Transfer grilles/jump ducts at bedrooms
Lighting	CFL lighting package all screw base
Appliances	Energy Star fridge, DW, clothes washer

Below is a summary of the Prosper House dimensions:

Plan	# stories	Floor area (ft^2)	Surface (ft^2)	Volume (ft^3)	Glazing Ratio (%)
Prosper House	2	3323	9033	51197	17.8%

The results of the EGUSA – BEopt comparison are summarized below:

1. BEopt benchmark heating end-use source load is very high compared to the EGUSA result (184% of the EGUSA heating calculation). So far this is the biggest problem and contributes quite a bit to the 60%/40% difference.
2. BEopt benchmark cooling end-use load is high compared to the EGUSA result (141% of the EGUSA cooling calculation).
3. All the other loads appear to match up pretty well. So it appears that the main issue is heating and cooling.

Energy Gauge USA Analysis

The Prosper house was first analyzed with EGUSA v2.7.03 with the manual method.

Parametric Run ID	Description of change	Total Source Energy Savings (H/C/DHW/Lights/Appliances/Plug) over BA Benchmark[1]	Incremental Over Bmrk	Annual energy cost	Item Savings	HERS INDEX	Cooling Design	Heating Design
							kBtu/hr	kBtu/hr
0	2008 BA Benchmark	n/a	n/a	$3,891	n/a	113.0	71.4	83.5
1	2008 BA Characteristics	44.1%	n/a	$2,198	n/a	61.0	38.3	54.0

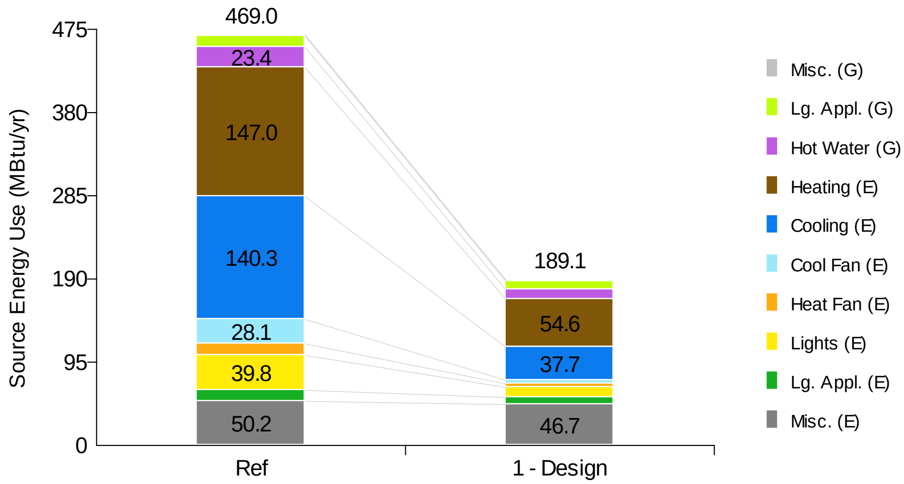
Note: Extra parametric steps have been calculated for the Prosper House in order to reach 50% vs. the 2008 BA Benchmark. However, to avoid confusion with the BEopt comparison, only a one-step improvement to the BA characteristics is shown here. The same one-step improvement is illustrated with BEopt in the next section for consistency.

	Annual Site Energy			
	Benchmark		Prototype	
End-Use	kWh	therms	kWh	therms
Space Heating	7235	0	5345	0
Space Cooling	10075		3100	
DHW	0	201	0	93
Lighting*	3815		1434	
Appliances + Plug	5413	114	5052	86
OA Ventilation**	709		388	
Total Usage	27247	315	15319	179
Site Generation	0		0	
Net Energy Use	27247	315	15319	179

	Estimated Annual Source Energy		Source Energy Savings % of End-Use	Source Energy Savings % of Total
	BA Benchmark	Prototype	Prototype	Prototype
End-Use	10^6 BTU/yr	10^6 BTU/yr	savings	savings
Space Heating	83.1	61.4	**26%**	**6%**
Space Cooling	115.7	35.6	**69%**	**23%**
DHW	21.9	10.2	**54%**	**3%**
Lighting*	43.8	16.5	**62%**	**8%**
Appliances + Plug	74.6	67.4	**10%**	**2%**
OA Ventilation**	8.1	4.5	**45%**	**1%**
Total Usage	347	195	**44%**	**44%**
Site Generation	0	0		**0%**
Net Energy Use	347	195	**44%**	**44%**

BEopt Analysis

Below is an end use graph for the Benchmark – Prototype (or Ref and 1 – Design) BEopt run.



The values are in the spreadsheet below with the % savings calculated. The far right columns show the individual BEopt loads percent above the EGUSA loads for both the benchmark and prototype.

BEopt Results	BA Benchmark	Prototype	Source Energy Savings		% over EGUSA	
End-Use	10^6 BTU/yr	10^6 BTU/yr	% of End-Use	% of Total	Bench	Proto
Total Heat	**160.1**	**58.7**	**63%**	**22%**	184%	92%
Total Cool	**168.4**	**42.0**	**75%**	**27%**	141%	117%
Hot Water	**23.4**	**11.2**	**52%**	**3%**	107%	110%
Lights	**39.8**	**11.1**	**72%**	**6%**	91%	68%
Total Misc	**77.3**	**66.1**	**14%**	**2%**	104%	98%
Total Usage	**469.0**	**189.1**	**60%**	**60%**		

As was stated before, the BEopt heating benchmark load is quite a bit higher than the EGUSA heating benchmark load, as is the cooling. The prototype loads match up ok for both software programs, except for lighting (68%). Lighting was inputted at 90% CFL in BEopt, but that resulted in more savings than what EGUSA calculated.

February 13, 2008

Chris Miles
GreenCraft Builders LLC
105 W. Main Street
Lewisville, Texas
214-718-8424

Building America Performance Analysis of the Prosper House

Mr. Miles,

BSC has completed initial Building America Performance Analysis on the 2008 Greencraft Prosper house. The house scores 43% without renewable energy sources. Therefore, solar DHW and PV will have to be employed in order to reach 50% vs. the 2008 Building America Benchmark.

If you have any questions you can email me at phil@buildingscience.com or call 617 800 2633 extension 222.

Sincerely,

Philip Kerrigan Jr., PE
Building Science Corporation

Cc: Betsy Pettit, AIA (Building Science Corporation)
Joseph Lstiburek, Ph. D., P. Eng. (Building Science Corporation)

Building Science Corporation 70 Main Street Westford, MA 01886 P: 978.589.5100 F: 978. 589.5103 www.buildingscience.com

Executive Summary

Below are the Building America Characteristics for this plan. These characteristics are represented in Parametric Run 1: 2008 BA Characteristics.

Building envelope	**Building America Version**
Ceiling	R-30 spray foam at roof deck to create Conditioned attic Icynene®
Walls	2x6, 24" oc framing with 3/4" XPS with R-19 Spray foam Icynene®
Foundation	51% Flyash concrete monolithic slab with Termimesh termite control
Windows	Vinyl LoE3 (U=0.30, SHGC=0.26)
Infiltration	2.5 sq in leakage area per 100 sf envelope
Mechanical systems	
Heat	9.5 HSPF Air Source Heat Pump in conditioned attic
Cooling	16 SEER split system in conditioned attic
DHW	Instantaneous Hot Water EF=0.84
Ducts	R-4.2 flex runouts in unvented attic or in floor joists
Leakage	none to outside (5% or less)
Dehumidification	Aprilaire Model 1700 integrated with HVAC system
Ventilation	Aprilaire VCS 8126 Supply-only system integrated with AHU
	33% Duty Cycle: 10 minutes on; 20 minutes off, 50 CFM average flow
Return Pathways	Transfer grilles/jump ducts at bedrooms
Lighting	CFL lighting package all screw base
Appliances	Energy Star fridge, DW, clothes washer

Below is a summary of the Prosper House dimensions:

Plan	**Floor area** (ft^2)	**Surface** (ft^2)	**Volume** (ft^3)	**Glazing Ratio** (%)
Prosper House	3323	9033	51197	17.8%

Parametric Analysis

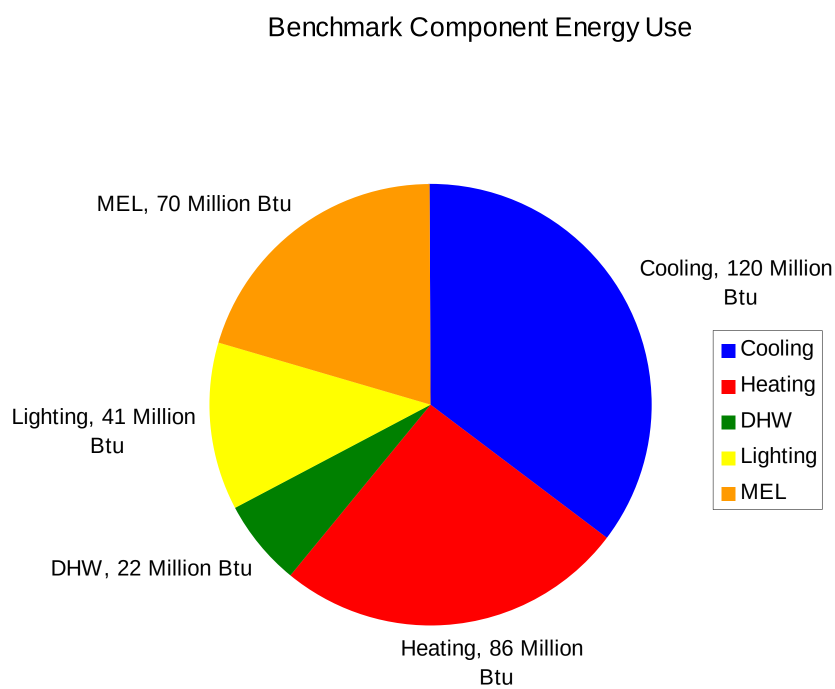
The spreadsheet below outlines the parametric analysis step by step.

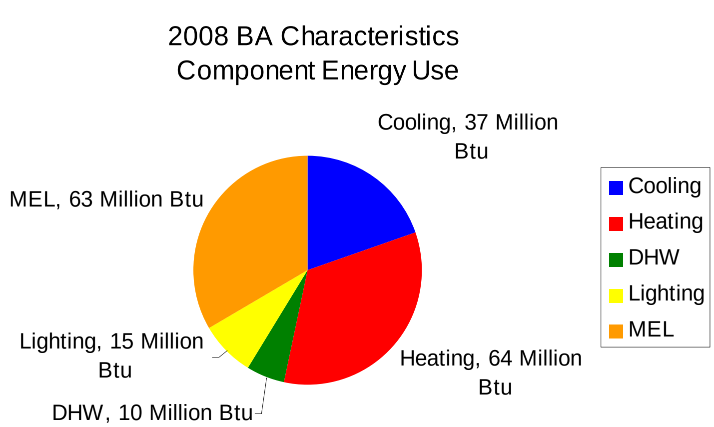
		Total Source Energy Savings (H/C/DHW/Lights/Appliances/Plug)						
Parametric Run ID	**Description of change**	**over BA Benchmark**[1]	**Incremental Over Bmrk**	**Annual energy cost**	**Item Savings**	**HERS INDEX**	**Cooling Design** kBtu/hr	**Heating Design** kBtu/hr
0	2008 BA Benchmark	n/a	n/a	$3,891	n/a	113.0	71.4	83.5
1	2008 BA Characteristics	44.1%	n/a	$2,198	n/a	61.0	38.3	54.0
2	Solar DHW	46.2%	2.1%	$2,116	$82	58.0	38.3	54.0
3	2.4 kW PV System	56.5%	10.3%	$1,694	$422	46.0	38.3	54.0

In order to reach 50% vs. the 2008 BA Benchmark, a PV system will have to be considered either alone or along with a solar DHW installation.

The pie charts below indicate the component energy use for benchmark and the BA characteristics model. Note the difference in heating/cooling ratio between the benchmark and the prototype. Heating becomes the dominant space conditioning load in the prototype. This is because the window technology (solar gain through windows drives the cooling load) has been handled quite well with extensive overhangs and a very low SHGC.

R-10 slab insulation as an example of a way to lower the heating load, however the % savings were negligible.





Appendix D.6.7.4
Mechanical System Design

Project Report

General Project Information

Project Title:	Prosper House Room By Room
Designed By:	Philip Kerrigan
Project Date:	06/2008
Client Name:	Chris Miles
Client Address:	P.O. Box 147
Client City:	Lewisville, TX 75067-0147
Client Phone:	214-718-8424
Client E-Mail Address:	chris.miles@verizon.net
Client Website:	http://www.greencraftbuilders.com/
Company Name:	Building Science Corporation
Company Representative:	Philip Kerrigan Jr
Company Address:	70 Main Street
Company City:	Westford, MA 01886
Company Phone:	(978) 589-5100
Company Fax:	(978) 589-5103
Company E-Mail Address:	phil@buildingscience.com
Company Website:	www.buildingscience.com

Design Data

Reference City:		Fort Worth, Texas
Daily Temperature Range:		Medium
Latitude:	32	Degrees
Elevation:	537	ft.
Altitude Factor:	0.981	
Elevation Sensible Adj. Factor:	1.000	
Elevation Total Adj. Factor:	1.000	
Elevation Heating Adj. Factor:	1.000	
Elevation Heating Adj. Factor:	1.000	

	Outdoor Dry Bulb	Outdoor Wet Bulb	Indoor Rel.Hum	Indoor Dry Bulb	Grains Difference
Winter:	20	0	30	72	23
Summer:	100	74	50	75	21

Check Figures

Total Building Supply CFM:	975	CFM Per Square ft.:	0.286
Square ft. of Room Area:	3,405	Square ft. Per Ton:	1,335
Volume (ft³) of Cond. Space:	43,910	Air Turnover Rate (per hour):	1.3

Building Loads

Total Heating Required Including Ventilation Air:	49,381	Btuh	49.381	MBH
Total Sensible Gain:	22,947	Btuh	88	%
Total Latent Gain:	3,016	Btuh	12	%
Total Cooling Required Including Ventilation Air:	25,963	Btuh	2.16	Tons (Based On Sensible + Latent)
			2.55	Tons (Based On 75% Sensible Capacity)

Notes

Calculations are based on 8th edition of ACCA Manual J.
All computed results are estimates as building use and weather may vary.
Be sure to select a unit that meets both sensible and latent loads.

Miscellaneous Report

System 1 First Floor Input Data	Outdoor Dry Bulb	Outdoor Wet Bulb	Indoor Rel.Hum	Indoor Dry Bulb	Grains Difference
Winter:	20	0	30	72	23.29
Summer:	100	74	50	75	21.03

Duct Sizing Inputs

	Main Trunk		Runouts	
Calculate:	Yes		Yes	
Use Schedule:	Yes		Yes	
Roughness Factor:	0.00300		0.01000	
Pressure Drop:	0.1000	in.wg./100 ft.	0.1000	in.wg./100 ft.
Minimum Velocity:	500	ft./min	450	ft./min
Maximum Velocity:	750	ft./min	500	ft./min
Minimum Height:	0	in.	0	in.
Maximum Height:	0	in.	0	in.

Outside Air Data

	Winter		Summer	
Infiltration:	0.100	AC/hr	0.100	AC/hr
Above Grade Volume:	X 43,910	Cu.ft.	X 43,910	Cu.ft.
	4,391	Cu.ft./hr	4,391	Cu.ft./hr
	X 0.0167		X 0.0167	
Total Building Infiltration:	73	CFM	73	CFM
Total Building Ventilation:	71	CFM	71	CFM

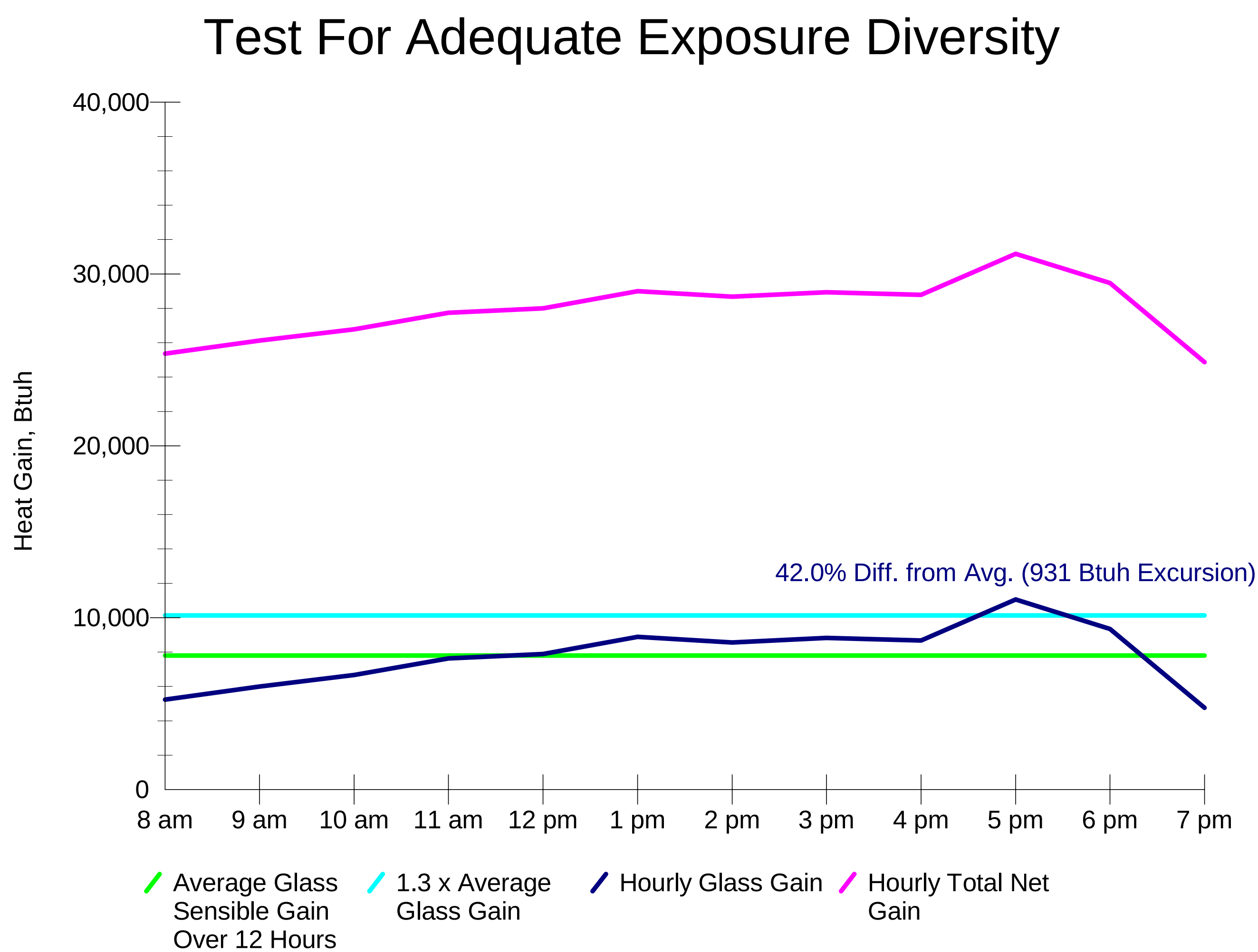
---System 1---

Infiltration & Ventilation Sensible Gain Multiplier:	26.97	= (1.10 X 0.981 X 25.00 Summer Temp. Difference)
Infiltration & Ventilation Latent Gain Multiplier:	14.03	= (0.68 X 0.981 X 21.03 Grains Difference)
Infiltration & Ventilation Sensible Loss Multiplier:	56.10	= (1.10 X 0.981 X 52.00 Winter Temp. Difference)

Load Preview Report

Scope	Has AED	Net Ton	Rec Ton	ft.² /Ton	Area	Sen Gain	Lat Gain	Net Gain	Sen Loss	Sys Htg CFM	Sys Clg CFM	Sys Act CFM	Duct Size
Building		2.16	2.55	1,335	3,405	22,947	3,016	25,963	49,381	601	975	975	
System 1	No	2.16	2.55	1,335	3,405	22,947	3,016	25,963	49,381	601	975	975	14x14
Ventilation						1,907	992	2,898	3,966				
Zone 1					3,405	21,040	2,024	23,064	45,415	601	975	975	14x14
1-Utility					92	1,583	21	1,604	2,598	34	73	73	1-6
2-Back Hall					110	810	25	835	2,129	28	38	38	1-4
3-Pantry					69	129	16	145	705	9	6	6	1-4
4-Kitchen					213	2,597	82	2,679	3,973	53	120	120	1-7
5-Dining					143	241	200	441	0	0	11	11	1-4
6-Library					203	1,726	90	1,816	4,770	63	80	80	1-6
7-Entrance Hall					84	436	16	452	1,219	16	20	20	1-4
8-Guest Bedroom					159	563	34	597	1,796	24	26	26	1-4
9-Family					483	1,535	450	1,985	3,298	44	71	71	1-6
10-Hall					67	89	0	89	142	2	4	4	1-4
11-Guest Bath					65	89	0	89	142	2	4	4	1-4
12-Guest WIC					56	469	43	512	1,857	25	22	22	1-4
13-Master Bedroom					337	2,315	515	2,830	5,909	78	107	107	1-7
14-Master Bath					135	838	39	877	1,977	26	39	39	1-4
15-Master WIC					128	831	67	898	3,008	40	39	39	1-4
16-Master Toilet					26	40	0	40	63	1	2	2	1-4
17-Bedroom 1					182	1,437	76	1,513	2,287	30	67	67	1-5
18-Bedroom 2					180	1,088	76	1,164	2,060	27	50	50	1-5
19-WIC 1					42	316	26	342	622	8	15	15	1-4
20-WIC 2					45	327	27	354	642	9	15	15	1-4
21-Vestibule					30	46	0	46	73	1	2	2	1-4
22-Storage					97	522	22	544	739	10	24	24	1-4
23-Game Room					459	3,013	199	3,212	5,406	72	140	140	1-8

System 1 - First Floor - Adequate Exposure Diversity Test



AED Calculation Summary

--- SYSTEM DOES NOT HAVE ADEQUATE EXPOSURE DIVERSITY. ---

System is on N, E, S, W rosette.
Peak load exceeds 12-hour average load by 42.0%.
AED Excursion (amount by which peak exceeds 1.3 x average): 931 Btuh

Definition: A system has adequate exposure diversity if the peak-hour glass load for the entire conditioned space does not exceed the average glass load for the entire conditioned space by more than 30 percent.

Total Building Summary Loads

Component Description	Area Quan	Sen Loss	Lat Gain	Sen Gain	Total Gain
Prosper Pella: Glazing-Prosper House - Greencraft 2008, outdoor insect screen with 100% coverage, light color drapes with medium weave with 50% coverage, u-value 0.28, SHGC 0.26	598.7	8,719	0	5,840	5,840
11P: Door-Metal - Polyurethane Core	40.2	559	0	397	397
12E-4sw: Wall-Frame, R-19 insulation in 2 x 6 stud cavity, R-4 board insulation, siding finish, wood studs	3923.2	11,219	0	4,898	4,898
12E-0sw: Part-Frame, R-19 insulation in 2 x 6 stud cavity, no board insulation, siding finish, wood studs	321.9	964	0	701	701
18B1-28o: Roof/Ceiling-Roof Joists Between Roof Deck and Ceiling or Foam Encapsulated Roof Joists, Spray Foam Insulation, White or Light Color Asphalt Shingle, Any Wood Shake, Dark or Medium Color Tile, Slate or Concrete, Light or Unpainted Metal, Light or Silver Membrane, Light Tar and Gravel, R-28 open cell 1/2 lb. spray foam in 2 x 8 joist cavity	2769.8	5,616	0	3,350	3,350
22A-pm: Floor-Slab on grade, No edge insulation, no insulation below floor, any floor cover, passive, heavy dry or light wet soil	232	14,235	0	0	0
Subtotals for structure:		41,312	0	15,186	15,186
People:	5		1,000	1,150	2,150
Equipment:			0	1,800	1,800
Lighting:	0			0	0
Ductwork:		0	0	0	0
Infiltration: Winter CFM: 73, Summer CFM: 73		4,103	1,024	1,973	2,997
Ventilation: Winter CFM: 71, Summer CFM: 71		3,966	992	1,907	2,898
AED Excursion:		0	0	931	931
Total Building Load Totals:		49,381	3,016	22,947	25,963

Check Figures

Total Building Supply CFM:	975	CFM Per Square ft.:	0.286
Square ft. of Room Area:	3,405	Square ft. Per Ton:	1,335
Volume (ft³) of Cond. Space:	43,910	Air Turnover Rate (per hour):	1.3

Building Loads

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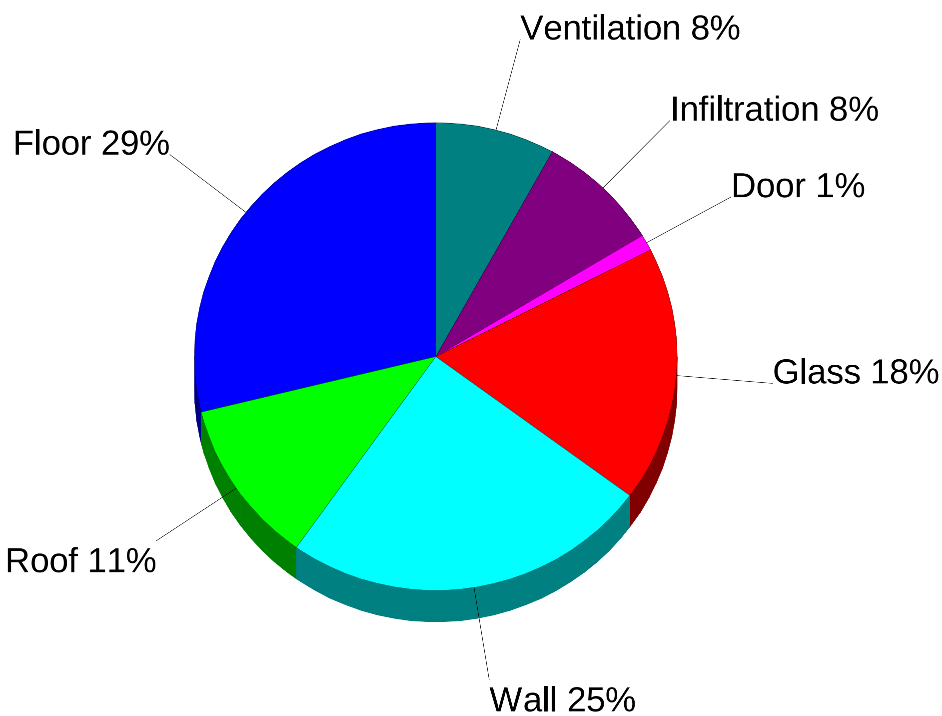
Total Cooling Required Including Ventilation Air:	25,963	Btuh	2.16	Tons (Based On Sensible + Latent)
			2.55	Tons (Based On 75% Sensible Capacity)

Notes

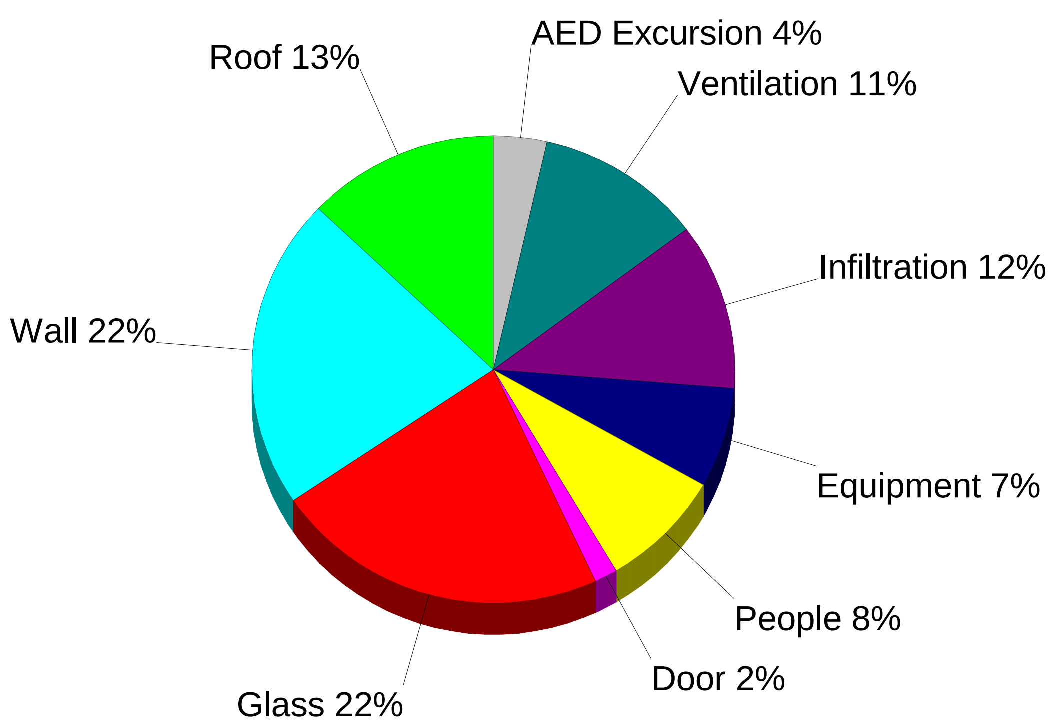
Calculations are based on 8th edition of ACCA Manual J.
All computed results are estimates as building use and weather may vary.
Be sure to select a unit that meets both sensible and latent loads.

Building Pie Chart

Building
Loss
49,381
Btuh



Building
Gain
25,963
Btuh



Whole House Dehumidifier 1300

Products that let you breathe a little easier

Protect and Control your Indoor Air for a Comfortable, Healthier Home

Features

- ***Optional Wall-Mounted Control***—The unit comes with self-contained controls but is easily converted to a dehumidistat control mounted in the living area (similar in appearance to a thermostat), saving trips to the basement or attic to change the setting.
- ***Cleanable Filter***—A permanent nylon mesh filter captures particulates and airborne dirt to improve indoor air quality; the filter is easily accessed from either side for cleaning.
- ***Frost Control***—Frost can collect on the coil after prolonged operation or if the home is kept at very cool temperatures. An automatic defrost system will turn off the compressor, but allow the fan to operate until any ice accumulation is melted. Once the coil is clear, the dehumidifier will resume normal operation.
- ***Minimal Maintenance***—The GeneralAire 1300 is built for long life and troublefree operation. Periodic cleaning of the filter keeps the unit operating at peak efficiency.
- ***Quiet Operation***—The GeneralAire 1300 is designed for quiet operation. The cabinet is lined with 1" thick high density, expanded polyethylene insulation that absorbs and reflects sound, keeping most unwanted noise from the duct system and living spaces. The compressor is mounted on rubber isolators to prevent vibration, and the entire unit can be placed on rubber feet or suspended using rubber isolators (optional) to further reduce noise transmission into the home.
- ***Energy Efficient***—When cooling a home drier air is more comfortable, many people actually raise the temperature setting on their air conditioner when a dehumidifier is installed, reducing the load on the air conditioner and helping extend its life.
- ***Fits Any Size Home***—With a dehumidifier, the greater the unit's capacity, the faster the home can be brought to a comfortable level. At 130 pints of moisture removed per day, the GeneralAire 1300 is effective in virtually every home and in the most humid conditions.

Effective, efficient dehumidification

When the dehumidifier fan is running, moist air from the living spaces is drawn into the unit via the inlet duct. It passes through the filter to remove air-borne contaminants, then continues on through the cold evaporator coil which causes the moisture to condense on the coil, much like condensation on the outside of a glass of ice water. The moisture falls into a stainless steel drain pan and is carried away by the drain hose.

The air then passes through the condensing coil where it is warmed before being discharged into the living space. To maximize this process, a thermostatic expansion valve provides precise refrigeration control over a wide range of operating temperatures.

Slide-out filter can be accessed from either side for easy cleaning

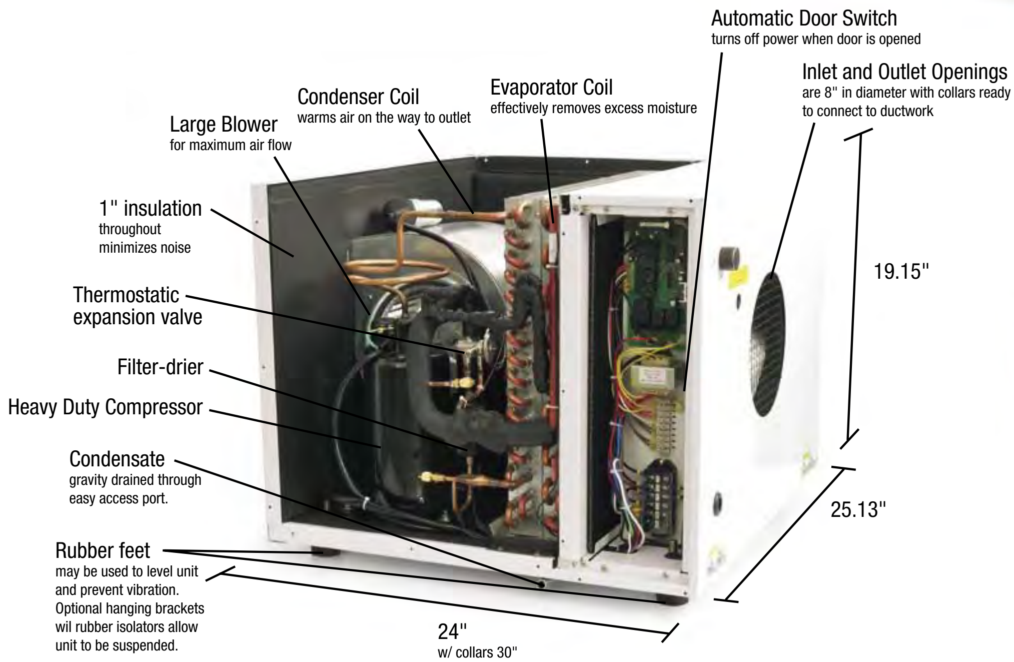
GENERALAire®
Fresh Indoor Air Quality

D-438

Climate control technology for healthier indoor air

Components

Easily accessible



Simple installation using existing ductwork

A whole house dehumidifier is installed as part of the heating and air conditioning system. Insulated, flexible ducts are used to connect the dehumidifier's inlet to the air conditioner's return duct; the dehumidifier outlet connects to the air outlet of the air conditioner.

The dehumidifier can be installed in new construction or existing structures, in basements, attics or crawl spaces—at roughly 2 feet square, it doesn't require a lot of room. It can sit on a flat surface using the rubber feet that are included to level the unit. It can also be suspended with the optional hanger kit WHD-HG14; four brackets and four rubber isolators come in the kit.

Power supply is standard 115V.

Specifications	
Capacity	130 pints per 24 hours @ 80˚F DBT/60% RH
Power Supply	115V 60 Hz, single phase, 15 amp dedicated circuit
Compressor	Rotary: Watts 1070, RLA 9.5, LRA 61
Fan Motor	1/10 HP, 1.15 FLA
Air Flow CFM	400 @ .6" w.c. e.s.p.
Inlet Air Operating Cond.	40˚ - 105˚F
Filter	Washable nylon mesh, 17" x 23.5"
Cabinet Insulation	EPE Material, 1" thick, R Value 4.5
Duct Connections	8" diameter (inlet and outlet)
Condensate Drain	1/2" O.D.
Weight	150 lbs
Dimensions	19.15"H x 25.13"W x 30" L (cabinet only: 24"L)

Dehumidifier Accessories

The entire range of GENERALAire controls is offered with features making your ventilations system simple, easy to operate.

DC1 Dehumidistat

- Automatic sampling sequence every hour.
- Fan runs for 15 minutes to sample air and sense humidity level.
- Sample passes sensor that turns compressor on if dehumidification is needed.
- Fan and compressor run until humidity level reaches preset level.

WHD-15 Damper Kit

- Optional Supply / Intake Control Damper

WHD-HG14 Four Point Grommet Hanger Kit

- Option includes 4 brackets and 4 isolators

Peace of Mind

LIMITED WARRANTY 5 years

GENERALAire Dehumidifier units are backed by the best limited warranty in the industry, for your peace of mind.

You benefit from a 5-year warranty on the compressor and a 1-year warranty on all other components with certain limitations. So you can breathe easy.

Distributed by:

GENERALAire®
Fresh Indoor Air Quality

CGF PRODUCTS
Canadian General Filters, Ltd.
Scarborough Ontario
www.CGFProducts.com
(416) 757-3691

Toll Free (866) 476-5101

General Filters, Inc.
Novi Michigan
www.GENERALAire.com

130DEH 0606 EGD

October 22, 2008

Chris Miles
GreenCraft Builders LLC
105 W. Main Street
Lewisville, Texas
214-718-8424

September 29th and 30th, 2008 site visit of Prosper House and Colleyville House

Mr. Miles,

Building Science Corporation conducted a site visit for both the 2008 Prosper house and the 2009 Colleyville house on September 29th and 30th. Both buildings will be BA Research homes and meet or exceed the 50% BA performance requirement.

BSC is considering being on-site to observe the ground source heat pump well drilling for the 2009 Colleyville house. However, this will depend on when the drilling is taking place and available Building America funds.

If you have any questions you can email me at phil@buildingscience.com or call (617) 863-5271.

Sincerely,

Philip Kerrigan Jr., PE
Building Science Corporation

Cc: Betsy Pettit, FAIA (Building Science Corporation)
Joseph Lstiburek, Ph. D., P. Eng. (Building Science Corporation)
Armin Rudd (Building Science Corporation)

2008 Prosper House

2008 Prosper House at 2481 Stoneybrook Drive, Prosper, TX

Currently, the house is framed and cladding is being installed. Greencraft is utilizing full OVE framing to maximize the enclosure U-value and reduce lumber use.

Tyvek® ThermaWrap™ is installed as the housewrap behind the cultured stone cladding on the first floor. The second floor will be framed with Hardie Board and will have the same housewrap.

Tyvek® ThermaWrap™ installed on first floor before cultured stone

Second Floor Hardie Board is installed.

Building Science Corporation   30 Forest Street Somerville, MA 02143   P: 978.589.5100   F: 978. 589.5103   www.buildingscience.com

Problems were observed with the window flashing. The header flap of the house wrap was not wrapped over the nailing flange of the Jeld-Wen windows. The installer came back and taped rectangular pieces of house wrap over the flange with Tyvek® Tape to ensure proper lapping. This fix should work as long as the tape is adhered properly to the house wrap. Another flashing observation was that some of the family room windows were initially installed too low to the ground. They had to be adjusted higher and this resulted in a double flashed sill. It is no problem as long as the flex wrap was adhered properly and remain adhered.

Header flashing piece added

Double flashed sill flashing with FlexWrap

Below are some photos that show proper flashing of the windows and the bottom plate of the OVE wall.

Window framing with FlexWrap

2x6 studs at 24” o.c. with poly wrapped under

The mechanical equipment is installed in the Prosper house. This includes a high efficiency air source heat pump / furnace and a whole house dehumidification unit. There will be two units, a three ton on the first floor and a two ton on the second. The heating and cooling system is a dual fuel air source heat pump/furnace for optimum heating efficiency.

HVAC system

GeneralAire Whole House Dehumidifier

Rather than the Aprilaire whole house dehumidifier installed in the Bannister house, the HVAC contractor decided to install a similar unit called a model 1300 GeneralAire dehumidifier. The contractor had to purchase an Aprilaire Model 8126 Ventilation Controller to provide fan cycling since the GeneralAire unit does not offer this function.

The whole house dehumidifier ductwork is installed correctly. The unit will draw air from the main living space below and will feed dehumidified air to the supply plenum.

Intake of dehumidifier installed over main space

Aprilaire 8126 VSC fan cycler installed

2009 Colleyville House

2009 Colleyville house at 1708 Oak Knoll Drive, Colleyville, TX

BSC also visited the 2009 Colleyville house on September 30th, 2008. It is expected to be finished in early 2009; hence it will be a 2009 BA research house.

Currently the house is framed and the windows are installed along with the HVAC system. This house is also OVE framed but Greencraft had a more difficult experience with the framers. However, all of the issues were eventually resolved.

Tyvek® DrainWrap™ was installed in this house and the cladding is a cultured stone and Hardie Board.

	
Tyvek® DrainWrap™ cap nailed and taped	Pella® Windows installed with proper flashing

Heating and Cooling will be provided by a ground source heat pump. The unit is called Envision™ and is manufactured by WaterFurnace®. On the first floor there is a 4 ton unit that has a GeneralAire dehumidifier as well as a FanTech ERV coupled to the outside air. The second floor has a 2 ton unit with a GeneralAire dehumidifier as well. Both units will operate in two stages, thus allowing for more efficient space conditioning during non-peak conditions.

	
HVAC system in unvented attic space	GeneralAire ERV coupled to outside air duct

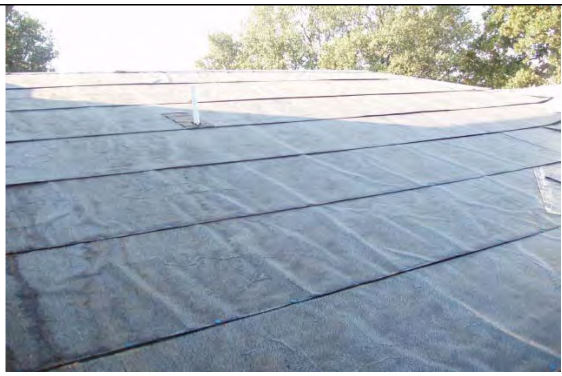
The Envision™ GSHP will also provide hot water via a 30 gallon low-boy that has not been installed yet. The closed ground loop feeds the air handler and hot water tank via the GeoLink®. A Rinnai® instantaneous hot water heater will be installed to provide supplemental hot water if necessary.

	
Horizontal air handler (with large pleated filter) with GeneralAire Model 1300 dehumidifier (on top)	Water Furnace® GeoLink® Flow Center will feed both the hot water tank and HVAC system.

The photo below shows the 2 ton unit with the Aprilaire fan cycler.

	
2-ton system with dehumidifier on second floor	Aprilaire 8126 Ventilation Control System installed

A fully adhered roofing membrane is installed as the photos show below. They are properly lapped in the valley of the roof and penetrations are sealed well.

	
Fully adhered roofing membrane lapped at valley	Fully adhered membrane lapped on roof with plumbing penetration properly flashed

Finally, the framers were able to upgrade the window construction on the Colleyvile house by eliminating the end cripple studs under the window.

	
No cripples adjacent to jack studs	Single top plate with stacked roof trusses (with 2x6 splice connector in one stud bay)

June 20, 2008

Chris Miles
GreenCraft Builders LLC
105 W. Main Street
Lewisville, Texas
214-718-8424

Framewalk of Prosper House and Colleyville House

Mr. Miles,

Building Science Corporation conducted a site visit for both the 2008 Prosper house and the 2009 Colleyville house. Both buildings will be BA Research homes and meet or exceed the 50% BA performance requirement.

BSC also discussed the option of installing the AAON CB/F1 heat pump with modulating gas reheat HVAC system. This system maintains very high efficiency ratings and also has supplemental dehumidification included.

BSC will follow up with the HVAC contractor and Greencraft to finalize the mechanical design.

If you have any questions you can email me at phil@buildingscience.com or call 617 800 2633 extension 222.

Sincerely,

P Kerrigan

Philip Kerrigan Jr., PE
Building Science Corporation

Cc: Betsy Pettit, FAIA (Building Science Corporation)
Joseph Lstiburek, Ph. D., P. Eng. (Building Science Corporation)
Armin Rudd (Building Science Corporation)

2008 Prosper House

Figure 1: Prosper House first floor framing

Framing has begun for the 2008 Prosper house. This will be a two story structure on a slab-on-grade with an unvented attic. Greencraft is utilizing OVE framing to reduce the number of framing members and increase the enclosure's overall U-value.

The photos below indicate the critical elements of advanced framing.

	
2 stud energy corners	Connector plate at corner framing

	
Top plate splice positioned on stud	Stud used as a splice connector in between studs

Below are photos of the second floor TJI stack framed. Greencraft is interested in using open web trusses in future projects to allow more flexibility in routing ductwork.

	
16" TJI floor joists stack framed over first floor studs	TJIs with sound isolation tape

BSC recommends that the edge cripples in the window framing can be removed to reduce thermal bridging and save lumber.

	
Window sill framing – edge cripples (in red) not necessary	Header hangers were considered but Greencraft decided to frame with jack studs.

Mechanical Recommendations

BSC met with Chris Miles of Greencraft and Keith Wolverton of Wolverton Air to discuss the HVAC design for the Prosper House.

BSC proposes to install the new AAON residential heat pump with hot gas reheat. Benefits of this system include:

- Two speed compressor to efficiently handle part load conditions
- 17 SEER/8.7 HSPF ratings
- ECM (Electronically Commuted Motor) directly coupled to the fan for maximum efficiency
- Modulating hot gas reheat coil to provide supplemental dehumidification

Manual J8 analysis results in a 3 ton unit for the Prosper house. However, because of duct routing limitations and the potential for stratification problems in a two story house, BSC and Wolverton Air are considering two units. At this point AAON smallest size is two tons, however they do intend to start manufacturing 1.5 ton systems. BSC is in the process of ascertaining when they will be available. It would be ideal to install two 1.5 ton systems as opposed to two 2 tons.

	
CB Condensing Unit	F1 Air Handler

2009 Colleyville House

Figure 2: 2009 Colleyville House framing

The Colleyville house has started framing. It is expected to be finished in early 2009; hence it will be a 2009 BA research house. This house will also be advanced framed. Below are some photos of the advanced framed elements.

	
Top plate splice positioned on stud	Stud used as a splice connector

	
Window framing	Bottom plate with stepped down slab edge for brick veneer front wall

Appendix D.6.7.5
Site Visit Reports

October 6th, 2009

Chris Miles
GreenCraft Builders LLC
105 W. Main Street
Lewisville, Texas
214-718-8424

Building America Performance Testing of the Prosper House

Dear Mr. Miles,

BSC visited the Prosper house on September 30, 2009 and performed a full battery of performance tests for commissioning the house as a Building America building. Overall, the house tested very well and complies with Building America Specifications.

BSC requests that monthly utility data be saved and submitted for performance analysis.

If you have any questions you can email me at phil@buildingscience.com.

Sincerely,

Philip Kerrigan Jr., PE

Building Science Corporation

Building Plan and Specifications

Building Science Corporation tested the Prosper House (originally a 2008 Building America Research house) on September 30th, 2009. This prototype reaches 52.7% vs. the Building America Benchmark. This prototype was given a full battery of tests, including multipoint blower door measurements; duct leakage (total and to the outside), and individual register flows. Overall, the Prosper house tested extraordinarily well. In addition to meeting Building America performance criteria the house employs many conservative design elements (salvaged wood floors, recycled material countertop) and is certified LEED Platinum.

Figure 1: Greencraft Prosper House at 2481 Stonybrook Dr, Prosper, TX

The building dimensions for the Prosper house are listed below.

Address	Town, State	Floor area (ft^2)	Surface (ft^2)	Volume (ft^3)	Glazing Ratio (%)
2481 Stonybrook Drive	Prosper, TX	3323	8895	42987	18.0%

The summary of our blower door data was as follows:

CFM $50_{measured}$ CFM @ 50 Pa	CFM 50_{goal} CFM @ 50 Pa	Pass/Fail 2.5 in^2	ACH 50 (cfm50/vol/hr)	EqLA (in^2@10 Pa)	ELA (in^2@4 Pa)	Leak Ratio (EqLA/surf/100)
994	2224	Pass	1.4	102.4	54.7	1.1

- Duct airtightness tests were run on the prototype; it met our requirement of 5% or less of nominal air handler flow duct leakage to outside (CFM 25), at 0% (15 CFM). Total duct leakage was on the order of 19% (380 CFM 50).
- A GeneralAire model 1300 whole house dehumidifier was installed and configured correctly.

- An Aprilaire Model 8126 Ventilation Control System was installed for outside air ventilation.
- An Energy Star Compact Fluorescent Lighting package was installed as well as an Energy Star refrigerator, dishwasher and clothes washer.

Construction

Construction of the Prosper House was well documented and they have a website solely dedicated to this project.

http://www.greencraftbuilders.com/greenspointhouse.html

GreenCraft Builders LLC., the builder for this project, is headed by Chris Miles. The house had guided tours throughout the construction process and over 4000 people were able to explore the project and get educated on the advanced technologies involved.

Below are the characteristics of the house:

Building Enclosure	
Roof	Composition shingles over #30 felt with fully adhered membrane at edges and ridges
Ceiling	Unvented cathedralized attic with R-30 open cell low density spray foam
Walls	2x6, 24" oc framing with 3/4" XPS with R-19 open cell low density spray foam
	Fibercement clapboard over 1x3 furring strips over Tyvek® ThermaWrap™
Foundation	51% Flyash concrete monolithic slab with Termimesh termite control
Windows	Jeld-Wen vinyl LoE^3 (U=0.33, SHGC=0.21)
Infiltration	1.1 sq in leakage area per 100 sf envelope (994 CFM 50)
Mechanical systems	
Heat	9.5 HSPF Air Source Heat Pump/sealed combustion 96% AFUE furnace in conditioned attic
Cooling	3 and 2 ton units 16 SEER split system in conditioned attic
DHW	Rinnai R94LSi Instantaneous Hot Water EF=0.82
Ducts	R-6 flex runouts in unvented attic or in floor joists
Leakage	0.75% leak to outside (15 CFM 25)
Dehumidification	GeneralAire Model 1300 whole house dehumidifier
Ventilation	Aprilaire Model 8126 Supply-only system integrated with AHU
	33% Duty Cycle: 10 minutes on; 20 minutes off, 50 CFM average flow
Return Pathways	Active Returns at Bedrooms
Lighting	CFL lighting package all screw base
Appliances	Energy Star fridge, DW, clothes washer

Walls

The house was cladded with Hardie Color Plus siding and stone over Tyvek® ThermaWrap™ over ¾" unskinned XPS sheathing over a wood framed wall with 2x6 24" OVE framing. The OVE framing includes a single top plate and two stud energy corners as well as windows framed at 2' intervals.

Figure 2: Walls wrapped with Tyvek® ThermaWrap™

Roof

The roof was constructed with an unvented cathedralized attic. Demilec® was sprayed to the underside of the roof sheathing to R-30. A fully adhered roof membrane was installed over the roof sheathing, see photo below.

Figure 3: Fully adhered roof membrane installed at edges and at roof intersections with #30 felt in the roof field for composition shingle roof.

Greencraft chose to construct an unvented cathedralized attic like in all of their prototype homes. This is the preferred attic design of Greencraft Builders, LLC since it allows for the placement of the HVAC system to remain in the attic space.

Figure 4: Composition Shingles metal roof

Foundation

Termimesh was installed as a physical termite barrier before the concrete pour. Below are some photos.

Termimesh protection around plumbing

Penetrations after casting

Lattimore Concrete poured the concrete foundation for the Prosper House. The concrete for the foundation of the house and porches consisted of 51% fly ash. This installation increases the strength of the concrete to 6000 psi (twice the normal strength).

Stone Exterior Walls

The first floor exterior walls were clad with stone. There is a 1" drainage space behind the stonewall that drains water out at the bottom through installed weep holes. See the photos below for the weep holes.

Close up of stone weep hole

Stone weep holes in exterior walls serve to drain water from drainage plane behind stone

Other sustainability improvements include:

95% Recycled Content Sheetrock
85% Recycled Garage Doors
Engineered Quartz Countertop
Low/No VOC paint
Water Wise Landscaping

Reclaimed Oak Flooring
FSC Certified Wood Used for Interior Trim and Cabinets

Mechanical Systems

An air source heat pump with a duel fuel air handler is installed. This will allow the heating system to switch from heat pump to furnace at around 40 degrees. The ductwork is assembled with flex with duct board.

The duct work is located in conditioned space as the photos show below.


Ductwork with dehumidifier showing


Ductwork in cathedralized attic

The ventilation system is a supply only central fan integrated supply (CFIS) system.


6” outside air duct with mechanical damper at return plenum


Inline fan connecting the three bathrooms to the outside via a single duct

The dehumidification system installed is a GeneralAire model 1300 whole house dehumidifier that draws directly from the main living space and dumps into the supply plenum of the HVAC system. This configuration allows for whole house dehumidification to run separate from heating and cooling because it is not fully coupled to the duct system (intake is from main living space). This prevents short circuiting as can happen when the dehumidifier is ducted to both supply and central return, which would require the air handle to run whenever there is a call for dehumidification.

Figure 5: GeneralAire Model 1300 installed on top of air handler

There were some ducts on HVAC System 2 that were sealed using grey vinyl duct tape. Most of the duct tape is not adhered properly, and air flow could be felt coming from the cracks. Below are a few photos showing this:

	
Duct tape connecting duct work	Duct tape is not adhering to the mastic coated ductboard cover

Also, HVAC system 2 has neither an outside air duct nor a fan cycler installed. BSC recommends that each HVAC system have these components installed.

10

Appendix D.6.7.6
Builder's Challenge Certificate

U.S. Department of Energy

EnergySmart Home Scale℠

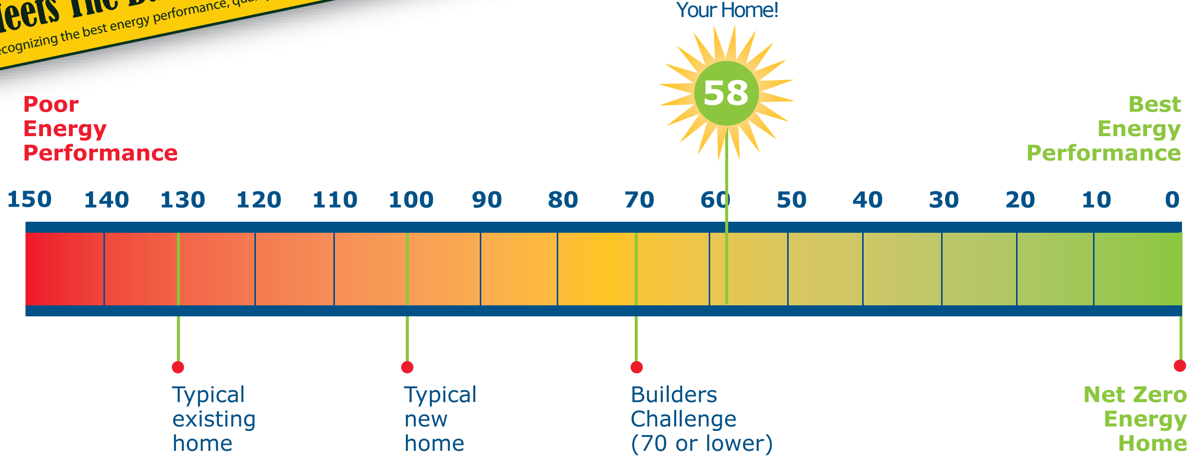
Estimated annual energy usage:
Electric (kWh) 16451
Natural Gas (therms) 156

Conditioned floor area (sq. ft.): 3370

2481 Stonybrook Drive, Prosper, TX
Rated by Building Science Corporation
Rating conducted **December 2, 2008**

www.buildingamerica.gov/challenge

Meets The Builders Challenge
Recognizing the best energy performance, quality, comfort, health and safety in the market.



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